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Strength Behaviour of Expansive Soil Treated with Rice Husk Ash-Phosphogypsum and Nylon Fibres

K. Venkatesh[1], Dr. D S V Prasad[2]

[1]M.Tech Student, Department of Civil Engineering, BVC Engineering College, Odalarevu, AP, India

[2] Professor & Principal, Department of Civil Engineering, BVC Engineering College, Odalarevu, AP, India

Abstract: ***Expansive soils, popularly known as black cotton soils, are basically susceptible to detrimental volumetric changes, with changes in moisture. Various remedial measures like soil replacement, moisture control, pre-wetting, lime stabilization have been practiced with varying degrees of success. Stabilization using solid wastes is one of the emerging techniques to improve the engineering properties of expansive soils to make them suitable for use in construction. In this project, an attempt has been made to study the influence of two wastes, Rice Husk Ash (RHA) and Phospho Gypsum (PG) in different percentages, as stabilizing materials and also further enhancing the properties by mixing it with Nylon Fibres (NF). Parametric evaluation of different characteristics of treated expansive soil is done by conducting various tests in the laboratory. The results will be analyzed to assess the influence of the materials used.***

Keywords: Expansive Soil, Rice Husk Ash, Phosphogypsum, Nylon Fibres, CBR and UCS

1. Introduction

In developing countries like India, due to remarkable development in road infrastructure, soil stabilization has become major issue in constructional activity, stabilization is not only a method of altering or modifying of one or more soil properties to improve the engineering . Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content. Expansive soils can be found on almost all the continents on the Earth. The major area of their occurrence is the south Vindhyachal range covering almost the entire Deccan Plateau. Proper remedial measures are to be adopted to modify the soil or to reduce its detrimental effects if expansive soils are indentified in a project. Additives such as lime, cement, calcium chloride, rice husk, fly ahs etc. are also used to alter the characteristics of the expansive soils. The characteristics that are of concern to the design engineers are permeability, compressibility and durability. The effect of the additives and the optimum amount of additives to be used are dependent mainly on the mineralogical composition of the soils. The positive effects of addition of industrial wastes like fly ash, rice husk ash, ground granulated blast furnace slag, cement kiln dust etc. to expansive soil with and without a binder [1-5]. Effects of polypropylene fibre on engineering properties of RHA-lime stabilized expansive soil. Polypropylene fibre added were 0.5 to 2% at an increment of 0.5%.The properties determined were compaction, UCS, soaked CBR, hydraulic conductivity and Ps. The effect of 0,7 and 28 days of curing ware also studied on UCS, soaked CBR, hydraulic conductivity and Ps .The optimum proportion of soil: RHA: lime: fibre was found to be 84.5:10:4:1.5[6]. Effect of Rice Husk ash and Lime on strength properties of marine clay and observed that, liquid limit of the marine clay has been decreased by 16.21% and further decreased by 29.86%, plastic limit improved by 7.40% and further improved by 16.29%;plasticity index has been decreased by 29.78% and further decreased by 56.38% ; OMC decreased by 18.52% and further decreased by 42.63%; MDD has been improved by 17.00% and further improved by 12.70% ;CBR increased by 282.0% and has been further improved by 449.14% ,DFS value of the marine clay has been decreased by 72.80% on addition of 25% Rice Husk Ash and it has been further decreased by 77.28% when 9% lime is added. The soaked CBR of the soil on stabilizing is found to be 9.632 and is satisfying standard specifications and finally concluded from the above results that the stabilized marine clay is suitable to use as subgrade material for the pavement construction and also for various foundations of buildings [7]. Stabilization with different percentages of Rice Husk Ash and a small amount of cement. The results obtained show that the increase in RHA content increases the Optimum Moisture Content but decreases the Maximum Dry Density. Also, the CBR value and Unconfined Compressive Strength of soil are considerably improved with the Rice Husk Ash content [8]. In this investigation, different laboratory experiments like Compaction CBR and UCS tests were conducted by varying percentages of 0 %, 3 %, 6 %, 9 % of Rice Husk Ash and 0 %, 3 %, 6 %, 9 % Phosphogypsum and 0 %, 0.5 %, 1.0 %, 1.5 % and 2% Nylon Fibers 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, Phosphogypsum and Nylon Fibers respectively.

