Effects of Rice Husk Ash – Cement Mixtures on Stabilization of Clayey Soils

Ishatpreet Kaur
Assistant Professor
Civil Engineering
Department, Baba
Banda Singh Bahadur
Engineering College,
Fatehgarh Sahib,
India. Professor & Head

J. N. Jha, PhD
Civil Engineering Department,
Guru Nanak Dev
Engineering College,
Ludhiana, India

ABSTRACT
Rice husk is an agricultural waste that can be used in soil stabilization for improving the quality of locally available soils. So an effort was made in which experimentation was done with locally available soils by mixing 0-15% of RHA along with 0-10% cement by weight of the dry soil. Using Indian Standard (IS) Code specifications performance was investigated for soil – RHA-cement mixture with respect to compaction characteristics & UCS test. The result obtained, indicates a general decrease in the maximum dry density (MDD) and increase in optimum moisture content (OMC) with increase in RHA and cement content. There was also improvement in the UCS with increase in the RHA content up to 10% and cement up to 10%. The peak UCS values were recorded at 10% RHA at 0% cement which decreases at 15% RHA. Similarly the trend follows for 6%, 8%& 10% of cement. From the observation of maximum improvement in strength, 10% RHA content is recommended as optimum amount for practical purposes.

Keywords
RHA, cement, clayey soil, UCS

1. INTRODUCTION
Locally available soils in an area may not be suitable for taking heavy loads of construction due to weak or low bearing capacity which can be improved by different techniques available in civil engineering. Different materials having cementitious properties or pozzolanic in nature are added in the conventional soils available to improve their properties in a technique known as soil stabilization. These materials may be industrial by-products such as blast furnace slag, fly ash, , foundry sand, foundry slag, bottom ash, and cement kiln dust or some agricultural waste like rich husk ash, jute etc which is available in abundance and creates the problem of disposal. This technique is effective in improving soil properties for pavements and roads by increasing strength and reducing cost of construction. Stabilization process also reduces the environmental impact of agricultural wastes by replacing some portion of the Portland cement with a secondary cementitious material like RHA. Rice Husk Ash (RHA) is obtained from the burning of rice husk which is a by-product of the rice milling industry. By weight, 10% of the rice grain is rice husk which upon burning, about 20% becomes RHA. Ash has been categorized under pozzolana, with about 67-70% silica and about 4.9% and 0.95%, Alumina and iron oxides, respectively. Clays generally possess undesirable engineering properties containing low shear strengths and to lose shear strength further upon wetting or other physical disturbances. They can be plastic and compressible and can

expand when wetted and shrink when dried. So the objective of this paper is to improve the properties of expansive soil as a construction

material using RHA, which is a waste material along with cement. RHA is pozzolanic in nature due to which even if added to the concrete mix even in low amounts of replacement will enhance the workability, strength, and impermeability of concrete mixes making the concrete durable to chemical attacks, abrasion, and reinforcement corrosion and increasing the compressive strength. From geotechnical engineering point of view great improvement is observed in improving the engineering properties of sub grade soils observed from previous studies with RHA [1] − [3].During this experimental programme different properties includes Index properties like liquid limit, plastic limit, and engineering properties like compaction and strength characteristics of soil with and without replacement of various proportions of RHA and cement were studied. Soil was replaced with RHA in 0%, 5%, 10% and 15% along with 0%, 6%, 8% & 10% of cement to dry weight of soil. So, this work was focused on investigating the optimum amount of RHA for practical purposes through the observation of effect of RHA on some geotechnical properties of soft clayey which are accountable for strength characteristics of soil. RHA can only be used as a partial replacement for other expensive stabilizing agents like cement and lime due to its inadequate cementation property required for durable binding of materials. Hence, in the present study, a small amount of cement was mixed with RHA and the effect of soil stabilization on soil properties like, optimum moisture content, maximum dry density and unconfined compressive stress was observed and the optimum content is found out from the maximum improvement. Tremendous increase in UCS was observed even by replacing a small amount of soil by cement and RHA which contributes towards economical construction by reducing cost and environmental hazard as waste material.

