Evaluation of Strength Characteristics on Black Cotton Soil – Stone Dust Mixtures Reinforced with Shredded Tyre Rubber

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Abstract. Disposal of waste materials is a big problem with exceptionally growing up country like India. Rapid industrialization, population explosion, an extensive repletion of natural resources produces large quantities of waste materials which cause serious Geo-Environmental problems. Expansive soil swells and shrinks with regular wetness variation make structures founded on it unhinged and in practical cause huge economic loss in transportation division. In this find out the waste material stone dust as a stabilizer and Shredded Tyre Rubber which acts as a reinforcing material are selected. In the present study Stone dust blend to black cotton soil in changeable percentages of 5 %, 10 %, 15% and 20% by dry weight and Shredded Tyre Rubber in varying of 1 %, 2 %, 3 % and 4 % added to black cotton soil stabilized with optimum percentage of stone dust .The treated and untreated samples were subjected to compaction, CBR (soaked and unsoaked) and Unconfined Compressive Strength tests. The experimental values proved that there is a significantly increase in strength parameters for the black cotton soil added with Stone Dust and Shredded Tyre Rubber Combination.

Keywords: Black Cotton Soil, Stone Dust, Shredded Tyre Rubber, Compaction, CBR, UCS

1 Introduction

The enhancement of soil character is essential to build the soil secure in behavior the load of structures. Waste land can be improved by using ground improvement techniques which consist of stabilization or reinforcement of soil by means of mechanical and chemical methods or both. Soil stabilization by waste material is most popular due to low cost. Stone dust is very common material found abundantly which received from stone crushers. It helps to improve the properties of cohesive soil. Stabilization is a method of improving soil distinctiveness by use of assured additives. Use of shredded rubber for groundwork has acknowledged a great awareness in current period. Lime and Cement are the most commonly used stabilizers. From the recent studies it is observed that Solid waste materials like Stone Dust, Fly ash, Blast Furnace Slag, Rubber Tyre, fibers etc for the stabilization of soils can be used as an alternative to conventional stabilizers. Stone dust is a solid waste produce from stone crushing units imposing environmental problems and respiratory problems for public.

Shredded Tyre Rubber, a Solid Waste which is produced from used tyres of vehicles and accumulating in large volumes posing serious Geo-Environmental problems. The Disposal of Stone dust and rubber tyres can be made in a proper and safe manner by using them in construction purposes for stabilization of soils in Embankments for Roadways, Railways, and Foundations due to their binding and reinforcing properties. Effect of shredded rubber used as a stabilizer to develop the engineering properties of black cotton soil added with a varying range of 0 %, 2.5 %, 5 %, 7.5 %, 10 % for experimental work of Standard proctor tests and CBR tests were performed on both virgin soil and mix soils. From the tests carried out, MDD of soil sample increases up to 2.5 % and reduces considerably with increase in rubber content. OMC reduces significantly as percentage of rubber increases. The CBR values shows a minor increase up to 5 % and there after increases significantly at 7.5% and then reduces drastically. The maximum enhancement of soaked CBR rate is found at 7.5% which is 2.62 and the percentage reduction in pavement thickness= 17.33 % [1]. Adopted Shredded rubber has been picked as the reinforcement material and marble dust as binding agent which was reinforced into the soil at different percentages with different combinations from 2%,4%,6%,8% and 10% by weight of soil. Results showed that addition of rubber in the soil the maximum dry density decreases and the optimum moisture content doesn't show much of changes. Whereas with addition of marble dust in the soil the maximum dry density starts to increases with a decrease in optimum moisture content. This could be due to specific gravity of marble dust and low plasticity, improvement in UCS value after the addition of Marble dust into the soil and plasticity of the soil decreases as we add the Marble dust in to the soil [2]. [3] Investigate done the use of waste stone dust and plastic glass strips in geotechnical applications by conducting compaction and CBR tests blending varying percentage of stone dust (5%, 10%, 15%, etc) and plastic glass strips (0.5%, 1 %, 1.5%, etc). The maximum dry density is 1.94 gm/cc and optimum moisture content 18.91%, CBR percentage goes on increasing at 15% stone dust and 1.5% plastic strip and further addition of stone dust and plastic strip the maximum dry density decrease and optimum moisture content is increases. From various study it has been found that adding of 50% of stone dust to the soil is decrease the water requirement during field compaction, increase the MDD and 30% of stone dust help to gain effective specific gravity. The optimum value of stone dust to improve the CBR & UCS 10 %-15 % and concluded that stone dust can be used as cost effective stabilized agent which improved the engineering properties of highly cohesive soil effectively [3&4]. Studies for utilization of Shredded Tyre Rubber and Marble Dust for the stabilization of expansive soils blended in rate of 2%, 4%, 6%, 8%, and 10% by dry weight of soil. Results found that addition of rubber in the soil the maximum dry density decreases and the optimum moisture content doesn't show much of changes. Waste shredded rubber-Soil mixture showed an improvement in UCS value after the addition of Marble dust into the soil [5]. Investigation regarding the appropriateness of Shredded Tyre Rubber for its use in geotechnical engineering, i.e. to stabilize the Subgrade of the pavements. Added amount of rubber tyre had been varied in proportions of 4%, 6%, 8% and 10%.Shredded Tyre Rubber mixed with soil showed enhancement in CBR value with adding up to 8 % and there beyond decreased with additional increment in tyre content in unsoaked condition. Hence the optimal value of Shredded Tyre Rubber is 8 % of size 25 mm × 50 mm in unsoaked conditions. The percentage

