Stabilization of Soil Using Rice Husk Ash

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Abstract— **Sometimes soil does not possess the required strength for which soil stabilization is done. A foreign material is mixed in soil in order to improve its engineering performance. Nowadays many waste materials are used for soil stabilization. In this study the soil is stabilized with rice husk ash and the improvement in its properties is observed**

Index Terms— **Stabilization, Clay, Rice husk ash**

I. INTRODUCTION

Soil, in the engineering sense, comprises all materials found in the surface layer of the earth's crust that are loose enough to be moved by spade or shovel. Such materials are natural systems that are normally composed of solid, liquid, and gaseous phases. The solid phases are contributed by particulate matter of inorganic or organic character. The liquid phase is usually an aqueous electrolyte solution. The gaseous phase in contact and exchange with the atmosphere may have a different composition from the latter, depending on location and biologic activity within the soil [1]. Soil is made by the disruption of rocks and through the succeeding divergence, transportation and weathering of the products of decomposition. Soil also may consist of accumulations of organic peats, inorganic deposits, plants roots and numerous trashes and rubbles of an industrialized society [2]. Inorganic soils derived from weathering of rocks. Organic soils are formed in place by decay of planet and animal. The soils will be defined 'organic soil' once their organic content exceeds 20% of their dry weight [3]. Organic soil is contained peat or fine, coarse or very coarse soil with an organic content [4]. It generally has low tensile and shear strength and its characteristics may depend strongly on the environmental conditions (e.g. dry versus wet) [5]. On the other hand, reinforcement consists of incorporating certain materials with some desired properties within other material which lack those properties [6]. Therefore, soil reinforcement is defined as a technique to improve the engineering characteristics of soil in order to develop the parameters such as shear strength, compressibility, density; and hydraulic conductivity [7]. Mainly, reinforced earth is a composite material consisting of alternating layers of compacted backfill and man-made reinforcing material [8]. The primary purpose of reinforcing soil mass is to improve its stability, to increase its bearing capacity, and to reduce settlements and lateral deformation [9–11]. Soil is considered one of the most important and principal materials for any types of construction work globally. The strength and durability of any infrastructure directly depends on the underlying soil strength properties. Therefore, it is very essential to confirm that the soil over which any infrastructure is constructed, is secure or sufficient stable [12]. Soil can be improved either by modification or stabilization, or both. The modification of soil is done by the adding different type of modifiers like (cement, lime, etc.) to a soil in order to change soil's index properties, though the stabilization of soil is its treatment to improve its strength and durability such that to make it suitable for building [13, 14]. Soil stabilization is modifications or adjustments of the soils properties in order to fulfill the specified engineering requirements. The ways to stabilize the soil are compaction and usage of admixtures. Commonly used stabilizers for altering the properties of soils are Lime and Cement. Recent studies indicates the use of solid waste materials like fly ash and rice husk ash for soil stabilization by means of or devoid of lime or cement [15]. Silica is the main component of Rice husk Ash, which oversees the reactivity of the ash. The compounds of silicon account for the maximum amount as eight seven of earth's-crust, and silica is that the major component of soil [16]. The technology of construction is subjected to modifications to overcome the ever changing transport pattern, materials for the building and sub-grade environments. Mostly pavement failures may be attributed to existence of pure sub-grade conditions and costly subgrade is one such challenging state [17]. Rice husk liable for around 30% of the gross weight of a rice kernel and commonly contains eightieth of organic and twenty percent of inorganic substances. Rice husk is created in numerous tons per anum as a waste in agricultural and industrial processes. It will contribute concerning twenty percent of its weight to Rice Husk Ash (RHA) after burning [18, 19].

