Study on Effect of Quarry Dust and Recron-3S Fibres on the Properties of Black Cotton Soil

Jyothi Raju K, Prasad D S V, Prasada Raju G V R

Abstract:--- Black Cotton soils are also known as collapsible soils which cause to damage to structures and pavements. Regressively these soils are harmful to pavements all over the world which leads to wastage of billions of dollars. Quarry Dust is a useless substance produced from quarry industry, which contributes to environmental pollution. Use of various waste materials from industry shows lot of improvement in geotechnical properties of soils which is a cost effective and ecological friendly method. This study, evaluate the typical features of black cotton soil treated through quarry dust and recron-3s fibres. This paper includes the evaluation of black cotton soil properties like compaction, soaked CBR and load tests by blending by varied proportions of f Quarry Dust (QD) and Recron-3S Fibres (RF). From the experimental results, it has been observed that remarkable improve in strength as judge against to the natural black cotton soil. The data of compaction characteristics has enhanced in California Bearing Ratio and also load carrying capacity which indicates that improved in strength. From these results, it was found that optimum percentage of Quarry Dust (DQ) 20% and Recron-3S Fibres (RF) 1.5% respectively when compared with all the other combinations.

Index Terms: Expansive Soil, Quarry Dust, Recron-3S Fibres, Stabilization, Load Tests.

I. INTRODUCTION

Expansive soils prevalently identified with the name 'black cotton soils', for the cause of their aptness for yielding cotton, cover almost 20% of the geographical land available in India. Physical and chemical changes will undergoes volume changes due to seasonal changes [1, 2].Engineering field which includes design, analysis, construction, repairs and maintenance of various structures. Reinforced earth has blown up in attractiveness in civil engineering due to its very much flexible moreover plastic character. Waste material quarry dust which is produced from stone crushing industries. The production of industrial waste causing harmful effect on environment and community health issues. Proper utilization of this waste material can reduce the harmful nature in a safe manner [3]. Many researchers are doing through investigation on unused substances and research projects as to the achievability and environmental acceptability. Alteration of soil properties by mechanical or chemical stabilization shows improved soil properties which possess the required engineering properties. Blending of quarry dust reduces the Plastic limit, Liquid limit, Plasticity index falling and shrinkage limit increasing with adding more in amount of lime in expansive soil quarry dust mixes, OMC raising and MDD reducing with attractive in proportion of lime in expansive soil-quarry dust mixes and up to 5% of lime content and MDD of expansive soil-quarry dust blend is more than that of natural soil, the shear parameters raised up to 5% inclusion of lime and furthermore fall with extra raise in lime content. The decrease in amount of UCS is minimum at 5 percentage lime and maximum dry density is at 10 percentage replacement of quarry dust which could be adequate to attain maximum compaction [4].The present investigate was to enhance the strength of soil and to obtain optimal quantity of Soil-Flyash Recron-3S mix. The proportions used of recron-3s are in 0.2, 0.4, 0.6, 0.8 and 1.0% and fly ash were 10, 15, 20, 30, 40 and 50% in amount by weight. From the results OMC raised and MDD fallen with increase in flyash and recron3s.The fly ash was recommended at 15% by doing tests. UCS value for natural soil was 214.76 kN/m^2, by mixing flyash it was raised to 458.13 kN/m^2 and adding 0.8% recron-3s strength was raised to 685.24 kN/m^2 for one week curing and 791.05 kN/m^2 for two week curing period. From this study recron-3s work as reinforcing material and offer strength to the soil as well as fly ash works as strengthening material [5]. Waste tire rubber and quarry dust were used as a stabilizing material for the expansive soil used in road construction, which will reduce the environmental effluence and also enhancement in the bearing capacity or strength properties of expansive soils and improvement in permeability. CBR value of soil indicates considerable progress by blending of crumb rubber & quarry dust and also there was considerable change in UCS and other factors regarding to the soil and their utilization in subgrade soil will shows the improvisation in bearing capacity of soil which intern will decrease the design thickness of pavement [6]. Stabilization of soil with 6% lime and quarry dust and fly ash quantities are varied by 5% in every sample. The maximum concentration of quarry dust is 25% and for fly ash it is 20%. The bearing capacity of the samples is determined by the California Bearing Ratio test. The sample showed the improved stability and bearing capacity with the addition of sustained amount of admixtures and the test results showed that lime, fly ash and quarry dust is fit for using together as a capable stabilizing agent in order to increase clay sample's load resisting capacity [7]. Laboratory assessment on black cotton soil mixed with Quarry Dust and Lime at a range of amount, reduced specific gravity value due to the reduction of

