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TO IMPROVE THE STRENGTH AND CBR VALUES IN SUB-BASE AND SUB-GRADE IN EXPANSIVE SOILS USING CHLORIDE COMPOUNDS

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ABSTRACT-The improvement in the properties of expansive soils, as road subgrade stabilized with chloride compounds varying in percentages. Laboratory tests were undertaken to study the strength characteristics of expansive soils performed on natural soil samples. Expansive soils such as black cotton soils are basically susceptable to determinental volumetric changes, with changes in moisture. This behaviour of soil is attributed to the presence of mineral montmorillonite, which has an expanding lattice .Understanding the behaviour of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers extensive research is going on to find the solutions to black cotton soils there have been many methods available to controlling the expansive nature of the soils. An infrastructure project for instance Highways Railways, reclamation etc require earth material in very huge quantity. Fairly often large areas are covered with highly plastic and clayey soils. Extensive laboratory and field trials have been carried out by various researches and have shown promising results for application of such expansive soils after Stabilization. soft soils form problematic sub grade for pavements due to its low bearing capacity and strength. Pavement loads carrying on the soft sub grade soil may cause detrimental pumping actions. when they are located in areas with high water table which cause both construction and in service performance problems. The common solutions on encountering such problems include excavation and replacement of soils. By chemical stabilization with chlorides NACL, $CACL_2$. On certain properties of soil such as OMC, MDD, UCC, CBR has been studied under both heavy and light compaction. Hence in the present work experimentation is carried out to investigate the influence of chlorides including Nacl,$Cacl_2$ on the engineering properties of expansive soils. Various amounts of salts (0.5%,1% ,1.5%,2.0%) were added to the soil to study the effect of salts on the compaction characteristics, consistency limits, compressive strength, ucsand cbr.The present investigation on expansive soils with chloride compounds.

I.INTRODUCTION

This project prescribes the appropriate type or types of additives to be used with different soils types, procedure for determining a design treatment level for each type of additive, and recommended construction practice for incorporating the additives into soils.

Scope of transportation system has developed very largely. Population of the country is increasing day by day. The need for travel to various places at faster speeds also increased. This increasing demand led to the emergence of other modes of transportation like railways and travel by air. While the above development in public transport sector was taking place, the development in private transport was at a much faster rate mainly because of its advantages like accessibility, privacy, flexibility, convenience and comfort. This led to the increase in vehicular traffic especially in private transport network. Thus road space available was becoming insufficient to meet the growing demand of traffic and congestion started. In addition, chances for accidents also increased. This has led to the increased attention towards control of vehicles so that the transport infrastructure was optimally used. Various control measures like traffic signals, providing Roundabouts and medians, limiting the speed of vehicle at specific zones etc. were implemented.

Soil **–** Soil is sediment or other unconsolidated accumulation of solid particles produced by the Definitions and Terminology physical and/or chemical disintegration of rock, soil may or may not contain organic material (ASTM D 2487).

Clay **–** Clay is type of cohesive soil composed of very fine material particles; clay is one of the fine-grained soils defined by the Unified Soil Classification System.

Stabilization of Black Cotton Soil

Modification of black cotton soils by chemical admixtures is a common method for stabilizing the swell-shrink tendency of expansive soils. Advantages of chemical stabilization are that they reduce the swell-shrink tendency of the expansive soils and also render the soils less plastic. Among the chemical stabilization methods for expansive soils, lime stabilization is most widely adopted method for improving the swell-shrink characteristics of expansive soils.

Expansive soils are predominantly found in many parts of the world. In India, they cover almost twenty percent of the land mass. Expansive soils undergo large amount of heaving and shrinking due to seasonal changes. The magnitude of such seasonal movements being dependent on several factors, still pose a problem for estimation of settlements. The swelling of clays has posed a serious problem for the development and maintenance of infrastructure like buildings, pavements, pipelines etc.

Significant research has been done in the area of stabilization of soft clays in past few decades. Haussmann lists three main soil modification techniques as mechanical, chemical, and physical methods. Among these most widely adopted are mechanical and chemical stabilization methods. Chemical stabilizers include lime and cement. Hunter reports that Lime is not preferred in sulphate rich soils since calcium present in lime reacts with sulphates and alumina present in the soil leading to formation of Ettringite and Thaumasites. Sherwood noted that Cement stabilized soils are susceptible to high temperature cracking, brittle failure and corrosive soil environment. With these drawbacks, there is need for other new alternative stabilizers which are effective in overcoming and addressing the associated problems. Hence as an alternative Organic stabilizer is considered in the present study and their ability to reduce swelling is examined.

