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A Study on Geotechnical Properties of Expansive Soil Treated with Rice Husk Ash and Terrasil

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----------ABSTRACT----------

Soils, which exhibit a peculiar alternate swell-shrink behavior due to moisture fluctuations, are known as expansive soils. Expansive soil is considered as the problematic soil for most of construction activities because of its expansive behavior. There are many way to solve this problematic behavior of expansive soil. Soil stabilization is one of the techniques to improve the geotechnical behavior of expansive soil. This paper presents the effect of Rice Husk Ash(RHA) and Terrasil on the geotechnical properties of black cotton soil blending with different percentages with a view to determine the geotechnical behaviour of black cotton soil-RHA-Terrasil. The results obtained show that the increase in RHA content increases the OMC but decreases the MDD, observing improvement of CBR value.

KEYWORDS *- Expansive Soil, Rice Husk Ash, Terrasil, Compaction, Soaked CBR.*

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I. INTRODUCTION

Black cotton soil is one of the significant soil stores of India. They display high swelling and contracting when presented to changes in dampness content and thus has been observed to be most troublesome from building contemplations. 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. Stabilization of black cotton soil with different percentages of rice husk ash and from test results, Specific Gravity of soil is decreases with increase in RHA, Coefficient of Curvature and Coefficient of Uniformity the soil is well graded and coarse grained, Liquid limit in soil increases up to 4% and then decreases with increase in addition of RHA to the soil, Plastic limit in soil first increases up to 4% RHA and then decreases with increase in addition of RHA, Maximum dry density Decreases with increase in proportion of RHA and CBR Value increases up to 12% RHA and then decreases hence at mixing 12 % RHA strength is maximum[1].Free Swell index is decreases with the addition of 0.6kg/m3 of Terrasil and Zycobond and decreased to 26.3%, 25%, 21.05% with the addition of 0.8kg/m3,1.0kg/m3,1.2kg/m3 when compared to 0% of Terrasil and Zycobond. Unconfined compressive strength is decreased when the dosage of the Nano chemicals (Terrasil and Zycobond) is increased. But many of journals say that Unconfined compressive strength should be increases by adding cement, Terrasil and Zycobond. Further investigation need to be done why the unconfined compressive strength is decreases [2].Index properties of expansive soil treated with different % of terrasil and concluded that Liquid limit of soil decreases from 61.34% to 58.17% with increase in terrasil (%) in Stage-I and with addition of 2% of lime with terrasil (%) i.e. in stage-II the Liquid Limit of soil get decreased from 61.34% to 53.89%, Plasticity index of soil decreases with increases in terrasil content up to 0.07% and after that with increase in terrasil content in stage-I slight increment is observed. Also when terrasil (%) added with 2% lime (i.e. stage-II), Differential free swell value decreases with increasing of terrasil content only upto0.07% and then slightly get increased in stage-I. Also when terrasil (%) added with lime (i.e. stage II) [3]. Series of tests were conducted on expansive soil treated with different percentages of quarry dust anf rice husk ash and from test results maximum dry density of the soil sample is increased with decreases in water content. Maximum water content during performing SPT excepting parent soil is 28 at 1.76 g/cc dry density Minimum water content during performing SPT excepting parent soil is 23 at 1.79 g/cc dry density. Maximum strength of mixture from the composition of 10% Stone dust and 20%

