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Stabilization of Black Cotton Soil Using Rock Salt

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ABSTRACT

Soil modification has emerged as a new area for research in the geotechnical engineering and the main purpose of most of researches is to determine optimum amount of additive with considering economy and effectiveness. In present study, black cotton salt has been used as an additive. The effect of addition of black cotton salt on properties of fine grained black cotton soil is determined in laboratory. This soil exhibits volume change behaviour with variation in the water content. Volume changes has caused reduction in sustainability of structure supported on black cotton soil. From experimental results, it will be observed that plastic limit, liquid limit, plasticity index swelling pressure and swelling index decrease or increases with addition of rock salt in soil. Optimum moisture content and maximum dry density tests will also be carried out with addition of salt in the soil.

Keywords- Black Cotton Soil, Index Properties, Optimum Moisture Content, Swelling, rock Salt.

INTRODUCTION

Increased costs associated with the use of high quality materials led to the need of local soils to be used in geotechnical and highway construction. Often however high water content and low workability create difficulties for construction projects. In many situation soil present in the field may be a problematic one such as expensive soils. Expansive soils with high swell and shrinkage behavior prone to be challenging for construction and pavement activities. Expensive soils will heave and can cause lifting of building or other structures during high moisture variations and they suffer shrinkage and can result in building settlement during dry spells. They also exert pressure on the vertical face of the foundations, basement and the retaining walls resulting in lateral movements. Apart from its effect on building construction and foundation they have severe impacts on roads, ground anchors and underground pipelines and other buried structures. Pavements are in particular susceptible to damage by expansive soils because they are light weight and extended over large areas. An expansive soil covers almost 20% of India's land. Hence they cannot be simply ignored of construction and pavement activities because of their problematic nature. There are several methods available for improving characteristics of expansive soils.

Fig.1. Soil Collection.

II. STABILIZATION OF BLACK COTTON SOIL

Soil stabilization involves the use of stabilizing agents to improve the geotechnical properties of unstable soils. Stabilization technology essentials contain soil or soil minerals and stabilizers or binding agents (cementitious materials). Much of the stabilization deserves to be undertaken in soft soils in order to obtain desirable engineering properties.

Clayey soil is easier to stabilize, owing to the flat and elongated shape of the particle due to a high surface area. Stabilization of expansive soil consists of altering the environment around and within clay particles and offering an efficient system of producing soil gradation, minimizing swelling and shrinking, lowering the plasticity index and enhancing the strength and durability of the soil. Now a day, soil stabilization are becoming the main issue for road infrastructure projects.

III. NEED OF STUDY

Studies have been conducted in the past about the problems and damages posed by the black cotton soil. A large number of researches have been done on the improvement of engineering properties of expansive soils to find out economical and efficient means of using common salt. However less work has been carried out on rock salt which is also available in large amount with minimum cost or no cost. So there is need to study the effect of rock salt on engineering properties of expansive soil like black cotton soil.

Due to low CBR values, excessive pavement thickness is required while the pavement section is being designed, soaked laboratory CBR value of black cotton soil is normally found in the range of 2 to 4 percent. Rural road design according to the (IRC) SP: 20- 2002 is focused on the ground subgrade CBR value and usually two extra layer with WBM and a thick that has at least 15% CBR of 75 mm need to be laid over the granular sub-base for BC soil;in order to deal, there have been scenarios in several states wherein the needed material is not accessible under normal lead, leading in longer transport with rising costs.

Measures such as avoiding the route, redesigning high thick sections of the pavement or replacing weak soils with good quality materials are possible, but increasingly costly alternatives, when inadequate construction materials are encountered. In view of the above, the use of industrial products such as Rice husk ash (RHA), Sugarcane baggase ash (SCBA), Ground granulated blast furnace slag (GGFBS) for black cotton soil stabilization due to silica in products is considered to be a key binding agent, in order to use new advanced stabilized materials for rural road construction. Thousands of hectares of land are needed for the storage of materials, which also damage the surroundings and cause problems for their disposal.