Fig. 1 Black Cotton Soil

II. GROUND WORK

Laboratory Investigation of Expansive Soil Stabilized with Calcium Chloride: Magdi M. E. Zarqawi, Khalid A. Eltayeb 2016**:** Chemical stabilization is a technique commonly usedto improve the expansive soil properties. In this regard, an attempt has been made to evaluate the influence of Calcium Chloride (CaCl2)stabilizer on the engineering properties of expansive soil. A series oflaboratory experiments including consistency limits, free swell,compaction, and shear strength tests were performed to investigatethe effect of CaCl2 additive with various percentages 0%, 2%, 5%,10% and 15% for improving expansive soil. The results obtainedshows that the increase in the percentage of CaCl2 decreased theliquid limit and plasticity index leading to significant reduction in thefree swell index. This, in turn, increased the maximum dry densityand decreased the optimum moisture content which results in greaterstrength. The unconfined compressive strength of soil stabilized with5% CaCl2 increased approximately by 50% as compared to virginsoil. It can be concluded that CaCl2 had shown promising influenceon the strength and swelling properties of expansive soil, therebygiving an advantage in improving problematic expansive soil.

Stabilisation of silty clay soil using chloride compounds tamadher t. Abood, anuar bin kasa, zamri bin chik(2007) :

The object of this paper is to investigate the effect of adding different chloride compounds including (NaCl, MgCl2, CaCl2) on the engineering properties of silty clay soil. Various amounts of salts (2%, 4%, and 8%) were added to the soil to study the effect of salts on the compaction characteristics, consistency limits and compressive strength. The main findings of this study were that the increase in the percentage of each of the chloride compounds increased the maximum dry density and decrease the optimum moisture content. The liquid limit, plastic limit and plasticity index decreased with the increase in salt content. The unconfined compressive strength increased as the salt content increased.

Effect of Common Salt (Nacl) on Engineering Properties of Black Cotton Soil PRAKHAR DUBEY,RAJESH JAIN (2015):The results of laboratory investigations on the influence of Common Salt (NaCl) on the engineering properties of black cotton soils are presented in this research paper. Black Cotton soil was mixed with Common Salt (NaCl) at 0%, 2%, 4%, 6% and 8%. Common Salt (NaCl) content (by dry weight of soil) in order to establish the soil stabilizing potentials. Common Salt (NaCl) increased the Maximum Dry Density, MDD, of the soil by 1.64 g/cc to 1.79 g/cc and reduced the Optimum Moisture Content, OMC, 21.16% to 14.95%. Soaked CBR increased with increase in Common Salt (NaCl) 1.43% to 3.10%. Common Salt increased the unconfined compressive strength of black cotton soil 73.54 KN/M2 to 119.64 KN/M2 and Common Salt also effected Triaxial strength parameters. The results indicate that there is a potential in the use of Common Salt (NaCl) to strengthen Black cotton soils.

.Effect of Common Salt (Nacl) On Index Properties of Black Cotton Soil (BCS) RajkumarVishwakarma , Ankur Dubey , Akash Jain (2017**):**investigated the effect of Common salt (NaCl) on the index properties of Black cotton soil. This black cotton soil were mixed with various amount of Common Salt (0, 2, 4, 6, and 8) % to study the effect of Common Salt (NaCl) on consistency limits or index properties. In this study, the common salt (NaCl) is collected from shop Garha Market, Jabalpur M.P. and the Soil sample collected from NSCB Medical College, near Hostel campus Jabalpur MP. The soil falls under highly expansive category, based on consistency index and free swell. The modification of properties of soil such as physical nature, chemical composition and metallurgical properties and that soil on the nature of contaminant. These contaminant soil such organic solved or organic matter and inorganic. The laboratory test results showed the significant improvements upon the use of Common Salt (NaCl). The plasticity index reduced from 22.21 to 16.94. The liquid limit decrease from 46.30 to 33.47%. Plastic limit decrease from 22.26 to 17.87 %. Anlo increase the shrinkage limit from 12.98 to 15.98% and the free swell value reduced from 43 to 18 is observed.Effect of Some Chloride Salts on Swelling Properties of Expansive Soil Magdi M. E. Zumrawi, Alla M. M. Mahjoub, Iman M. Alnour(2016):Chemical stabilization has been increasingly adopted for improving the properties of expansive soils in recent years. The use of chloride salts to stabilize expansive clays has been investigated by many researchers. In this regard an attempt has been made to evaluate the influence of adding three chloride salts (AlCl3, FeCl2, NH4Cl) to an expansive clay of high swelling potential on its swelling properties. Laboratory tests conducted on natural and treated soils include Atterberg's limits, free swell, swell potential, and swell pressure tests. Various amounts of each salt (0%, 5%, 10%, and 15%) were added to the soil to study their effect on plasticity and swelling characteristics.Comparing the results obtained for the natural and treated soils, the increase in the percentage of the salt decreased the liquid limit and plasticity index of the soil. The reduction in the plasticity index values of the treated soil with addition of 15% salt is more than 78% of the virgin soil. A significant decrease in the free swell index, swell potential and swell pressure of the treated soil was experienced. The tests results indicated that among the three chloride salts tested, ammonium chloride showed promising results. It can be concluded that the chloride salts studied had shown great potential to improve swelling properties of expansive soils.stabilization of soil using chemical methods p.durga bhavani, dr. D s v prasad :In India, expansive soils popularly known as black cotton soils are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Understanding the behavior of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Extensive research is going on to find the solutions to black cotton soils. There have been many methods available to controlling the expansive nature of the soils. Treating the expansive soil with electrolytes is one of the techniques to improve the behavior of the expansive ground. Hence, in the present work, experimentation is carried-out to investigate the influence of electrolyte viz. potassium chloride, calcium chloride and ferric chloride on the properties of expansive soil. A methodical process, involving experimentation on Atterberg limits (liquid limit, plastic limit), sieve Analysis, specific gravity, proctor compaction test, California Bearing Ratio(CBR), Unconfined Compressive Strength(UCS) test, Triaxial test were conducted by adding 0.5%, 1%, 1.5% of Potassium Chloride, Calcium Chloride and Ferric Chloride to the expansive soil by dry weight under controlled conditions in the laboratory. It is observed form the laboratory studies that maximum reduction in properties is observed for Ferric Chloride treatment compared to other electrolytes tried in this investigation.Study On Effect Of Chemical Stabilizing Agents On Strength And Swelling Properties Of Soils Mallika , B. Ganesh **:**In India, expansive soils popularly known as black cotton soils are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Understanding the behavior of expansive soil and adopting the appropriate control measures have been great task for the geotechnical engineers. Proper characterization and selection of suitable foundation is essential in case of problematic soils. Extensive research is going on to find the solutions to black cotton soils. There have been many methods available to control the expansive nature of the soils. Treating the expansive soil with electrolytes are one of the technique to improve the behavior of the expansive ground. Hence, in the present work, experimentation is carried-out to investigate the influence of electrolytes like calcium chloride and ferric chloride on the properties of expansive soil.