RHA (Rice Husk Ash) .The compressive strength of soil is increases for a particular composition after that it goes falling down. For this soil treatment mixing of soil with right composition is not very easy process it is also a very important process for best performance at lowest coast [4]. Execution of bio-enzyme balanced out soil has been researched in this work. The value of Liquid limit decreases for terrazyme treated soil, the value of Plastic limit decreased; dry density of soil is increased to 1.828 gm/cc from 1.665 at Optimum moisture content of 18.33 and 14.49, respectively. The swelling property shows significant improvement. The value of CBR also have significant rise in value at 4.13% of treated soil from average CBR of 2.49 of untreated soil samples [5]. The liquid limit and the free swell index of the soil decreased with the increase in the % of RHA .In case of alluvial soil the liquid limit decreased from a value of 59% to 19.2% for the same quantum of addition of RHA. The decrease in the free swell Index was from 59% to 13.6%. The shrinkage limit of soil increased to 23.7 and 24.2% respectively for alluvial soil and clay soil from 12% initially for virgin soil. The Maximum dry density increased in case of addition of 80% RHA to alluvial soil the soil and Optimum moisture content decreased steeply with % RHA 17.8% to 13.25%. The maximum and minimum dry density of alluvial soil is 21.8kN/m^3 and 18.4kN/m^3 respectively. The Optimum moisture content decreased steeply with 80% RHA for clay soil from 17.89% to 13.25% and maximum dry density The undrained cohesion value of the soil mixed with RHA for clay soil decreased from 60 kN/m^2 to 30 kN/m^2 and angle of internal friction value increased from 17°5' to 38°. The unsoaked CBR value of the soil increased and soaked CBR value increased in the case of addition of RHA to alluvial soil [6]. Bio Enzymes are non poisonous, organic and biodegradable in nature and the effect is permanent**.** The Maximum dry density of local soil without TerraZyme was 1.79gm/cm3 and optimum moisture content to be 17%**.** The initial cost of using TerraZyme is high but the maintenance cost is less or zero, Terrazyme economically and effective in sub base preparation and consistency limits and CBR with different curing periods, consistency limits are reduced and the soaked CBR increased after curing period of two weeks[7].In this investigation laboratory experiments like Atterberg's limits, Compaction and CBR tests were conducted by varying percentages of 0 %, 5 %, 10 %, 15% and 20% of Rice Husk Ash and 0.04 %, 0.06 %, 0.08 % and 1.0 % Terrasil were blended to the expansive soil with different combinations by conducting various tests in the laboratory and it is found that there is an improvement in geotechnical properties and the behaviour of black cotton soil. From the test results it is observed there is an improvement in engineering properties and the optimum percentages were arrived accordingly.

II. MATERIALS USED

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

2.1 Expansive Soil: The black cotton soil was collected 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 presented in Table.1.

Table I: Physical Properties of Expansive Soil

Property	Value
Liquid Limit (%) W_L	88
Plastic Limit (%) W_P	38
Plasticity Index (%) I_P	50
Gravel (%)	0.0
Sand (%)	5.0
Silt (%)	12.0
Clay (%)	83.0
Soil Classification	CH
Specific Gravity G	2.69
Differential Free Swell (%) DFS	130
Optimum Moisture Content (%)OMC	27.68
Maximum Dry Density(g/cc)	1.451
Natural Moisture Content (%)	11

2.2 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 as shown in the Fig.2. The properties of Rice Husk Ash are presented in Table.2.

Table.2 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

2.3 Terrasil: It is a nanotechnology based material. Terrasil is environmental friendly as it uses the in situ soil and conserves restricted resources like aggregates and bitumen which minimizes use of fuel for transporting good soils over long. Terrasil delivers proven results with all types of soils and doesn't change their appearance. Terrasil was purchased from Zydex Industries Pvt. Ltd, Gujarat and the properties are presented in Table.3.

Table.3 Physical and Chemical Properties of Terrasil

Property	Description & Range
Appearance	Pale Yellow Liquid
Density	1.01g/ml
Viscosity at 25^0C	20-100 cP
Solubility	Forms Water Clear Solution
Flash Point	$>80^0$C
Freezing point	5^0C
Hydroxyalkyl-alkoxy-alkylsilyl	65 –70 %
Benzyl alcohol	25 –27 %
Ethylene glycol	3 –5 %

Fig .1 Black Cotton Soil

Fig.2 Rice Husk Ash

III. LABORATORY EXPERIMENTATION

Laboratory tests were conducted for finding the index and other important properties of the soil used during the study. Atterberg's limits, Compaction and Soaked CBR tests were conducted by using different percentages of Rice Husk Ash (RHA) and Terrasil blending with black cotton soil for finding optimum percentages and strength parameters.