IV. PROBLEMS OF BLACK COTTON (BC) SOIL

Construction of pavement layers with weak soil constituting clay or silt particles is a difficult task. BC soil is one among these, which exhibits low strength and drastic volume changes with moisture imbalance. BC soils are characterized by high shrinkage and swelling properties. These soils are very hard when dry but lose their strength completely in wet conditions. A pavement structure constructed on this soil without improving its strength and other engineering properties may fail by sinking, upheaval due to moisture absorption and increase in swell pressure, rut formations, cracks in the bituminous surface, pothole formations, mud pumping, and edge failure due to insufficient support in rigid pavements. There will be a functional failure of the pavement due to the wide shrinkage cracks developed in BC soil due to moisture loss during the summer season that may propagate to other layers. The rectification of such pavements is a difficult task. Therefore, wherever BC soil is encountered, proper treatment should be given to improve the engineering properties before construction. Either these soils are entirely replaced with better soil, or in-situ improvements are undertaken based on laboratory investigation.

V. ENGINEERING PROPERTIES OF THE SOIL

Mainly in economically backward countries, the economies lead by the construction field for the development of the country, and it also depends on the durability aspect of construction. In this regard, one step for strengthening the rural economy is based on by providing all weather resistant roads have been emphasized. In countries like India, the biggest handicap is to provide a complete network of road system with the limited finances available to build the road by conventional methods.

Therefore there is a need to resort one of the suitable methods of low cost road construction. The construction cost can be considerably decreased by local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course. The layers of the pavement may comprise of different types of soils. One of them is black cotton soil and it is highly weak because of the large changes in volume due to fluctuations in the moisture content. In monsoon seasons, water which is absorbed by soil results in swelling, and also in the reduction of bearing capacity. In dry seasons, these soils shrink or reduce in volume due to evaporation of water and they become harder. 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. Regarding the strength of clay soils, air drying in a humid environment produces a hard and strong mass.

VI. RESEARCH MOTIVATION

The Black cotton soil is a type of expansive soil with high plasticity and can retain moisture throughout the dry season which is why they are valuable for growing crops. It exhibits low bearing capacity, low permeability and high volume change due to presence of montmorillonite in its mineralogical content and these properties makes it unfit for construction of embankment and other engineering structures. Black cotton soil is expansive clay with the potential for shrinkage or swelling under moisture change.

VII. OBJECTIVES

• To increase the shear strength of soil.

• To improve the soil strength using rock salt solution.

• To compare the test results of normal soil and rock salt added to the soil.

VIII. EXPERIMENTAL INVESTIGATION

The most important characteristic of the soil is, when dry, it shrinks and is hard like stone and has the very high bearing capacity. Large cracks are formed in the bulk of the soil. The whole area splits up and cracks. But when the soil is moist it expands, becomes very soft and loses bearing capacity. Due to its expansive character, it increases in volume to the extent of 20% to 30% of original volume and exerts pressure.

The upward pressure exerted becomes so high that it tends to lift the foundation upwards. This reverse pressure in the foundation causes cracks in the wall above. The cracks are narrow at the bottom and are wider as they go up. The unusual characteristics of the soil make it difficult to construct a foundation in such soil. A special method of construction of foundation is needed in such soil. Setbacks with Black Cotton soil:

• High compressibility

• Low strength

Hence an experimental program is planned to improve the engineering properties of black cotton soils using lime separately and lime rice husk ash combinations for the stabilization.

SAMPLE COLLECTION LOCATION

For this experimental program, clay samples are collected from ghana Jabalpur. The identification tests were conducted on these collected soil samples to confirm whether it is a black cotton soil or not and to know the properties of the collected soil samples. After identifying the various properties (viz… plastic limit, liquid limit, plasticity index, California bearing ratio test, unconfined compressive strength test etc) we are concluded that it is necessary for stabilization of soil.

According to Census 2011 information the location code or village code of Ghana village is 489861. Ghana village is located in Jabalpur tehsil of Jabalpur district in Madhya Pradesh, India. It is situated 15km away from Jabalpur, which is both district & sub-district headquarter of Ghana village. As per 2009 stats, Ghunsaur is the gram panchayat of Ghana village.

