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Experimental Investigations on Black Cotton Soil Stabilized with Sand and Cement

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Abstract: Has our Lands getting increasing of population and the reduction of available land, more and more construction of building sand other civil engineering structures has to be carried out on weak or soft soil. Owing to such soil of poor shear strength and high swelling & shrinkage, a great diversity of ground improvement techniques such as soil stabilization and reinforcement are employed to improve mechanical behavior of soil, thereby enhancing the reliability of construction. Black cotton soil is one of the major soil with this we are going to improve the soil by using sand and cement in deposits of India. The disappointments of asphalt in from of hurl dejection splitting and unevenness are brought about by the occasional dampness variety in subgrade soil. So, in this we using the various type of tests like plastic limit, liquid limit, California bearing ratio test, free well index and specific gravity. Instead of cutting out and replacing the unstable soil, soil adjustment is the only alternative as it saves lot of time and of money too. Theexhibithigh swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations.
Keyword: Black cotton soil, stabilization, CBR, sand and cement, sub- grade, Montmorinolite kaolinite, hydrated cations, Liquid Limit, Plastic Limit, Free swell index, Specific gravity.

I. INTRODUCTION

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. Soil deposits in nature exist in a extremely erratic manner producing there by a infinite variety of possible combination which will affect the strength of the soil and theprocedure to make it purposeful. So, in the particular case of Black cotton soil with wide range of challenges associated with the construction. All the Black cotton soils are not expansive soils and all the expansive soil are not Black in color. These soils possessed high strength in summer and decreased rapidly in winter. Swelling and shrinkage of expansive soil cause deferential settlement resulting in severe damage to the foundation, buildings, roads, retaining structures and canal linings. To prevent the structure from such damages, stabilization of soil is required with the stabilizing materials like fly ash, lime, sand, bitumen, cement, rice husk ash etc. The engineering properties of Black cotton soil (B.C. soil) can significantly be improved with these stabilizing agents. The technique of stabilizing the soil with sand and cement is being carried from long time. Mixing Portland cement, sand and pulverized black cotton soil with the optimum moisture content and compacting the mix to attain required density. The material obtained by mixing soil, cement and sand is known as cement sand soil. Cement in the range of 2 to 5 percent brings remarkable improvement in the engineering characteristics of B.C. soil. Similarly increasing proportion of sand as stabilizer also improves the properties of soil.

A. In subgrade of Pavement

If locally available soil is found to be unsuitable as a subgrade material for the construction of important road pavements (like the National and State highway), there are two alternatives namely,

1) To find suitable soil from various nearby and other borrow areas that have acceptable soil properties, transport the borrowed soils from the borrow pits to the construction sites, compact the same in layers and to construct the subgrade of specified thickness.
2) To resort to appropriate soil stabilization technique and improve the properties of the local soil itself to the acceptable level, compact in layers and construct the subgrade of specified thickness.

B. In sub-base Course

Soil stabilization technique have been very successfully adopted to improve locally available soils and soil-aggregates mixes for the construction of lower layers of the pavement structures such as the sub-base course of even important highways. Thus, there will be substantial saving in the cost of superior aggregates and other materials for the construction of sub-base course & effective utilization of locally available materials and using suitable stabilization method, it is possible to construct satisfactory sub-base coarse of highways at reasonable cost.

C. In Base And Surface Courses Of Low-Volume Roads

Soil stabilization methods could be successfully adopted for the construction of base course and even surface course of low volume roads. In the case of roads providing connectivity to small villages, the traffic mainly consists of agricultural tractors, tractor-trailers, light commercial vehicle and other automobiles in addition to pedal cycles and animal drawn carts. In all such low-volume roads it is possible to plan and construct low-cost road using local soils by adopting appropriate soil improvement techniques. Such techniques have been and are being successfully made use of in low- volume roads, in various developing and developed countries all over the world.

