Evaluation Studies on The Influence of Phospho Gypsum, Rice Husk Ash And Random Inclusion of Sisal Fibres on The Problematic Expansive Soil

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Abstract- *Expansive Soils, popularly known as Black cotton soils in India, are highly problematic because of their property of high degree of swelling and shrinkage. These soils when encountered as sub grade of Pavement constructions pose problems in the form of cracking and increased maintenance. Hence in order to improve the properties of such soils many methods are available like soil stabilization, soil replacement, moisture control, prewetting etc. In recent years, soil stabilization by using various industrial wastes was a most common practice. These solid wastes are day by day increasing in India, which is not environmental friendly hence they have to be recycled. Soil stabilization is the process by which strength properties of soil can be improved with the use of adding some materials like rice husk ash, phosphor gypsum and waste fibers etc. There is a rapid increase in waste quantity of rice husk ash, these waste materials are generally dumped or thrown, which may deteriorate the ecology and environment. Hence, 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 Sisal Fibres (SF). Different characteristics of treated expansive soil are 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 (RHA), Phospho Gypsum (PG), Sisal Fibres (SF).

I. INTRODUCTION

Soil is a precious resource that humans depend upon for all activities. With each passing day, the pressure on soil due to human activities is increasing. Acute shortage of land has come to the forefront due to the development activities of modern man. Land becomes more scarce with growth of cities and it often becomes essential to construct buildings and other structures on sites where unfavorable conditions are present. Certain soils like expansive soils are extremely problematic and cause a wide range of problems to a geotechnical engineer. Expansive soils are the soils which swell significantly when they come in contact with water and shrink when the water squeezes out. It has long been known that volume change behavior of expansive soils causes severe distress to the overlying structures. Due to volume change, the soils exert pressure on overlying structures resulting in cracks in sidewalks, basement floors, driveways, pipelines, and foundations.

Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This project report deals with a parametric study on the influence of RHA, Phospho Gypsum (PG) and Sisal Fibres in stabilizing the problematic expansive soil.

OBJECTIVES OF THESTUDY

The study is focused on

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using different ratio of RHA, Phospho Gypsum (PG) and Sisal Fibres
- Determination of appropriate soil, RHA and Phospho Gypsum (PG) content ratio to achieve the maximum gain in strength from the mixture.

II. LITERATUREREVIEW

Soil stabilization is a technique to improve the soil by using different stabilizers to enhance the properties of weak soil. Numerous methods are available for stabilizing soil. A brief review of literature on stabilization of soil with rice husk ash and sugarcane bagasse ash along with certain other materials is presented below.

The recent research in the field of geotechnical engineering and construction materials focuses on agricultural and industrial wastes being locally available and has disposal problem. The use of different industrial and agricultural wastes has become a common practice in the construction industry. Fly ash, sugarcane bagasse ash, coconut husk ash and rice husk can be sited as an example. Those by-products are increasingly playing a part in road construction and concrete technology, hence minimizing the problem of resource depletion, environmental degradation and energy consumption. This research focuses on the potential utilization of bagasse ash in soil stabilization, specifically expansive clay. In recent years there has been focus on agricultural and industrial by-product for soil stabilization because of pozzolanic activity of ash materials, including the ash derived from combustion of sugarcane solid wastes Villar-Cocina, and Valencia, (2008).

Yadu, Tripathi, and Singh, (2011) presented the laboratory study of black cotton soil stabilized with fly ash (FA) and rice husk ash (RHA). The soil was stabilized with different percentages of FA (i.e., 5, 8, 10, 12, and 15%) and RHA (i.e., 3, 6, 9 11, 13, and 15%). The Atterberg limits, specific gravity, California bearing ratio (CBR), and unconfined compressive strength (UCS) tests were performed on raw and stabilized soils. Results indicated that addition of FA and RHA reduces the plasticity index (PI) and specific gravity of the soil.

