Improvement of Strength of Clayey Soil by Adding Rice Husk Ash and Cement

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Abstract: **Soil stabilization is a process by which natural weak soil is stabilized physically and chemically by adding stabilizers. Normally used primary stabilizers to improve soil properties are cement and lime. But due to increase in cost of stabilizers we cannot use this alone to cover large area. Thus we use industrial waste to reduce certain portion of primary stabilizers. Here rice husk ash, an agro industrial waste is used to improve soil property. This paper presents the experimental results obtained from Thonnakkal clay blended with various percentages (4% to 16%) of rice husk ash (RHA) and cement. Soil-RHA-cement mixtures were compacted using standard compactive efforts at optimum water content. Unconfined compressive strength were tested for 7 day 14 day and 28 day for soil stabilized with rice husk ash alone, and soil stabilized with RHA – 6% cement combination. Volumetric shrinkage strain was noted for soil stabilized with RHA and cement combinations.**

Key words: Rice husk ash; Unconfined compressive test; Compaction; Volumetric shrinkage strain.

I. INTRODUCTION

Soil stabilization includes alteration of soil properties to meet the specified engineering requirement. Lime and cement were the commonly used stabilizers. From the recent studies, certain portions of these stabilizers are replaced by industrial wastes like fly ash, blast furnace slag, rice husk ash etc. Rice husk ash is an agro industrial waste produced from rice mill. RHA is a pozzolanic material which will react in the presence of moisture to yield cementitious products. RHA is a biodegradable material so we cannot adopt this alone for the treatment of long duration. It contains large amount siliceous compound, hat provide pozzolanic reaction. On the basis of temperature range and burning process the rice husk ash can be classified in to high carbon ash, low carbon ash and carbon free ash. In order to study the behaviour of RHA treated soil, it is necessary to analyse shrinkage characteristics of stabilized soil.

II. MATERIALS

A. Soil

The soil samples were taken from Thonnakkal quarry. They were dried and crushed in to small pieces in laboratory, and then it is passed through 4.75 mm sieve. The geotechnical index properties of natural soil are summarized in Table 1. Grain size distribution is shown in Fig. 1. According to Unified Soil Classification system, soil sample was classified as clay of intermediate plasticity (CI).

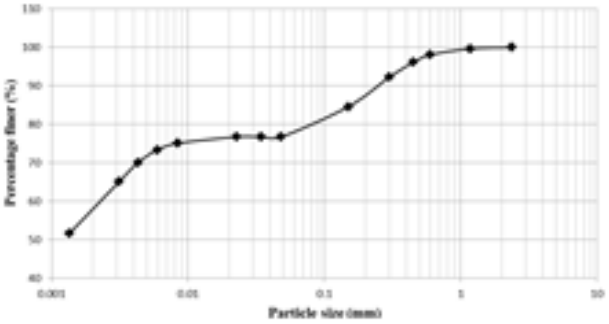

Fig. 1. Particle size distribution of natural soil.

TABLE 1. PROPERTIES OF SOIL USED

Characteristics	Value obtained
Natural moisture content (%)	22.5
Specific gravity	2.1
Liquid limit (%)	47
Plastic limit (%)	27
Shrinkage limit (%)	19.4
Plasticity index	20.3
Maximum dry density (g/cc)	1.4
Optimum moisture content (%)	30.8
Unconfined compressive strength(kN/m^2)	103
Percentage of clay (%)	58
Percentage of silt (%)	20.5
Percentage of sand (%)	21.5
Soil classification(USCS)	CI

B. Rice husk ash (RHA)

Rice husk were collected from local rice mill Kilimanoor, and then it is burned to obtain rice husk ash.Chemical composition of rice husk ash is shown in Table 2 [6]. Specific gravity of RHA was obtained as 1.30.

TABLE 2. CHEMICAL COMPOSITION OF RHA

Constituent	Composition (%)
SiO_2	75.2
Al_2O_3	5.2
Fe_2O_3	1.02
CaO	1.4
MgO	1.75
Loss of Ignition	15.43

C. Cement

Locally available portland cement of grade 43 were used in this study. Specific gravity was obtained as 2.1

III. METHODOLOGY

A. Compaction

Air dried samples passing through 4.75 mm sieve was mixed with 4%, 8%, 10%, 12% and 16% rice husk ash by weight of dry soil. Standard proctor compactive effort was carried in accordance with IS 2720 Part 7(1980). Variation of optimum moisture content (OMC) and maximum dry density (MDD) were noted also for soil stabilized with 6% cement and various RHA combination.

B. Unconfined compressive strength

Unconfined compressive strength (UCS) test was carried in accordance with IS 2720 .1991(Part X).Air dried samples passing through 4.25 mm sieve was mixed with 4%, 8%, 10%, 12%, 16% rice husk ash by weight of dry soil. Also 6% cement is added to the soil, and RHA is varied from 4% to 16 % of its dry weight. Prepared UCS specimens were properly wrapped by plastic cover and immersed in water tanks inorder to provide constant moisture condition. Variation of UCS values with RHA and RHA – cement combination for 7 day, 14 day and 28 day strengths were calculated.