II. LITREATURE REVIEW

Likhitha.H, Raghavendra.H.N, Rakesh.K.P, UdayShrihari.P, (2018). “Stabilization of Subgrade Black Cotton Soil using Cement and M- Sand”. International Journal of Engineering Technology Science and Research IJETSR Volume 5, Issue 1 (January -2018).In their experimental work have study to improvements in the properties of expansive soils, as road subgrade stabilized with cement, and M-sand in varying percentages. Laboratory tests were undertaken to study the strength characteristics of expansive soils stabilized with cement and M-sand keeping cement percentage as constant. Because Highways are viewed as supply routes of a nation which are vital for feasible monetary development. Quick populace development and industrialization created the utilization of transportation office to convey business heavier vehicle loads and redundant uses of it subsequently delivering heavier focuses particularly on roads running in clayey soil zones are known for bed condition and unusual conduct for which the way of the clayey soil add to some degree.

V. Ramesh Babu, K. Niveditha, Dr. B. Ramesh Babu Did their work on the “Stabilization of Black Cotton Soil with Sand and Cement as a Subgrade for Pavement”, International Journal of Civil Engineering and Technology (IJCIET) Volume 7, Issue 2, (March-April 2016).In their experimental work have study to make the subgrade soil stable, by improving its engineering properties. In the present work, stabilization of subgrade soil by using sand and cement is used to enhance the strength of subgrade soil. The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength of soil which is suitable for pavement structure.

G. Fulzele, V.R. Ghane, D.D. Parkhe, (2016). “Study of Structures in Black Cotton Soil”, International Journal of Advances in Science Engineering and Technology, ISSN: 2321-9009, (Dec- 2016).This Paper discussed the Black Cotton Soil problems their remedies, precaution taken and covers the guidelines to construct the structure in Black Cotton Soil. Because the rapid development in Soil improvement, construction technique and social need various constructions of structure are taking place. The possibility of good construction sites to build structures on Black Cotton Soils is difficult due to their poor strength and deformation characteristics. The average depth of this Black cotton soil is 3.7 m approximately.

Haresh D. Golakiya, Chandresh D. Sravani. “Studies on Geotechnical Properties of Black Cotton Soil Stabilized with Furnace Dust and Dolomitic Lime", International Research Journal of Engineering and Technology (IRJET) Volume: 02 Issue: 08 (Nov2015).In present work attempt has been made to evaluate the effect of waste addition in black cotton soil for improvement of geotechnical property by performing various laboratory test by varying the proportion of industrial waste to find the optimum mixture for use in geotechnical construction work.

Kavish S. Mehta, Rutvij J. Sonecha, Parth D. Daxini, Parth B. Ratanpara, Miss Kapilani S. Gaikwad. “Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using by Lime”. Miss K S. Gaikwad et al Int. Journal of Engineering Research and Applications, ISSN: 2248-9622, Vol. 4, Issue 5, May 2014). In their experimental work Stabilization occurs when lime is added to black cotton soil and a pozzolanic reaction takes place. The hydrated lime reacts with the clay particles and permanently transforms them into a strong cementation’s matrix.

Mrs. Neetu B. Ramteke, Prof. Anil Kumar Saxena, Prof. T. R. Arora. “Stabilization of Black Cotton Soil with Sand and Cement as a Subgrade for Pavement”. IJESRT ISSN: 2277-9655, (June 2014).In their experimental work stabilization of subgrade soil by using sand and cement (varying percentage of sand and constant percentage of cement by weight of soil) isused to enhance the strength of subgrade soil. The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength of soil

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III. OBJECTIVE

With limited finances available, the biggest challenge in developing countries like India is to provide a complete network of road system, particularly in providing connectivity to remote villages. The cost of road construction using conventional construction materials and methods have been increasing by leaps and bounds year after year. Therefore, there is a need to resort to one of the suitable low-cost road construction methods by effectively utilizing locally available materials and adopting soil stabilization techniques.

Thus, the object of soil stabilized road construction is:

1) Improvement of bearing capacity of Black Cotton Soil on addition of sand and cement.
2) Effect of sand and cement on CBR value of the soil.
3) Effect of sand and cement on Compressive strength of soil.
4) To effect economy in the initial cost of lower layers of the pavement such as subgrade and sub- base course.
5) Possibilities to upgrade to pavement structures of higher satisfaction at a later stage by resorting to the stage – construction of the pavement to meet the growing needs of the road traffic.