Dayakar, Sree, Prasad and Madhurimanmadha, (2003) conducted laboratory investigation for stabilization of expansive soil using silica fume and tannery sludge with percentage of solid wastes varying from 0, 10, 20,30, 40, 50, 60- 70%. The addition of wastes did not improve the index properties and maximum dry density but there was gain in strength of the expansive soil with both tannery sludge and silica fume up to 15%.

Okagbue (2007) evaluated the potential of wood ash to stabilize clayey soil. Results showed that the geotechnical parameters of clay soil are improved substantially by the addition of wood ash. Plasticity was reduced by 35%, CBR, UCS increased by 23–50% and 49–67%, respectively, depending on the compactive energy used. The highest CBR and strength values were achieved at10% wood ash.

Ramírez, Montes, Martínez, Altamirano and Gochi, (2012) noted that Bagasse ash exhibits satisfactory behavior in blended cementitious materials in concrete and has greater potential for use in other applications. The addition of 10% Bagasse ash increased the compressive strength of cement paste at all ages of hydration. The chemical deterioration of blended cement is also reduced due to the pozzolanic nature of Bagasse ash and the reduced permeability of Bagasse ash-containing mixtures. Replacement of fine aggregate with up to 20% by Bagasse ash resulted in equivalent or higher compressive strength and reduced water permeability and chloride diffusion Chusilp, Likhitsripaiboon, and Jaturapitakkul, (2009).

Jagdish Chand and AdityaAgarwal (Dec, 2013): discussed about the use of rice husk ash and fly ash combination for the stabilization of highly compressible clay. Clay was stabilized by taking 5%, 10%, 15%, 20% and 25% of fly ash and rice husk ash and effect of stabilization on index properties like shrinkage limit, plastic limit, liquid limit, and compaction were studied. A general decrease in shrinkage limit was observed when clay was stabilized using rice husk and fly ash. A large decrease in compression index and increase in stiffness was observed with increase in percentage of rice husk ash and fly ash as stabilizer. It was also observed that OMC increase and MDD decrease using rice husk ash while MDD increase and OMC decrease using fly ash. However, a general increase in shear strength was observed when soil was stabilized using rice husk ash and fly ash.

Addition of lime reduce linear shrinkage to a greater degree than the same percentage of bagasse ash. When the lime and bagasse ash were used in a combination of 4:1, the stabilization result confirms with the set standard of California bearing ratio, plasticity index and linear shrinkage with negligible swelling.

III. STABILIZATION

The process of soil stabilization refers to changing the physical properties of soil in order to improve its strength, durability, or other qualities. Typically, this is important for road constructions and other concerns related to the building and maintenance of infrastructure. Soil that has been stabilized will have a vastly improved weight bearing capability, and will also be significantly more resistant to being damaged by water, frost, or inclement conditions.

There are different types of stabilization. they are:-

- Mechanical stabilization
- Cement stabilization
- Lime stabilization
- Bituminous stabilization
- Chemical stabilization
- Thermal stabilization

IV. LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the expansive clay to find the properties of virgin expansive soil.

4.1 LIST OF TESTS CONDUCTED

The following tests were conducted as per IS codes of practice.

- Specific gravity of soil
- Determination of soil index properties (Atterberg Limits)
  - Liquid limit
  - Plastic limit
- Particle size distribution by sieve analysis
- Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test.
- Penetration tests-California bearing ratio test
- Unconfined Compression Test-Triaxial

V. METHODOLOGY

5.1 MATERIALS USED AND THEIR PROPERTIES

The details of the various materials used in the laboratory experimentation are reported in the following sections.

5.1.1 EXPANSIVE SOIL

For conducting the study, soil samples were collected from Komarigiripatnam (Odalarevu) in East Godavari District, A.P. The soil excavated from below 3ft depth.

