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Performance of Recron-3s Fiber with Lime in Expansive Soil Stabilization

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Abstract: *The black cotton soils undergo excessive volume changes, making their use in the construction of civil engineering projects very difficult. The properties of the black cotton soils can be altered in many ways viz. mechanical, thermal and chemical means. Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which is highly active; also it saves a lot of time. In the present work, an attempt has been made to study the compaction and CBR characteristics tests of black cotton soil mixing with different percentages of lime and Recron-3s Fibre with a view to determine the optimum percentage. Test results shows that stabilizing clayey soils with lime and imparting Recron 3s fibers enhance the strength.*

Keywords: *Black Cotton Soil, Lime, Recron-3s Fibre, Compaction, CBR Tests*

I. Introduction

Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content Lime has been known as one of the good soil stabilization materials, especially for clay stabilization properties that have a large swelling and generally contain high levels of clay, but its swelling properties will be much reduced, even eliminated, if the soil mixed with lime. The presence of Ca_2^+ cations on the elements of lime can provide bonding between the larger particles that expands on soil properties. The influence of lime on the compaction behavior of soils with varying content of lime content from 0 to 13 % and from the results better compaction density with the addition of 5 % or more lime content to clays. They also reported an increase in the optimum moisture content till 3 % lime content and decreased with the increase in lime content [1]. The influence of lime on Free Swell Index, swell potential, swelling pressure, consolidation, compaction and strength behavior with lime content varied by 0%, 2%, 4% and 6% and from results swell potential, swelling pressure decreased with increase in lime up to 4% and beyond 4% resulted in increased swell potential and swelling pressure. A lime content of 4% resulted in the maximum reduction in plasticity index. FSI decreased from 250% to 125% when the lime content was increased from 0% to 4%. Swelling pressure reduced by 52% at a lime content of 4%. Compression index was 0.5, 0.64 and 0.16 for the respective lime contents of 0%, 2% and 4% [2]. The effects of lime stabilization on engineering properties of an expansive soil with lime contents of 3 %, 6 %, 9 %, 12 % and 15 % and reported a decrease in maximum dry unit weight and increase in optimum moisture content with the increase in the lime content. They also observed an increase in the unconfined compressive strength of soil with the increase in the lime content with curing period. The increase in UCS was more pronounced with the addition of lime content more than 3 % [3]. The thickness of pavement decreases by 66% and the CBR value goes on increasing is due to addition of Lime and Fly ash as admixtures to the BC soil. It also reduces the hydraulic conductivity of BC soil. There will be no need of drainage layer after treatment of BC soil as sub grade with lime and fly ash [4]. The effect of lime on Atterberg limits, MDD, OMC, shear strength and durability of quarry dust stabilized expansive soil mixes and from test results with increase in percentage of lime in expansive soil-quarry dust mixes, Liquid limit, Plasticity index goes on decreasing and plastic limit, shrinkage limit and OMC goes increasing and MDD goes on decreasing and the cohesion and angle of internal friction value increases up to 5% addition of lime. Addition of lime makes the soil-quarry dust mixes durable [5]. The influence of Recron-3s fibers on the properties of locally available with and without admixture and from the results, the fiber reinforcement improves the soil properties in terms of improved stress-strain patterns and progressive failure in place of quick post peak failure of plain samples. The unconfined compressive strength of Clay soil is increased by 7 times with admixture stabilization and 9 times for admixture with fiber modification with respect to plain samples. The CBR value also increased significantly even for soaked CBR tests. By addition of CKD the Liquid limit of the mixture is decreased 23 %, where as plastic limit is increased by 41%. [6]. The properties of expansive soil mixing with fly ash and lime in varying percentages and from the results stabilized clay has lesser swelling potential whereas increase in OMC, change of expansive soil texture takes place. Lime and flyash mixed with expansive soil, Plastic limit increases by mixing lime and liquid limit decreases by mixing fly ash, which decreases plasticity index. The amount of fly

