EXPERIMENTAL INVESTIGATION ON STABILIZATION OF BLACK COTTON SOIL BY USING LIME AND RUBBER CHIPS

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ABSTRACT - Construction of roads and other civil engineering structures on expansive soil is risky due to its high compressibility, low shear strength and high permeability. Soil stabilization is a process which enhances the engineering strength properties of expansive soil such as compaction characteristics, bearing capacity etc. These properties can be achieved by controlled compaction using the mechanical equipment or addition of suitable stabilizers (admixtures) like cement, fly ash, lime etc. But in recent years cost of these additives becomes expensive, to overcome these soil stabilizers like rubber chips are used.

This project is to carry out an experimental study to improve the engineering properties of black cotton soil by using lime and rubber chips. Black cotton soil is collected from Walayar, Coimbatore district, Tamilnadu. Standard proctor test and California Bearing Ratio (CBR) test are conducted on both virgin soil and reinforced soil with varying percentage of rubber chips (6%,10%,14%,18%) and lime (10%). The result from the study reflect that with the addition of increase in percentage of rubber chips and constant lime proportion, engineering properties of black cotton soil such as dry density and CBR value are also increased significantly compared to the virgin soil.

Keywords: Soil stabilization, Black cotton soil, Rubber chips, Lime, Expansive soil, CBR value, MDD value.

1. INTRODUCTION

Marginal and weak soils including soft clay, black cotton soil, organic and loose sand are often unsuitable for construction due to their poor engineering properties. Expansive soil experiences volume change due to alternation moisture content. Black cotton soil is inorganic clays of medium to high compressibility and forms a major soil group in India. Due to its peculiar characteristics of high plasticity, excessive swelling, shrinkage and low strength when wet the soil is regarded as unsuitable for construction.

Soil stabilization is a process by which we can improve the soil characteristics and economy of construction on it. Stabilization, in a board sense, incorporates the various methods implemented for modifying the properties of soil and improves the engineering properties and performance of soil.

At present in India, the rubber tyre chips are generating in large volumes and accumulated in leaps and bounds and which carries an adverse effect to the health of environment and for recycling these are used. Rubber tyre chips aids in improving the strength of black cotton soil and also its properties.

Lime is a chemical admixture which can be used as a stabilizing material in weak or expansive soil from the experimental results and experience it is shown that lime can react well with black cotton soil. It also increases the strength and workability properties of soil and overcome the soil problem of ability to swell.

a) Objectives of the Study

- The main objective of this experimental study is to improve the properties of the black cotton soil by adding lime and rubber tyre chips as stabilizing agent.
- To achieve the whole project some experimental investigation is needed in laboratory. The experiments which to be conducted are Specific Gravity of the soil sample , Grain size Distribution of soil sample and liquid limit plastic limit test to identify the material and Standard Proctor test to obtain maximum dry density and optimum moisture content of soil sample, and finally CBR test to measure bearing capacity of soil.
- The principal objective of the study is to investigate the behaviour of Black cotton soil by adding lime(10%)and waste rubber tyre chips in different volume proportions (6%,10 %,14%,18%).
- To compare the behavior of normal black cotton soil and reinforced black cotton soil.

2. MATERIAL PROPERTIES

The different materials used in this investigation are:

- Black cotton soil
- Lime
- Rubber tyre chips

a) BLACK COTTON SOIL

Black cotton soil is formed by the decomposition of lava rocks. Dark brown or black colour in soil indicate that the soil has a high organic matter content. Due to plastic nature the black cotton soil stick onto wheels, animals feet, clog cultivation machine and are hard to remove. Expansive nature of this soil negatively affects its bearing capacity. If black cotton soil stabilization is not applied, the damage will apparent usually several years after construction.

Fig.1. Block Cotton Soil

Table.1. Properties of Natural soil

S.no	Properties of natural soil	Value
1	Specific gravity (G_S)	2.18
2	Liquid limit	56%
3	plastic limit	32%
4	Free Swell Index	42.1%
5	Compaction Properties	MDD=1.723g/cc OMC=22%
6	Un-Soaked CBR Test	3.3%

b) LIME

Lime is a chemical admixture which can be used as a stabilizing material in weak or expansive soil from the experimental results and experience it is shown that lime can react well with black cotton soil. It also increases the strength and workability properties of soil and overcome the soil problem of ability to swell

Table.2. Properties of lime

s.no	properties	values
1	Density	2700kg.m3
2	Poisson's ratio	0.27
3	JCS	120Mpa

Fig.2. Lime

c) RUBBER TYRE CHIPS

Rubber tyre material was obtained from the waste generated from tyre re-threading industry. The tyre material used is 2mm to 5mm in length and thickness ranging from 1to 2mm and they don't contain steel wire or nylon fibers

Fig.3. Rubber tyre chips

3. EXPERIMENTAL PROGRAM

Virgin soil

a) Specific gravity of soil
b) Particle size analysis
c) Atterberg limits
d) Free swell index test
e) Standard proctor test
f) CBR test

Reinforced Soil with Lime and Rubber Chips

1. Standard proctor test
2. CBR test

a) Specific Gravity

Specific gravity of a substance is defined as the ratio of its mass in air to the mass of an equal volume of water.