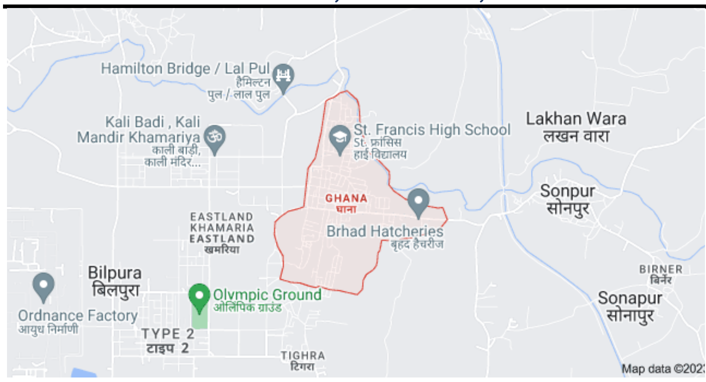

Fig. 2 Ghana Jabalpur, Madhya Pradesh.

Fig. 3 Sample Collection.

ROCK SALT

Halite commonly known as **rock salt**, is a type of salt, the mineral (natural) form of sodium chloride (NaCl). Halite forms isometric crystals.[1] The mineral is typically colorless or white, but may also be light blue, dark blue, purple, pink, red, orange, yellow or gray depending on inclusion of other materials, impurities, and structural or isotopic abnormalities in the crystals.[1] It commonly occurs with other evaporite deposit minerals such as several of the sulfates, halides, and borates. The name *halite* is derived from the Ancient Greek word for "salt".[3]

There are three principal methods of producing sodium chloride. The oldest method is the solar process in which the sun is used to evaporate a salt-bearing water, leaving the salt in a crystalline form. The second oldest method is the mechanical mining of rock salt. A variation of the last method is the production of salt brine (from wells), which is then evaporated by artificial heat, often producing nearly 100 percent pure salt. Sodium chloride is normally furnished in a dry form consisting of solid crystals that dissolve in the presence of moisture. The crystals are somewhat hygroscopic in nature. The predominant type of salt used today is the rock salt variety, which may be purchased in two grades, fine-grained (FC) or coarse-grained (CC), with a purity of at least 95 percent NaCl. Specifications for gradation are contained in ASTM and AASHO standards.

Fig. 4 Rock salt.

OBSERVATION AND CALCULATION

OBSERVATION GENERAL

The potential of Rock salt as a stabilizing agent for highway construction has been investigated. The results of laboratory tests with mixtures of several soils and a gravel with a commercial montmorillonite clay stabilized with rock salt and brine are presented. Soils treated with sodium chloride fall into two broad groups, as does the usage of the material.

1. Rock salt treatment is aimed at modifying the soil properties by reducing plasticity, improving workability, increasing grain size etc., the criteria for mechanically stabilized mixture are applied.

2. Rock salt treatment is limited to pavements and substantial stabilization of a soil, then the criteria are based on strength bearing capacity etc., in a similar manner to that developed for cement stabilized soils.

PARTICLE SIZE DISTRIBUTION

To access the geotechnical properties of the Black Cotton Soil.

SIEVE ANALYSIS OF CLAY

Wet sieve analysis of soil-252gm Total weight of black cotton soil= 1000gm

1. LIQUID LIMIT

- **SAMPLE 1 (Simple soil+0%Rock salt)**
- **SAMPLE 2 (Simple soil+4%Rock salt)**
- **SAMPLE 3 (Simple soil+6%Rock salt)**
- **SAMPLE 4 (Simple soil+8%Rock salt)**

LIQUID LIMIT

SAMPLE 1 (Simple soil+0%Rock salt)

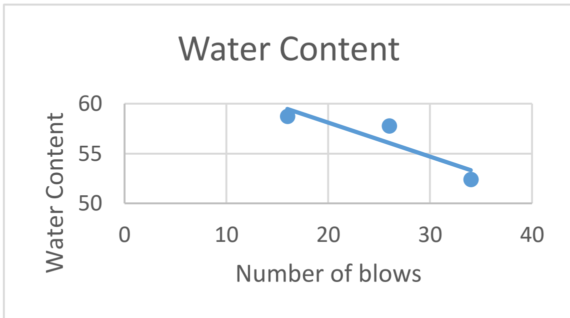

Fig. 5 Liquid limit.

