A Study on Stabilization of Expansive Soil by using Agricultural By-Products

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Abstract

The growing cost of traditional stabilizing agents and the need for the economical utilization of agricultural wastes for beneficial engineering purposes has prompted an investigation into the stabilizing potential of RHA & SCBA in highly expansive soil. This research work is aimed to evaluate the suitability of RHA & SCBA for stabilization of expansive soil. The laboratory work involved index properties to classify the soil sample. The preliminary investigation of the soil shows that it belongs to MH class of soil by USCS A-Line Chart soil classification system. Soils under this class are generally of highly expansive & poor engineering use. Atterberg's limits, free swell index, compaction, CBR and UCS tests were used to evaluate properties of stabilized soil. In this project an attempt has been made to study the compaction, CBR and UCS characteristics of expansive soil blended with different percentages of RHA and SCBA in a view to determine the optimum percentage. These test results shows that stabilization of expansive soil with agricultural by-products (RHA & SCBA) enhances the strength.

Keywords: *Expansive Soil, Rice Husk Ash, Sugarcane Bagasse Ash, Compaction, CBR and UCS*

I. INTRODUCTION

The wide spread of the expansive soil has posed challenges and difficulties in the construction activities because of its shrink-swell behavior and low strength. The inadequate natural stability of expansive soil can be reduced using various techniques one of them is through admixtures. Stabilization techniques can be adopted on large scale when the treatment is low cost and durable. Disposal of solid waste on the land fill can be minimized if the waste is having desirable properties such that they can be utilized for various geotechnical application viz. land reclamation, construction of embankment etc. The scarcity and rising cost of traditional stabilizers like Lime and Cement has led to the research into clay soil stabilizing potential of sugar cane bagasse ash, Rice Husk Ash that are available cheaper, readily available and environmental friendly and has a serious disposal problem. Rice husk ash (RHA) is an agricultural waste generated due to burning of rice husk for various purposes and it is a pozzolanic material. The main constituent is silica. Bagasse is a fibrous residue of sugarcane stalks that remains after extraction of sugar and when incinerated gives the ash. The chemical analysis on bagasse ash was found to contain mainly silica, and potassium, iron, calcium, aluminium, magnesium as minor components and exhibit pozzolanic properties. Bagasse Ash is a major waste of sugar industry and Rice husk ash is a waste from paddy industry which has serious waste disposal problems. Using these two ashes for stabilization not only solves the disposal problem but also its optimum usage in subgrade soil stabilization will bring down the construction cost of the pavements. The potential use of RHA as a soil stabilizer by conducting compaction and strength characteristics. From test results there is a decrease of maximum dry density (MDD) and an increase of optimum moisture content (OMC) when the soil is treated with 5 to 20% of RHA by dry weight of the soil, unconfined compressive strength (UCS) increases up to 10% addition of RHA by dry weight of soil, there after it decreases. For the best stabilization effect the optimum percentage of RHA was found to be 10% by weight of dry soil sample. MDD goes on decreasing and OMC goes on increasing with the increasing percentage addition of rice husk ash on the soil. Maximum UCS of soil found at 10% addition of rice husk ash on soil. For best stabilization effect optimum percentage of rice husk ash on soil is obtained as 10% by weight of dry soil [1]. Stabilization of the black cotton soil by using mixture of bagasse ash and lime and conducted various laboratory tests and from the test results, there was decrease of plasticity index and increase of California bearing ratio of Stabilized Black Cotton Soil when optimum ratio of Bagasse Ash to Lime was used. As per results and observations, the best proportion for stabilization for Black Cotton Soil is recommended to be 2:3 of Bagasse Ash: Lime [2]. Laboratory tests like plasticity index, specific gravity, compaction characteristics, CBR value and unconfined compressive strength of Bagasse Ash stabilized black-cotton soil. The Plasticity index showed a decreasing trend with increase is ash content, whereas strength properties were observed to be increased to peak values at optimum ash content and decreased on further addition of ash [3]. Consolidation and rebound characteristics of expansive soil by using lime and Bagasse ash, based on the test results, increases in Bagasse ash content with Lime, reduction in liquid limit whereas plastic limit is increases, change of Atterberg limit is due to the cation exchange reaction and flocculation-aggregation for presence of more amount of Bagasse ash -Lime, which reduces plasticity index of soil. A reduction in plasticity index causes a significant decrease in swell potential and removal of some water that can be absorbed by clay minerals. The maximum dry density of soil decreased with the addition of Bagasse ash - Lime and value of optimum moisture content mixes treated soil increased because of the Puzzolanic action of Bagasse ash - Lime and soil, which needs more water [4]. CBR and UCS tests were conducted on black cotton soil with partial replacement by Bagasse Ash at different percentages and the optimum value of Bagasse ash content was find out at which the soil-ash mix exhibited the maximum strength properties[5]. Laboratory tests were undertaken to investigate the effect of Marble dusts on strength and durability of an expansive soil stabilized with optimum percentage of Rice Husk ash and optimum percentage of RHA was found out be 10% based on Unconfined Compressive Strength tests. Marble dust added to RHA stabilized expansive soil up to 30%, by dry weight of the soil, at an increment of 5%. Compaction ,UCS , Soaked CBR, Swelling pressure and Durability tests were conducted on these samples after 7 days of curing and from the results UCS and Soaked CBR of RHA stabilized expansive soil increased up to 20% addition of Marble dust and MDD and Swelling pressure of expansive soil goes on decreasing, OMC goes increasing irrespective of the % of addition of Marble dust to RHA stabilized expansive soil. For best stabilization effect the optimum proportion of Soil: Rice husk ash: Marble dust was found to be 70: 10: 20[6]. In this investigation, different laboratory experiments like Compaction, CBR and UCS tests were conducted by varying percentages of 0 %, 2.5 %,5 %,7.5 % and 10% of Rice Husk Ash and 0 %, 2.5 %, 5 %, 7.5%,10% and 12.5% Sugar Cane Bagasse Ash were blended to the expansive soil with different combinations by conducting various laboratory tests and from test results it is found that there is an improvement in geotechnical properties. Testing is conducted with a view to find the optimum percentages Rice Husk Ash, Sugar Cane Bagasse Ash respectively.