ash & lime increases apparent reduction in modified dry density, free swell index and increase in OMC. It can be concluded that the mixing lime & fly ash in specific proportion with the expansive soil is an effective way to tackle the problem of shrinkage, swelling and unequal settlement [7]. Recron-3s Fiber as used the stabilizers with four proportion i.e. 0.5%, 1.0%, 1.5% and 2.0% were used to quantify the optimum quantity of Recron-3s on the performance in terms of CBR value and UCS of the soil and from test results the value of CBR increases with increase in addition of Recron-3s up to 1%, and further increase in Recron-3s decrement in CBR value and UCS value at this dose is 3.9 kg/cm^2. The value of CBR for Natural Soil without recron-3s at 5 mm penetration is 3.24 % and adopting Recron-3s the rising CBR value is more than two times that of natural soil i.e. 7.41 %. This indicates, by using Recron-3s the thickness of pavement can be reduced which will prove more economical and will also increase load carrying capacity [8]. A complete analysis of the improvement of soil properties and its stabilization using lime, by chemical or physical means in order to enhance the engineering quality of the soil. Soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. Lime is used as an excellent soil stabilizing materials for highly active soils which undergo through frequent expansion and shrinkage. Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, and increase in CBR value and subsequent increase in the compression resistance with the increase in time. The reaction is very quick and stabilization of soil starts within few hours and improvement in the properties of soil after adding lime [9]. The effect of fibers in geotechnical applications and to evaluate the strength of unsaturated soil by carrying out compaction and CBR tests on two different soil samples with the fibers are cut in lengths of 6mm and mixed randomly with lime-soil mixture in varying percentages (0.50%, 1.00%, 1.5%, 2.0% 2.5% and 3.0%) by dry weight of soil and compacted to maximum dry density at optimum moisture content. The test results indicate a reduction in the maximum dry density and the optimum moisture content of soil due to the addition of Recron fiber. It also indicates an improvement in the CBR value [10]. The effect of coir fibers on the compaction and UCS of expansive soil-lime-gypsum mixture. The coir fiber content varied from 0.5 to 2 %. The results indicated that the dry unit weight and the optimum moisture content of expansive soil-lime mix increased with the addition of gypsum. The UCS of the expansive soil increased with the increase in the lime content up to 8%, but beyond 8 % the unconfined compressive strength decreased. The dry unit weight of the expansive soil-lime-gypsum mix increased, and the optimum moisture content decreased with the addition of coir fibre. The unconfined compressive strength increased for the mix of expansive soil and 8 % lime with addition of 4 % gypsum, but beyond 4 % addition of gypsum the unconfined compressive strength decreased. The unconfined compressive strength of the expansive soil-lime-gypsum mix increased with the addition of coir fibre up to a fibre content of 1.5 %. The unconfined compressive strength of the expansive soil increased with the addition of lime and gypsum and with the increase in the curing period [11]. Experiments on four samples of soil - fibre mixture with fibre content as 0.15%, 0.30%, 0.45% and 0.60% of dry weight of soil. From CBR test results that CBR value of untreated soil increases from 3.50 % to 20.2 %, UCS of untreated soil increases from 2.81 % to 4.26 % with addition of 0.15% Recron 3S fibre and further increase in the quantity of Recron 3S fibre increases the CBR and UCS value of the silty soil [12]. The effect of randomly distributed polypropylene fibers on MDD, OMC, UCS, soaked CBR, hydraulic conductivity and swelling pressure of an expansive soil stabilized with rice husk ash and lime. From the results OMC increase and MDD goes on decreasing and OMC goes on increasing, with increase in percentage of poly propylene fiber in the rice husk ash-lime stabilized expansive soil, addition of rice husk ash and lime increases the UCS and soaked CBR of the expansive soil, addition of polypropylene fiber to rice husk ash-lime stabilized expansive soil, the UCS and soaked CBR increases, up to 1.5 % addition of polypropylene fiber, and decreases with further increase in polypropylene fiber content. The UCS and soaked CBR increases with increase in curing period irrespective of the percentage of addition of polypropylene fiber in rice husk ash-lime stabilized expansive soil [13]. Thus, it can be concluded that stabilization of expansive black cotton soil using lime is a good way of improving then engineering behavior of expansive soil. Moreover it cost effective also as the cost of pavement is reduced flexible pavement. In the present work, an attempt has been made to study the compaction, CBR tests were conducted with varying percentages of lime and Recron 3S of black cotton soil mixing with different percentages of lime with a view to determine the optimum percentage and also the effect on compaction and CBR tests. From the test results overall CBR values increases due to the lime has effectively bonded the soil particles to form a closely packed due to fibres.