A methodical process, involving experimentation in the laboratory under controlled conditions is done. With addition of electrolytes to the expansive soil, improvement in its physical and engineering properties is observed. It is observed that the maximum improvement in properties of expansive soil is obtained for Ferric Chloride treatment compared to other electrolytes tried in this investigation .Stabilization of Clayey Soils Using Chloride Components Habiba Afrin : Soils exhibit generally undesirable engineering properties. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Stabilization and its effect on soil indicate the reaction mechanism with additives, effect on its strength, improve and maintain soil moisture content and suggestion for construction systems. The main objective of this paper is to improve the physical and chemical properties of clay soil by using chemical additives like chloride compounds as NaCl, CaCl2 and MgCl2. Various proportions of NaCl, CaCl2 and MgCl2 was mixed with soil and basic engineering properties such as specific gravity, liquid limit, compaction characteristics and consolidation parameters were determined. It has been observed that an addition of different percentages like 4%, 8% and 12% of chloride compounds into clayey soils increased the dry density and decreased the moisture content. The liquid limit, plastic limit and plasticity index decreased with the increase in chemical content. This appears due to the fact that addition of NaCl, CaCl2 and MgCl2 filled up the voids between particles of soil as particle size of NaCl, CaCl2 and MgCl2 is smaller than soil particles and can be easily replaced the voids. The compression index and swelling index was decreased with the increase in chloride compound percentage.

Effect of Calcium Chloride Solution on Engineering Properties of Black Cotton Soil Sangita Lajurkar ,Dr. Y. S. Golait , Dr. S. R. Khandeshwar (2016):Expansive soil popularly known as black cotton soil is very problematic for Civil engineering structure. Its swell-shrink behavior with seasonal moisture content change cause serious damages to the structure founded on it. This behavior of black cotton soil necessitates in-situ ground improvement with respect to increasing the bearing capacity and reducing swelling. This paper reveals the efficacy of calcium chloride solution in improving swell and strength properties of Black Cotton Soil by physical diffusion technique.

III.MATERIALS

The laboratory testing program was undertaken to achieve the objective of the study. Tests were conducted on black cotton and treated soils using two different chloride salts to investigate their influence on swelling properties.

Materials used

In this study, the materials used in the experimental investigation are expansive soil and two chloride salts sodium chloride and calcium chloride.

Expansive soil: The expansive soil used in this study was obtained from Gowdavalli railway station near Medchal. The soil is dark black stiff clay of high plasticity.

Fig.2 Black Cotton Soil collected in Medchal

Sodium chloride

Sodium chloride is also known as salt or halite, is an ionic 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, 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.

Physical properties:

Sodium chloride is a white crystalline solid with a density of 2.16 g/mL, and a melting point of 801 °C. It is also available as aqueous solutions of different concentrations, called saline solutions.

Chemical properties

Sodium chloride is readily soluble in water and other polar solvents. It is a stable solid. It only decomposes at high temperatures to give toxic fumes of hydrochloric acid (HCl) and disodium oxide (Na_2O).

Characteristics of a Sodium Chloride

Sodium chloride is formed when sodium atoms interact with chlorine atoms. When this occurs, sodium will donate an electron (which is a negatively-charged particle) to chlorine. This makes sodium slightly positive and chlorine slightly negative.