LIQUID LIMIT

SAMPLE 2 (Simple soil+4%Rock salt)

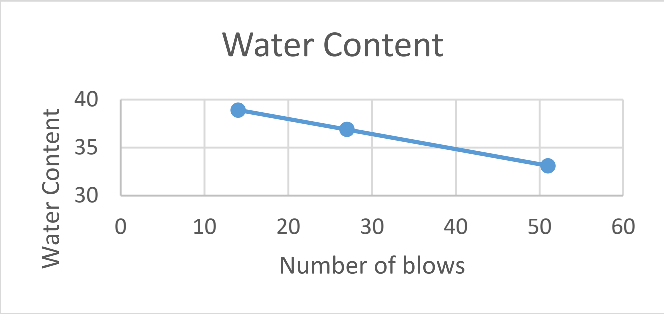

Fig. 6 Liquid limit.

LIQUID LIMIT

SAMPLE 3 (Simple soil+6%Rock salt)

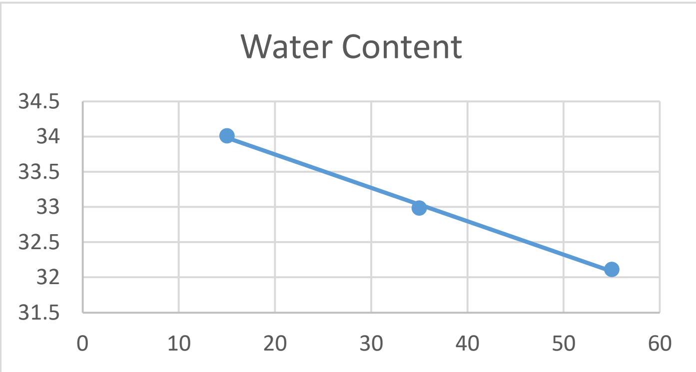

Fig. 7 Liquid limit.

LIQUID LIMIT

SAMPLE 4 (Simple soil+8%Rock salt)

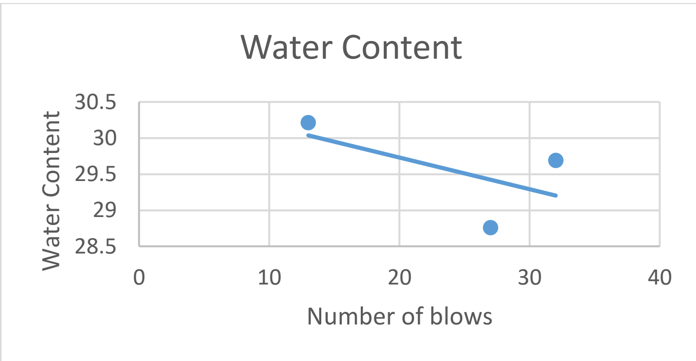

Fig. 8 Liquid limit.

2. PLASTIC LIMIT

SAMPLE 1 (Simple soil+0%Rock salt)

Table 1 Plastic limit of Simple soil+0%Rock salt.

Lid No.	(W1) Wt Lid (gm)	(W2) Wt Lid (gm)+wet Thread gm	(W3) Oven dried Soil (gm)	Water Content %= $\frac{W2-W3}{W3-W1}X100$	Average
17	9.78	21.44	18.79	29.41	
64	9.87	25.05	21.79	27.34	28.05 %
55	9.85	22.48	19.78	27.19	

SAMPLE 1 (Simple soil+4%Rock salt)

Table 2 Plastic limit of Simple soil+4%Rock salt.