II. Materials Used

Details of various materials used during the laboratory experimentation are reported in the following section**.**

2.1 Black Cotton Soil

Natural black cotton soil was obtained from Amalapuram, East Godavari district, Andhra Pradesh. The soil is dark grey to black in color with light clay content. The obtained soil was air dried, pulverized manually and soil

passing through 4.75 mm IS sieve was used as shown in the fig. 1. The physical properties of black cotton soil are Specific Gravity=2.65, W_L=84%, W_P=55%, I_p=29%, I.S. Classification=CH (Clay of High Compressibility), OMC = 22%, MDD=15.90 kN/m^3, Differential Free Swell = 100 %, Unsoaked CBR=3.0%.Permeability = 1.49 $\times 10^{-7}$ cm/sec, Unconfined Compressive Strength =118 kN/m^2

2.2 Lime

The commercial Birla lime taken from market for the purpose of stabilizing soil, which imparts cementing property to the soil mix. Commercial grade lime mainly consisting of 58.67% of Cao and 7.4% Silica was used in the study as shown in the fig.2. The quantity of lime was varied from 0% to 6% by dry weight of soil. The specific gravity of lime was 2.37. Lime in the form of lime stone $CaCO_3$, was first sieved through 150 micron sieve and stored in airtight container for subsequent use.

2.3 RECRON 3s- FIBERS

Recron 3s- fiber used in this study is the most commonly used synthetic material fiber due to its low cost and hydrophobic and chemically inert nature which does not allow the absorption or reaction with soil moisture or leachate and it is a polypropylene fiber which is a stabilizer to improve CBR and UCS values. Recron -3sfiber used in the experiment is of 12mm length and it was manufacture by Reliance industries shown in fig. 3. Fibers are randomly mixed in soil due to the fact for making a homogeneous mass and maintaining the isotropy in strength. The Properties of Recron 3s- fibers are Colour = White, Specific gravity = 1.334, Cut length = 12mm, Equivalent diameter (*u*m) = 32-55, Water absorption (%) = 85.22, Tensile strength (MPa) = 600, Acid resistance = Excellent, Melting Point (°C) = >250 and Alkali resistance is Good (*courtesy Reliance industries*).

Fig .1 Black Cotton Soil

Fig .2 Lime

Fig: 3 Recron 3s- fibers

III. Laboratory Experimentation

Various tests were carried out in the laboratory for finding the index and other important properties of the soils used during the study. Compaction and CBR tests were conducted by using different percentages of lime mixed with black cotton soil materials for finding optimum percentage of lime. The overall testing program is conducted black cotton soil mixed with different lime contents, i.e. 2%, 4% and 6% by weight was used for preparing samples mixed in powdered form. The compaction study was followed by CBR tests. In second phase Compaction and CBR tests were conducted by mixing 0.5%, 1%, 1.5% and 2% of Recron-3s Fibres mixed with black cotton soil and optimum percentage of lime (4%) materials for finding optimum percentage of Recron -3s fibers.

3.1 Index Properties ***:***Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972],were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

3.2 Compaction Properties***:*** Optimum moisture content and maximum dry density of black cotton soil and stabilized Black cotton soil with different percentages of lime mixes were determined according to I.S heavy compaction test IS: 2720 (Part VIII).

3.3 California Bearing Ratio (CBR) Tests :Different samples were prepared for CBR test using expansive soil material mixing with different percentages of lime and Recron-3s Fibres with a view to determine optimum percentages. The CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979) under unsoaked condition.

IV. Results And Discussions

I.S heavy compaction and CBR tests were conducted as per (IS: 2720 (Part VIII) and IS: 2720 (Part-16)-1979) respectively in the laboratory for expansive soil materials mixed with different percentages of lime and Recron-3s Fibres with a view to find the optimum percentage and the results are furnished below.

4.1 Effect of Lime on Index Properties

Liquid limit values were reduced from 84, 79, 75 and 67, plastic limit values are increased 55, 57, 59.2, and 60.5 by adding 0 %, 2%, 4% and 6% of lime respectively when blended with the expansive soil as shown in the Fig. 4.