II. MATERIALS USED

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

A. Expansive Soil

The Expansive soil sample used for this research work is collected from Thumalapalli village of Allavaram mandal in East Godavari district, Andhra Pradesh, soil taken from one test pit. The soil is grayish black in colour and highly plastic in nature. A disturbed sample is collected from test pit at a depth below 1.5m in order to avoid the inclusion of organic matter.

Table 3 Physical Properties of Expansive Soil

Property	IS Code	Valve
Liquid Limit (%)	IS 2720 (Part 5) - 1985	84
Plastic Limit (%)	IS 2720 (Part 5) - 1985	51
Plasticity Index (%)	IS 2720 (Part 5) - 1985	33
Soil Classification	A – Line chart	MH
Specific Gravity	IS 2720(Part:3/1)-1980	2.613
Free Swell (%)	IS 2720 (Part 40) - 1977	132
Natural Moisture Content (%)	IS 2720 (Part 2) - 1973	31.71
OMC (%)	IS 2720 (Part 7) - 1980	26.53
MDD (g/cc)	IS 2720 (Part 7) - 1980	1.551
Unsoaked CBR (%)	IS 2720 (Part 16) - 1987	2.33
Soaked CBR (%)	IS 2720 (Part 16) - 1987	1.477

B. Rice Husk Ash (RHA)

RHA sample used for the research work is collected from Gowthami Solvent Oils Limited in Tanuku of Andhra Pradesh. In the spinning division oils are extracted from the rice husk (crude rice bran oil, rice bran oil & refined rice bran oil). Finally the Rice Husk Ask is obtained which is a huge waste produced from this industry.