enhancement in CBR value of stabilized soil is 66.28 % in unsoaked condition whereas an increase in CBR value can considerably trim down the total thickness of the pavement and hence the total cost concerned in the project [6]. Adding stabilizers or binders either in dry or wet situation to develop the stiffness and strength of the weak soil and from the results of experiments, there is an increase in unconfined compressive strength due to increase in percentage of tyre scrap of various sizes, the value of UCS is greater in comparison to that of parent soil and soil treated with 18 % of tyre-scrap, highest UCS value of 1.75 kg/cm^2 has been observed and no significant variation in the values of strain at failure [7]. In the present research work, an attempt has been made to calculate the Index and engineering properties of Black Cotton Soil blend with different proportions of Stone Dust and Shredded Tyre Rubber by weight. From the test results there is an improvement in geotechnical properties of stabilized black cotton soil blend with admixture and reinforcement material.

2 Study Design

The present study has planned in a three stages. In the first stage, it is proposed to carryout individual geotechnical properties in laboratory of the materials used during the study. In the second phase, stabilization method tried in the laboratory carried out blending with different proportions of stone dust to calculate the optimum percentage as shown in Fig. 1. In the third phase, different percentages of Shredded Tyre Rubber as a reinforcement material to the optimum soil – stone dust sample as shown in Fig. 2. Based on the assessment of results, optimum percentage of Shredded Tyre Rubber find out from the laboratory experimentation and comparison will be made with a view to know the improvement in geotechnical properties. The details of each of stages are explained in the following articles.

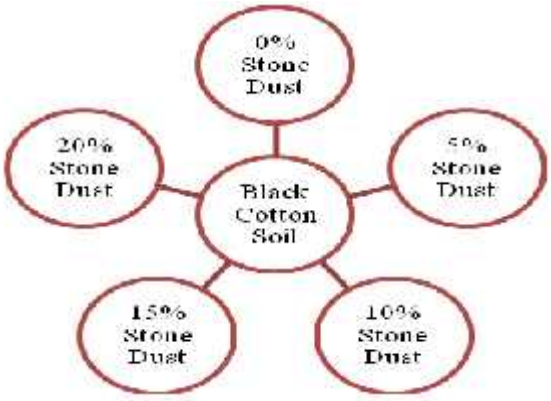

Fig. 1. Flow Chart Showing Different Percentages of Stone Dust Blend with Black Cotton Soil

Fig. 2. Flow Chart Showing Various Mix Proportions of Black Cotton Soil with 15% Stone Dust and % of Shredded Tyre Rubber.