4.2 Compaction Test

All the Samples are tested as per I.S.Heavy compaction IS: 2720 (Part VIII). Graphs drawn between water content and dry density for each percentage, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The results and graphs from these tests are presented below form Figs. 5 & 6. From the compaction test results the maximum dry density values are decreases from 15.9 kN/m^3,15.54 kN/m^3,15.2 kN/m^3,14.8 kN/m^3 and the optimum moisture content values are increasing from 22%,23.5%,24.52%,26.4 % respectively when the soil is mixed with 0 %, 2 %, 4 % and 6 % of lime. From the compaction test results the maximum dry density values are decreases from 15.2 kN/m^3,14.4 kN/m^3,14.27 kN/m^3,14 kN/m^3 and 13.4 % and optimum moisture content values are increasing from 24.52%,32 %,32.4 %,35 % and 38.4% respectively and when the soil is mixed with optimum of 4% of lime and varying percentages of recron-3s fibres 0 %, 0.5 %, 1.0 %,1.5% and2.0 % respectively. The optimum percentage of recron-3s fibres is 1%. The decrease in dry unit weight is attributed to the fact that lime reacts quickly with black cotton soil resulting Base Exchange aggregation and flocculation which leads to increase in void ratio of the mixture leading to decrease in the dry unit weight of the black cotton soil -lime mixture. This increase in optimum moisture content is attributed to the fact that additional water held within the flocs resulting from flocculation due to lime reaction.

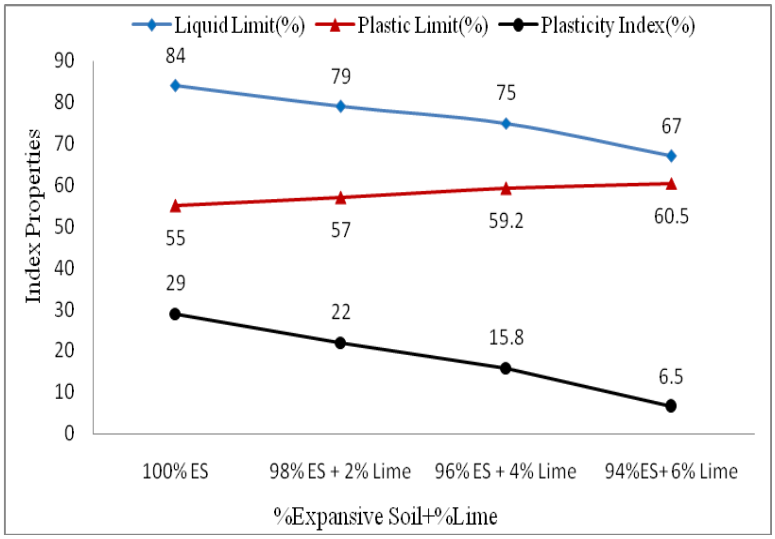

Fig. 4 Effect of Lime on Liquid Limit, Plastic Limit and Plasticity Index of Expansive Soil

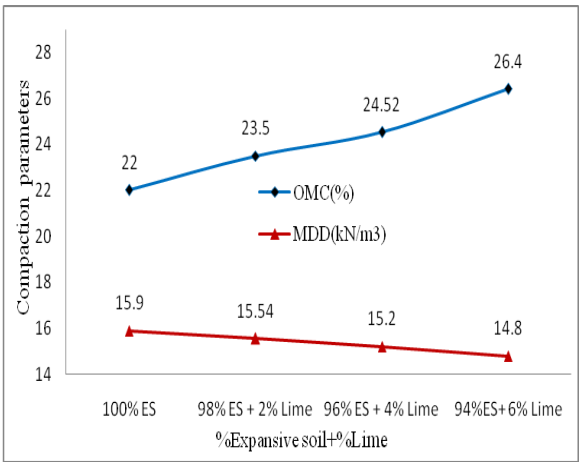

Fig.5 Variation of OMC and MDD with Different Percentages of Lime

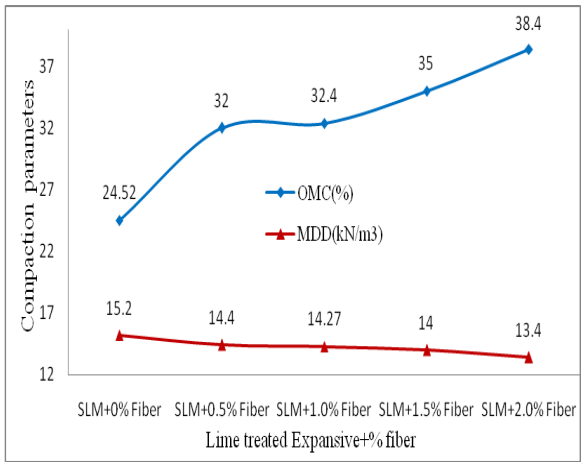

Fig. 6 Variation of OMC and MDD with Different % of Recron-3s Fibre at 4% of Optimum Lime

