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Performance of Recron-3S Fiber with Quarry Dust in Expansive Soil Stabilization

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Abstract: ***Geotechnical engineering face various problems while designing the foundations on highly compressible clayey soil due to poor bearing capacity and excessive settlement Utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. Stabilization of the expansive soil is studied by using Quarry Dust and Recron-3S fibres . This paper includes the evaluation of soil properties like compaction and California Bearing Ratio (CBR) test. Detailed experimental study has been undertaken to investigate the characteristics and behavior of expansive soil mixed with Quarry Dust and Recron-3S fibres with different percentage. From the experimental results, it has been observed that various properties of soil added with these stabilizers at certain percentage show remarkable positive changes as compared to the natural soil. The value of compaction parameters has increased enabling increase California Bearing Ratio which indicates that improved in strength. From these results, it was found that optimum Quarry Dust and Recron-3S fibres 20% and 1.5% respectively gives the maximum increment in the CBR compared with all the other combinations.***

Keywords: Expansive Soil, Quarry Dust, Recron-3S Fibres, Compaction and California Bearing Ratio Tests.

1. Introduction

Expansive soils are so widespread that it becomes impossible to avoid them for highway construction. Many highway agencies, private organizations and researches are doing extensive studies on waste materials and research projects concerning their feasibility and environmental suitability. With the rise in development of countries the rate of production of wastes has increased tremendously in almost all parts of the world in the past few decades. Quarry dust is a waste material producing from aggregate crushing industries. The quantities of these waste materials imposing hazardous effect on environment and public health. In order to eliminate the negative effect of these waste materials it can dispose proper and safe manner. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Recron 3S Fibres , mixed with soil, fiber absorbs everything and keeps the road surface intact and many problems can be solved like potholes, cracking & failure of pavement, OMC of the strengthen soil increments with the pickup of the fiber content, considerable decrease in cohesion of soil with Recron Fibre thread, Unconfined compressive strength of the soil increases with the addition of Recron Fibre and OMC of the reinforce soil increases with the gain of the fiber content[1]. Effect of fibers in geotechnical applications and to evaluate the strength of unsaturated soil by carrying out compaction test and CBR tests by blending fibers in varying percentages 0.50%, 1.0%, 2.0%, 4.0% of length of 6 mm and 12 mm and mix randomly by dry weight of soil and compacted to maximum dry density at optimum moisture content. From the test results it is found that the OMC of the reinforce soil increases with the gain of the fiber content and MDD of decreases as compared to OMC with the fiber content increase, CBR of the reinforced soil for the aspect ratio 6 mm and 12 mm increases to 76.37%, 106.30% as compared to the unreinforced soil and soaked CBR of the reinforced soil for the at same aspect ratios increase to 58.47% and 98.30% as compared to the unreinforced soil. The increase in the CBR value is due to the reason that the inclusion of randomly distributed fiber into the soil improves its load and deformation behavior [2]. An attempt to study the compaction and CBR characteristics tests of black cotton soil mixing with different percentages of lime and Recron-3s and from test results addition of lime has shown decrement in liquid limit, improvement in plastic limit, plasticity index decreased 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 due to the agglomerated and flocculated particles of lime mix soil occupy large voids and the OMC has increases 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 with the addition of different % of fibers, CBR values of unsoaked sample increases from 3% to 7.3% up to the addition of 4% of lime, unsoaked CBR value goes increasing from 7.3 % to 12.7% up to the addition of 1% fiber, 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 and from the above experimental results the optimum percentage of lime and Recron -3S fibres are 4% and 1% respectively and shows that stabilizing clayey soils with lime and imparting Recron 3s fibers enhance the strength[3]. Effect of stone dust on geotechnical properties of poor soil and concluded that the CBR and MDD of poor soils can be improved by mixing stone dust. They also indicated that the liquid limit, plastic limit, plasticity index