C.Volumetric shrinkage strain

Volumetric shrinkage was calculated by extruding cylindrical specimen from compaction mould with optimum moisture content. Soil specimens were compacted using 4%, 8%, 10%, 12%, and 16% of RHA content. The extruded compacted cylindrical specimens were air dried in a laboratory table with room temperature for 30 days. Three measurements of height, diameters were calculated with vernier calliper accurate to 0.05mm. The average diameter, height and weight were used to measure volumetric shrinkage strain [4].Variation of volumetric shrinkage strain were also calculated for soil – cement-RHA combination. Fig.2. represents the extruded specimen from compacted mould.

Fig.2. Extruded specimen from compaction mould

IV. TEST RESULTS AND DISCUSSION

A. Compaction characteristic

Two sets of compaction tests were carried out. First set include soil stabilized with rice husk ash ranging from 4% to 16%. The addition of RHA increases the moisture content from 30.2% to 35.6% and decreases maximum dry density from 1.4g/cc 1.24g/cc. Increase in moisture content is due to formation of coarser particle by the addition RHA, this process need much more water. Rice husk ash is an agro industrial wastes of lower specific gravity compare to soil, this lead to decrease in maximum dry density. [7].Second set of compaction include soil with 6% cement kept as constant and RHA is varied from 4% to 16%. Here also with addition of RHA the OMC increased from 21.7% to 34.7% and MDD decreased from 1.53 g/cc to 1.23 g/cc. Fig.3. represents variation of OMC with RHA and Fig.4. represents variation of MDD with RHA.

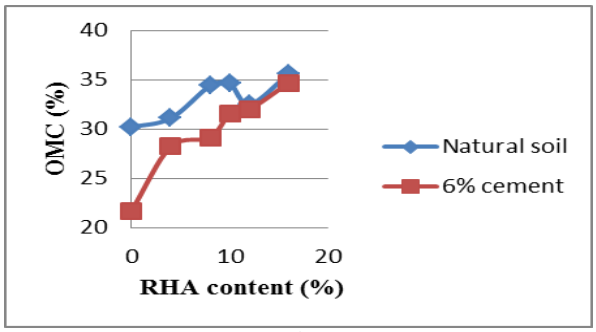

Fig.3. variation of OMC with RHA

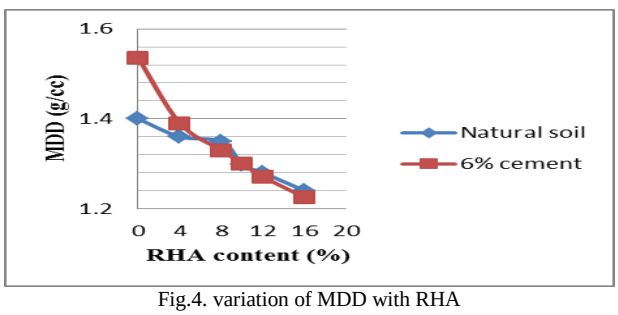

Fig.4. variation of MDD with RHA

B. Unconfined Compressive Strength (UCS)

The strength of stabilized soil is evaluated by using unconfined compressive strength test. The unconfined compressive strength increases up to its optimum RHA content. Fig.5. represents variation of UCS value in natural soil stabilized with RHA content. Unconfined compressive strength is increased up to 10 % treatment of RHA then it tends to decreased. For natural soil 7 day UCS value is 103kN/m^2, this is increased to 184.3kN/$m^2$for 10% addition of RHA. 14 day, 28 day strength shows slight increase in UCS strength. This is due to low pozzolanic reaction of RHA.

Unconfined compressive strength for 7 day, 14 day, and 28 day were also determined for soil stabilized with 6% cement and various RHA combinations. Here 6% cement is kept constant and RHA is varied from 4% to 16%.Variation of UCS strength shows in Table 3. Here S6C4R represents soil stabilized with 6% cement and 4% RHA. Optimum value of RHA addition on 6% cement stabilized soil was obtained as 8%. 7day UCS strength increased from 886.2kN/m^2 to 1203.3 kN/$m^2$for 8% RHA stabilization. 14 day strength increased from 918.97kN/m^2 for 0% RHA to 1280.04kN/m^2 for 8% RHA. 28 day strength also increased for 8% RHA content. 7 day strength for optimum combination of RHA got 10.6 times improvement in strength compare to natural soil, 14 day strength got 11.4 times and 28 day strength got 12 times improvement in strength compare to natural soil. Improvement of UCS strength for 7 day, 14 day and 28 day may also due to setting of cement. Fig.6. represent variation of UCS with RHA in cement stabilized soil.