Lid No.	(W1) Wt Lid (gm)	(W2) Wt Lid (gm)+wet Thread gm	(W3) Oven dried Soil (gm)	Water Content %= $\frac{W2-W3}{W3-W1}X100$	Average
25	8.94	19.23	17.10	26.1	
40	11.04	20.66	18.77	24.45	24.289 %
13	9.05	22.16	19.77	22.29	

SAMPLE 1 (Simple soil+6%Rock salt)

Table 3 Plastic limit of Simple soil+6%Rock salt.

Lid No.	(W1) Wt Lid (gm)	(W2) Wt Lid (gm) +wet Thread gm	(W3) Oven dried Soil (gm)	Weight of water	Weight of dry soil	Water Content %= $\frac{W2-W3}{W3-W1}$	Average
24	10.32	17.02	15.72	1.3	5.4	24.07	
40	11	17.68	16.34	1.34	5.34	25.093	24.541%
25	8.87	21.54	19.05	2.49	10.18	24.46	

SAMPLE 1 (Simple soil+8%Rock salt)

Table 4 Plastic limit of Simple soil+8%Rock salt.

Lid No.	(W1) Wt Lid (gm)	(W2) Wt Lid (gm) +wet Thread gm	(W3) Oven dried Soil (gm)	Weight of water	Weight of dry soil	Water Content %= $\frac{W2-W3}{W3-W1}$	Average
27	9.77	23.32	20.72	2.6	10.95	23.74	
3	10.20	16.38	15.17	1.21	4.97	24.35	24.91%
13	9.07	17.22	15.77	1.45	6.7	26.642	

3. PLASTICITY INDEX

Table 5 Plasticity index of Samples

		0%SIMPLE	4% Rock salt	6% Rock salt	8% Rock salt
water	Initial	10	10	10	10
	Final (Vd)	14	13.6	13.5	13.4
kerosene	Initial	10	10	10	10
	Final (Vk)	10	10	10	10
DFS %		40	36	35	34

Sample No.	**Liquid limit % (LL)**	**Plastic limit % (PL)**	**PLASTICITY INDEX % PI= LL- PL**
1.) **soil+0%Rock salt**	57.43	28.05	29.405
2.) **soil+4%Rock salt**	36.912	24.289	12.63
3.) **soil+6%Rock salt**	33.476	24.541	8.935
4.) **soil+8%Rock salt**	30.052	24.91	5.142

SHRINKAGE LIMIT

To calculate by the relation:

Shrinkage limit (WS) % = {WC - $(\frac{(V-Vd)}{Md})$ x 100}

Where, (WS) = Shrinkage limit

WC= Moisture content of the soil

V=Volume of the wet pat

Vd= Volume of the der pat

Md=weight of dry soil pat

4. DIFFERENTIAL FREE SWELL

DFS= [V_d – V_k] / V_k x 100%

Where,
V_d = volume of soil specimen read from the graduated cylinder containing distilled water.
V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

Table 4.10 DFS Sheet of Samples.

5. MODIFIED PROCTOR COMPACTION TEST

The weight of the mould, base plate and compacted soil is taken. A representative sample is taken for water content determination. The bulk density and dry density for the compacted soil is calculated from relations:

ρ = M/V (gm/cc)

ρd = ρ /(1+w)gm/ce)

Where,

ρ = bulk density of soil (gm/cc)

ρ d=dry density of soil (gm/cc)

M-mass of the wet compacted specimen (gm)

V=volume of the mould

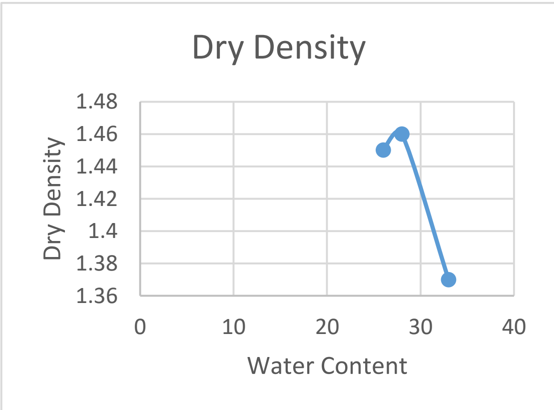

Fig. 9 SAMPEL 1 BCS+0% Rock salt.