Table 1 Chemical Properties of Rice Husk Ash (RHA)

Chemical Constituents	% Weight in India	Weight %
Silica as SiO_2	86-94	87.69
Alumina as Al_2O_3	0.2- 5.0	2.43
Iron as Fe_2O_3	0.30-2.0	0.91
Calcium as CaO	0.5-2.5	1.62
Potassium as K_2O	0.1-2.3	0.75
Magnesium as MgO	0.10-1.8	1.04
Sodium as Na_2O	0.1-0.5	0.39
Loss on Ignition	4.62-5.3	5.17

C. Sugarcane Bagasse Ash (SCBA)

Ash sample used for the research work is collected from Andhra Sugars Limited in Tanuku of Andhra Pradesh. By-products of sugarcane with combination of Molasses from Andhra Pradesh is being used to make rocket propellant fuels, ethanol, rectified spirit used in preparation of liquor, for generation of power and in the paper industry as raw material for making newsprint.

Table 2 Chemical Properties of Sugarcane Bagasse Ash (SCBA)

Chemical Constituents	Weight %	Chemical Constituents	Weight %
SiO_2	60.98	K_2O	3.53
$Al2O_3$	7.39	Na_2O	0.25
$Fe2O_3$	6.07	P_2O_5	0.61

CaO	12.66	SO_3	1.23
MgO	2.51	Loss of Ignition	4.77

III. LABORATORY EXPERIMENTATION

Laboratory tests were conducted for finding the index and other important properties of the soils used during the study. Compaction, CBR and Unconfined compressive strength tests were conducted by using different percentages of Rice Husk Ash (RHA) and Sugarcane Bagasse Ash (SCBA) mixed with black cotton soil materials for finding optimum percentages and strength parameters.

A. 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.

B. Compaction Properties

Optimum moisture content and maximum dry density of Black cotton soil mixed with different percentages of Stone Dust and Shredded Rubber Tyres mixes were determined according to I.S compaction test IS: 2720 (Part VIII)-1983.

C. California Bearing Ratio (CBR) Test

CBR test was carried out on prepared soil samples of Untreated and Treated expansive soil with various percentages of Stone Dust and shredded rubber tyre under soaked and unsoaked conditions as per recommendations in IS: 2720 Part XVI-1987.

D.Unconfined Compression Strength Test

The unconfined compression strength tests were conducted in the laboratory as per IS Code (IS: 2720, Part X (1991). Unconfined compressive strength is one of the most widely referenced properties of stabilized soils. For strength testing, specimens are generally tested at their maximum dry density and optimum moisture content. The load frame of compression testing machine apparatus was used for conducting the unconfined compressive strength test. The strain rate was kept as 1.2 mm/min in all the experiments. The proving ring of capacity 2 kN was used fortesting specimens as shown in the Fig. 5.

IV. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by replacing different percentages of Rice Husk Ash and Sugar Cane Bagasse Ash **(SCBA)** in the Expansive soil. Liquid Limit, Plastic Limit and Compaction, soaked and unsoaked CBR and UCS tests at different curing periods were conducted with a view to determine the optimum combination of Rice Husk Ash and Sugar Cane Bagasse Ash. The influence of the above said materials on the Index, Compaction and Strength properties were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice. The test results are presented in the Figs.6.1 to 6.11.

A. Effect of RHA and SCBA on Compaction

From the compaction test results the maximum dry density values are increases from 15.51 kN/m^3, 15.97 kN/m^3, 16.30 kN/m^3 16.88 kN/m^3 and 16.61 kN/m^{3}and optimum moisture content values are decreases from 26.53%, 23.57%, 21.92%, and 20.78% and 18.42 % respectively when the soil is mixed with 0 %, 2.5 %, 5 %, 7.5 % and 10% of RHA as shown in the Fig. 1. The optimum percentage of RHA is 7.5 %. The decrease in optimum moisture content is attributed to the fact that additional water held within the flocs resulting from flocculation. From Fig. 2. it is observed that, the OMC values are decreasing from 20.34 %, 19.6 % ,18.34% ,16.67% and 16.08% and the MDD values are varied from 16.91kN/m^3, 16.98 kN/m^3,17.13 kN/m^3,17.4 kN/m^3 and 17.07kN/m^3 respectively due to the addition of 2.5%, 5% ,7.5% ,10% and 12.5% SCBA blended in the expansive soil and 7.5 % optimum percentage of RHA.

