# Influence Of Fibre Reinforced Alkali Activated Binder On The Geomechanical Properties Of Black Cotton Soils

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***Abstract-*** *Black cotton soils occurring in arid and semi-arid climate regions of the world cause serious problems on structures that are built on these type of soft soils. Such soils swell when given an access to water and shrink when they dry out. Several attempts are being made to control the swell-shrink behaviour of these soils. Hence in order to improve the properties of such soils many methods are available like soil replacement, moisture control, stabilization, prewetting etc. In recent years, soil stabilization by using various industrial wastes was a most common practice. Hence, in this project, an attempt has been made to study the influence of alkali activated binder (AAB) with polypropylene (PPF) at different proportions of Rice Husk Ash (RHA). Alkali activated binder (AAB) was prepared by mixing an alkali activator solution of sodium silicate and sodium hydroxide with aluminosilicate precursors. An experimental program has evaluated the effects of rice husk ash (3%, 6%, 9% and 12%) and AAB (5%, 10%, and 15%) and polypropylene fiber were varied from 0 to 2% with 0.5% increment in the black cotton soil. Properties like FSI, plasticity, compaction and strength characteristics of expansive soil to understand the performance of stabilized soil..*

***Keywords***- Black cotton soils (BCS), Rice Husk Ash (RHA), Alkali activated binder (AAB), Polypropylene Fibres (PPF).

## I. INTRODUCTION

Expansive soils, popularly known as black cotton soils, are basically susceptible to detrimental volumetric changes, with changes in moisture. This behaviour of soil is attributed to the presence of mineral montmorillonite, which has an expanding lattice. These types of soils are generally found in arid and semi-arid regions of the world and are considered as a potential natural hazard, which if not treated well can cause extensive damages to the structures built upon them. Among several techniques adopted to overcome the problems posed by expansive soils, lime stabilization gained prominence during the past few decades due to its abundance and adaptability. Various remedial measures like soil replacement, moisture control, pre-wetting, lime stabilization have been practiced with varying degrees of success. However, these techniques suffer from certain limitations with respect to their adaptability. Stabilization using solid wastes is one of the emerging techniques to improve the engineering properties of expansive clays to make them suitable for use in construction.

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 influence of fibre reinforced alkali activated binder on the geotechnical properties of black cotton soils.

## II. LITERATURE REVIEW

Using rice husk ash have been more attractive recently due to its promising results compared to other sources. Overview about the methods and the basis of application will be presented in this section. Soil stabilization is the process of improving engineering properties of the soil and thus making it more stable. Soil stabilization means the improvement of the stability or bearing power of the soil by the controlled compaction; proportioning and/or addition of suitable admixture or stabilizers. Soil stabilization is the alteration of soil to enhance their physical properties.

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. Rice husk ash as an example. 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.

Numerous studies proved the effectiveness of discrete fibres(natural and synthetic) combining with cementitious binders for different soil and considered as a good earth reinforcement material. However, limited studies were reported on the strength characterization of BCS treated with PPF reinforced AAB. Also, comprehensive research is required to analyse the bonding interaction between fibre surface and the aluminosilicate precursorbased AAB admixed 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%.

**Chandra et al.(2005),**had stabilized a non-expansive clayey soil with RHA and lime sludge. RHA added to soil was from 5 to 20%in steps of 5% and lime sludge from 4 to 16% in steps of 4%. Properties of the stabilized soil studied were, Atterberg’s limits,maximum dry density (MDD), optimum moisture content (OMC), unconfined compressive strength (UCS) and soaked Californiabearing ratio (CBR) of soil.

**Ramakrishna and Pradeep Kumar (2006),** had studied combined effects of RHA and cement on engineering properties of blackcotton soil. From strength characteristics point of view they had recommended 8% cement and 10% RHA as optimum dose forstabilization.

**Rao et al. (2011),** had studied the effects of RHA, lime and gypsum on engineering properties of expansive soil and found thatUCS increased by 548% at 28 days of curing and CBR increased by 1350% at 14 days curing at RHA- 20%, lime -5% andgypsum -3%.

**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.

**Sabat (2012),** had studied the 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, hydraulicconductivity and Ps .The optimum proportion of soil: RHA: lime: fibre was found to be 84.5:10:4:1.5.

**Ms. Aparna (2014)** has presented a study which gives details about soil which is stabilized with different percentages ofRice Husk Ash and a small amount of cement. The results obtained show that the increase in RHA content increases the OptimumMoisture Content but decreases the Maximum Dry Density. Also, the CBR value and Unconfined Compressive Strength of soil areconsiderably improved with the Rice Husk Ash content.