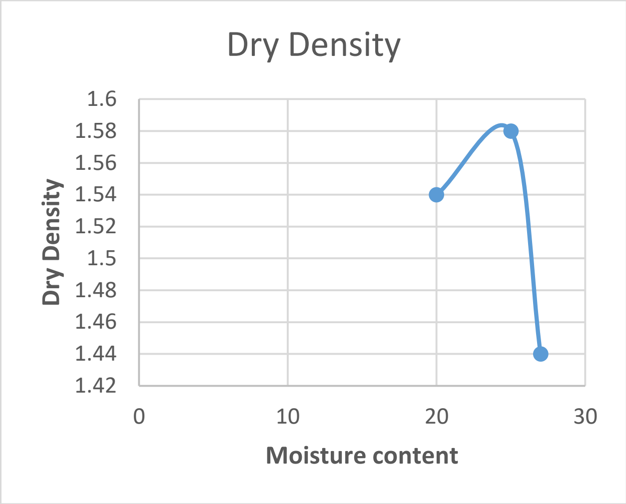

Fig. 10 SAMPEL 1 BCS+4% Rock salt.

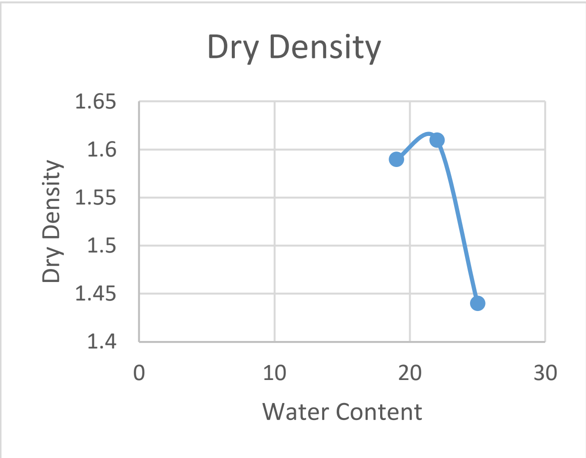

Fig. 11 SAMPEL 1 BCS+6% Rock salt.

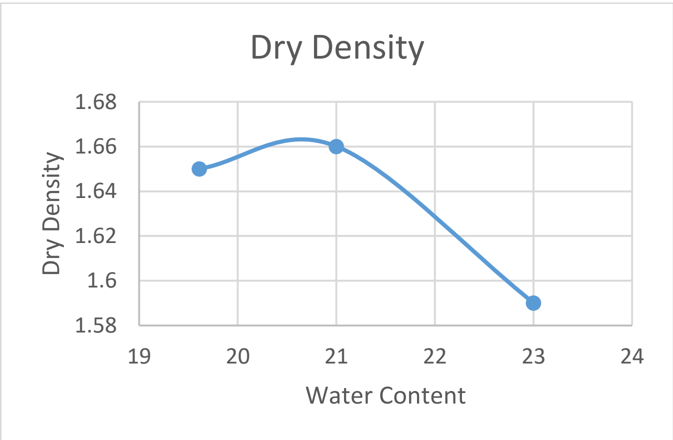

Fig. 12 SAMPEL 1 BCS+8% Rock salt.

6. CALIFORNIA BEARING RATIO TEST

Sample taken 10 kg.

Wt. of mould =17.35 kg,

Division = 0.002 mm 2.73 kg

Proving ring least count =0.002 mm

Deformation dial gauge =0.01 mm

CBR at 2.5mm penetration -Load for 2.5mm penetration/standard load X 100 CBR at 5.0mm penetration =Load for 5.0mm penetration/standard load X100

Table 6 CBR Observation data sheet.