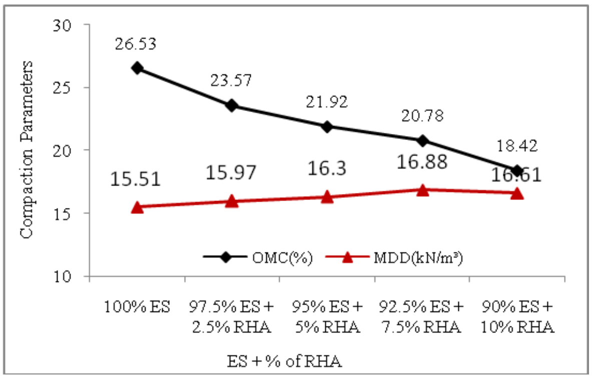

Fig 1: Variation of Compaction Parameters of Expansive Soil with Different Percentages of RHA

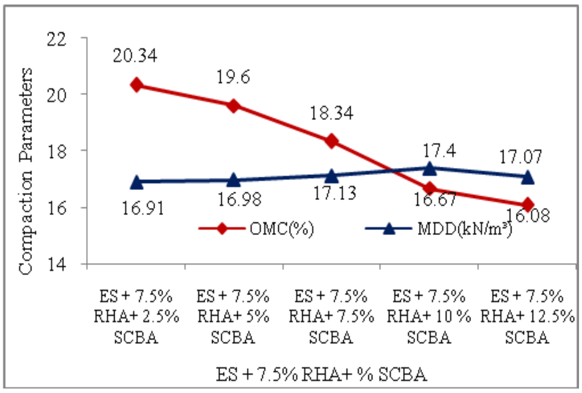

Fig 2: Variation of Compaction Parameters of Expansive Soil and 7.5 % RHA with Different Percentages of SCBA

B. Effect of RHA and SCBA on California Bearing Ratio (CBR):

Unsoaked and Soaked CBR tests were conducted for expansive soil mixed with different percentages of RHA and SCBA and the results were presented in the Figs.3 & 4. It is observed from that expansive soil mixed with different percentages of RHA the unsoaked and soaked CBR values are 2.33,1.447;2.91,1.83;3.417,2.556;4.039,2.706 and 3.852,2.518 respectively at 0%, 2.5 %, 5 % ,7.5% and 10 % blending of RHA as shown in the Fig.3. From the above Figure the optimum percentage of RHA is 7.5 %. The optimum sample mix of expansive soil and 7.5 % RHA, different percentages of SCBA 0%, 2.5 %, 5 %,7.5%,10% and 12.5 % respectively blending in the above mix and the unsoaked and soaked CBR values are 4.917,3.26; 5.623,3.751; 7.145,4.187; 8.38,4.84 and 7.802,4.691 SCBA blended with the expansive soil respectively. From the above test results the optimum percentage is 10 % SCBA as shown in the Fig.4.