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 mixed with different percentages of RHA and Terrasil mixes were determined according to I.S heavy compaction test IS: 2720 (Part VIII)

3.3 California Bearing Ratio (CBR) Test: Different samples were prepared for CBR test using expansive soil with different percentages of RHA and Terrasil in the laboratory as per IS: 2720 Part- XVI-1987 as shown in the Figure 3.

Fig. 3 California Bearing Ratio Test Apparatus

IV. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by mixing different percentages of Rice Husk Ash(RHA) and Terrasil blending in Expansive soil. Liquid Limit, Plastic Limit, Compaction and soaked CBR tests were conducted with a view to determine the optimum combination of Rice Husk Ash and Terrasil and the results are furnished below.

4.1 Effect of Rice Husk Ash and Terrasil on Index Properties*:* Liquid limit and plastic limit values were reduced from 87.5% to 53% and 38% to 28.8% with blending of different percentages of RHA varying from 0 % to 20% blending in expansive soil respectively as shown in the Fig.4.Considering 15% RHA blending with expansive soil as base soil mix adding different percentages of Terrasil , liquid limit and plastic limit values varies from 60% to 33% and plastic limit values are reduced from 30.3% to 16% as shown in the Fig.5.

4.2 Effect of RHA and Terrasil on Compaction: From the compaction test results the maximum dry density values are decreases from 15.14 kN/m^3, 13.34 kN/m^3, 13.05 kN/m^3 12.85 kN/m^3 and 12.56 kN/$m^3$and optimum moisture content values are increasing from 28 %, 30.03 %, 32.11 33.98% %, and 34.03% respectively when the soil is mixed with 0 %, 5 %, 10 %, 15% and 20 % of RHA as shown in the Fig.6. The increase in optimum moisture content is attributed to the fact that additional water held within the flocs resulting from flocculation. This reduced the bond in the soil RHA mixture. The MDD is decreased while the OMC is increased with increase in the RHA content. The decrease in the MDD can be attributed to the replacement of soil and by the RHA in the mixture The decrease in the MDD may also be explained by considering the RHA as filler (with lower specific gravity) in the soil voids. There is increase in OMC with increase RHA contents. The 52 Aparna Roy increase is due to the addition of RHA, which decreases the quantity of free silt and clay fraction and coarser materials with larger surface areas, are formed. This implies also that more water is needed in order to compact the soil-RHA mixtures. OMC values are increasing from 33.98%, 33.31 % ,32.69 % ,32.12 % and 31.21% and the MDD values are increasing from 12.85 kN/m^3, 13.34 kN/m^3,14.51 kN/m^3,13.05 kN/m^3 and 12.05 kN/m^3 respectively due to the addition of 0.04%, 0.06 % ,0.08 % and 0.1 % terrasil blended in the expansive soil shown in Fig.7. It has been observed that maximum dry density of Black Cotton soil increase with increase in Terrasil content up to 0.06%.

4.3 Effect of RHA and Terrasil on California Bearing Ratio (CBR): As an indicator of compacted soil strength and bearing capacity, it is widely used in the design of base and sub-base material for pavement. It is also one of the common tests used to evaluate the strength of stabilized soils. Soaked CBR tests were conducted for expansive soil mixed with different percentages of RHA and Terrasil and the results were presented in the Figs.5& 6. It is observed from that expansive soil mixed with different percentages of RHA, the soaked CBR values are 1.2%, 2.7%, 4.5%, 5.8% and 3.6 % respectively at 0%, 5%, 10%, 15% and 20 % blending of RHA as shown in the Fig.8.From the above results at 15% RHA attains maximum CBR value of 5.8% as compared to other samples tried in this investigation. Considering 15% optimum RHA blending with different percentages of Terrasil, the soaked CBR values are 5.8 %,6.2%,8.1%,6.7 % and 5.4 % at 0.04%, 0.06 % ,0.08 % and 0.1 % terrasil mixing in the expansive soil respectively shown in the Fig.9. From the above Figure the optimum percentage of Terrasil 0.06% attains 8.1% CBR as compared to other samples.