2. Materials Used

The details of different types of materials used in this study are Black Cotton Soil, Rice Husk Ash (RHA), Phosphogypsum (PG) and Nylon Fibers and their details along with properties are explained in the following sections

2.1 Expansive Soil

The soil used was a typical black cotton soil collected from Appaniramuni Lanka, Near Dindi village, Sakhinetipalli

Mandal, E.G.Dt., Andhra Pradesh State, India. The properties of soil are presented in the Table.1. All the tests carried on the soil are as per IS specifications.

Table 1: Properties of Expansive Soil

Property	Value
Specific Gravity	2.66
Differential Free Swell Index (%)	105
Atterberg's Limits	
i) Liquid Limit (%)	70.5
ii) Plastic Limit (%)	26.9
iii) Plasticity Index (%)	43.6
Grain Size Distribution	
i) Sand Size Particles (%)	13
ii) Silt & Clay Size Particles (%)	87
IS Soil Classification	CH
Compaction Parameters	
i) Max. Dry Density (g/cc)	1.41
ii) Optimum Moisture Content (%)	28.2
CBR - Soaked (%)	1.7
Shear Parameters at OMC & MDD	
i) Cohesion, Cu (kPa)	40
ii) Angle of Internal Friction, Øu (Degrees)	0

2.2 Rice Husk Ash (RHA)

For the present study, the rice husk ash has been brought from local the rice mill and the properties are furnished below in the Table.2.

Table 2: Properties of Rice Husk Ash (RHA)

Property	*Value*
Specific Gravity	1.12
Atterberg's Limits	
i) Plasticity index (%)	NP
Grain Size Distribution	
i) Sand Size Particles (%)	24
ii) Silt & Clay Size Particles (%)	76

2.3 Phosphogypsum (PG)

The production of phosphoric acid from natural phosphate rock by means of the wet process gives rise to an industrial by-product named phosphogypsum (PG). These are generally located in coastal areas close to phosphoric acid plants, where they occupy large land areas and cause serious environmental damage. PG is mainly composed of gypsum but also contains a high level of impurities such as phosphates, fluorides and sulphates, naturally occurring radionuclides, heavy metals, and other trace elements. Phosphogypsum stand for the chemical origin gypsum generated in fertilizers production, in which phosphate rock is attacked by sulphuric acid resulting in phosphoric acid (H_3PO_4) and phosphate fertilizers.

Table 3: Proprieties of Phosphogypsum

Property	**Value**
Specific Gravity	2.14
Grain Size Distribution	
i) Sand Size Particles (%)	9
ii) Silt & Clay Size Particles (%)	91
Compaction Parameters	
i) Max. Dry Density (g/cc)	1.35
ii) Optimum Moisture Content (%)	14.5

2.4 Nylon Fibers

Nylon was the first truly synthetic fiber to be commercialized. It is a polyamide fiber, derived from a diamine and a dicarboxylic acid, because a variety of diamines and dicarboxylic acids can be produced, there are a very large number of polyamide materials available to produce nylon fibers.

3. Laboratory Experimentation

In order to determine the effect of Rice Husk Ash (RHA), Phosphogypsum (PG) and Nylon Fibers in Black Cotton Soil, different tests were conducted as per IS Code procedure explained in below sections.

3.1 Index Properties:

Liquid Limit, Plastic Limit, Specific Gravity, and Differential Free Swell (DFS) tests were carried on collected soil by following IS standard procedures. IS: 2720 - Part 5 (1985) was used to determine the Liquid and Plastic limits. By using these and plasticity chart, the type of soil was classified. Pycnometer method described in IS: 2720 – Part 3 (1980) was used to determine the Specific gravity.