Opposite charges attract So then, sodium ions will attract chloride ions and form an ionic bond. By the way, chloride is the term used to designate the anion form of chlorine. The result is a crystallized salt that has properties that are different from the two parent elements (sodium and chlorine). The chemical formula for sodium chloride is NaCl, which means that for every sodium atom present, there is exactly one chloride atom.

Sodium chloride has a molar mass of 58.44 grams per mole. It appears as a solid, clear crystal with little or no odour. As a salt, sodium chloride dissolves well in water and the ions in the crystals will separate when in solution.

Sodium chloride molecules can also stack on top of each other in a structure known as a lattice and the solid crystals of sodium chloride will contain this lattice-type arrangement.

Fig.3 Sodium Chloride

Calcium chloride: Calcium chloride is an inorganic compound, a salt with the chemical formula CaCl2. It is a colour less crystalline solid at room temperature, highly soluble in water.

Formula and Structure of Calcium Chloride: Calcium chloride is created from the ionic bonds that form between calcium cations and chloride anions. Calcium ions have a charge of +2, while chloride ions have a charge of -1.The molecule for calcium chloride has one calcium ion (+2) and two chloride ions (-1), which means that the overall charge for the molecule is 0, or neutral. On screen is the chemical reaction for the formation of calcium chloride.Calcium chloride salts can also form crystals based on these same ionic properties. Positive calcium ions can orient themselves so that they are close to the negative chloride ions in another molecule. This allows for the solid crystal structure shown on screen. The uses of calcium chloride are numerous. They range from natural production in the environment to uses in food and medications. The following examples represent a small number of these uses.

Calcium Chloride Uses: Building Materials: Calcium chloride is used in building materials. It is a large component of limestone, which means that it has a natural function in many marine environments. Additionally, limestone is often used commercially to serve as building material in the process of making concrete.

Physical properties: Calcium chloride is found as an odorless white powder, granules or flakes. It has a density of 2.15 g/mL, melting point of 782 °C and a high boiling point over 1600 °C.

Chemical properties: $CaCl_2$ is highly water soluble, hygroscopic (absorbs moisture from air) and deliquescent (absorbs enough water to turn into liquid). Calcium chloride dissolves in water in a very exothermic manner (releasing a large amount of heat). Calcium chloride fully dissociates in water to give calcium cations and chloride anions.

TABLE I - Chemical Information

Chemical Formula	$CaCl_2$
CAS number	10043-52-4
Molecular Weight	110.983
Colour	White
Density	2150 kg / m^3
Appearance	solid crystalline powder / flake / granule
Melting point	782°C
Boiling point	>1600°C

IV.EXPERIMENTAL INVESTIGATION

Brief steps involved in the experiments:

free swell test:

Free swell index is the increase in volume of soil without any external constraints on submergence in water.

Free swell index = $[V_d - V_k] / V_k \times 100\%$
where,
V_d = volume of soil specimen read from the graduated cylinderContaining distilled water.

V_k = volume of soil specimen read from the graduated cylinder Containing kerosen.

Fig.4 free-swell index

Specific Gravity of the soil: Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air. The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc

It is determined in the laboratory using the relation

$$G = \frac{M_2 - M_1}{(M_2 - M_1) - (M_3 - M_4)}$$

Where,

M_1 = mass of empty bottle

M_2 = mass of the bottle and dry soil

M_3 = mass of bottle, soil and water

M_4 = mass of bottle filled with water only.

The specific gravity of a soil is used in relating a weight of soil to its volume and in calculation of phase relationship, i.e. the relative volume of solids to water and air in a given volume soil. The specific gravity is used in the computations of most of the laboratory tests, and is needed in nearly all pressure, settlement, and stability problems in soil engineering

The specific gravity of the soil particles lie within the range of 2.65 to 2.85. Soils containing organic matter and porous particles may have specific gravity values below 2.0. Soils having heavy substances may have values above 3.0.

Fig.5 Density bottle method

Liquid limit: The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. This is the limiting moisture content at which the cohesive soil passes from liquid state to plastic state.

Liquid limit is significant to know the stress history and general properties of the soil met with construction. From the results of liquid limit the compression index may be estimated. The compression index value will help us in settlement analysis. If the natural moisture content of soil is closer to liquid limit, the soil can be considered as soft if the moisture content is lesser than liquids limit, the soil can be considered as soft if the moisture content is lesser than liquid limit. The soil is brittle and stiffer.

Plot the relationship between water content (on y-axis) and number of blows (on x-axis) on semi-log graph. The curve obtained is called flow curve. The moisture content corresponding to 25 drops (blows) as read from the represents liquid limit. It is usually expressed to the nearest whole number.

Flow index $I_f = (W_2 - W_1)/\log(N_1/N_2)$

Fig.6 liquid limit test

Plastic limit: Plastic limit: The plastic limit of a soil is the moisture content, expressed as a percentage of the mass of the oven-dried soil, at the boundary between the plastic and semi-solid states. The plastic limit is expressed as the moisture content in percentage of the mass of the oven-dried soil and is calculated as follows:

Plastic limit =weight of water/mass of oven dried soil *100

In the case of plastic soils, a considerable amount of kneading and rolling is required in order to reduce the moisture content of the moist material to the plastic limit. This is time consuming, and it is therefore suggested that the moist material from the liquid limit determination be spread out in a thin layer on the table and left to dry out appreciably before rolling is commenced. The moisture content should not be reduced by the admixture of dry soil.