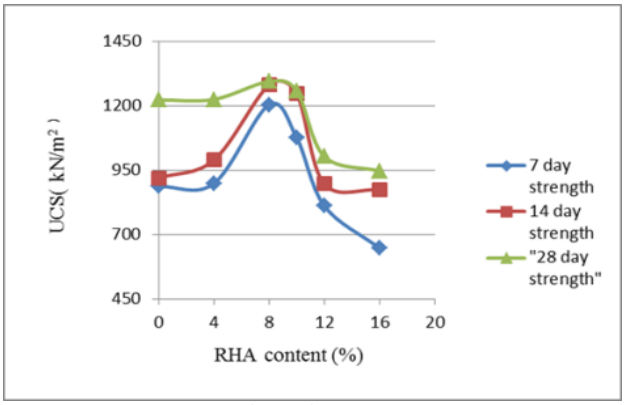

Fig.5.Variation of UCS for natural soil with RHA

The pozzolanic reaction between siliceous compound of RHA with $Ca(OH)_2$of cement producing calcium silicates hydrate compound, which improve soil strength considerably.

TABLE 3. USC VALUES WITH VARIOUS PERCENTAGE OF RHA

Materials used	7 Day strength (kN/m^2)	14 day strength (kN/m^2)	28 day strength (kN/m^2)
S6C0R	886.2	918.97	1222.14
S6C4R	897.54	988.54	1224.03
S6C8R	1203.3	1280.04	1293.64
S6C10R	1076.27	1247.34	1258
S6C12R	811.02	896.07	1002.6
S6C16R	646.66	873.03	945.99

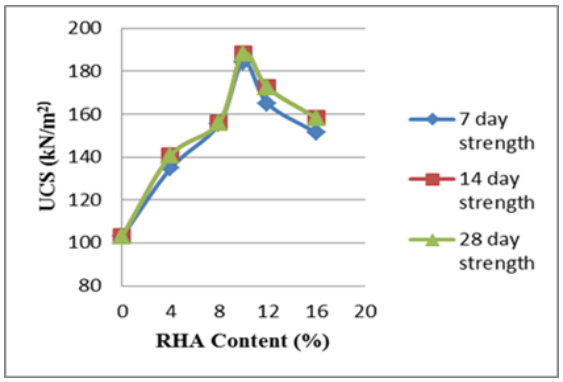

Fig.6.Variation of UCS in cement stabilized soil

C. Volumetric shrinkage strain

Variation of volumetric shrinkage with various percentages of rice husk ash at optimum is shown in Fig. 7. Volumetric shrinkage strain increases with increasing rice husk ash content. It is due to increase in OMC with increase of RHA content [4]. For natural soil VSS is 8.2%, and for soil blended with 16% RHA the VSS increases to 15.95%. But soil with cement and RHA combination the VSS value is very less compare to soil stabilized with RHA alone.

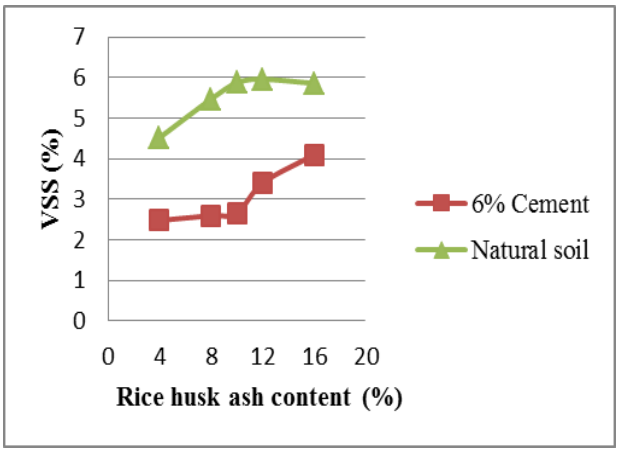

Fig.7. Variation VSS with RHA content

V. CONCLUSIONS

This study represents the improvements of rice husk ash stabilized clayey soil collected from Thonnakkal. The soil was identified to be clay of intermediate plasticity (CI) according to Unified soil classification system. With the addition of RHA, the maximum dry density decreases and optimum moisture content increases. Replacing soil with lower specific gravity material like ash causes decrease in dry density. Formation of coarser particle on addition of RHA leads to increase in moisture content. Addition of RHA alone in natural soil shows slight improvement in unconfined compressive strength.7 day strength for optimum combination of RHA in 6% cement stabilized soil got 10.6 times improvement in strength compare to natural soil, 14 day strength got 11.4 times and 28 day strength got 12 times improvement in strength compared to natural soil .From the analysis of volumetric shrinkage, addition of RHA causes increase in volumetric shrinkage strain. This is due to the increase in optimum moisture content with the addition of RHA. For cement – RHA combination this VSS strain is slightly increased with increasing RHA content. The maximum improvement in strength was obtained in the range of 8 to 10% RHA addition in soil, and this is recommended for optimum usage of RHA in this soil.

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