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plasticity nature of Black Cotton Soil and Maximum Dry Density raised for mixing of Quarry Dust and Lime. From the results that the strength factors of Black Cotton Soil are suitable at Soil blending with 8% lime + 20% quarry dust [8]. Laboratory trial was done to obtain the best engineering characteristics of black cotton soil by adding Quarry Dust (QD), which is a misuse substance obtained at the time of stone quarrying. Different experiments were conducted for black cotton soil combination with various percentages of quarry dust in the laboratory. The Differential Free Swell (DFS) has fallen from 58% to10%, Optimum Moisture Content (OMC) has reduced starting 21.1% to 12.6% and Maximum Dry Density (MDD) has grown starting 1.6 g/cc to 1.76 g/cc, inside the exceptionally wet CBR values with mixing of quarry dust. By blending of 40% of quarry dust in black cotton soil will obtain the CBR values from 1.75 % to 7.05% [9]. Laboratory test is conducted to examine the acceptability of utilizing quarry dust as a stabilizer to get the best index properties of black cotton soil blended with various percentages of quarry dust by mass of dried up soil and found that, liquid limit fallen from 70% to 43.5%, plastic limit fallen from 26.45% to 17.37%, plasticity index fallen from 43.55% to 26.13% and differential free swell fallen from 58% to 10%. Investigation shows that the index parameters of black cotton soil increased considerably by blending of quarry dust [10]. Laboratory test was conducted on nearby accessible soil by blending stone dust with 10%, 20%, 30%, 40% and 50% randomly by desiccated weight of soil and performed string of compaction, specific gravity and CBR tests in the laboratory. The percentage of stone dust mixing 50%, is useful in reducing OMC of soils which is useful in reducing amount of water needed during compaction, with raise in the proportion of stone dust MDD of soil rises and also found to enhance its CBR. Mixing only 30% of stone dust is establish to rise the CBR of soil by almost 50% and there is a great out come on specific gravity of soils on adding stone dust with them. Mixing 30% stone dust is establish to be most favorable in case of specific gravity [11]. Compaction and soaked CBR tests were conducted by blending quarry dust to flyash with different percentages at an increment of 10% and the optimum percentage was found 40% at which maximum improvement in compaction parameters and CBR Values.

Mixing of Polypropylene Fiber(PF) with flyash stabilized with best percentage of quarry dust, from 0 to 1.5% at an growth of 0.25%. From the test results optimum percentage of polypropylene fiber and quarry dust are 1% and 40 %. There is minor drop-off in MDD and OMC, 28 % rise in cohesion, 45% growth in angle of internal friction, and 597% rise in saturated CBR of the flyash [12,15]. Laboratory test is conducted by mixing of quarry soil (i.e.murrum/gravel soil) different with stone dust in various percentages. On basis of the test outcome, as the proportion of stone dust supplement grows from 10% to 25%, the plasticity reduces from 23.2 % to 20.14 %, stone dust supplement rises from 10 % to 30 % the MDD values of the murrum stone dust mixture– grows from 1.70 gm/cc to 2.07 gm/cc and OMC values reduces from 11% to 7.95%, CBR values increases from 14.37% to 28.74%. The data at 30% stone dust are satisfy the necessity of granular sub base substances but when we are achieving our acceptability of admixes on less % of stone dust i. e. 25% then observed as economy of construction the 25% stone dust is suggested[13,15]. 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 sample fibres cut in lengths of 6 mm and mixed randomly with lime-soil mixture with different proportions by dry weight of soil. From the outcome MDD increases with the adding up of lime with rise in OMC owing to adhesion between the water and soil particles increases up to 2% and additional lime MDD reduce and OMC increases. The addition at random distributed recron fiber to BC soil with various percentages reduces MDD and increases OMC up to some extent. The BC soil blend with optimal percentage of lime and 0.5 % of fiber has utmost dry density and comportment resistance of sample is found to boost with the fibre content. The adding of varied percentage of fibers with lime to BC soil proved that the 2.5% fibers gave higher CBR value [14]. The current investigation was focused to get better strength in expansive soil and to get an most advantageous amount of Quarry Dust - Recron-3s Fibres mix. The percentages used of and recron-3s was in 0.5, 1.0, 1.5 and 2.0% and quarry dust were 10, 15, 20 and 25% in amount by weight. For this, number of compaction, soaked CBR and Load tests were carried out.