Figs.7 plastic limit *Fig.8 plastic limit test*

Particle size distribution by sieve analysis: The soil is sieved through a set of sieves. The material retained on different sieves is determined. The percentage of material retained on any sieve is given by

$$P_n = \frac{M_n}{M} \times 100$$

Where M_n = mass of soil retained on sieve 'n

M= total mass of the sample.

The distribution of different grain sizes affects the engineering properties of soil. Grain size analysis provides the grain size distribution, and it is required in classifying the soil. The grain size analysis is widely used in classification of soils. The data obtained from grain size distribution curves is used in the design of filters for earth dams and to determine suitability of soil for road construction, air field etc. Information obtained from grain size analysis can be used to predict soil water movement although permeability tests are more generally used.

Fig.9 Particle size distribution by sieve analysis:

Standard Proctor compaction test: Compaction is a method of mechanically increasing the density of soil, and it's especially valuable in construction applications. If this process is not performed properly, soil settlement can occur, resulting in unnecessary maintenance costs or failure of the pavement or structure.

Proctor Tests: The Proctor Compaction Test and its variants are used to determine optimal moisture content for soils. This test is especially useful when determining the relationship between water content and the dry unit weight of soils to establish the maximum density of a soil needed for a fill area. The laboratory test serves a two-fold purpose by first determining the maximum density achievable for the materials in the field, as a reference. Secondly, it measures the effect moisture has on soil density. These values are often determined before earthwork begins to provide reference values for field testing.

$$\text{Dry density} = \frac{M/V}{1+W}$$

Where, M = total mass of the soil,

V= volume of soil

w= water content.

***CBR test*:** It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material. The California Bearing Ratio Test (CBR Test) is a penetration test developed by *California State Highway Department (U.S.A.)* for evaluating the bearing capacity of subgrade soil for design of flexible pavement.

Load-Penetration curve: The load penetration curve is plotted taking penetration value on x-axis and Load values on Y-axis. Corresponding to the penetration value at which the CBR is desired, corrected load value is taken from the load-penetration curve and the CBR calculated as follows

California bearing ratio = (P_T/P_S) x100
Where,

P_T =Corrected unit (or total) test load corresponding to the chosen

Penetration curve,

P_S = Unit (or total) standard load for the same depth of penetration as for

the same depth of penetration as for P_S taken from standard code.

V.RESULTS

TABLE II
Physical properties of black cotton soil

properties	soil
Liquidlimit (%)	43
Plastic limit (%)	25
Plasticity index (%)	18
Free swelling index (%)	47
specific gravity	2.65
Compaction test: Optimum moisture content (%)	27.2
Maximum dry density (KN/m^2)	1.56

TABLE III

Compaction test for 0%, 0.5%, 1.0%, 1.5% and 2.0% Nacl

moisture content%					dry density g/cc				
0.0	0.5	1.0	1.5	2.0	0.0	0.5	1.0	1.5	2.0
10.7	13.20	18.30	20.00	23.00	1.42	1.32	1.30	1.35	1.52
19.04	21.04	21.04	21.04	23.04	1.47	1.41	1.41	1.48	1.48
20.58	23.58	23.00	25.00	25.00	1.50	1.47	1.50	1.56	1.56
21.7	24.70	28.60	28.60	26.60	1.52	1.52	1.58	1.62	1.56
27.2	28.20	29.00	23.00	25.00	1.56	1.59	1.60	1.78	1.78
28	30.00	25.00	25.00	28.00	1.51	1.51	1.40	1.60	1.56

TABLE IV

Compaction test for different percentages

% of Nacl	water content	dry density
0	27.2	1.56
0.5	28.2	1.59
1	29	1.6
1.5	23	1.79
2	25	1.78