3 Materials Used

Details of assorted materials used throughout the laboratory testing are presented in the succeeding segment

3.1 Black Cotton Soil (BCS): The soil used was a typical black cotton soil procured from 'Amalapuram', East Godavari District, Andhra Pradesh State, India. All the tests carried on the soil are as per IS specifications .The geotechnical properties of soil are Differential Free Swell = 140, Specific Gravity (G) = 2.67, Liquid limit = 85%, Plastic limit = 39%, Coefficient of Uniformity = 6.7, Coefficient of Curvature = 2.01, OMC = 23 %, MDD = 14.38 kN/m^3. Soaked CBR=1.35% and UCS= 40.74 kN/m^2.

3.2 Stone Dust (SD): Stone dust can be considered as cost effective stabilizer for ground improvement techniques of weak soils. Stone dust for this study was collected from Mahalakshmi Stone Crushing Unit, Nidadavole, Andhra Pradesh. The air dried Stone dust was passed through IS sieve 4.75mm was used for this work and its properties are Specific Gravity (G) = 2.57, Optimum Moisture Content (OMC) = 13.45 % and Maximum Dry Density = 1.59 gm/cc.

3.3 Shredded Tyre Rubber (SRT): Shredded Tyre Rubber was collected from Tyre Shredded unit, Palakol, West Godavari, Andhra Pradesh. Tyre cutting machine removes the steel belts during cutting and shreds off the tyre in to pieces. Shredded Tyre Rubber are in a length ranging between 10 mm-25 mm and thickness 2 mm-3 mm. The specific gravity of rubber tyre is in the range of 1.1-1.2.

4 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, Soaked CBR and unconfined compressive strength tests were conducted by using different percentages of Stone Dust (SD) and Shredded Tyre Rubber (SRT), with a view to find the optimum percentages and its effect on strength properties of black cotton soil .The details of these test results presented in the following sections

4.1 Index Properties: Regular 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 cram.

4.2 Compaction Properties: Optimum Moisture Content and Maximum Dry Density of Black cotton soil blend with dissimilar percentages of Stone Dust and Shredded Tyre Rubber mixes were indomitable according to I.S compaction test IS: 2720 (Part VIII) -1983.

4.3 California Bearing Ratio (CBR) Test: CBR test was carried out on prepared soil samples of untreated and treated black cotton soil with various percentages of Stone Dust and Shredded Tyre Rubber under soaked conditions as per IS: 2720 Part XVI-1987 recommendations as shown in the Fig.3.

4.4 Unconfined Compressive Strength (UCS): These tests are carried out in the laboratory under the IS Code (IS: 2720, Part X (1991) from compaction parameters i.e. Maximum dry density and optimum moisture content at a displacement rate of 1.2 mm / min. Proving Ring used 2 kN capacity for testing models as shown in Fig. 4.

Fig. 3. CBR Test Apparatus

Fig. 4. UCS Test Apparatus

5 Results & Discussions

Laboratory tests were conducted for finding the index and other important geotechnical properties of the materials used during the study. Compaction, soaked CBR

and UCS tests were conducted by using different percentages of stone dust and Shredded Tyre Rubber mixed with black cotton soil for finding optimum percentages and its effect on geotechnical properties.

5.1 Variation of Liquid & Plastic Limit Properties: The liquid limit and plastic limit values are decreasing as blending of stone dust percentage increasing as shown in the Fig. 5.The liquid limit values are decreasing from 85% to 49% and the plastic limit values are also decreasing from 37% to 19% when the percentage of stone dust varies from 0% to 20% respectively.