Table 5.1: Properties of Expansive soil

Properties of Marine Clay		
S. No.	**Property**	**Value**
1	Specific gravity	2.66
2	Differential free swell Index (%)	103
3	Atterberg's Limits	
	i) Liquid limit (%)	68.7
	ii) Plastic limit (%)	25.3
	iii) Plasticity index (%)	43.4
5	Grain Size Distribution	
	i) Sand Size Particles (%)	13
	ii) Silt & Clay Size Particles (%)	87
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.44
	ii) Optimum Moisture Content (%)	27
8	Penetration Parameters	
	i) CBR - Soaked (%)	1.5
9	Unconfined compressive strength (kPa)	78

5.1.2 RICE HUSK ASH

For the present study, the rice husk ash has been brought from the lalitha rice mill, peddapuram, Andhra Pradesh.

Table 5.2 Properties of Rice Husk Ash (RHA)

S. No.	**Property**	**Value**
1	Specific gravity	1.12
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Sand Size Particles (%)	24
	ii) Silt & Clay Size Particles (%)	76

5.1.3 PHOSPHOGYPSUM

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). About 5 tonnes of PG are generated per tonne of phosphoric acid production, and worldwide PG generation is estimated to be around 100-280 Mt per year. Most of this by-product is disposed of without any treatment, usually by dumping in large stockpiles. 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. All of this adds up to a negative environmental impact and many restrictions on PG

Table 5.3 Proprieties of Phosphogypsum

S. No.	Property	Value
1	Specific gravity	2.14
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Sand Size Particles (%)	9
	ii) Silt & Clay Size Particles (%)	91
4	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.35
	ii) Optimum Moisture Content (%)	14.5

5.1.4 SISAL FIBERS

In India Sisal plant was brought by the Portuguese in the fifteenth century and first time cultivated in Goa and later on in Orissa and now found throughout the country. Sisal grows in semi-arid regions around the world Sisal fiber is a type of natural fiber also acts as reinforcement in clay sisal mix soil. Sisal fibers are cellulose-rich (> 65%) and show tensile strength. Sisal is a natural fiber material, cheap, easy laying in field and biodegradable. Sisal has low moisture absorption, excellent durability and high initial tensile strength. Sisal is not like as fiber as coir or jute. Sisal fiber was obtaining from the Indian market. The fiber strands are 0.8mm to 1.2 mm in diameter is adopted.

VI. 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 Sisal Fibres. 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.