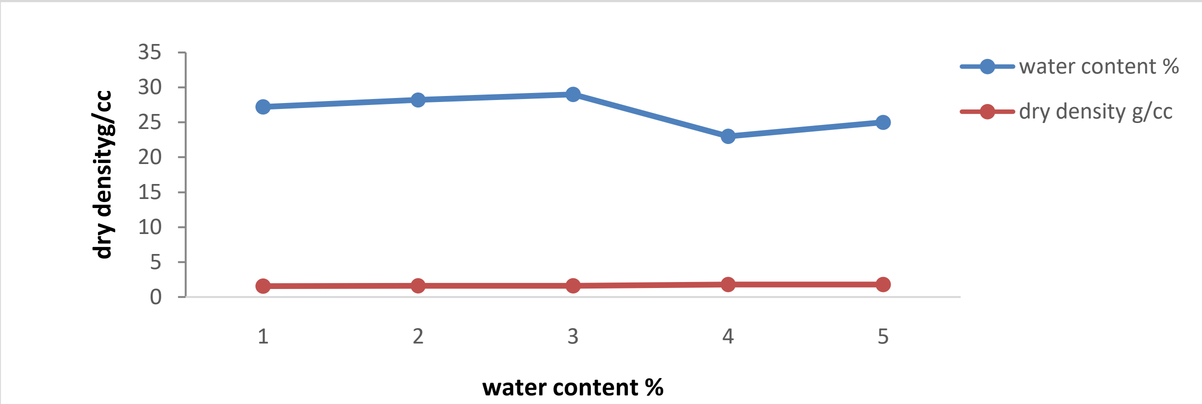

Fig.10 comparison of water content vs. dry density

TABLE VI

Compaction test for 0%, 0.5%, 1.0%, 1.5% and 2.0% Cacl2

moisture content%					dry density g/cc				
0.0	0.5	1.0	1.5	2.0	0.0	0.5	1.0	1.5	2.0
10.70	21.23	20.23	22.30	18.20	1.42	1.40	1.56	1.48	1.46
19.04	23.54	23.14	23.10	23.32	1.47	1.42	1.52	1.47	1.48
20.58	24.85	24.25	24.50	25.07	1.50	1.40	1.43	1.40	1.43
21.70	26.62	25.62	25.20	25.62	1.52	1.56	1.42	1.46	1.45
27.20	21.60	21.60	27.80	26.40	1.56	1.41	1.96	1.41	1.56
28.00	23.30	22.30	26.30	27.90	1.51	1.43	1.42	1.43	1.43

TABLE VII

Compaction test for different percentages

% of $Cacl_2$	OMC	MDD
0%	27.2	1.56
0.50%	26.62	1.52
1.00%	21.6	1.96
1.50%	22.3	1.48
2.00%	26.4	1.56

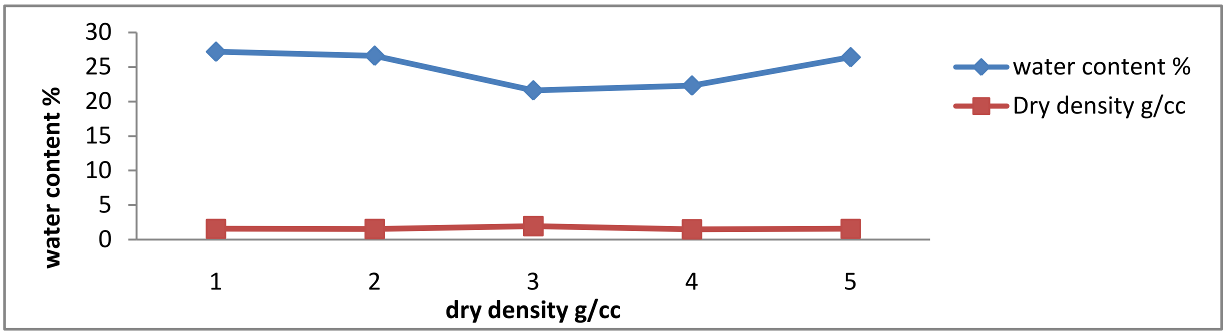

Fig.11 comparison of water content Vs dry density

Experiments on CBR Test for Black CottonSoil

TABLE VIII - CBR Test for Nacl

penetration in mm	Load in KN				
	0% Nacl	0.50% Nacl	1% Nacl	1.50% Nacl	2% Nacl
0	0.00	0.00	0.00	0.00	0.00
0.5	39.27	35.70	34.51	32.13	26.42
1	44.03	39.51	38.08	35.70	39.27
1.5	46.65	45.82	41.65	39.27	46.77
2	51.77	47.60	44.03	41.65	54.74
2.5	59.26	51.77	46.65	47.60	61.17
3	62.00	57.36	47.60	51.17	67.00
3.5	65.69	59.02	51.41	55.93	70.21
4	68.90	66.88	52.96	59.50	74.97
4.5	71.52	63.31	59.62	60.69	77.35
5	75.21	66.28	63.31	65.45	81.52
5.5	76.76	71.52	65.93	66.64	85.09
6	83.54	81.16	67.59	71.40	86.87
6.5	87.47	82.47	71.76	74.38	91.63
7	89.49	86.28	74.26	83.30	94.01
7.5	95.56	89.25	85.92	93.06	96.39