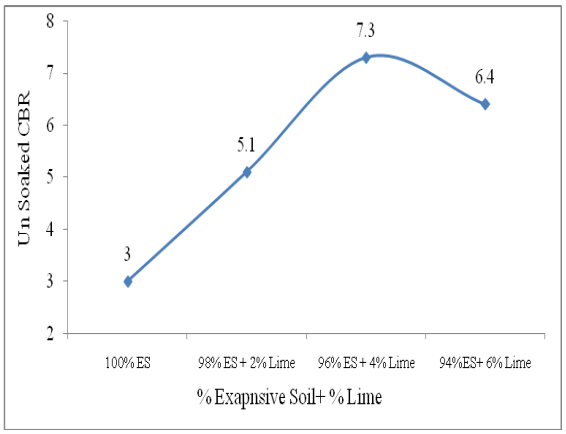

Fig.7 Variation of Unsoaked CBR Values at Different % of Lime

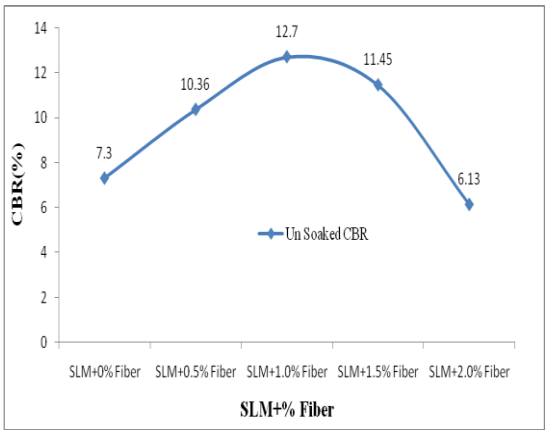

Fig.8 Variation of Unsoaked CBR Values at Different % of Recron-3s Fibre at 4% of Optimum Lime

4.3 California Bearing Ratio (CBR) Test

CBR tests were conducted for expansive soil material mixed with different percentages of lime and Recron-3s fibres and the results were presented in the Figs. 7 & 8. It is observed from that expansive soil mixed with different percentages of lime the unsoaked CBR values are 3.0, 5.1, 7.3 and 6.4 for 0%, 2%, 4% and 6% of lime respectively. From the above results the optimum percentage of lime is 4%. The unsoaked CBR values are increased from 7.3%,10.36%,12.7% ,11.45% and 6.13% for the addition of recron - 3s fibres 0.5%, 0.5%, 1.0%,1.5% and 6.13% respectively at 4% of optimum lime expansive soil mixture and the optimum percentage of recron -3s fibres is 1%.

V. Conclusion

The study yielded the following conclusions based on the laboratory experimentation carried out in this investigation. Addition of lime has shown decrement in liquid limit from 84% to 67% and improvement in plastic limit from 55% to 60.5% and plasticity index decrease from 29% to 26.4% when the lime content varies from 0% to 6% mixed in expansive soil as a result of cation ions from the lime which reduces the volumetric changes.

MDD decreased to14.8kN/m^3 from 15.9kN/m^3 due to the agglomerated and flocculated particles of lime mix soil occupy large voids and the OMC has increases from 22 % to 26.4 % at 6 % lime due to the action of lime which needed more water for pozzolanic action.Compaction characteristics of treated expansive soil-lime mix at optimum 4% of lime, and OMC increasing from 24.52% to 38.4% and MDD from 24.52kN/m^3to13.4kN/m^3 with the addition of different percentages of fibers due to of the reason that as fiber content increases, soil packing becomes loose and it's become difficult to make samples.

CBR values of unsoaked sample increases from 3% to 7.3% up to the addition of 4% of lime, then decreases to 6.4% with the addition of 6% of lime to the expansive soil. Unsoaked CBR value goes increasing from 7.3 % to 12.7% up to the addition of 1% fiber, beyond it is decreased with further addition fibbers. The overall CBR values increases due to the reason that lime has effectively bonded the soil particles to form a closely packed mass that resists the ingress of water. From the above experimental results the optimum percentage of lime and Recron -3S fibres are 4% and 1% respectively.

This work shows that the potential benefit of stabilizing clayey soils with lime and imparting Recron 3s fibers to enhance the strength. And the disadvantage of lime i.e. brittle nature is overcome by the inclusion of fiber which gives ductility to the soil.

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