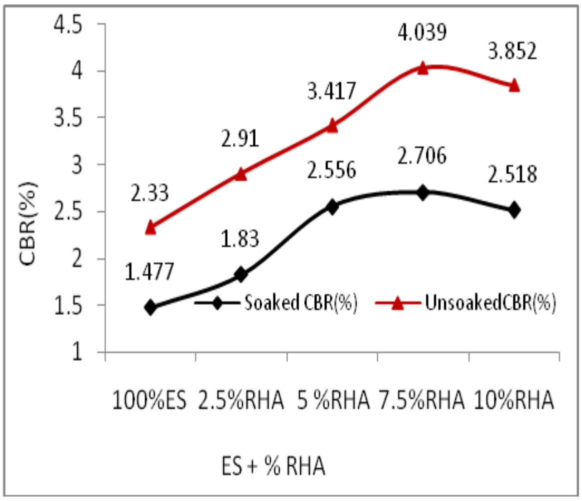

Fig3: Variation of CBR Values on Expansive Soil Treated with Different % of RHA

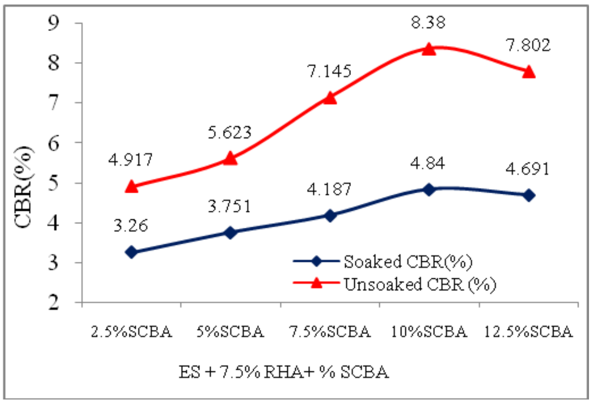

Fig4: Variation of CBR Values on Expansive Soil Treated 7.5% RHA and Different % of SCBA

C. Effect of RHA and SCBA on Unconfined Compressive Strength (UCS):

Unconfined compressive strength test was conducted at different curing periods at a strain rate of 1.25 mm/min. Specimens of 38 mm diameter and 76 mm height were prepared at OMC for different percentages of RHA 0%,2.5%, 5%,7.5% and 10 % blended in black cotton soil and cured for 1, 3, 7, 14, 21 and 28 days and the unconfined compressive strength values are Periods152 kPa,164 kPa,172 kPa,175 kPa,178 kPa and181 kPa respectively at 7.5 % of RHA as shown in the Fig.5. After finding the optimum percentage of RHA , different percentages of SCBA 0%,2.5%, 5%, 7.5%,10% and 12.5% blended in black cotton soil and cured for 1, 3, 7, 14, 21 and 28 days and the unconfined compressive strength values are 185 kPa, 192 kPa, 208 kPa, 220 kPa, 225 kPa and 234 kPa respectively at 10% SCBA as shown in the Fig.6. From the above test results the optimum percentages of RHA and SCBA are 7.5 % and 10 % respectively.

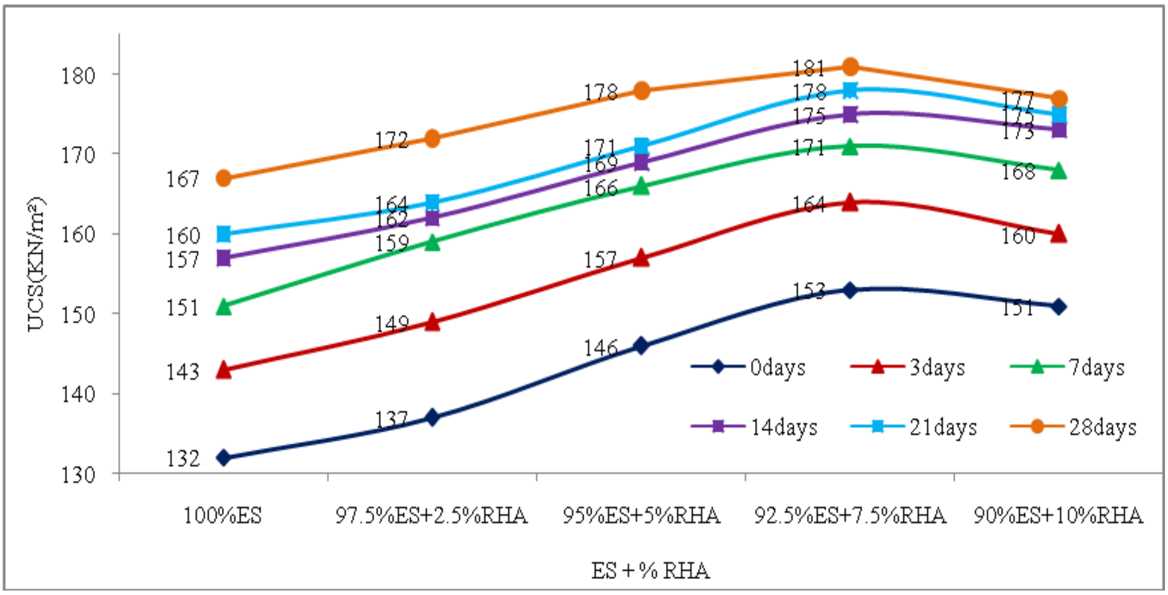

Fig.5 Variation of Unconfined Compressive Strength of Expansive Soil Treated with Different % of RHA at Different Curing