II. MATERIALS

A. Black Cotton Soil (ES)

The soil used in this investigation has been collected from Ttummalapalli, Andhra Pradesh, India. IS code procedures were used to decide the Geotechnical characteristics of Expansive soil, those features are 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, Maximum Dry Density =14kN/m^3, Optimum Moisture Content (%) = 27.99, Soaked CBR (%) = 1.23.

Fig. 1: Expansive Soil

B. Quarry Dust (QD)

Quarry Dust sampled for the study was extracted from Rajamahendravaram of the same district mentioned above. Here also, IS codes are taken as reference to decide the features of the quarry dust and are Specific Gravity = 2.54, Coefficient of Uniformity (Cu) = 18.59, Coefficient of

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Curvature (Cc) = 3.95, Optimum Moisture Content (%) = 12.19, Maximum Dry Density = 15.58 kN/m^3 and California Bearing Ratio = 7.0.

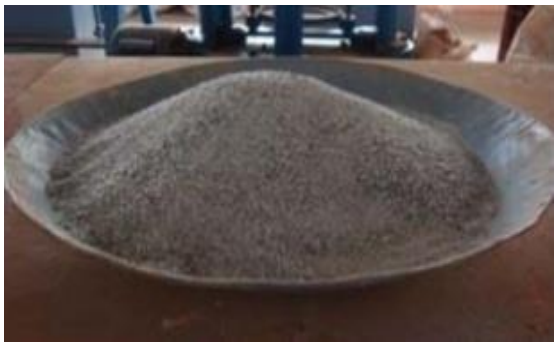

Fig. 2: Quarry Dust

C. Recron-3S Fibres (RF)

Fiber used in this work is frequently used synthetic fabric due to less cost and chemically inert, no absorption of soil moisture. From the literature survey polypropylene fiber is a good stabilizing material to improve geotechnical properties like CBR and UCS values. The recron-3s fibre is a product from polymerization of Terapthalic acid and Mono Ethylene Glycol as catalyst. Recron -3S fibre used in the experiment is of 12 mm length and it was supplied by Reliance industries shown in Fig. 3. Fibers were mixed randomly in soil to obtain a homogeneous mass and maintaining the isotropy in strength. The Properties of Recron 3S- fibers are Colour = White, Specific gravity = 1.34, Cut length = 12 mm, Equivalent diameter (um) = 32-55, Water absorption (%) = 85.22, Tensile strength (MPa) = 600, and Alkali resistance is Good (courtesy Reliance industries).

Fig. 3: Recron-3S Fibres

III. EXPERIMENTAL INVESTIGATION

In this investigation black cotton soil composed with diverse proportions of Quarry Dust (QD), by weight and determined various geotechnical properties in the laboratory with a view to determine the effect of quarry dust and also optimum percentage. After that expansive soil with optimum percentage of quarry dust as base sample blended with different percentages of Recron-3S Fibres as a reinforcement material and determined the compaction, and soaked CBR and cyclic plate load tests. 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 of black cotton soil.

A. Compaction Characteristics

The Compaction constraints of black cotton soil treated with and without blending Quarry dust and Recron-3S fibres were calculated in the laboratory as per IS 'Modified compaction test' - IS 2720 part-VIII.

B. California Bearing Ratio (CBR)

CBR test has been conducted on treated and untreated expansive soil soils as per IS: 2720 part XVI-1987 as shown in the Fig.4 with various proportions of Quarry dust and Recron-3S fibres under soaked condition.