IV. MATERIALS FOR EXPERIMENT

A. Materials

In the present study, the following materials are used

1) *Black Cotton Soil:* This type of soil is made up of volcanic rocks and lava. Black soil is also known as 'regur' which is derived from a Telugu word 'reguda'. Black soil is also known as Black Cotton Soil as cotton is an important crop which is grown in this type of soil. The soil content is rich in calcium carbonate, potash, lime and magnesium carbonate but has poor phosphorus content. It is mostly found in areas such as Gujarat, Madhya Pradesh and Maharashtra. It is also found in states like Tamil Nadu, Andhra Pradesh and Karnataka.

a) Physical Properties

Table.no4.1. Physical properties

Sr No	Properties	Values.
1	Liquid Limit (L.L.) %	40 – 120 %
2	Plastic Limit (P.L.) %	20 – 60 %
3	Optimum water content(OMC) %	20 – 35 %
	Free swell index (DFS) %	40 – 180 %
5	Specific gravity (G)	2.60 – 2.75
6	Swelling pressure	50 – 800 KN/m2
7	C.B.R. (soaked)	1.2 – 4.0
8	Fines (<75 μ)	70 – 100 %
9	2 μ Fraction	20 – 60 %
10	Soil classification IS 1498 – 1970	CH or MH Clay /Silt of High plasticity
11	Procter Density	1350 – 1600 Kg/m3

b) Chemical Properties

PH Value> 7 (Alkaline) Organic Content 0.4 to 2.4 % $CaCo_3$ 1 – 15 %
SiO_2 50 – 55 % SiO_2 / Al_2O_3 3 – 5 %
Montmorillonite Minerals 30 – 50 %

Fig 4.1: Topological view of study area

Fig 4.2: Black cotton soil

The soil taken was air dried and pulverized to pass through IS425 microns sieve and then oven dried at 1100C before testing, for the study of different Engineering properties table 4.1

2) *Sand:* Sand used for the work is clean and coarse sand passing through 425-micron sieve as shown in fig 4.3 was oven dried for 24 hrs to eliminate sand's moisture before the conduction of tests and the specific gravity of 2.6. Table 4.1 shows the properties of sand.

3) *Cement:* The cement used is Portland pozzolanic cement (PPC) used for the study was purchased from the market with the specific gravity of 3.14 as shown in fig 4.4

Table 4.2: Properties of Black Cotton Soil Grain Size Distribution

Gravel (%)	13.6%
Sand (%)	2%
Silt (%)	84.4%
AASHTO Classification	A-2-7
IS Classification	CH
Specific Gravity	2.6

V. METHODOLOGY

In this work, the black cotton soil is stabilized with sand and cement. The amount of sand for stabilization is taken in the proportion of 5%, 10%, 15%, 20% by dry weight of soil and the amount of cement was taken as 2% by dry weight of soil. Using these proportions, mix samples were prepared as given below and a set of laboratory tests were performed to determine the index properties and CBR values of both natural soil and mixed proportion samples.

Mix Proportion Samples of soil, Sand and cement used for Stabilization.

1) Natural soil.
2) Soil +5% Sand +2% Cement.
3) Soil +10% Sand +2% Cement
4) Soil +15% Sand +2% Cement.
5) Soil +20% Sand +2% Cement.

Soil classification is carried out from engineering point of view to find out the suitability of soil as a subgrade for construction of pavement. The following are the different test to be conducted.

A. Specific Gravity

Specific gravity can be determined using a density. Test is conducted as per IS: 2720 (part II) 1980. Oven dried sample of 200 gm passing 4.75 mm IS Sieve is poured into bottle and weighed (W3). The bottle is emptied and filled with distilled water completely and weighed (W4). Specific gravity is determined by the following

$$= \frac{(w2-w1)}{((w2-w1)-(w3-w4))}$$

B. Atterberg Limit Test

The Atterberg limits are a basic measure of the nature of fine-grained soil. Depending up on the water content of the soil, it may appear in four states namely Solid, semi solid, Plastic, Liquid. In each state the consistency and behavior of the soil is different . Thus, the boundary between each state can be defined based on a change in the soil behavior. These limits were created by Albert Atterberg and were later refined by Arther Casagrande. Liquid limit test, Plastic limit test are being carried out with the following results.