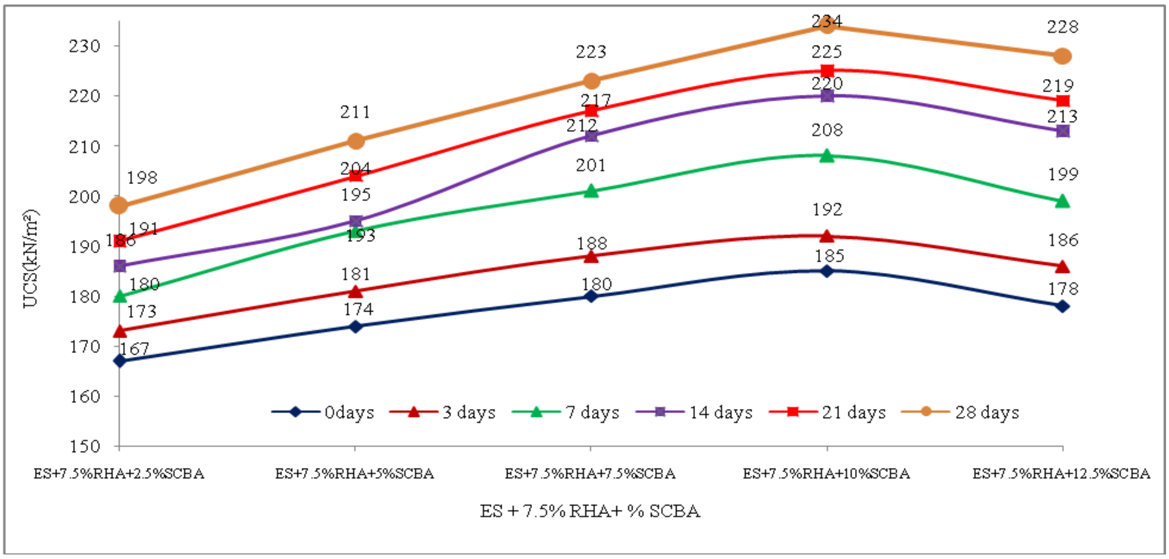

Fig.6 Variation of Unconfined Compressive Strength of Expansive Soil Treated with 7.5% RHA and Different % of SCBA at Different Curing Periods

V. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation

With the increase in the percentage of RHA the MDD increases from 1.551g/cc to 1.688g/cc at 7.5% and the OMC has decreased from 26.53% to 20.78% at same 7.5%.

Compaction characteristics of RHA treated having optimum at 7.5% expansive soil such as MDD goes on increasing from 1.651g/cc to 1.74g/cc and OMC goes on decreasing from 22.81% to 16.67% with the addition of different percentages of RHA.

CBR values of unsoaked sample increases from 2.33% to 4.039% on addition of 7.5% of RHA, then decreases to 3.852% with the addition of 10% of RHA to the Expansive soil. CBR values of soaked sample increases from 1.477% to 2.706% on addition of 7.5% of RHA, then decreases to 2.518% with the addition of 10% of RHA to Expansive soil.

Unsoaked CBR value goes on increasing from 4.917% to 8.38% on addition of 10% SCBA, then decreased to 7.802% with the addition of 12.5% SCBA to the RHA treated ES and soaked CBR value goes increasing from 3.26% to 4.84%with addition of 10% SCBA, then decreased to 4.691% with the addition of 12.5% of SCBA.

UCS values for RHA treated soil increases on addition of 7.5% and then decreases at further increment of 10% for curing periods of 0, 3, 7, 14, 21 and 28 days.

From the above test results, the optimum percentages of RHA and SCBA are 7.5% and 10% SCBA respectively.

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