II. MATERIAL

The soil sample was collected from the city of Bikaner. It was taken at a depth of around 2 m from the standing earth surface by manual excavation. The rice husk was collected from a rice mill of Bikaner. Husk is known as a byproduct produced by rice mill. Almost 78% weight of paddy is received as broken rice and bran during milling process. Rest of 22% by paddy weight is generated as husk [20]. This husk is used as fuel in the rice mills to produce steam for the parboiling method. This husk comprises around 75% organic instable substance. Nearly 25% of husk weight is converted into ash through the firing process, is called RHA [21]. About 220 kgs (22%) of husk is produced from every 1000 kgs of paddy by milling process. When this rice husk is burnt in the boilers, about 55 kgs (25%) of RHA is generated. It is considered as a valueless or waste material [22, 23]. It is a carbon neutral green product and super pozzolanic material. The non-crystalline silica and high specific surface area of the RHA are mainly responsible for its high pozzolanic reactivity. This super-pozzolana can be used in a huge way to make special concrete mixes. Due to contain high proportion of fine amorphous silica, RHA is in highly demand in the manufacture of special cement and concrete mixed, high performance concrete, high strength, low permeability concrete for use in bridges, harbors, embankments, barrages, marine environments, nuclear power plants port structures and so on. RHA contribute to excellent stability and load bearing capacity. In this research, collected rice husk was burnt at 650 °C temperature for 1 h. As received ash was sieved for 15 min. Physical and chemical properties of RHA are given in Tables I and II respectively. Table III gives the basic properties of soil sample.

TABLE I
Physical Properties of RHA

S No	Particulars	Properties
1	Color	Gray
2	Shape-texture	Irregular
3	Odour	Odorless
4	Appearance	Very fine
5	Specific Gravity	2.19
6	Mean particle size (µm)	12.23
7	Passing 150 µm sieve	96.45

TABLE II
Chemical Properties of RHA

S No	Particulars	Properties
1	Silicon dioxide (%)	89.02
2	Potassium oxide (%)	2.29
3	Calcium oxide (%)	0.54
4	Magnesium oxide (%)	0.38
5	Aluminum dioxide (%)	0.21
6	Sodium oxide (%)	0.8
7	Iron oxide (%)	0.23
8	Loss on ignition (LOI) (%)	5.91

TABLE III
Soil Properties

Particulars	Value
Liquid Limit (%)	38.1
Plastic Limit (%)	17.5
Plasticity Index (%)	20.6
Specific Gravity	2.75
Water Absorption (%)	16.9

III. EXPERIMENTAL PROGRAM

The soil sample was collected from the city of Bikaner. Similarly rice husk is gathered from the waste of a rice mill of Bikaner city. Rice husk ash was mixed with soil sample in proportion of 3%, 6%, 9% and 12%. Various tests on soil with or without reinforcement were conducted as follows:

1. Particle size distribution in accordance with IS-2720 (Part IV):1985 (Reaffirmed- May 2015).
2. Specific gravity of soil in accordance with IS : 2720 (Part III/Sec 2) – 1980.
3. Liquid limit and plastic limit in accordance with IS: 2720 (Part V) 1985.
4. Compaction test of soil in accordance with IS-2720 (Part VII)-1980.

Particle size distribution test for soil is conducted to determine the percentage of soil particles retained by various IS sieves arranged in the descending order of their aperture size. The sample is air dried and then the sample is sieved through the set of sieves and the weight of particles retained on various sieves is measured and a semi log graph is plotted for particle size distribution.
Specific gravity test for soil is conducted to determine the specific gravity of soil particles.

Liquid Limit test is done by liquid limit apparatus designed by A. Casagrande. A soil sample which passing through 425 micron and air dried mixed with water to form paste. 1cm thick layer is levelled in cup. Then groove is cut in the soil in the cup and the handle is rotated at the rate of 2 blows per sec. Water content just sufficient to close the groove for 13mm length at 25blows gives liquid limit.
Plastic limit test is done to determine the plastic limit of soil sample. The plastic limit of a soil is the moisture content at which soil begins to behave as a plastic material. At this water content (plastic limit), the soil will crumble when rolled into threads of 3.2mm (1/8in) in diameter. A small sample of about 20 g is taken and mixed with sufficient amount of water and then it is kneaded till it crumbles at 3 mm diameter thread. At that instant the water content is determined to record as plastic limit of soil sample.
Standard Proctor test is conducted to determine the maximum dry density (MDD) the soil sample can achieve and the optimum moisture content (OMC) at which it has attained the MDD. A proctor mould is filled in three layers with soil and specified water content, compacted with standard hammer by 25 blows falling through standard height. After which its dry density of the sample is determined. The test is repeated with varying water content a graph is plotted to determine MDD and related OMC.

IV. RESULTS

Figure 1 shows the particle size distribution of the soil sample taken.