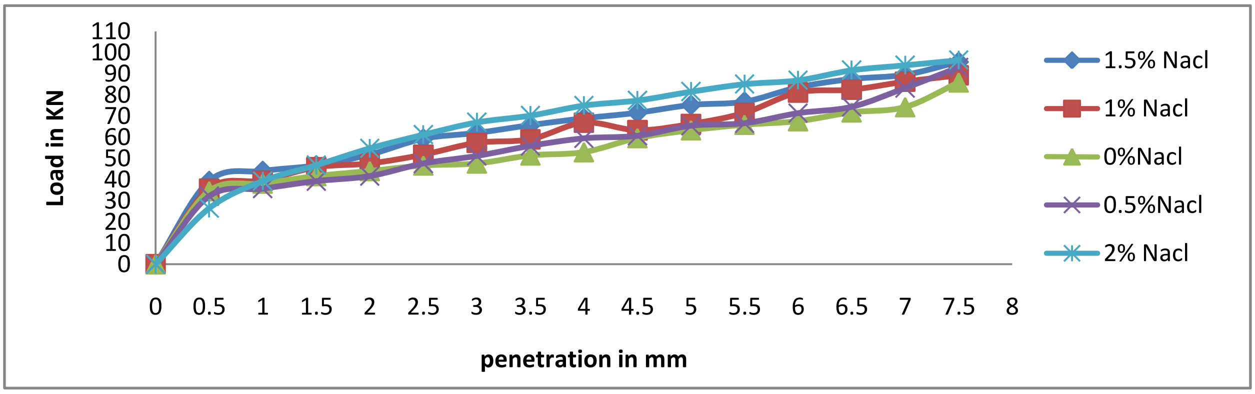

Fig.12 Soaked CBR values penetration vs. load

TABLE IX - CBR test for different percentages

% of Nacl	CBR VALUES for Nacl
0	3.4
0.5	3.47
1	3.77
1.5	4.5
2	4.32

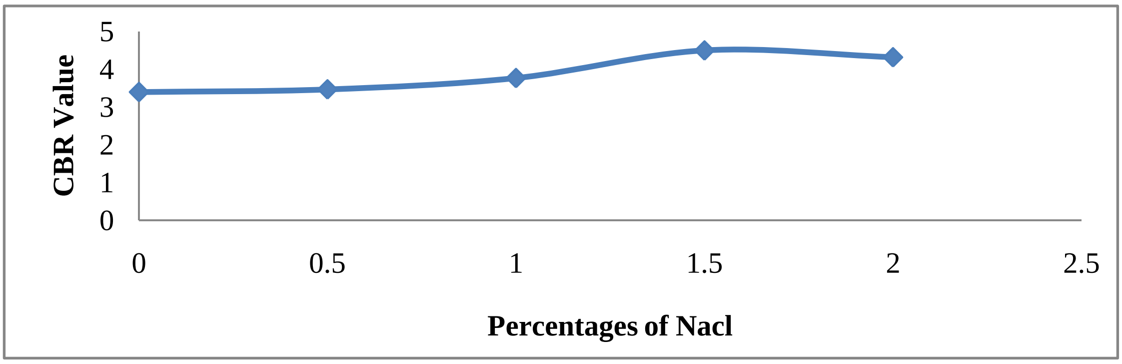

Fig.13 soaked CBR values penetration vs. load

TABLE X - CBR Test for $CaCl_2$

penetration in mm	Load in KN				
	0% $Cacl_2$	0.5% $Cacl_2$	1% $Cacl_2$	1.50% $Cacl_2$	2% $Cacl_2$
0	0	0	0	0	0
0.5	5.95	7.14	10.71	16.66	23.8
1	17.85	19.04	22.61	28.56	35.7
1.5	36.89	38.08	41.65	47.6	54.74
2	47.6	48.79	52.36	58.31	65.45
2.5	54.74	55.93	59.5	65.45	72.59
3	63.67	64.26	67.83	73.78	80.92
3.5	66.64	67.83	71.4	77.35	86.87
4	72.59	73.78	77.35	83.3	90.44
4.5	76.16	77.35	80.92	86.87	94.01
5	78.54	79.73	83.3	89.25	96.39
5.5	79.73	80.92	84.49	90.45	97.58
6	84.49	85.68	89.25	95.2	102.34
6.5	83.3	84.49	88.06	94.01	101.18
7	79.73	80.92	84.49	90.44	97.58
7.5	78.54	80.92	83.3	89.25	96.39