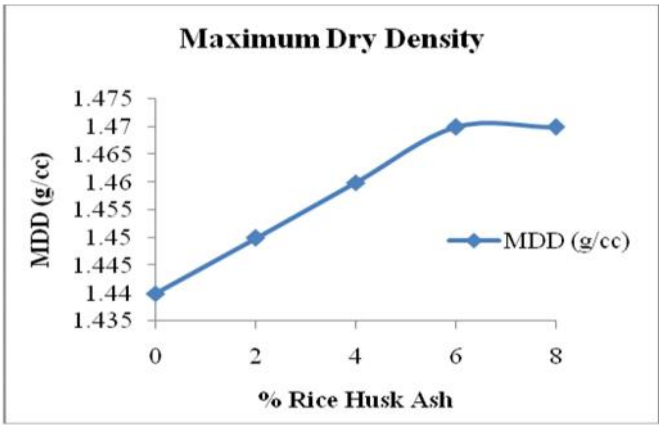

Fig 6.1 Plot showing the Variation in MDD with Addition of RHA to 0 % PG

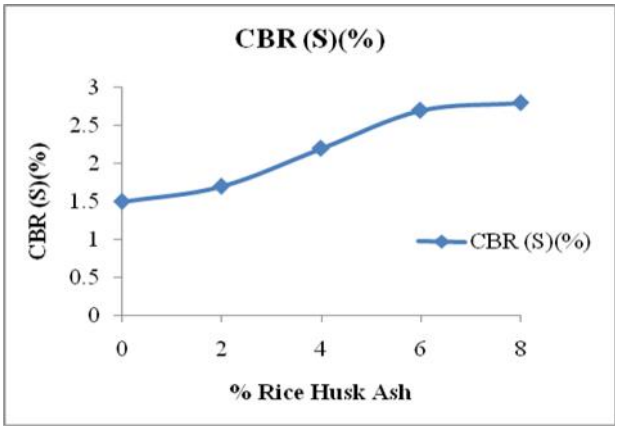

Fig 6.2 Plot showing the Variation in CBR with % Addition of RHA to 0 % PG

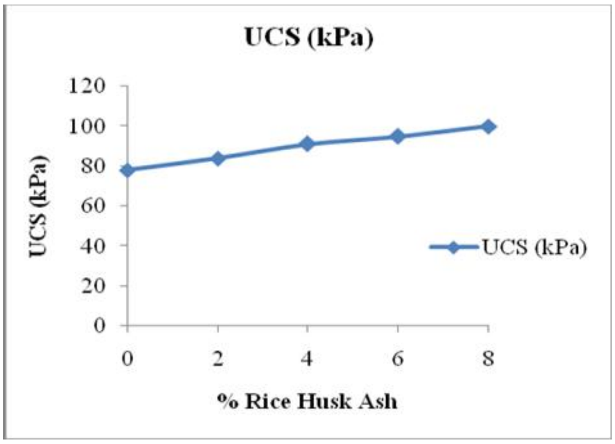

Fig 6.3 Plot showing the Variation in UCS with % Addition of RHA to 0 % PG

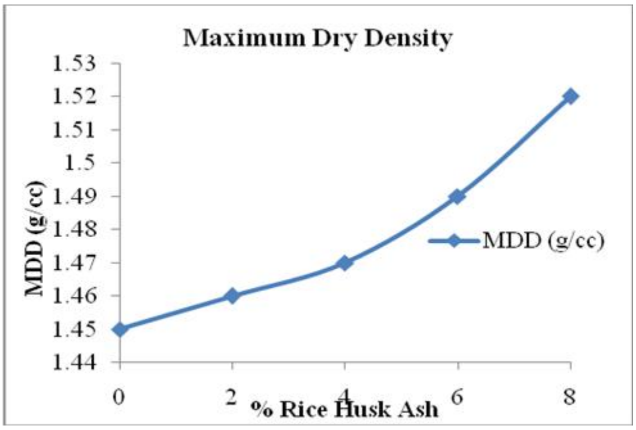

Fig 6.4 Plot showing the Variation in MDD with Addition of RHA to 3 % PG

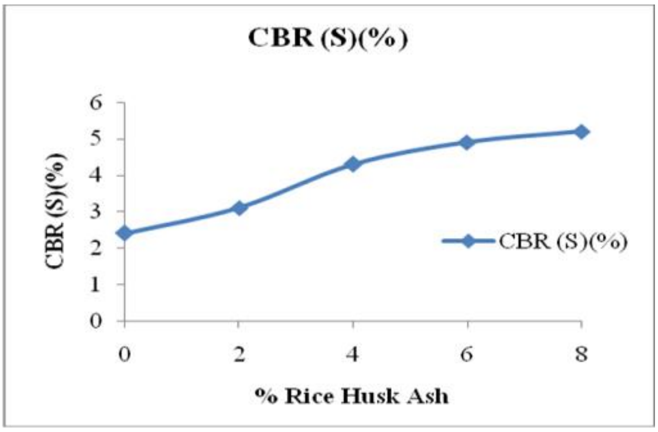

Fig 6.5 Plot showing the Variation in CBR VALUES with Addition of RHA to 3 % PG

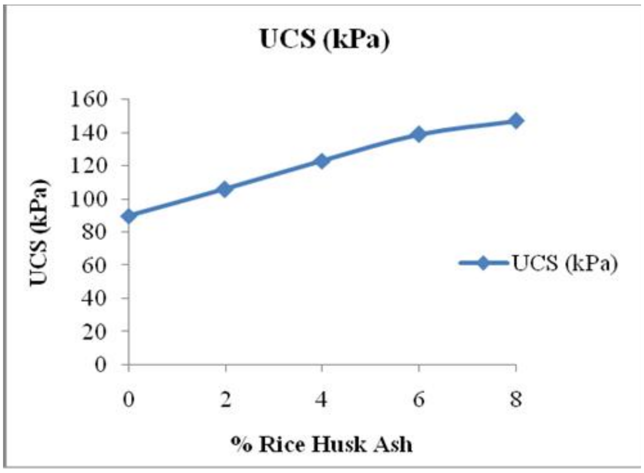

Fig 6.6 Plot showing the Variation in UCS with % Addition of RHA to 3 % PG

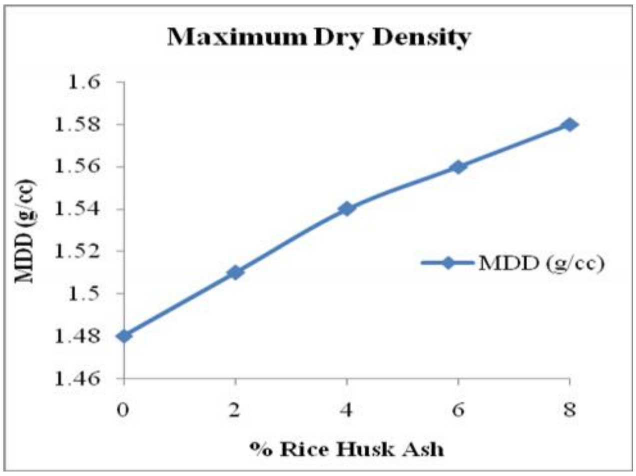