and optimum moisture content decrease by adding stone dust which in turn increases usefulness of soil as highway sub-grade material[4]. Recron-3s Fiber as stabilizers with four proportion i.e. 0.5%, 1.0%, 1.5% and 2.0% were used to quantify the optimum quantity of Recron-3son 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/cm2. 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[5]. Influence of polymer fibers on the properties of locally available Black cotton soil with and without admixture modification by conducting various tests and from the results , 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, 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, shear strength parameters of clay soil are also significantly increased upon admixture stabilization and admixture with fiber treatment and both unsoaked and soaked CBR values are increased significantly and with the addition of Cement Kiln Dust Plasticity index of the soil reduced significantly[6]. 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 [7]. Stabilized expansive soil using quarry dust and lime and found the stabilization effects with improvement in unconfined compressive strength (UCS), soaked California bearing ratio (CBR) and reduction in swelling pressure etc[8]. In this investigation, different laboratory experiments like compaction and CBR tests were conducted by varying percentages of Quarry Dust 10%, 15%, 20% and 25% and Recron-3S fibres 0.5%,1%1.5%and 2% blended with expansive soil with a view to determine optimum percentages. From test results, it is found that there is an improvement in geotechnical properties.

2. Materials Used

The materials used for the stabilization of expansive soil are Quarry Dust and Recron-3S Fibres and the properties and availability are mentioned below.

2.1 Expansive Soil

The Expansive Soil used in this investigation was brought from Tummalapalli village, Allavaram Mandal East Godavari District of Andhra Pradesh State, India. Index and Engineering properties of Expansive soil were determined as per IS codes and are presented in Table-1. The soil is classified as CH.

Figure 1: Expansive Soil

Table 1: Physical Properties of Expansive Soil

Property	Value
Liquid Limit (%) W_L	87
Plastic Limit (%) W_P	37.5
Plasticity Index (%) I_P	49.5
Soil Classification	CH
Specific Gravity G	2.65
Differential Free Swell (%)DFS	130
Optimum Moisture Content (%)	27.99
Natural Moisture Content (%)	11
Soaked CBR (%)	1.23

2.2 Quarry Dust

Quarry Dust for this study was collected from Rajahmundry, East Godavari District of Andhra Pradesh, India. The index and Engineering properties of the soil were determined as per IS codes and are presented in Table-2.

Figure 2: Quarry Dust

Table.2 Physical Properties of Quarry Dust

Property	Value
Index properties	
Liquid Limit (%)	Nil
Plastic Limit (%)	NP
Plasticity Index	NP
Specific Gravity	2.53
Grain(Particle) size Distribution	
Coefficient of Uniformity(Cu)	18.59
Coefficient of Curvature(Cc)	3.95
Engineering Properties	
Optimum Moisture Content (%)	12.19
Maximum Dry Density(kN/m^3)	15.58
California Bearing Ratio	7.0

2.3 Recron-3S Fibres

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 -3S fibre 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*).

Figure 3: Recron-3S Fibres

3. Experimental Investigation

The overall testing program is conducted in two phases. In first phase, expansive soil was blending with different percentages of Quarry Dust (QD), i.e., 5%, 10%, 15%, 20% and 25% by weight was used for conducting various tests in the laboratory with a view to determine the optimum percentage of Quarry Dust . The optimum percentage of Quarry Dust content is obtained from the results of compaction and soaked CBR tests. In second phase, expansive soil with optimum percentage of quarry dust as base sample blended with Recron-3S Fibres as a reinforcement material with 0.5 %, 1%, 1.5 % and 2 % weight was used for preparing different samples for compaction and soaked CBR test. All the tests are conducted as per Indian Standard Codes for finding optimum percentage of quarry dust and recron-3s fibres material and the effect on strength characteristics of expansive soil.

3.1 Index Properties

Liquid Limit, Plastic Limit of all the samples tried in this investigation were determined by following Standard procedures as per IS: 2720 (Part-5)-1985 and IS: 2720 (Part-6)-1972.

3.2 Compaction Characteristics

The Compaction Characteristics of untreated and treated Expansive soil with various percentages of Quarry dust and Recron-3S fibres were determined in the laboratory by following standard test procedure of IS heavy compaction test as per IS 2720 part-VIII.

3.3 California Bearing Ratio (CBR) Test

CBR test was carried out on prepared soil samples of Untreated Expansive soil and treated Expansive soil with various percentages of Quarry dust and Recron-3S fibres under soaked condition as per recommendations in IS :2720 part XVI-1987 as shown in the Fig.4

Figure 4: California Bearing Ratio Test Apparatus

4. Results and Discussions

Atterberg's limits, I.S heavy compaction and CBR tests were conducted as per IS: 2720 (Part-5)-1985 and IS: 2720 (Part-6)-1972 IS: 2720 (Part VIII) and IS: 2720 (Part-16)-1979) respectively in the laboratory for expansive soil materials mixed with different percentages of quarry dust and Recron-3s Fibres with a view to find the optimum percentage and the results are furnished below.