The specific gravity of the soil has been determined using the density bottle method, as per IS: 2720-(part III section I, 1980).

$$\text{Specific gravity of solids (G)} = \frac{(M2-M1)}{(M2-M1)-(M4-M3)}$$

Specific gravity **(G) = 2.18**

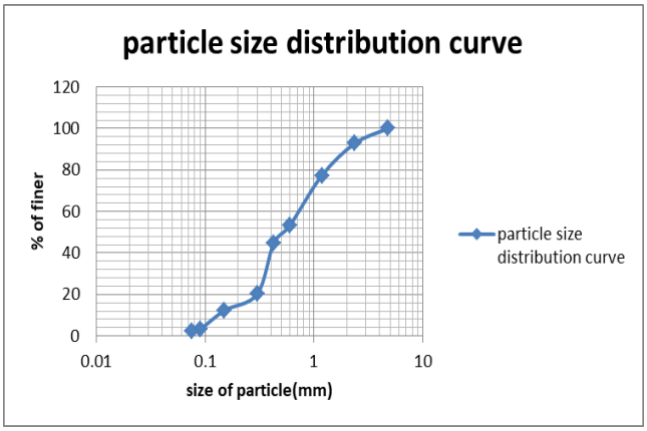
Fig.4. Pycnometer

b) *Grain Size Distribution*

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 Sieve analysis has been conducted as per IS: 2720 (Part-IV-1965).

Fig.5. IS set of sieves

Fig.6.Particle Distribution Result in Graph



c) *Liquid Limit*

The test has been carried out using the standard Casagrande liquid limit apparatus as per IS: 2720-(PartV-1965).Liquid limit is the moisture content at which 25 blows in standard liquid limit apparatus will just close a groove of standard dimensions cut in the sample by the grooving tool by specified amount. The flow curve is plotted in the log-scale on the x-axis, and the water content in the arithmetic scale on y-axis. The flow curve is straight line drawn on the semi-logarithmic plot, a nearly as possible through three or more plotted points. The moisture content corresponding to 25 blows is read from this curve rounded off to the nearest whole number and is reported as the liquid limit of the soil. The liquid limit is the water content at which soil changes from liquid state to plastic state.

Liquid limit =56%

Fig.7. Liquid limit apparatus

d) *Plastic Limit*

The plastic limit has been determined according to the IS: 2720- (Part V-1970).Plastic limit is the moisture content at which a soil when rolled into thread of smallest diameter possible, starts crumbling and has a diameter of 3mm.

The Plastic limit (wp) is expressed as a whole number by obtaining the mean of the moisture contents of the plastic limit.

Plastic limit is the water content below which the soil stops behaving like a plastic material.

Plastic limit=32%

e) Free Swell Index

The free swell index test has been determined according to IS: 2720(part40) 1977. Free swell index is the increase in volume of soil, without any external constraints on submergence in water. Two oven dried soil samples of 10gm is passed through 425mic sieve and the soil sample is filled in two graduated cylinders. Fill one cylinder with kerosene and other with the distilled water then allow the samples to settle in both cylinder for 24 hr and final volume of soil is recorded

$$\text{FREE SWELL INDEX (\%)} = \frac{(V_d - V_k)}{V_k} \times 100$$

FREE SWELL INDEX = 42.10 %

Fig.8. Free swell index

f) Proctor compaction test

Standard proctor compaction test is used to determine the compaction of different type of soil and the procedure of soil with a change in moisture content. From the standard proctor compaction test, percentage of water content and dry density relationship of the given soil reinforced with different percentages of rubber tyre chips (6%, 10%, 14% and 18%) and mixed with lime at a constant percentage of 10% is obtained. A series of Standard Proctor Compaction Tests are performed on reinforced soil with rubber chips and lime as per (IS-2720 Part-VII) code procedure. At first, the quantity of tyre chips and lime required to be mixed with given natural black cotton soil (d W =2500gm) is estimated for a particular percentage of tyre chips (6%, 10%, 14% and 18%) and lime of 10% as given by the Eq. Rubber chips and lime thus obtained are added to virgin soil after making dry natural soil into partially wet soil by adding sufficient amount of water to ensure reinforced soil sample becomes uniform and paste could be formed.