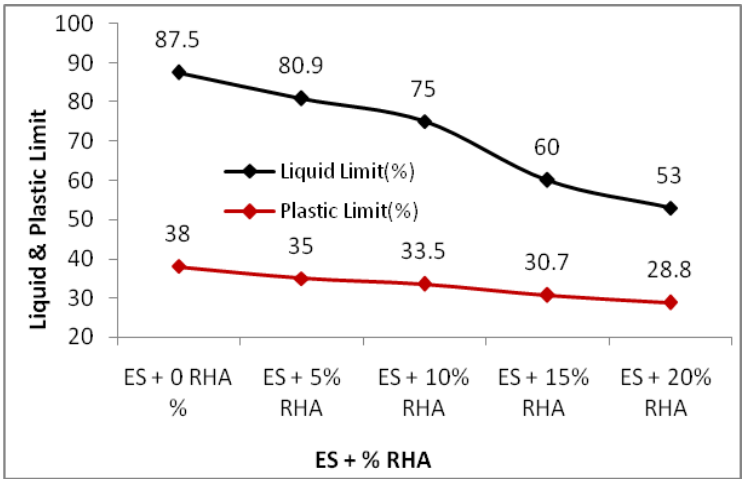

Fig 4: Variation of Consistency Limits of Expansive Soil Treated with Different % of RHA

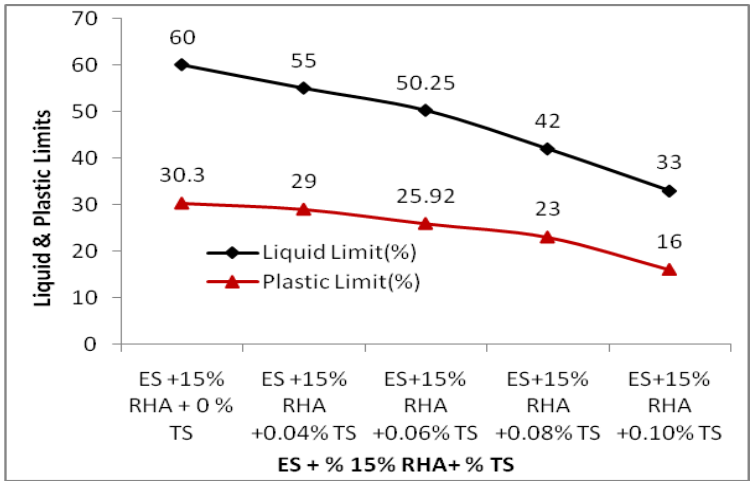

Fig 5: Variation of Consistency Limits of Expansive Soil and 15% RHA with Different % of Terrasil

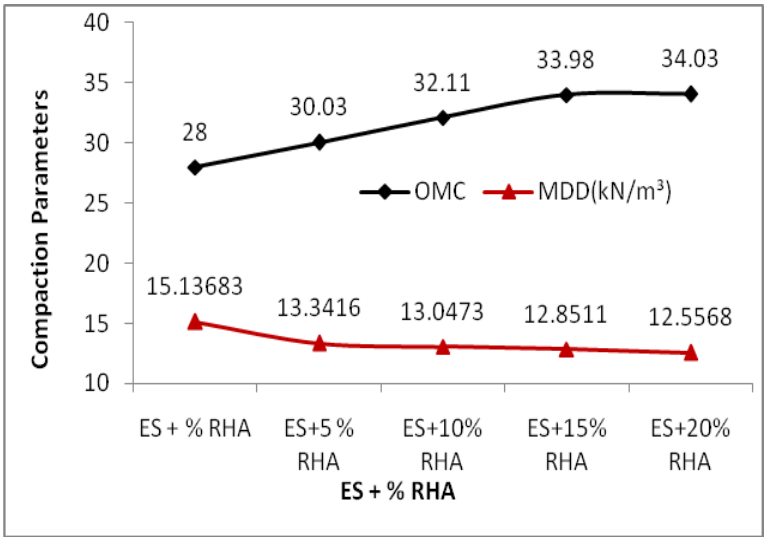

Fig 6: Variation of Compaction Parameters of Expansive Soil Treated with Different % of RHA