4.1 Consistency Characteristics

Liquid and plastic limit values of expansive soil treated with different percentages Quarry Dust (QD), i.e.,0%, 5%, 10%, 15%, 20% and 25%, liquid limit values are decreasing from 87 % ,76 %,70 %,65 % and 61 %and the plastic limit values are 37.5%, 34%,32.2%, 30.9% and 28.2% respectively as shown in the Fig.5.

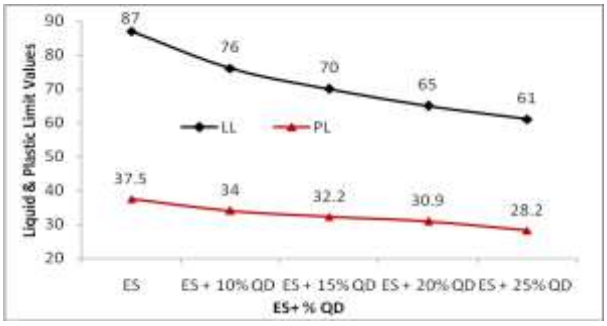

Figure 5: Variation of Liquid Limit and Plastic Limit Values of Expansive Soil Treated with Different % of Quarry Dust

4.2 Compaction Properties

The optimum moisture content (OMC) of the treated soil samples decreased and maximum dry density (MDD) increased as the quarry dust percentage varies from 5%, 10 %, 15 %, 20% and 25 % are 25.99 %,25.36 %,24.59 %, 24.38 %, and 23.29 % and the maximum dry density varies from 14.19 kN/m^3, 14.66 kN/m^3, 14.92 kN/m^3, 15.47 kN/m^3 and 14.24 kN/m^3 respectively as shown in the Fig.6. From the above results 20% of quarry dust is the optimum. Recron-3S Fibres as a reinforcement material blending with 0.5 %, 1 %, 1.5 % and 2 % in the quarry dust (20%) treated expansive soil, the MDD values are 15.47 kN/m^3, 15.69 kN/m^3, 15.94 kN/m^3, 16.23 kN/m^3 and 15.46 kN/m^3 and the OMC values are 28.38%,24.74%,25.12%,25.83%,26.17% are shown in the Fig.7.

4.3 California Bearing Ratio (CBR)

Soaked CBR tests were conducted for expansive soil mixed with different percentages of Quarry Dust (QD) and Recron-3S Fibres and the results were presented in the Figs.8&9. It is observed from that expansive soil mixed with different percentages of Quarry Dust soaked CBR values are 1.23, 2.69, 3.14, 4.03 and 3.59 respectively for 5%, 10%, 15%, 20% and 25% blending in expansive soil shown in the Fig. 8. From the above results 20% quarry dust attained maximum CBR value. Recron-3S Fibres blending with 0.5 %, 1 %, 1.5 % and 2 % in the quarry dust (20%) treated expansive soil, the soaked CBR values are 4.48, 6.27,8.06 and 5.83 respectively with 0.5 %, 1%, 1.5 % and 2 % as shown in Fig.9.From the above the optimum values of quarry dust and recron fibrs are 20% and 1.5%.

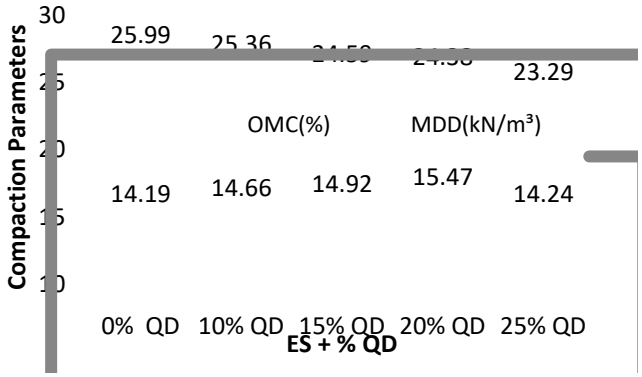

Figure 6: Variation of Compaction Parameters of Expansive Soil Treated with Different % of Quarry Dust