2. MATERIALS AND METHOD
2.1 Soil
The soil used in this study was obtained from RAJPURA, PUNJAB, India. It was collected by open excavation, from a depth of 0.5m below natural ground level. The properties of the soil are evaluated and presented in Table 1. The soil chosen in this investigation is clayey soil (CL).

Table 1. Physical properties of soil

S. No.	Parameters	Results
1	Light compaction test MDD (kN/m^3) OMC (%)	18.35 14.2
2	Liquid limit (%)	29.6
3	Plastic limit (%)	17.8
4	Plasticity index (%)	11.8
5	Specific gravity	2.64
6	Indian soil classification	CL

2.2 Ordinary Portland cement 43 grade

The Ordinary Portland cement obtained from Ambuja Cement Company with grade 43 was used in the investigation whose physical properties are listed in Table: 4 below.

Table 2. Physical Properties of Cement used

Properties	Value
Grade	43
Initial Setting time (min)	96
Final Setting time (min)	364
Compressive strength 3Days strength (MPa) 7Days strength (MPa) 28Days strength (MPa)	 25.5 36.7 41.5

2.3 Rice Husk Ash

The rice husk ash (RHA) used in the investigation is local RHA which was collected from Vardhmaan spinning Mills, Ludhiana. The physical & chemical properties of RHA are mentioned in Table 3 as per Indian standards [9]. From the Table 4 it is clear that silica is the major constituent of the rice husk ash.

Table 3. Physical properties of RHA

S. No	Properties	Values
1.	Specific Gravity	1.97
2	Grain Size Analysis a) Gravel Size Fraction (%) b) Sand Size Fraction (%) c) Silt & Clay Size Fraction (%)	 0.00 54.4 45.6
3.	Maximum Dry Density (kN/m^3)	9.25
4.	Optimum moisture content (%)	52.4

Table 4. Chemical Properties of RHA

S. No	Component	%
1.	Silica (SiO_2)	91.58
2.	Alumina (Al_2O_3)	1.95
3.	Iron Oxide (Fe_2O_3)	0.48
4.	Lime (CaO)	0.78
5.	Magnesia Oxide (MgO)	0.58
6.	Potassium (K_2O)	2.92
7.	Other oxides	1.71

2.4 Water

Ordinary tap water of laboratory was used throughout the study.

2.5 Specimen Preparation

The soil collected from the site was pulverized with wooden mallet to break the lumps and then air dried. After that it was sieved through 2.36mm IS sieve and then dried in an oven at 105^0 C for 24 hours. Similar procedure was adopted for RHA as that of soil. Required quantity of soil was weighed and desired quantity of RHA and cement were added to get the uniform mix required for sampling. A set of 16 specimens were prepared according to Indian Standard specifications. All the desired tests were conducted as IS guidelines. The test results reported are the average of three tests.

2.6 Methods of Testing

The laboratory tests were carried firstly on the natural clayey soil which include Particle size distribution, Atterbergs limits, Compaction and UCS. After the tests on natural soils were over geotechnical properties of the soil along with RHA and cement were determined in accordance with Indian Standard [9]. Specimen for Unconfined compressive strength (UCS) test are prepared at the Optimum moisture contents (OMC) and Maximum dry densities (MDD).In the second phase of the study, three different percentages of RHA 5%,10%,& 15% are mixed with soil in three different tests. In each case 6%, 8% &10% cement is mixed with the soil-RHA mix to get adequate cementation property to the mix. For the above three different proportions, tests are carried out to observe the changes in the properties of soil i.e. Maximum dry density, Optimum moisture content and Unconfined compressive stress of soil.

3. TEST RESULTS & DISCUSSION

3.1 Compaction Characteristics

The variations of MDD and OMC with RHA contents mixed with soil and cement are shown in Figure 1.The MDD is decreased while the OMC is increased with increase in the RHA content. The decrease in the MDD can be due to the replacement of soil by RHA in the mixture as RHA acts as filler (with lower specific gravity) in the soil voids.[5] Also there is increase in OMC with increase RHA contents as due to the addition of RHA, the quantity of free silt and clay fraction reduced to a certain value leading to formation of larger surface areas. These processes need water to take place so more water is needed in order to compact the soil-RHA mixtures[6].