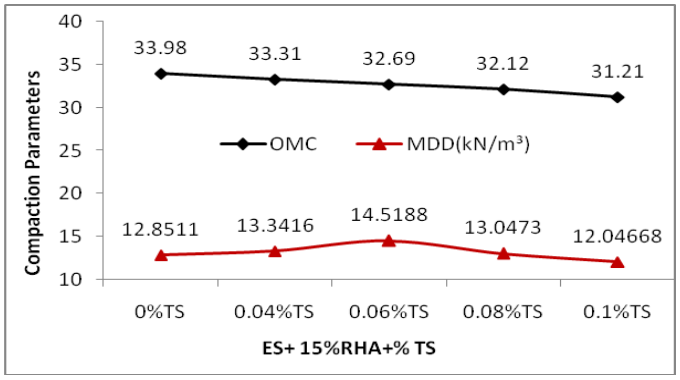

Fig.7: Variation of Compaction Parameters of Expansive Soil and 15% RHA with Different % of Terrasil

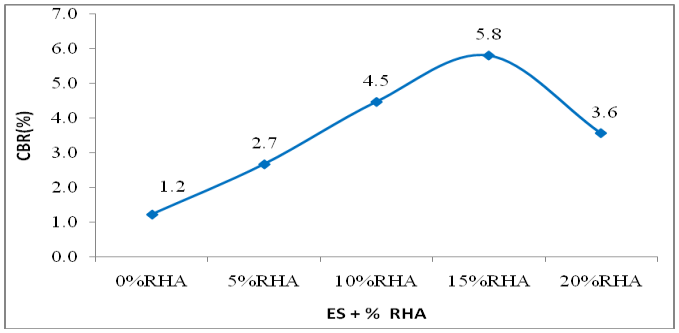

Fig 8: Variation of Soaked CBR Values on Expansive Soil Treated with Different % of RHA

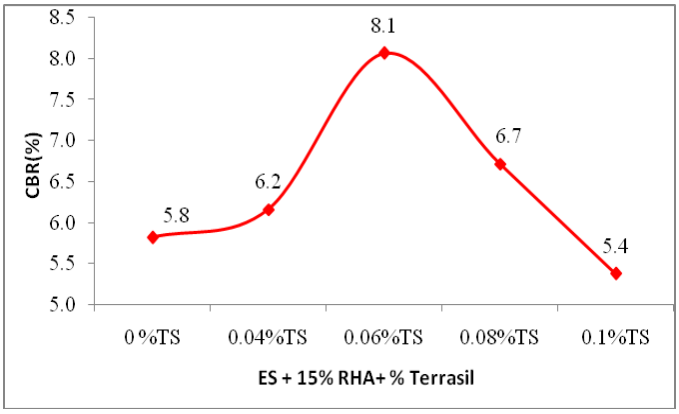

Fig 9: Variation of Soaked CBR Values of Expansive Soil and 15% RHA with Different % of Terrasil.

V.CONCLUSION

The following conclusions are drawn based on the laboratory studies carried out in this investigation.

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- The liquid limit and plastic limit of the expansive soil decreased with the increase in the % of RHA and addition of different % of Terrasil to the optimum RHA soil mix, further decreases the liquid limit and plastic limit
- MDD values are decreasing OMC is increasing with the addition of different percentages of RHA.
- Addition of different ml of Terrasil to optimum expansive soil and RHA mix MDD Increases up to 0.0 6% Terrasil and further decreases where as the OMC decreasing continuously.
- Soaked CBR value increases by 3.83 times at 15% RHA content and 5.75 times at 15% RHA and 0.06% Terrasil compared with the CBR of the untreated expansive soil.

Based on the studies the optimum percentages of Rice Husk Ash and Terrasil are 15% and 0.06% respectively.

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