C. Determination of Liquid Limit

Liquid Limit is defined as the water content at which the soil changes from liquid state to plastic state. Liquid Limit is determined by Casagrande apparatus as per IS: 2720 (Part 5) 1985.This test to be conducted by using apparatus like, Grooving tool, oven, Spatula, Containers for determination of moisture content, etc.

1) *Test Procedure:* Take representative soil sample of approximately 120gms passing through 425 micron IS sieve and mix thoroughly with distilled water in the evaporating dish to a uniform paste. Place the paste in the cup above the spot where the cup rests on the base, and make a clean, sharp groove by a grooving tool along the diameter through the center line of the cup. Drop the cup by turning the crank at the rate of two-revolutions/ sec, until the two halves of the soil cake come in contact. Record the number of drops required to cause the groove close and determine the moisture content. The specimens shall be of such consistency that the number of drops required to close the groove shall not be less than 15 or more than 35

D. Determination of Plastic Limit

Plastic limit is defined as minimum water content at which soil remains in plastic state. Plastic Limit is determined as per IS: 2720 (Part-5) 1985. This test to be conducted by using apparatus like Porcelain evaporating dish, Flat glass plate, Spatula, Ground glass, containers, balance of capacity 500grams and thermostatically controlled oven

1) *Test Procedure:* Take representative soil sample of approximately 20g from the portion of the material passing 425 micron IS sieve and mix thoroughly with distilled waterin an evaporating dish till the soil mass becomes plastic enough to be easily molded with fingers. Form a ball with about 8 grams of this soil mass and roll between the fingers and the glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. Continue the rolling till the thread crumbles exactly at 3mm diameter. If the soil thread doesn't crumble exactly at 3mm knead the soil together to a uniform mass and roll it again. Continue this process of alternate rolling and kneading until the thread crumbles under the pressure exactly at 3mm diameter. Collect the pieces of crumbled soil thread in an airtight container and determine its moisture content.

E. Modified Proctor Test

The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

1) *Test Procedure:* Take a representative oven-dried sample, approximately 5 kg in the given pan. Thoroughly mix the sample with sufficient water to dampen it with approximate water content of 4-6 %.Weigh the proctor mould without base plate and collar. Fix the collar and base plate. Place the soil in the Proctor mould and compact it in 5 layers giving 55 blows per layer with the 4.89 kg rammer falling through. The blows shall be distributed uniformly over the surface of each layer.Remove the collar; trim the compacted soil even with the top of mould using a straight edge and weigh.Remove the sample from mould and slice vertically through and obtain a small sample for water content.Repeat the above procedure for each increment of water added. Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

F. California Bearing Ratio (CBR)

1) *Preparation of Test Specimen:* Remoulded specimen: it may be prepared at proctor's maximum dry density and optimum water content. The material should pass through 4.75mm IS sieve and prepared by dynamic compaction.Take about 5kg of soil and mix thoroughly with desired water.Fix the extension collar and base plate at the bottom and a filter paper above it.Compact the mixed soil in 5 layers by giving 56 blows by the 206kg hammer. Remove the collar and trim off the excess soil and turn the mould upside down and remove base plate.
2) *Penetration Test:* Place the surcharge weights back on the top of the soaked soil specimen and plate the mould assemble on the penetration test machine.Seat the penetration piston at the center of the specimen with the smallest possible load but in no excess of 4kg so that full contact is established between the surface of the specimen and the piston.Set the stress and strain dial gauge to zero. Apply the load on the penetration piston so that penetration rate is 1.25mm/min. record the maximum load and penetration if it occurs for a penetration of less than 12.2mm.
3) *Determination of Pavement Thickness:* Thickness of the pavement can be determined on the basis of CBR values and traffic classification based on commercial vehicles per day. By using CBR design chart as in shown figure below.