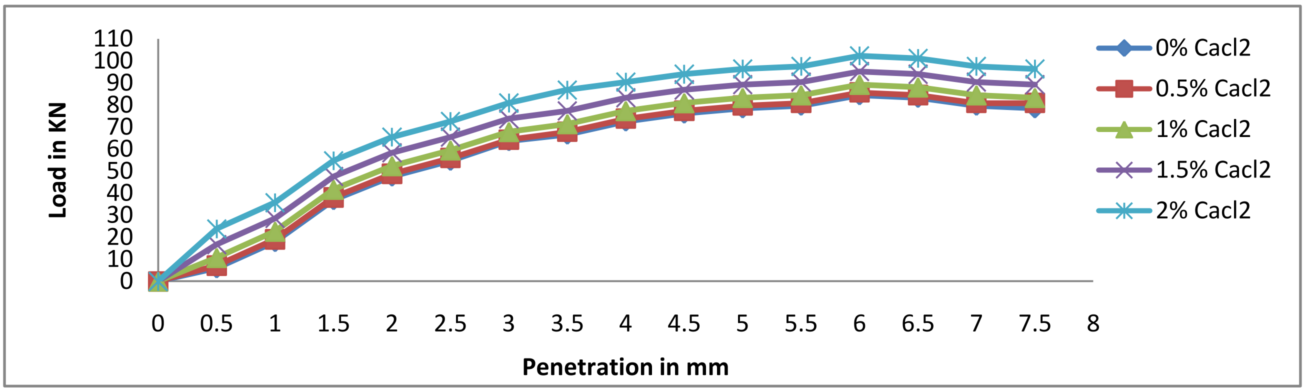

Fig.14 Soaked CBR values penetration vs. load

TABLE XI - CBR test for different percentages

% of $Cacl_2$	CBR VALUES for $Cacl_2$
0	3.35
0.5	4.08
1	4.34
1.5	4.77
2	5.29

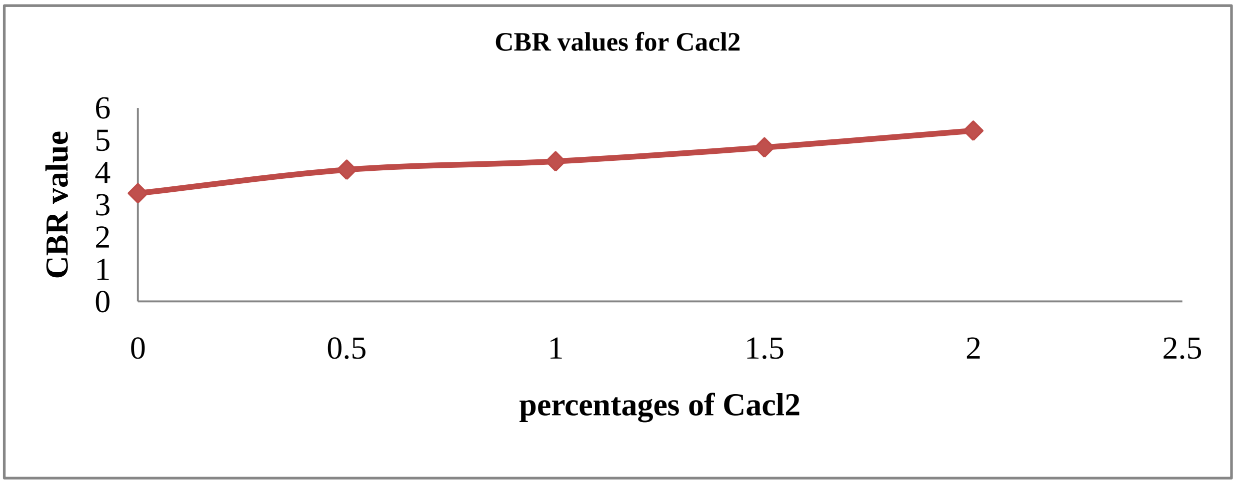

Fig.15 Soaked CBR values penetration vs. load

VI. CONCLUSIONS

As a result of soil stabilization, the bearing capacity of the foundation of the structure is increased and its strength, water tightness, resistance to washout, and other properties are improved. Soil stabilization is widely used in the construction on sagging soils of industrial and civil buildings stabilization has shown little to very high improvement in physical properties of soils. This little improvement may be due to chemical constituent of the soil, which has low reactivity with Nacl. Therefore, it is advisable to first examine the effect of Nacl on soil stabilization in the laboratory before actual field trials. In some cases where the soil is very weak like highly clay to moderate soil, like silty soil to sandy soil, the effect of stabilization has improved the CBR.

In the present study various geotechnical experiments were performed onvirgin soil. Adding Nacl and $Cacl_2$ soil showed significant improvement in consistency limits, standard proctor test, California bearing ratio of local soil with different dosages. Duration of treatment of Nacl and $Cacl_2$soil played a vital role in improvement of strength.

The experiments conducted and the graphs generated there by conclude that Black Cotton Soil

*Specific Gravity:*The addition ofNacl and $Cacl_2$ increases specific gravity consistently from 2.65 the maximum specific gravity value is obtained at 0.5 ml is high with a value as 2.962.

Plastic Limit: The addition of Nacl and $Cacl_2$, increases plastic limit consistently from 27.702 to 32.222, the maximum plastic limit value is obtained at 0.75ml is high with a value as 32.222.

Liquid Limit: The addition of Nacl and $Cacl_2$, increases Liquid limit consistently from 44.414 to 52.262, the maximum Liquid limit value is obtained at 0.5 ml is high with a value as 52.262.

Plastic Index: The value of plastic limit has increases consistently from 16.712 to 21.375, the maximum value is obtained at 0.5 ml is high with a value as 21.375.

Proctor test: The addition of Nacl and $Cacl_2$, increases proctor test consistently from 25 % to 27 %, the maximum proctor test value is obtained at 0.5 ml is high with a value as 27 %.

C.B.R Test: The addition of Nacl and $Cacl_2$, increases C.B.R Test consistently from 6.1667 % to 8.809 %, the maximum C.B.R Test value is obtained at 0.5 ml is high with a value as 8.809 %.

The cost of the pavement is reduced by using Nacl and $Cacl_2$ as a admixture. The pavement construction value is reduced 30% of the total cost with the help of my laboratory testing results.

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