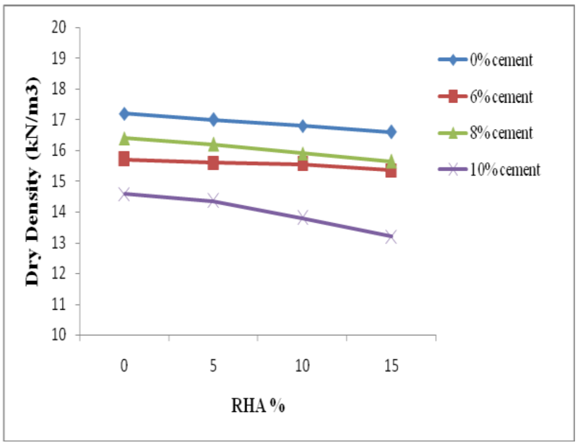

Figure 1: **Variation of MDD with RHA Content**

3.2 Unconfined Compressive Strength

Unconfined compressive strength (UCS) is the most common method of evaluating the strength of stabilized soil [8]. It is considered the main test for the determination of the required amount of additive for stabilization of soil. In this study variation of UCS with increase in RHA from 0% to 15% were investigated and the results are shown in Figure 2.The UCS is increased by 90.6% for RHA content of 10%.. The UCS values increase with subsequent addition of RHA to its maximum at 10% RHA after which it dropped. The increase in the UCS is due to the formation of cementitious compounds between the CaOH present in the soil and the pozzolans present in the RHA. The decrease in the UCS values after the addition of 10% RHA may be due to the excess RHA introduced to the soil and therefore forming weak bonds between the soil and the cementitious compounds formed [9].

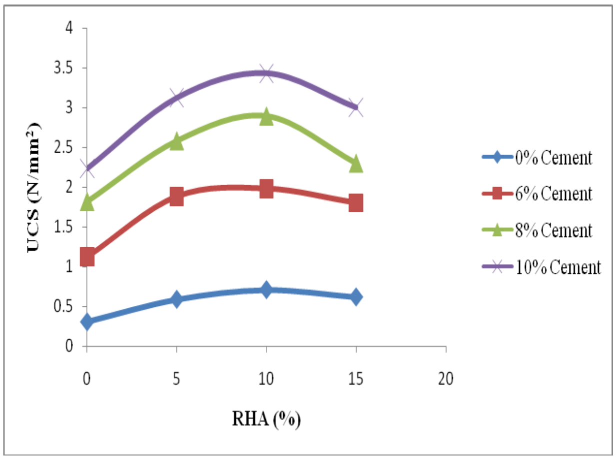

Figure 2: Combined Graph showing UCS of different proportions of Soil: RHA: Cement at 7days curing period

4. CONCLUSIONS

The following conclusions can be made on the basis of test results obtained from cement-RHA stabilized clayey soil:

1. The UCS of 7 days cured samples shows an increasing trend up to 10% RHA for various proportions of cement and further increase in RHA content does not contribute much towards strength. It may be due to pozzolanic reaction between lime liberated from hydration reaction of cement and RHA to form secondary cementitious materials.
2. With increase in percentage of RHA the strength tends to increase and reaches a certain value and thereafter it starts decreasing but it is always higher than respective soil – cement mixture. Hence even in smaller amounts, RHA is beneficial in improving the properties of soils. The maximum value is obtained at an addition of 10% RHA.
3. RHA when used as an alternative or as a partial replacement along with cement in stabilizing clayey soils reduces the cost of material for construction as well as solving the disposal problem.

5. FUTURE SCOPE

Further research can be carried out on this topic by adding certain other easily available materials like lime, gypsum etc in addition to RHA and cement and also by performing other major tests used in pavement design like CBR for future study.

6. REFERENCES

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