5.2 Effect on Compaction Parameters: The maximum dry density of black cotton soil was 14.38 kN/m^3.When optimum percentage of stone dust (15%) blend with black cotton soil the maximum dry density increased to 16.86 kN/m^3.The maximum dry density of black cotton soil treated with optimum percentages of stone dust (15%) and Shredded Tyre Rubber (2%) the density was decreased to 16.32 kN/m^3 where as the optimum moisture content decreases respectively as shown in the Fig. 6.

5.3 Effect on soaked CBR: Addition of stone dust to black cotton soil, the soaked CBR values varies from 1.85 %, 2.52 %, 3.27 %, 4.75% and 4.57% addition of 5 % increments stone dust as shown in the Fig. 7. Soaked CBR values changes from 4.75%, 5.91%, 7.68%, 7.11% and 6.25 % with the addition of 0%, 1%, 2%, 3% and 4% Shredded Tyre Rubber as shown in the Fig. 8. From the above Figures at 15 % blending stone dust to black cotton soil attained maximum CBR value 4.75 and blending 2% Shredded Tyre Rubber to optimum soil – stone dust mix attained 7.68 respectively.

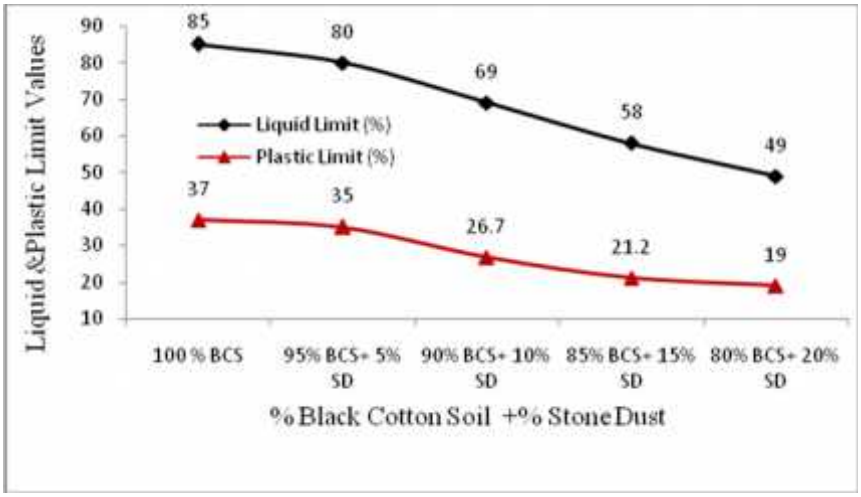

Fig.5. Variation in Liquid and Plastic Limit Values of Black Cotton Soil Treated with Different Percentages of Stone Dust.

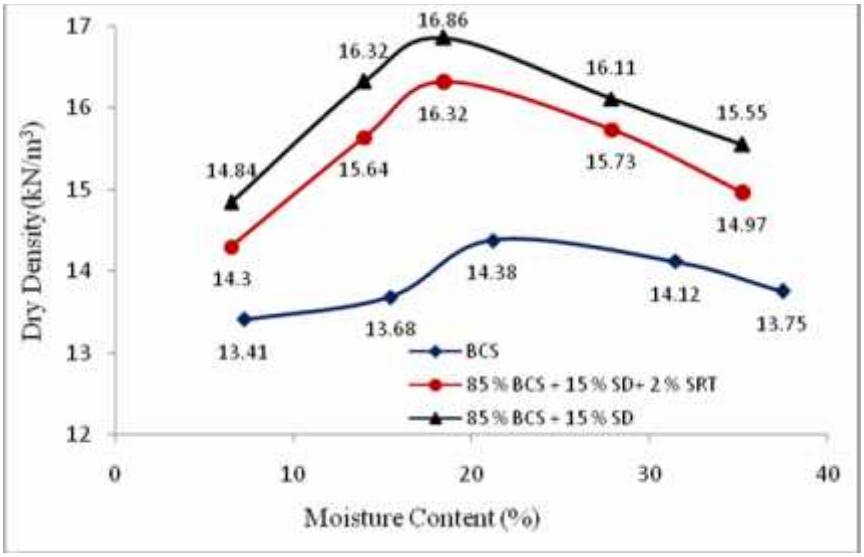

Fig.6. Variation in Compaction Parameters of Black Cotton Soil Treated with Different Percentages of Stone Dust and Shredded Tyre Rubber.