Fig. 4: California Bearing Ratio Test Apparatus

C. Cyclic Plate Load Test

Laboratory Cyclic Plate Load Test was carried for determining the ultimate load carrying capacity of soil and the maximum settlement under an applied load. The dimensions of model flexible pavement is of 25 cm untreated or treated expansive soil subgrade, 5 cm of gravel cushion as sub-foundation and WBM -III as foundation for conducting laboratory load test as shown in the Fig. 5. The loading took place by using a round metal platter of 10 cm span put on the model lithe pavement system. The steel container was kept on the base of the compression testing machine. Two disks measure of least count 0.01mm were maintained as indicating in plate 3.6 for achieving the deformations. A 500 kN capacity hydraulic jack was kept on the loading. Cyclic load tests were carried out at OMC state subsequent tire pressures of 500, 560, 630, 700, 1000 and 1200 kPa. At every pressure ascend, six cycles of loading and unloading is done until there is no significant change in deformation. Each pressure increment was applied until there was no significant change in deformation between the consecutive cycles. These tests were conducted on all the model flexible pavements prepared. These tests were carried out at soaked condition during the study.

Fig. 5: Experimental Cyclic Plate Load Set For Finding Load - Settlement

IV. TEST RESULTS

In the laboratory, various tests were conducted by using black cotton soil stabilized with various proportions of quarry dust and recron-3s fibres to find the optimal percentages and its cause on strength properties of soil used and the results are presented below.

A. Compaction Properties

The Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) data differ as 25.99 % , 14.19 kN/m^3; 25.36 %,14.66 kN/m^3;24.59 %,14.92 kN/m^3; 24.38 %, 15.47 kN/m^3 and 23.29 %,14.24 kN/m^3, when different proportion of quarry dust blending with 5%, 10 %, 15 %, 20% and 25 % correspondingly as shown in the Fig.6. According to the above outcome the MDD attained at 20% blending of quarry dust to black cotton soil. The best (20%) percentage of quarry dust composed of 0.5 %, 1 %, 1.5 % and 2 % of Recron-3S Fibres the OMC and MDD values are 28.38%, 15.47 kN/m^3; 24.74%, 15.69 kN/m^3; 25.12%, 15.94 kN/m^3; 25.83%, 16.23 kN/m^3 and 26.17%, 15.46 kN/m^3 correspondingly as shown in Fig.7. From the above at 1.5% of Recron-3S Fibres attain maximum dry density as compared to other combinations tried in this investigation. From the test results optimum percentage of polypropylene plastic fibers and quarry dust are 1.5% and 20 % respectively.

B. California Bearing Ratio (CBR)

Soaked CBR tests were conducted for black cotton soil blended with variable content of Quarry Dust (QD) and Recron-3S Fibres and the outcome were presented in the Figs. 8 to 12. It is found that black cotton 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 black cotton soil shown in the Fig. 8. The above study revealed the result of 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 laboratory results the best values of quarry dust and Recron fibres are 20% and 1.5% respectively. The value of compaction parameters has increased enabling increase California Bearing Ratio which indicates that improved in strength.

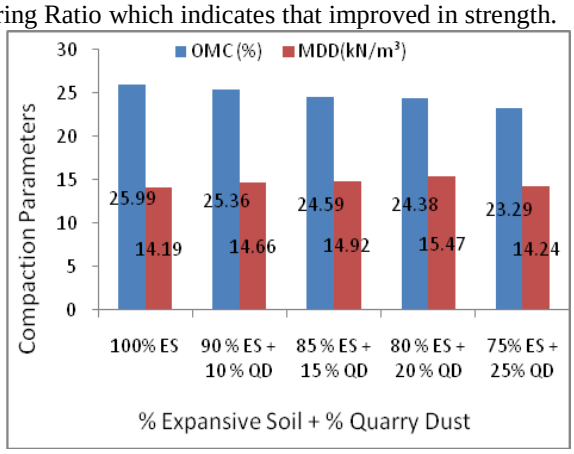

Fig. 6: Compaction Values of Black Cotton Soil Treated of Different % of Quarry Dust

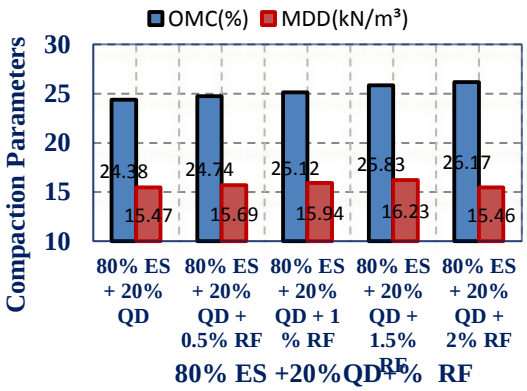

Fig.7: Compaction Values of 80% Black Cotton Soil Blended with 20% Quarry Dust and % of Recron-3S Fibres