Fig 6.7 Plot showing the Variation in MDD with % Addition of RHA to 6 % PG

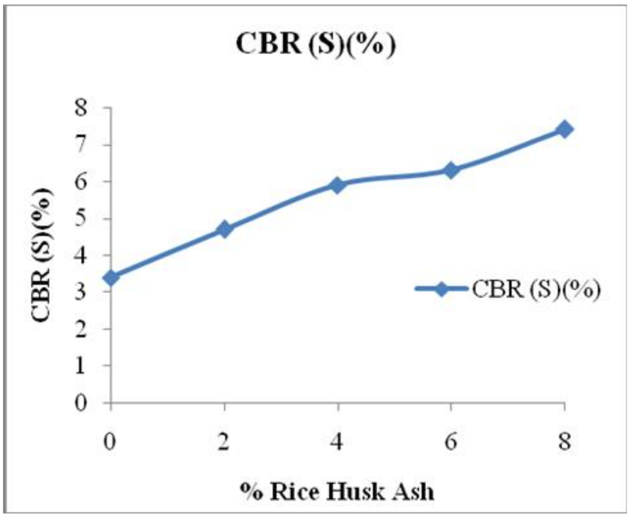

Fig 6.8 Plot showing the Variation in CBR with % Addition of RHA to 6% PG

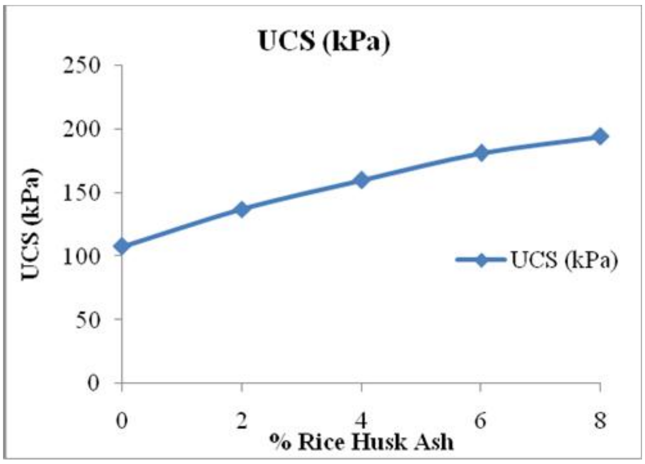

Fig 6.9 Plot showing the Variation in UCS with % Addition of RHA to 6% PG

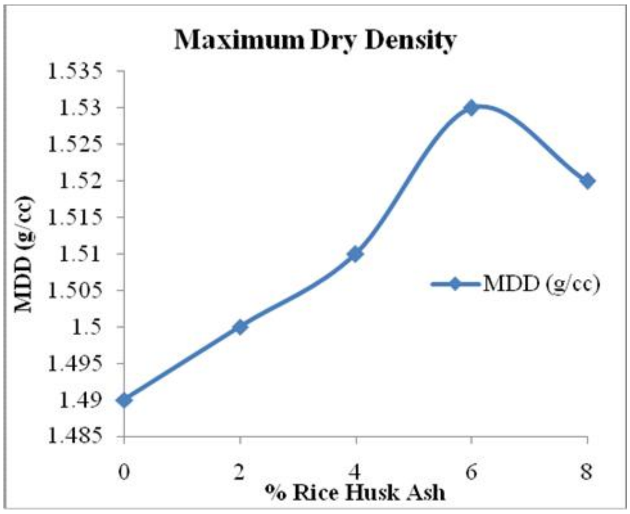

Fig 6.10 Plot showing the Variation in MDD with % Addition of RHA to 9% PG

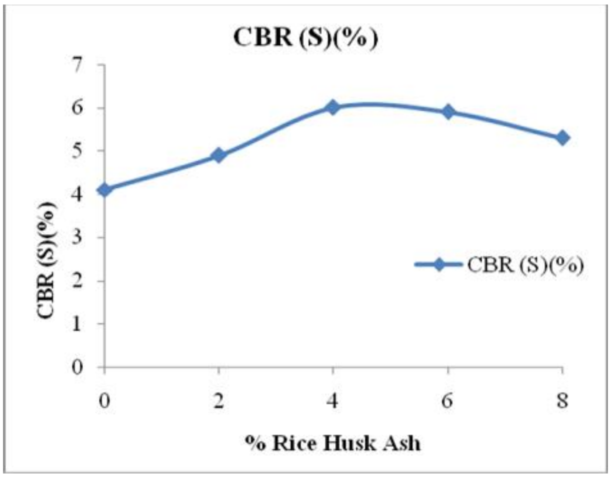

Fig 6.11 Plot showing the Variation in CBR with % Addition of RHA to 9% PG

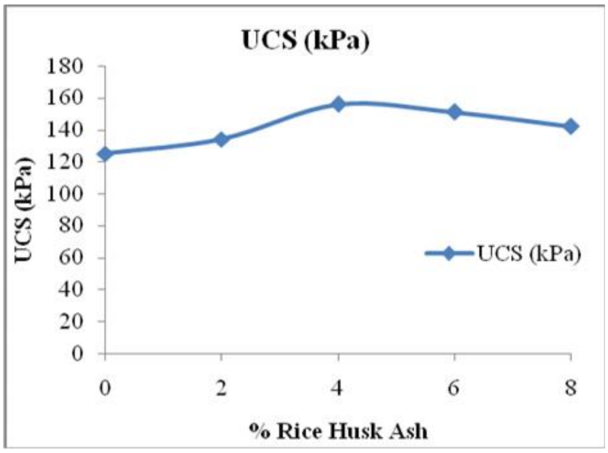

Fig 6.12 Plot showing the Variation in UCS with % Addition of RHA to 9% PG

6.1 Effect of sisal fibre on the properties of weak expansive soil + rice husk ash and phosphogypsum

The influence of sisal fibre on the Compaction CBR, UCS properties of weak Expansive soil + 8 % Rice husk ash + 6 % Phospho gypsum mixes are clearly presented in Table 6.5 Figures 6.25, 6.26, 6.27 and 6.28 for different percentages of Sisal fibre respectively. The percentage of sisal fibre was varied from 0%, to 2 % with an increment of 0.5%.In the laboratory, tests were conducted by including different percentages of Sisal fibre to Weak Expansive soil + Rice Husk Ash and Phosphogypsum .It is observed from the graphs, for the addition of 1.5% Sisal fibre that there is an improvement in Maximum dry density is improved by an amount of 2.1% and it was about 25.8 % for UCS and 17.56% for Soaked CBR respectively.