5.4 Effect on Unconfined Compressive Strength: The unconfined compressive strengths were conducted in the laboratory blending different percentages of Stone Dust and Shredded Tyre Rubber as per IS 2720 - part X at different curing periods 0, 7, 14 and 28 as presented in the Fig.9. Blending stone dust to the black cotton soil, Unconfined Compressive Strength values increasing up to 15% addition of stone dust and beyond it decreases. Considering 15% stone dust as optimum percentage, black cotton soil blend with different percentages of Shredded Tyre Rubber UCS value is maximum at 2% Shredded Tyre Rubber and beyond it decreases irrespective of curing. The maximum UCS values are 49.36 kN/m^2, 54.6 kN/m^2, 56.28 kN/m^2 and 59.3 kN/m^2 respectively at optimum soil-stone dust - Shredded Tyre Rubber at different curing periods.

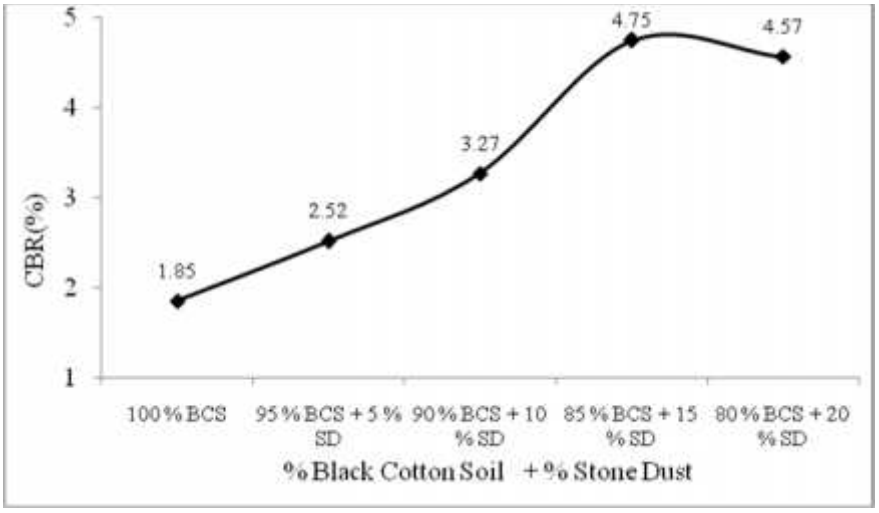

Fig.7. Variation in Soaked CBR Values of Black Cotton Soil Treated with Different Percentages of Stone Dust.