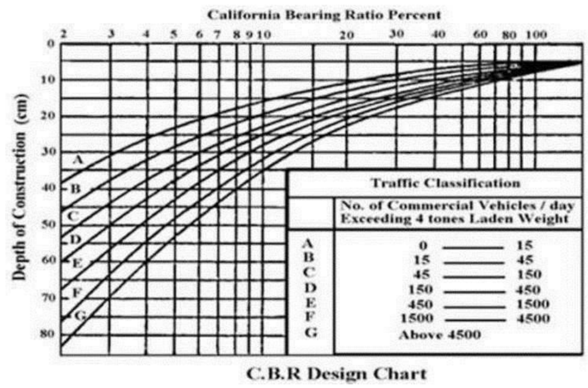

Fig.4.10 CBR Chart

4) *Unconfined Compression Test Procedure:* The first step in the procedure is to examine the loading frame. Turn the crank and learn how to read the load and deformation dial gages. Determine the calibration constant for the proving ring and the units of the deformation dial gauge. We will be shearing the samples at a strain rate of 1% per minute. From the length of your soil sample, determine the deformation at 1% strain. Depending on the units of the vertical deformation dial gauge (usually 0.001 inches or 0.0001 inches), determine the number of dial divisions per 1 strain- Practice turning the crank at his number of dial divisions/minute. It is important that the soil sample not be sheared faster than this specified rate. Measure the initial height and diameter of the soil sample with scale. It is unlikely that the sample will be a perfect right cylinder. Place the soil sample in the loading frame, seat the proving ring and zero the dials. During this lab you will record the load applied at specified strain values. It is recommended that readings be taken at strains of 0, 0.1, 0.2, 0.5,1,2,3,4,5,6,8,10, 12, 14,16, 18 and 20 percent. Readings of force (F) are taken from the proving ring dial gauge and the stress applied to the ends of the sample and is computed as follows: For a saturated soil that undergoes no volume change during shear the equivalent or average area(A) at any strain (e) is computed from the initial area (Ac) and the assumption that volume is conserved: A=A0/1-E. The unconfined compressive strength (Qu) is the maximum value σ1, which may or may not coincide with the maximum force measurement (depending on the area correction). It is also equal to the diameter of Mohr's circle as indicated in Fig 4.11S Portland pozzolanic cement. The un drained shear strength (su) is typically taken as the maximum shear stress.

Su=1/2*Qu

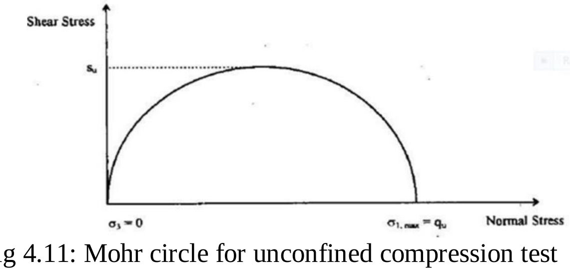

Fig 4.11: Mohr circle for unconfined compression test

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VI. CASE STUDIES

A. The problem has assumed economic importance at the national plane, as approximately one third of the surficial deposits of the country are of black cotton soil. These deposits are predominant in the states of Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Tamilnadu and Madhya Pradesh. All these states are engaged in increasing the irrigation potential of their states. Heavy investments are made for the construction of dams, canals, cross drainage structures, roads and buildings. Several thousand kilometers of canals androads pass through black cotton soil deposits. A large number of dams and embankments are also constructed in these regions needing gigantic quantities of earth for construction. Development is accompanied by need to construct buildings for human habitation. Thus, it is clear that varied types of civil engineering activities are taking place on black cotton soil deposits. These activities are increasing during the past few plan periods. There is definite indication that these activities will be increasing. During the last two to three decades several research workers and organizations in the country are making sustained effort to understand the behavior of black cotton soil deposits and suggest solutions to solve problems arising out of these deposits to civil engineering structures (Grim 1953, Ranganatham anrl - Satyanarayana 1969, Tretoar 1950). The author came across these deposits in the year 1952-1953 in Mahuva, Navsari, wherein, he was engaged in constructing a subdivisional irrigation colony on such deposits. It was a disappointing feeling to hear from other senior engineers that the buildings would crack and fall apart in a few years due to swelling and shrinkage of the underlying black cotton oil deposit. A large number of buildings in the area were heavily damaged. Since 1958 an attempt is also made by the author to tackle the problems of black cotton soils from various angles. The studies were directed.