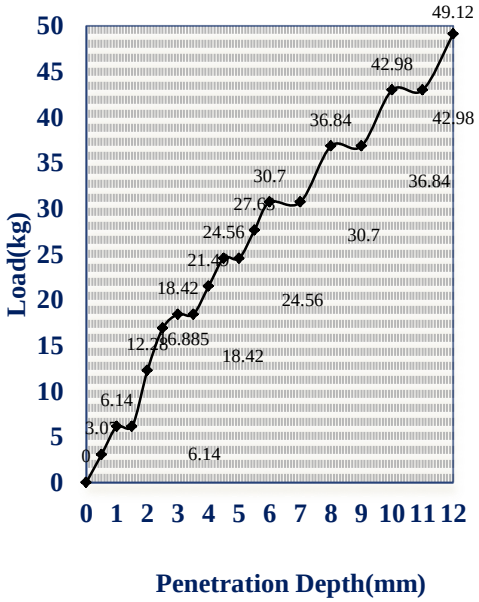

Fig. 8: Load Vs Penetration values of soaked CBR values for Black Cotton Soil

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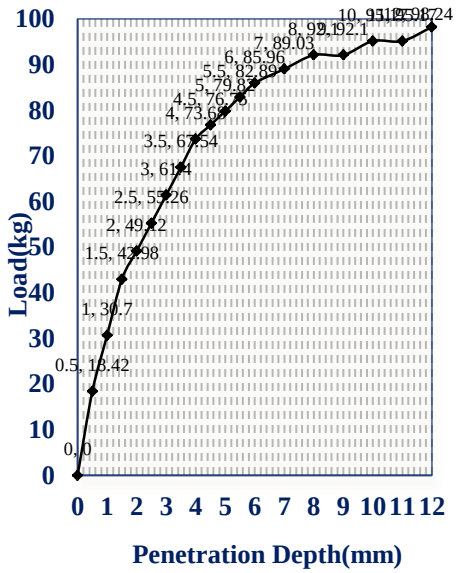

Fig. 9: Load Vs Penetration values for soaked CBR for Black Cotton Soil Treated of 20% Quarry Dust

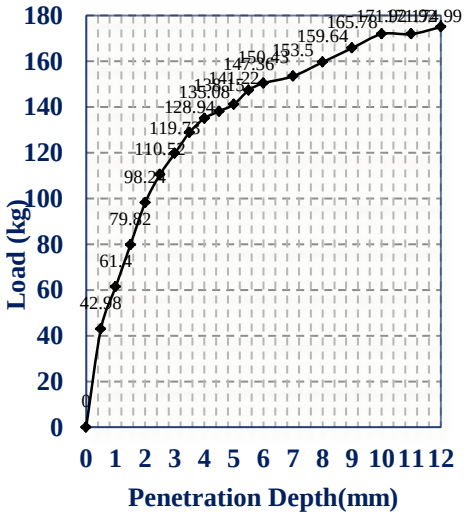

Fig.10: Load Vs Penetration values for soaked CBR of Black Cotton Soil with 20% Quarry Dust and 1.5% of Recron-3S Fibres

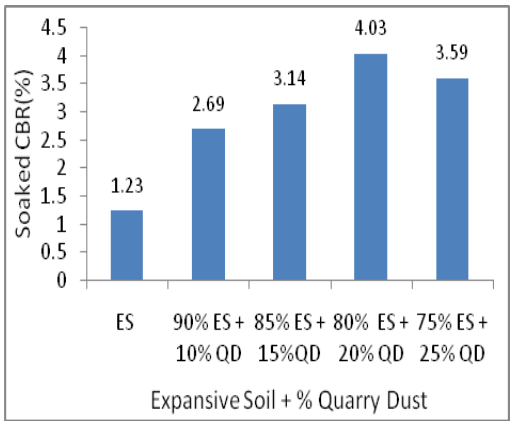

Fig.11: Soaked CBR Values for Black Cotton Soil Treated with Different % of Quarry Dust