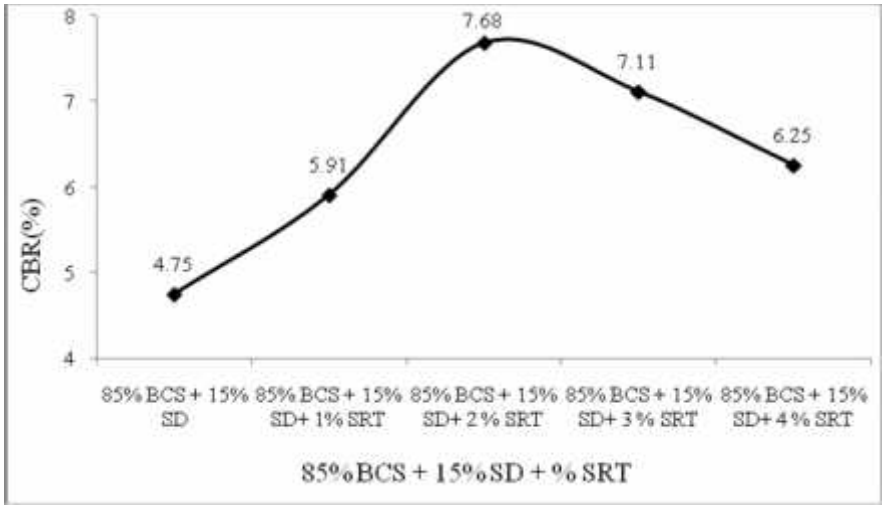

Fig.8. Variation in Soaked CBR Values of Black Cotton Soil Treated with Different Percentages of Stone Dust and Shredded Tyre Rubber.

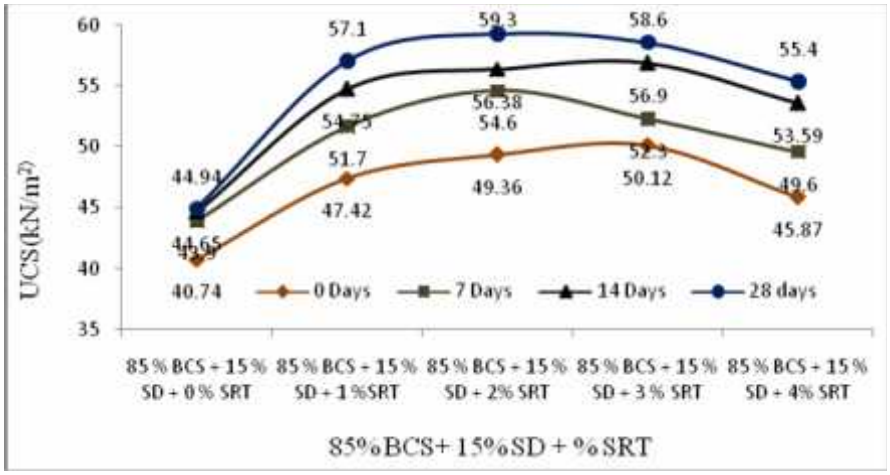

Fig.9. Variation in Unconfined Compressive Strength of Black Cotton Soil Treated with 15% of Stone Dust and Different Percentages of Shredded Tyre Rubber at Different Curing Periods.

6 Conclusions

The following conclusions were made based on the experiments carried out in this investigation.

Addition of stone dust to the black cotton soil considerably decreases the liquid and plastic limits due to change in soil structure.

Maximum dry density increased from 14.38 kN/m^3 to 16.86 kN/m^3 when 15% stone dust blend to black cotton soil and decreased to 16.32 kN/m^3 when 2 % Shredded Tyre Rubber to optimum soil mix respectively.

The soaked CBR value of black cotton soil treated with 15% stone dust and 2% Shredded Tyre Rubber is found to be 4.75 % and 7.68 % which increases 160% and 315% and also it is satisfying standard specifications. CBR value for increase in percentage of stone dust and Shredded Tyre Rubber that show the densification of soil takes place and more suitable for foundation.

Unconfined compressive strength increased by 40% when soil treated with 15% stone dust and 2% Shredded Tyre Rubber and curing significantly increases the strength.

Stone dust is a waste product which is produced abundantly from quarry industry, as it is having high specific gravity of 2.57 is used as stabilizing material. It has coarser particles which can be considered as a good binding agent and Shredded Tyre Rubber can act as a Reinforcing material. The Properties of black cotton soil improves significantly by the addition o Stone Dust and Shredded Tyre Rubber and their use in stabi-

lization of black cotton soil can reduce construction cost and provide a better environmental solution for their disposal.The utilization of industrial wastes is an alternative to reduce the construction cost of roads particularly in the rural areas of developing countries.

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