3.2 Compaction Characteristics

The Compaction Characteristics of soil samples blending with different percentages of RHA, Phosphogypsum (PG) and Nylon Fibres were determined by using Modified (Heavy) Compaction method as per IS: 2720 – Part 8 (1983). By using this test, the relationship between the OMC and MDD for different samples was evaluated.

3.3 California Bearing Ratio

The standard procedure mentioned in IS: 2720 – Part 16 (1979) was followed to determine the CBR value. The CBR test was conducted on Black Cotton Soil with different percentages of RHA, Phosphogypsum (PG) and Nylon fibres were conducted at soaked conditions. In order to calculate the soaked CBR, sample was immersed in water for 96 hrs.

3.4 Unconfined Compressive Strength: UCS Test was carried on cylindrical soil samples with different percentages of Black Cotton Soil with different percentages of RHA, Phosphogypsum (PG) and Nylon fibres. Split Mould was used to prepare the sample, and test was conducted on samples as per IS: 2720 – Part 10 (1991).

4. Results and Discussions

In the laboratory, various experiments were conducted by replacing different percentages of Rice Husk Ash and Phosphogypsum in the Expansive soil and also further stabilizing it with Nylon Fibres. Liquid Limit, Plastic Limit and Compaction, CBR and UCS tests were conducted with a view to determine the optimum combination of Rice Husk Ash and as addition in weak Expansive soil and

Phosphogypsum as a binder and CBR and UCS are conducted for durability studies. 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.**1 to 11.