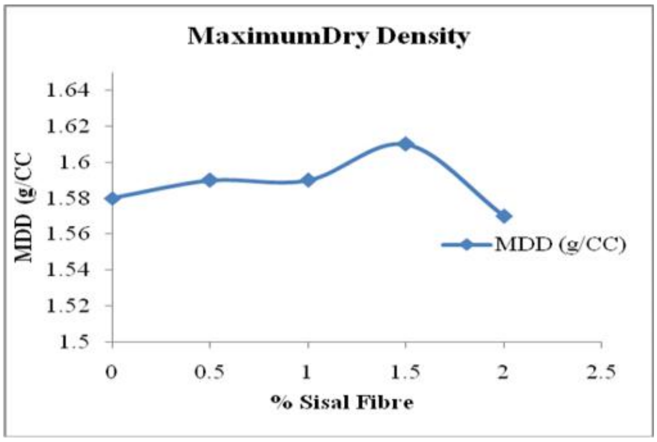

Fig 6.13 Plot showing the Variation in MDD with different percentages of (SISAL FIBRE) with 8% RHA + 6% Phosphogypsum Content

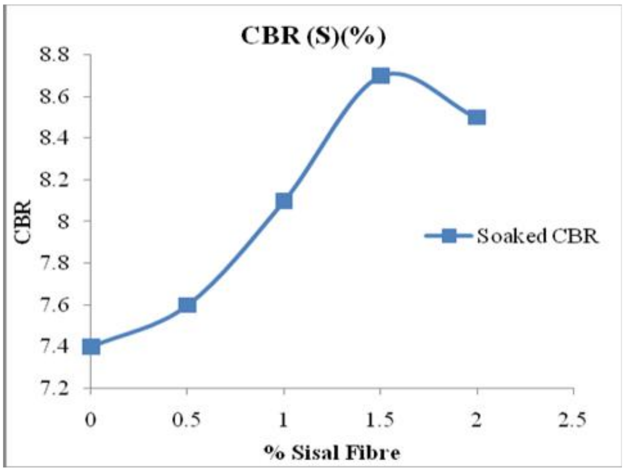

Fig 6.14 Plot showing the Variation in CBR with different percentages of (SISAL FIBRE) with 8% RHA + 6% phosphogypsum Content

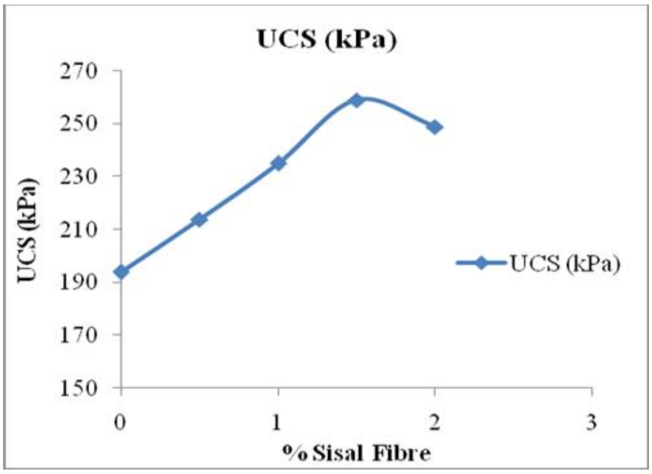

Fig 6.15 Plot showing the Variation in UCS with different percentages of (SISAL FIBRE) with 8% RHA + 6% phosphogypsum Content

VII. 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 sisal 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 sisal fibre, the improvement was more pronounced.
- Finally it can be summarized that the materials Rice Husk Ash and phosphogypsum and sisal 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.