1) To understand the nature and properties of various fractions of black cotton soils from the country,
2) To evaluate the engineering behavior of the black cotton soil deposits with depth under various seasonal conditions
3) To develop mechanical and/or chemical methods to tackle the problems created by black cotton soils for engineering construction .In this lecture an attempt is made to briefly focus the outcome of the studies wherein, a large number of postgraduate students participated in different aspects of the studies. Prior to. planning the studies to evaluate the swelling pressure, heave or consolidation characteristics, lateral pressures etc. the general property studies and insitu field studies

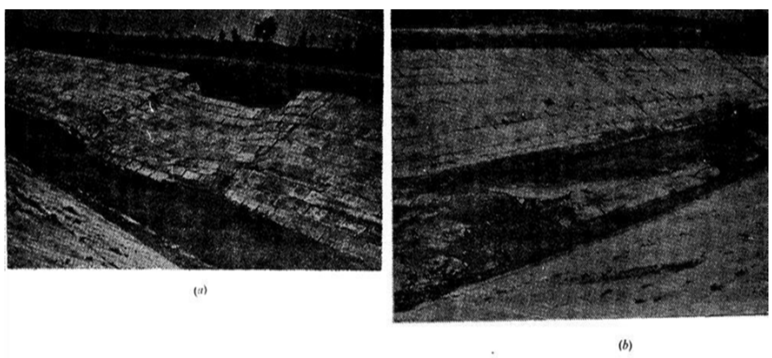


FIGURE 1 Damages to various structures in expansive soil (black cotton soil) area of Malaprabha river valley project constructed without using CNS layer (a) Canal lining at Km 22, (b) Bed heaving

Malaprabha river valley project (a)Canal lining at 22km; (b)Bed heaving

B. In Rajkot area BC Soil is spread over southern part of District. Rich proportion of montmorillonite is found in BC Soil from mineralogical analysis. High percentage of montmorillonite renders high degree of expansiveness. These property results cracks in soil without any warning. These cracks have sometimes extent severe limit like ½” to 12” deep. Use of this type of land may suffer severe damage to the construction with the change in atmospheric conditions. The method of soil stabilization selected should be verified in the laboratory before construction and preferably before specifying or ordering. BC Soils are inorganic clays of medium to high compressibility and form a major soil group in India. They are characterized by high shrinkage and swelling properties. This BC Soils occurs mostly in the central and western parts and covers approximately 20% of the total area of India. Because of its high swelling and shrinkage characteristics, the BC Soils have been a challenge to the highway engineers. The BC Soils is very hard when dry, but loses its strength completely when in wet condition. It is observed that on drying, the BC Soil develops cracks of varyingdepth. shows the typical Cracks in BC Soil in a dried state. As a result of wetting and drying process, vertical movement takes place in the soil mass. All these movements lead to failure of pavement, in the form of settlement, heavy depression, cracking and unevenness.

C. Sand is the most available construction material in Bangladesh. Sand- cement stabilization is more cost effective and environment friendly for the construction of sub-base pavement layer in perspective of Bangladesh. The researchers conducted an investigation for the use of cement stabilized fine to medium sand in the construction of roads. Sands from various location such as—Mymensingh, Fajilpur Munshigonj and Sunamganj are procured for this research work.

D. The present work is done in stabilizing the black cotton soil by using Sand, Cement and Terrasil chemical. The tests conducted for this study were Atterberg's limit, specific gravity, sieve analysis, standard proctor, unconfined compression test and California bearing ratio test. So in this present study the black cotton soil is collected from HAGARGA (KALABURAGI). It has been stabilized by using Sand, Cement and Terrasil chemical.The present work aims to determine the optimum dosage of Terrasil chemical using 30% Sand and 3% Cement as constant in improving the strength characteristics of soil. The effectiveness of Terassil is tested by conducting various tests like UCS, SPT, CBR. On the soil sample treated with different dosages of Terrasil as 0.6Kg/m3, 0.75Kg/m3and 1Kg/m3. The combination of all these, i.e. 30% Sand, 3% cementand different dosages of Terrasil chemical has great influence on swelling behavior of black cotton soil. It proved to be worthwhile as well as versatile stabilizer in case of expansive soil as it enhances almost all geo-technical properties of soil.