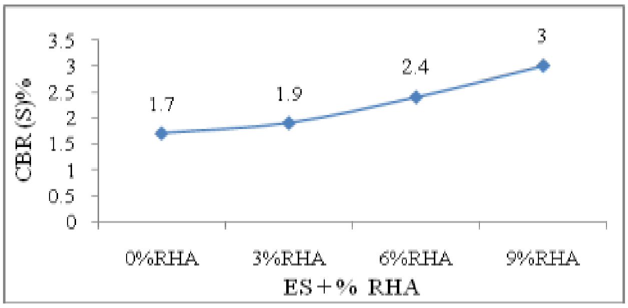

Figure 1: Variation in CBR with Different % of RHA

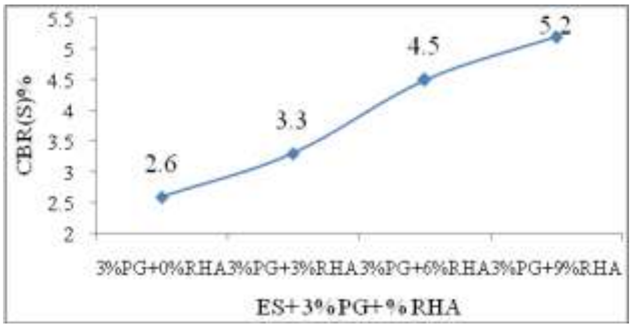

Figure 2: Variation in CBR with 3 % PG and Different % of RHA

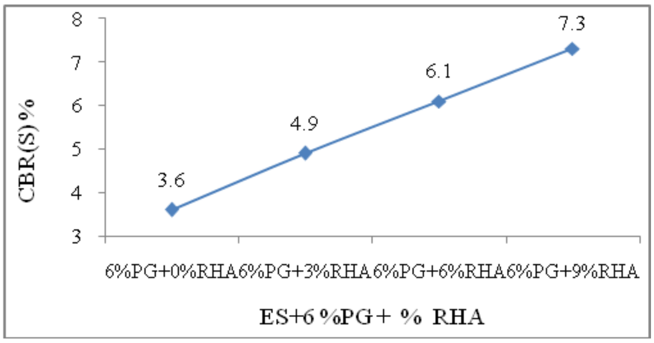

Figure 3: Variation in CBR with to 6% PG and Different % of RHA

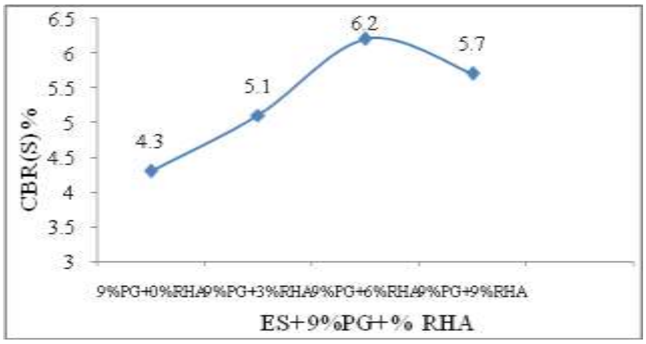

Figure 4: Variation in CBR with to 9% PG and Different % of RHA

Figure 5: Variation in UCS with Different % of RHA

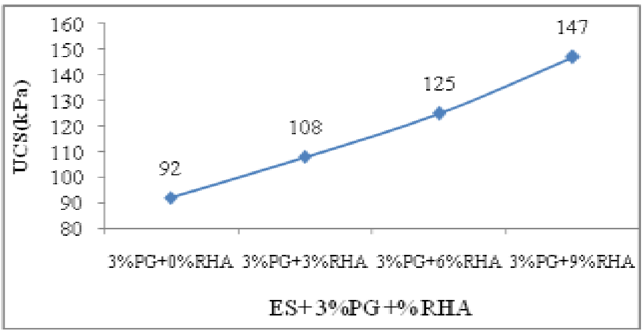

Figure 6: Variation in UCS with 3 % PG and Different % of RHA

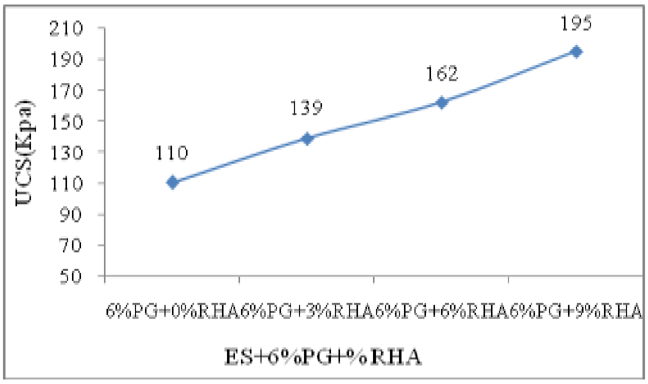

Figure 7: Variation in UCS with 6 % PG and Different % of RHA

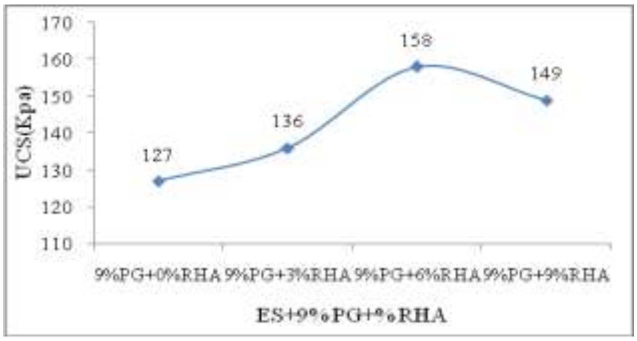

Figure 8: Variation in UCS with 9 % PG and Different % of RHA

It can be inferred from the above results from the above results, 9 % Rice Husk Ash (RHA) + 6 % Phospho Gypsum (PG) can be considered as Optimum Combination As additives in improving the various properties of problematic expansive soil