SAMPLES			**0% Rock salt**	**4% Rock salt**	**6% Rock salt**	**8% Rock salt**
S.N.	**Penetration (mm)**	**Deformation**	**Load Kg**	**Load Kg**	**Load Kg**	**Load Kg**
1	0.5	50	5.2	4.8	8.3	1.9
2	1.0	100	5.9	5.9	8.98	5
3	1.5	150	6.1	5.9	9.6	6
4	2.0	200	6.3	6.87	10.4	7.8
5	2.5	250	6.7	6.97	10.9	8.1
6	3.0	300	7.5	7.8	11.5	8.4
7	3.5	350	7.8	7.94	11.8	8.8
8	4.0	400	9.05	8.6	12.6	8.9
9	4.5	450	9.64	8.96	13.8	9.5
10	5.0	500	9.9	9.85	14.7	9.9
11	5.5	550	10.5	10.9	15.9	10.8
12	6	600	10.8	11.8	16.7	11.6
CBR% For 2.5mm			**1.77**	**1.92**	**3.2**	**1.8**
CBR% For 5mm			**1.89**	**2.97**	**3.5**	**1.9**
Final CBR%			**1.9**	**3.7**	**3.9**	**2.3**

7. TRIAXIAL

TABLE-4.16 TRIAXIAL TEST

(1). SIMPLE +0% Rock salt

SAMPLE HEIGHT= 7.6cm

SAMPLE DIAMETER = 3.8cm

SAMPLE WEIGHT

PRESSURE APLLY

S.N.	**SIMPLE +0% Rock salt**	**Wt of sample**	**Pressure σ_3 kg/cm^2**	**σ_1 kg/cm^2**	**σ_d**
1	**SAMPLE**	164	1	3.92	2.92
2	**SAMPLE**	167	1.5	4.26	2.76
3	**SAMPLE**	168	2	5.13	.031

TABLE-4.17 TRIAXIAL TEST

(1). SIMPLE +4% Rock salt

SAMPLE HEIGHT= 7.6cm

SAMPLE DIAMETER = 3.8cm

SAMPLE WEIGHT

PRESSURE APLLY

S.N.	SIMPLE +0% Rock salt	Wt of sample	Pressure σ_3 kg/cm^2	σ_1 kg/cm^2	σ_d
1	SAMPLE	168	1	3.3	2.31
2	SAMPLE	170	1.5	4.50	2.30
3	SAMPLE	166	2	5.15	2.75

TABLE-4.18 TRIAXIAL TEST

(1). SIMPLE +6% Rock salt

SAMPLE HEIGHT= 7.6cm

SAMPLE DIAMETER = 3.8cm

SAMPLE WEIGHT

PRESSURE APLLY

S.N.	SIMPLE +0% Rock salt	Wt of sample	Pressure σ_3 kg/cm^2	σ_1 kg/cm^2	σ_d
1	SAMPLE	171	1	1.4	0.4
2	SAMPLE	169	1.5	2.14	0.64
3	SAMPLE	174	2	2.83	0.83

TABLE-4.19 TRIAXIAL TEST

(1). SIMPLE +8% Rock salt

SAMPLE HEIGHT= 7.6cm

SAMPLE DIAMETER = 3.8cm

SAMPLE WEIGHT

PRESSURE APLLY

S.N.	SIMPLE +0% Rock salt	Wt of sample	Pressure σ_3 kg/cm^2	σ_1 kg/cm^2	σ_d
1	SAMPLE	173	1	3.48	2.48
2	SAMPLE	171	1.5	4.12	2.62
3	SAMPLE	164	2	5.306	3.3061

IX. CONCLUSION

Studies have been conducted in the past about the problems and damages posed by the black cotton soil. A large number of researches have been done on the improvement of engineering properties of expansive soils to find out economical and efficient means of using common salt. However less work has been carried out on sea salt which is also available in large amount with minimum cost or no cost. So there is need to study the effect of Salt on engineering properties of expansive soil like black cotton soil. All the laboratory tests will be conducted in accordance with Indian standards codes. Index properties, swelling properties and OMC of black cotton soil will be determined in laboratory. Index properties such as liquid limit, plastic limit and plasticity index of black cotton soils will be tested with addition of salt in soil. Engineering properties of soil may be changed, but authors are not sure about the changes in engineering properties of black cotton soil. Number of tests will be required on soil of different plasticity to draw a certain conclusion regarding the change in strength of soil.

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