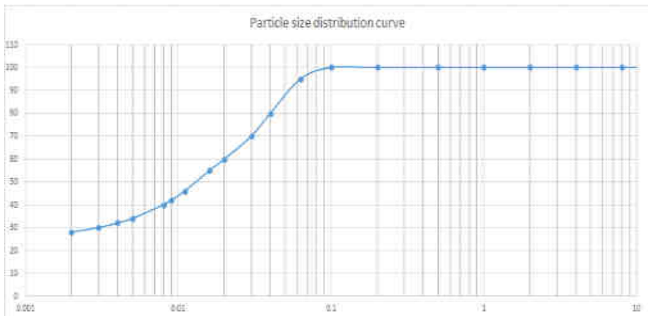


Fig 1 Particle Size Distribution Curve

Table IV shows the change in the values of liquid limit, plastic limit and plasticity index when soil is reinforced with various percentages of rice husk ash. Figure 2 shows the graphical representation of the change in the values of liquid limit, plastic limit and plasticity index when soil is reinforced with various percentages of rice husk ash.

TABLE IV
Effect of RHA on soil behavior

Percentage of RHA	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
0	38.1	17.5	20.6
3	36.6	16.8	19.8
6	33.3	15.4	17.9
9	31.2	14.1	17.1
12	29.9	13.5	16.4

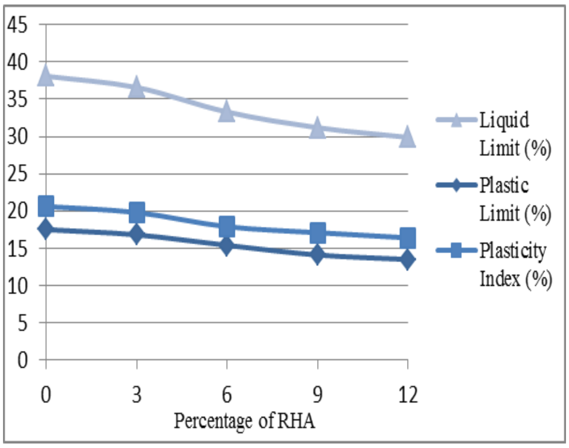


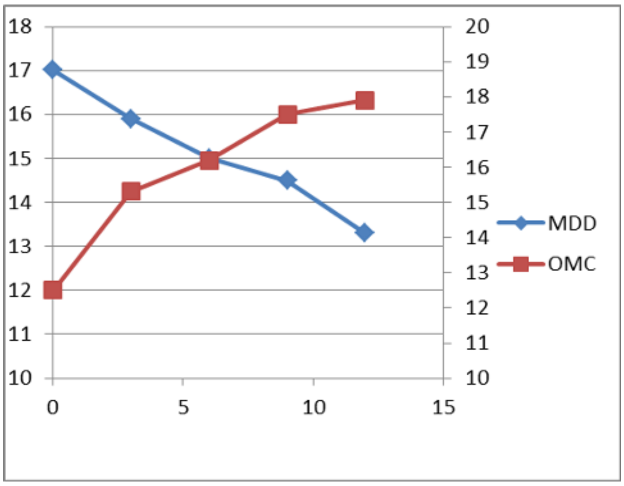
Fig 2 Effect of RHA on soil behavior

Table V shows the change in values of MDD and OMC due to the addition of rice husk ash.

TABLE V
Effect of RHA on MDD and RMC

Percentage of RHA	MDD	OMC
0	17.01	12.5
3	15.9	15.3
6	15.01	16.2
9	14.5	17.5
12	13.3	17.9

Figure 3 shows the graphical representation of effect of RHA on MDD and OMC



DISCUSSIONS AND CONCLUSION

Experiment shows the effect of Liquid Limit behaviour due to different percentage of RHA. It can be seen that with addition of RHA, the liquid limit continuously decreases from a water content of 38.1% to 29.90%. Increase or decrease in liquid limit highly effect the compressibility and swelling characteristics of soil. Generally reduction in the liquid limit means reduction in the compressibility and swelling characteristics which is beneficiary for sub grade soil. Increase or decrease in liquid limit mainly depends on clay minerals present in soil. So we can conclude that the liquid limit decreases with addition of rice husk ash.

The MDD is decreased 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.

OMC is increased with increase in the RHA content.The 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. These processes need water to take place. This implies also that more water is needed in order to compact the soil-RHA mixtures.

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