Rubber chips, lime and natural soil are mixed thoroughly until the mix becomes uniform and homogeneous. As per Standard Proctor Compaction Test procedure, reinforced soil sample is filled in the compaction mould by three equal layers and each layer is being given with 25 blows of 2.6 kg hammer from height of 30 cm. Water contents and dry densities are evaluated from the test data and are presented below. The test as per the mentioned procedure is performed for all reinforced soil specimens containing different percentages of tyre chips and lime

Fig.9. Proctor compaction test

Table.3. Proctor Compaction

Sl.No	Rubber Chips (%)	Lime (%)	OMC (%)	MDD (G/Cc)
1	0	0	22	1.723
2	6	10	20.21	1.760
3	10	10	18.11	1.792
4	14	10	18.00	1.796
5	18	10	22.5	1.689

Fig.10. Compaction test result graph

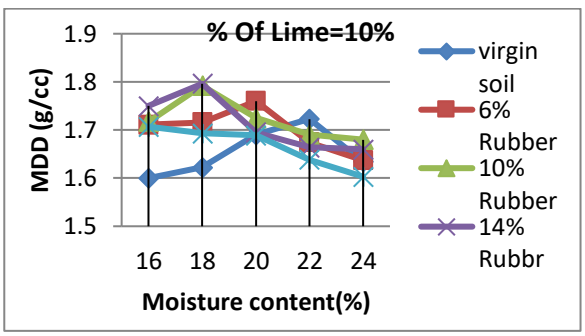
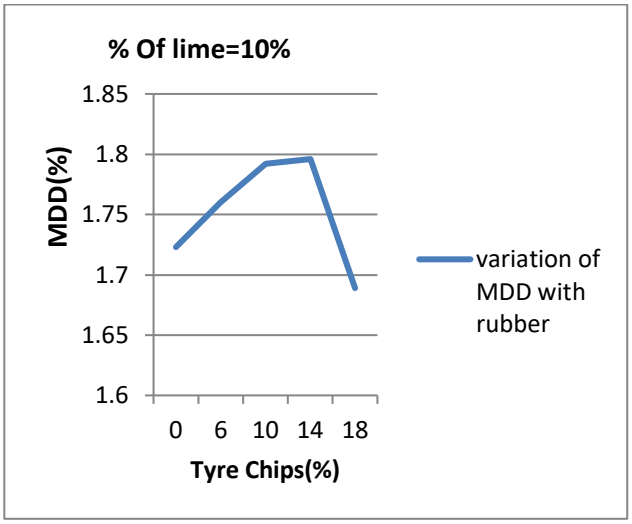


Fig.11.Effect of rubber chips and lime on MDD



g) California Bearing Ratio Test

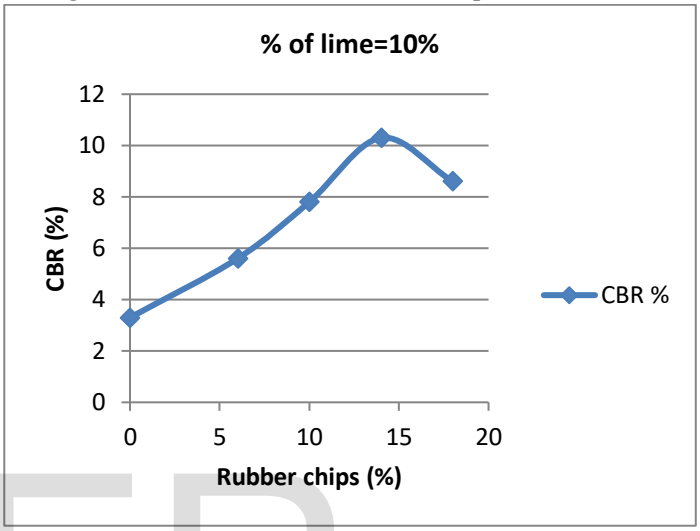
A series of un-soaked California Bearing Ratio Tests are conducted on natural soil reinforced with varying percentages of rubber chips (6%, 10%, 14% and 18%) and lime (Constant percentage of 10%) as per IS-2720 Part 16 procedure for light static compaction. At first, required quantity of tyre chips and lime are estimated and are blended with 5kg of dry natural soil. After adding rubber tyre chips and lime, they are mixed thoroughly until homogeneous mix and uniformity is obtained. After reinforced soil sample is prepared, the sample is filled in the CBR mould with three equal layers and each layer is being given by 56numbers of blows by a 2.6kg rammer for light static compaction. Load required for penetrating the piston through the reinforced soil sample up to 10mm penetration depths is recorded. From the loads obtained, CBR values for all reinforced soil samples are determined and the results are presented below.

Fig.12 CBR test

Table.4. test result for CBR

Sl.no	%of rubber chips	% of lime	CBR ratio %
1	0	10	3.3
2	6	10	5.6
3	10	10	7.8
4	14	10	10.3
5	18	10	8.6

Fig.13. Effect of lime and rubber chips on CBR



4. CONCLUSIONS

- From this study it is concluded that there is a considerable improvement in California Bearing Ratio (CBR) of black cotton soil with addition of 14% of rubber chips as soil stabilization when compared to only black cotton soil.
- Based on the result from standard proctor test it can be stated that with increase in percentage of rubber chips the compaction parameters also increased.
- Up to the range of 14% the CBR value get increased and at 16% it shows a decrease in the value.
- Observing its economic cost and quality of stabilization improvement, it is clear that this type of stabilization may be applicable in stabilization of black cotton soil in construction of road or in shoulder portion of highways.

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