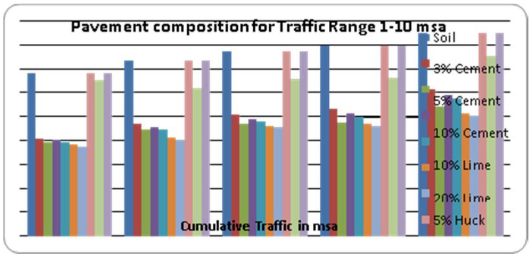

Preparation to mix samples


Tampering the layer with rod

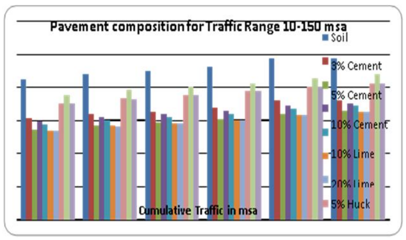

Cracks develop after crashing.


Unconfined compressive strength

E. Soil stabilization is the addition of external materials to soil to improve the properties of soil. It is one of the most suitable alternatives which are widely used in pavement construction But, in recent days, many of the waste materials are tested to improve the black cotton soil properties. Few of such waste materials are fly ash, municipal waste, egg shell powder, quarry dust, rice husk, ground nutshell powder, construction waste etc.It is already known that, owing to the construction of capital city Amravati, there will be large civil constructions, infrastructure, and road networks constructed in future 10-20 years in Andhra Pradesh. As it is already discussed that most parts of Amaravati are covered by BCS, if we use soil stabilization techniques for road network construction, large amount of economy will be saved. From the work doneit was found that, Free swell index of black cotton soil was found to be 85%. Plastic limit of soil is found to be 12.35%. Liquid limit for black cotton is 56.35%. Plasticity index for black cotton soil was found to be 44.50%. Soil classification was found out to be CH (Inorganic Clays of high plasticity). The OMC and MDD values are found to be 28.5 % and 1.51 g/cc. The CBR value is found to be 1.08 %. The pavement thickness is drawn from the CBR value for the Traffic range of 1-10 msa and 10-150 msa as per IRC: 37-2001. The pavement thicknesses are drawn and it was found that with increase in the percentage of cement, quarry dust and lime, the strength increases, therefore the thickness of the pavement decreases for the range 1-10 msa.But the thickness is increased for the range of 10- 150 msa. The pavement thicknesses are drawn and it was found that with increase in the percentage of rice husk, the strength increases up to 7% and then it decreases for 10%. Therefore, the thickness of the pavement decreases only for certain level for the range 1-10 msa. But the thickness is increased for the range of 10- 150 msa. Hence the final conclusion is that Rice husk is not suggested for stabilization with soil. Whereas Quarry Dust is the best suitable when compared with cement, lime, rice huck for the stabilization of road bases.



Pavement Composition of for Traffic Range 1-10



Pavement Composition of for Traffic Range 10-150 MSA MS

VII. CONCLUSION

A. *Standard Compaction Test Conducted On Black Cotton Soil With Admixtures*

With the varying percentages of Manufactured sand with cement & fly ash for the calculation of Maximum dry density & Optimum moisture content. It has been found that with the increase in percentage of M-sand with cement & fly ash there is an increase in Maximum dry density values where as there is considerable reduction in optimum moisture content for the given soil.

B. *California Bearing Ratio Test conducted on black Cotton soil with Admixtures*

By considering the 2.5mm & 5.0mm penetration values for the soil mixture it has been noticed that CBR values for 2.5mm penetration is more than 5.0mm penetration values. With the conduction of CBR test by varying the percentage of admixtures like Cement, M–sand and Fly ash in the soil mix, there is an increase in the CBR values with the increase in percentage of stabilizers.

Based on the various laboratory tests as per IS standards for the porous concrete by varying the composition the following are:

1) Replacement of some percentage of cement with fly ash will increase the engineering properties of Black Cotton soil which also increase its stability.
2) With the conduction of CBR test by varying the percentage of admixtures like Cement, M–sand and Fly ash in the soil mix, there is an increase in the CBR values with the increase in percentage of stabilizers.
3) It has been found that with the increase in percentage of M-sand with cement & fly ash there is an increase in Maximum dry density values where as there is considerable reduction in optimum moisture content for the given soil.
4) Fly ash is environmentally friendly material & can be used for construction purposes which also leads to increase in bonding properties of BC soil which also leads to reduction in swell & shrink behaviour of BC soil.
5) It is one of the economical methods of soil stabilization of BC soil where the raw materials are cheaper when compared to other methods of stabilization of soil.

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