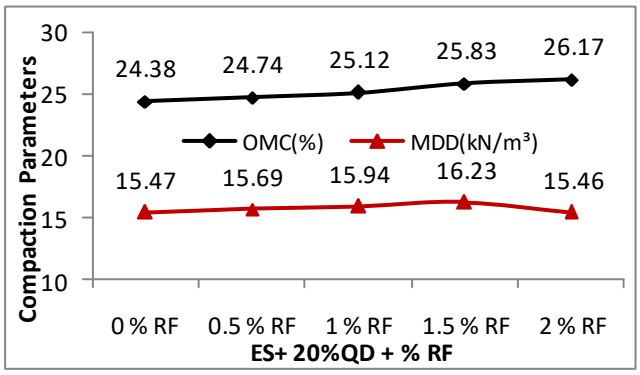

Figure 7: Variation of Compaction Parameters of Expansive Soil Treated with Optimum % of Quarry Dust (20%) Treated with Different % of Recron-3S Fibres

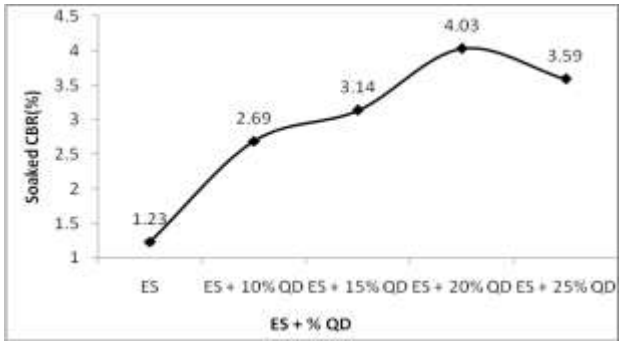

Figure 8: Variation of Soaked CBR Values of Expansive Soil Treated with Different % of Quarry Dust

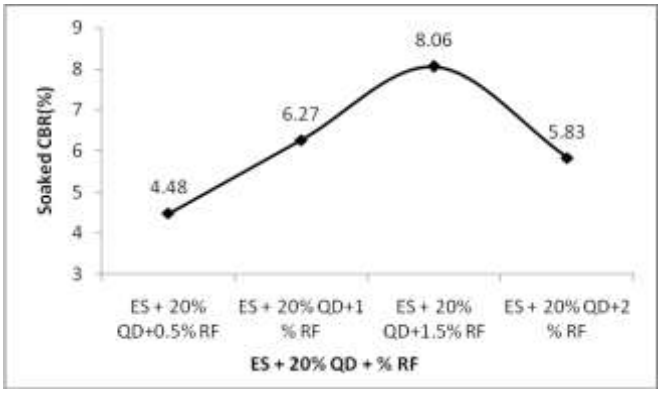

Figure 9: Variation of Soaked CBR Values of Expansive Soil Treated with Optimum % of Quarry Dust (20%) Treated with Different % of Recron-3S Fibres

5. Conclusions

The study yielded the following conclusions based on the laboratory experimentation carried out in this investigation.

The liquid limit and plastic limit decreasing irrespective of the percentage of addition of quarry dust. The Maximum Dry Density attained at 20% quarry dust and 1.5% Recron-3S fibres and OMC goes decreasing with increase in percentage of quarry dust. Hence compact ability of soil increases and making the soil more dense and hard

The soaked CBR goes increasing with increase in percentage of addition of quarry dust. There is 220% increase in soaked CBR value as compared to untreated soil, when 20% quarry

dust was added, 100% increase in CBR with the addition of 1.5% of Recron-3S fibres to the stabilized soil mix with quarry dust and 706% increase in CBR value both the addition of 20% quarry dust and 1.5% of Recron-3S fibres.

From the above study it is found that quarry dust up to 20% and 1.5% Recron -3S fibres can be utilized for strengthening the expansive soil with a substantial save in cost of construction.

Both Quarry dust and Recron-3s fibres are cohesion less materials which will improve dry density and CBR. Blending of these materials in expansive soil will change the soil structure which will improve the geotechnical properties of the expansive soil. Hence, the use of quarry dust and Recron-3s fibres in geotechnical applications is economically beneficial and environmentally advantageous.

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