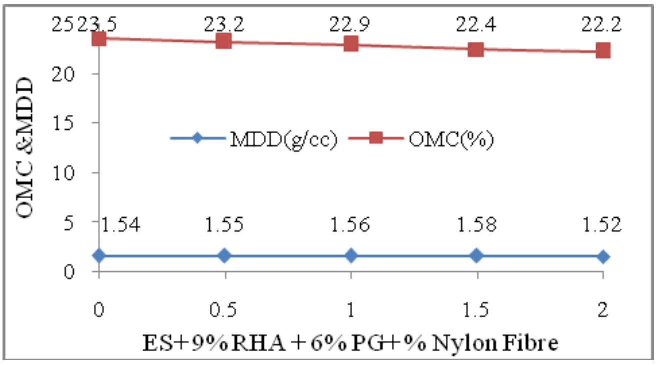

Figure 9: Variation of Compaction Parameters with Different % of Nylon Fibre with 9% RHA + 6% Phosphogypsum

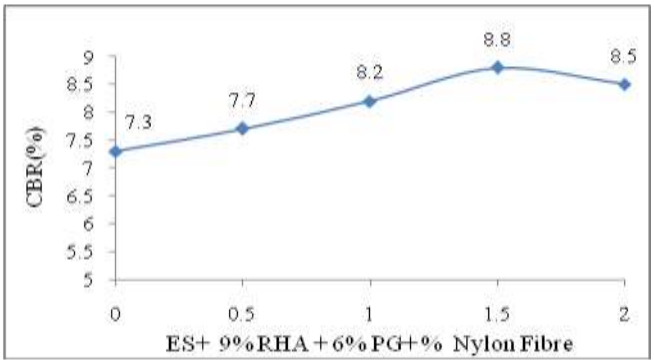

Figure 10: Variation in CBR Values with Different % of Nylon Fibre with 9% RHA + 6% Phosphogypsum

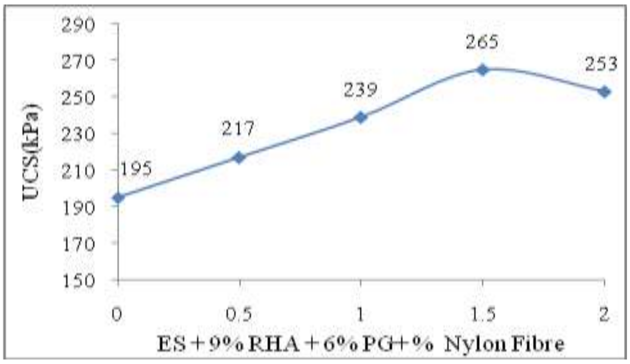

Figure 11: Variation in UCS with % of Nylon Fibre with 9% RHA + 6% Phosphogypsum

It can be inferred from the above results the optimum content of nylon fibre is 1.5% with 6% phosphogypsum + 9% rice husk ash as addition of expansive soil had maximum improvement in strength as compared to other combinations tried in this investigation.

5. Conclusions

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

- From the laboratory studies, it is observed that the Expansive soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as combination with 9% of Rice Husk Ash and 6% Phosphogypsum has moderately improved the Expansive soil.
- It can be inferred from the graphs, the treatment as combination with 9% Rice Husk Ash + 6% Phosphogypsum has moderately improved the Expansive soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index improvement of about 28.8 %. Also maximum dry density is improved by an amount of 9.21 % and it was about 143.7 % for UCS and 329% for Soaked CBR respectively.
- There is an improvement in Plasticity & Strength characteristics with an increase in the Nylon Fibre from 0 % to 1.5 % with an improvement of 0.5% for MDD.
- There is an improvement by an amount of 35.8 % for UCS and 2.05% for Soaked CBR respectively.
- It is evident that the addition of Rice Husk Ash and Phosphogypsum to the virgin Expansive soil showed an improvement in properties to some extent and on further addition of Nylon Fibre, the improvement was more pronounced.

Finally it can be summarized that the materials Rice Husk Ash and Phosphogypsum and Nylon Fibre had shown promising influence on the properties of Weak Expansive soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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