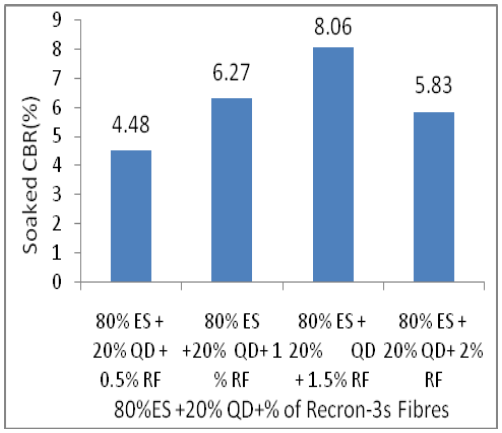

Fig.12: Soaked CBR Values for Black Cotton Soil Treated with 20% Quarry Dust and % of Recron-3S Fibres

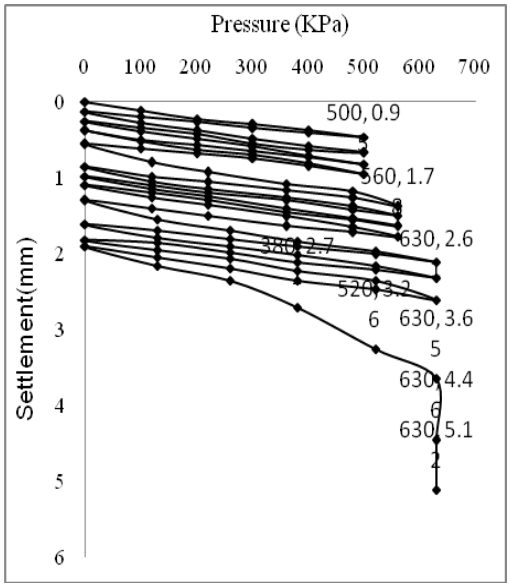

Fig.13: Load Vs Settlement Curve for Black Cotton Soil on the Laboratory Model Pavement

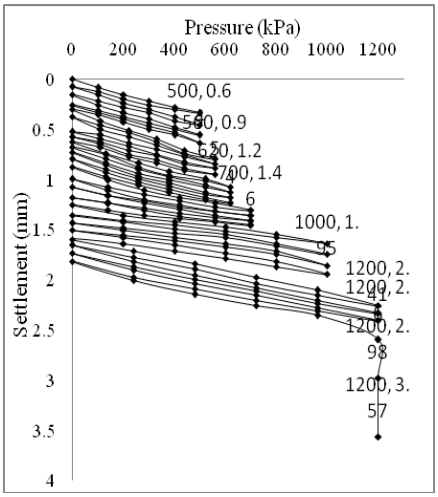

Fig.14: Load Vs Settlement Curve for Black Cotton Soil Treated with 20% Quarry Dust and 1.5% Recron-3S Fibres on the Laboratory Model Pavement

C. Cyclic Plate Load Test

From the results of laboratory cyclic load test, untreated black cotton soil subgrade model flexible pavement have exhibited an ultimate pressure of 630 kPa at 2.61 mm as deformation. Expansive soil treated with 20% Quarry dust and 1.5% Recron-3S-Fibers soil subgrade model flexible pavement has exhibited an ultimate pressure of 1200 kPa at 2.41mm as deformation as shown in the Fig.13 &14. The strength of the laboratory tank study significantly increased for Black Cotton Soil blending with 20% quarry dust and 1.5% Recron-3s fibers in comparison with untreated Soil.

V. CONCLUSION

The following conclusions haggard based on the laboratory experimentation during this study.

The soaked CBR values increases with increasing in percentage of adding 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.

Laboratory investigation that the ultimate bearing capacity increased from 630 kPa to 1200 kPa with the addition of 1.5% Recron-3S Fibers and 20% Quarry dust as an optimum when compared with untreated expansive soil.

Laboratory investigation that the settlements got reduced from 2.61 mm to 2.41 mm with the addition of 1.5 % Recron-3S-Fibers and 20% Quarry dust as an optimum when compared with untreated expansive soil.

From the above study it is found that quarry dust up to 20% and 1.5% Recron -3S fibres can be employed for improving the expansive soil with a great 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 develop the expansive soil's geotechnical characteristics. Hence, the use of quarry dust and Recron-3s fibres in pavements is economically beneficial and economically cheaper.

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