REFERENCES

[1] GopalRanjan, A.J.R. Rao, a text book on "Fundamentals of soil mechanics." New Age International Publishers.

[2] Sharma, V.B., Reddy, A.R. and Sastry, S.S. (1992). "Some studies on utilizing agro-industrial wastes in soil stabilization". Proceedings of National conference on CBMIW, Hyderabad, pp. 34-42.

[3] A.K. Sabat, and R. P. Nanda, ―Effect of marble dust on strength and durability of rice husk ash stabilized expansive soil,‖ International journal of Civil and Structural Engineering, vol.1 (4), pp.939-948, 2011.

[4] A.N. Ramakrishna, and A.V. Pradeep Kumar, ―Stabilization of black cotton soil using rice husk ash and cement,"" in Proceedings of National conference Civil Engineering meeting the challenges of tomorrow,2006, pp.215-220.

[5] Dr. D. Koteswararao et.al (April 29-May 4th 2013) the effect of Rice Husk ash and Lime on strength properties of marine clay has been studied.

[6] Felt, E.J (1955), Factors Influencing Physical Properties of Soil-Phosphogypsum Mixtures, Portland Phosphogypsum Association, Skokie, Illinois, DX016, 1955.

[7] Can BurakSisman and ErhanGezer(2011), Effects of rice husk ash on characteristics of the briquette produced for masonry units.

[8] D.K.Rao, P.R. T. Pranav, and M.Anusha, ―stabilization of expansive soil with rice husk ash, lime and gypsum- an experimental study,‖ International journal of Engineering Science and Technology, vol. 3(11), pp.8076-8085, 2011.

[9] E.A. Basha, R. Hashim, and A.S. Muntohar, „„Effect of the cement- rice husk ash on the plasticity and compaction of soil, ―Electronic Journal of Geotechnical Engineering, Vol. 8, Bundle A, 2003

[10] E ABasha, R Hashim, H B Mahmud and A S Muntohar (2005), Stabilization Of residual soil with rice husk ash and cement, Construction and Building Material, 19, Issue 6, P 448-453.

[11] N. K. Bhasin, N. K. Go swami, P. Oli, N.Krishan, and N.B. Lal ―A laboratory study on utilization of waste materials for the construction of roads in black cotton soil Areas, ―High way research bulletin,No.36, pp.1-11. 1988

[12] Pradip D. Jadhao and Nagarnaik, P.B (2008), Influence of Polypropylene Fibres on Engineering Behaviour of Soil – Fly Ash Mixtures for Road Construction, Electronic Journal of Geotechnical Engineering, Vol. 13, Bund, pp. 1-11.

[13] Shweikani, R., Kousa, M., and Mizban, F. (2013)." The use of phosphogypsum in Syrian cement industry: radiation dose to public". Annals of Nuclear Energy, 54, 197-201.
[14] Mishra A (1998) "Stabilisation characteristics of clay using Class C fly ash." Transport Research Board Record 1611, Transport Research Board, 46-54.
[15] R.S. Sharma, B.R. Phani Kumar, and B.V.Rao, ― Engineering behaviour of a remoulded expansive clay blended with lime , calcium chloride and rice- husk ash,‖ Journal of materials in civil engineering , ASCE , vol.20(8), pp. 509-515,2008.
[16] Soltani, A. Deng, and A. Taheri, (2018) 'Swell–compression characteristics of a fibre–reinforced expansive soil', Geotext. Geomembranes, Vol. 46, No. 2, pp. 183–189.
[17] I.S: 2720, Part VII, (1980), Determination of Water Content Dry Density Relation Using Light Compaction.
[18] I.S: 2720-Part III, Section I, 1980, Determination Specific Gravity.
[19] I.S: 2720-Part IV, 1975, Determination of Grain Size Distribution.
[20] I.S;2720-Part V, 1970, Determination of Liquid Limit and Plastic Limit.