**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).

## 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
- Atterberg Limits
  - Liquid limit
  - Plastic limit
- Particle size distribution by sieve analysis
- Maximum dry density (MDD).
- 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 BLACK COTTON 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 Expansive Soil** | | |
|---|---|---|
| **S.No.** | **Property** | **Value** |
| 1 | Specific gravity | 2.64 |
| 2 | Differential free swell Index (%) | 105 |
| 3 | Atterberg's Limits | |
| | i) Liquid limit (%) | 70.5 |
| | ii) Plastic limit (%) | 26.9 |
| | iii) Plasticity index (%) | 43.6 |
| 5 | Grain Size Distribution | |
| | i) Sand Size Particles (%) | 12 |
| | ii) Silt & Clay Size Particles (%) | 88 |
| 6 | IS soil classification | CH |
| 7 | Compaction Parameters | |
| | i) Max. Dry Density (g/cc) | 1.41 |
| | ii) Optimum Moisture Content (%) | 28.2 |
| 8 | Penetration Parameters | |
| | ii) CBR - Soaked (%) | 1.7 |
| 9 | Shear Parameters at OMC & MDD | |
| 10 | Unconfined compressive strength | 80 |

### 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 POLYPROPYLENE FIBRE

This material has been chosen due to its low cost andhydrophobic and chemically inert nature which does not absorb or react with soil moisture or leachate. The length of fibres was maintained at 1.2cm and is randomlymixed with soil in varying percentages (0.5%, 1%, 1.5% and 2.0%) by dry weight of soil. The physical properties areshown in Table 5.4

**Table 5.4 Proprieties of polypropylene fibers**

| **S. No.** | **Property** | **Value** |
|---|---|---|
| 1 | Fibre type | Single fibre |
| 2 | Average length | 12mm |
| 3 | Melting point | 165°C |

| | | |
|---|---|---|
| 4 | Acid resistance | High |
| 5 | Alkali resistance | High |
| 6 | Absortion | Nil |
| 7 | Thermal conductivity | Low |

## VI. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by replacing different percentages of Rice Husk Ash and alkali activated binder in the Expansive soil and also further stabilizing it with polypropylene 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.

### 6.1 EFFECT OF % RICE HUSK ASH AS BINDER ON THE PROPERTIES OF BLACK COTTON SOIL

The influence of rice husk ash on the Index, Compaction, CBR, UCS properties of black cotton soil are clearly presented in the below figures 6.1, 6.2 and 6.3 respectively.

The percentage of rice husk ashwas varied from 0%, 3%, 6%, 9% and 12%. From the above graphs, it was observed that the treatment with 9% rice husk ash(RHA) has moderately improved the black cotton soil.

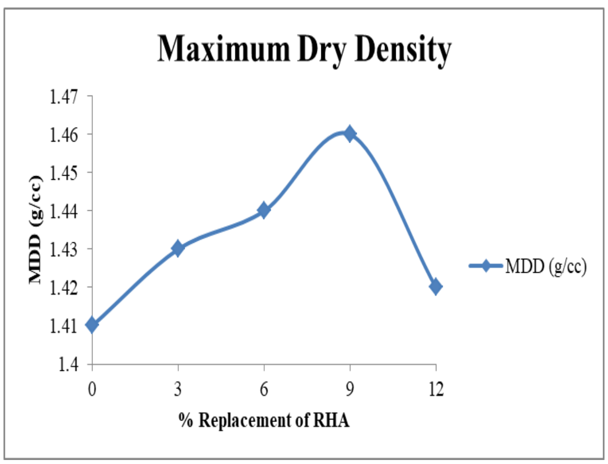


Fig 6.1 Plot showing the Variation in MDD with percentage replacement of RHA

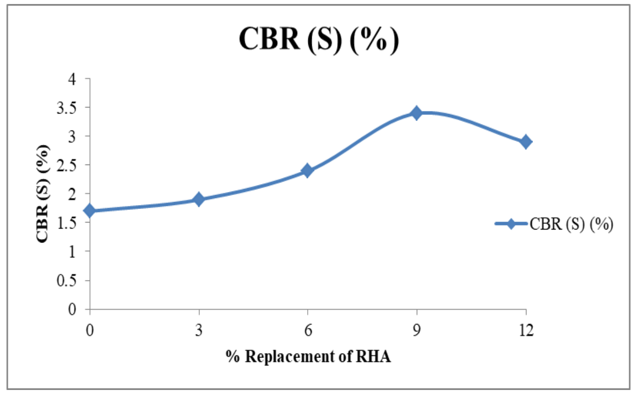


Fig 6.2 Plot showing the Variation in CBR percentage replacement of RHA

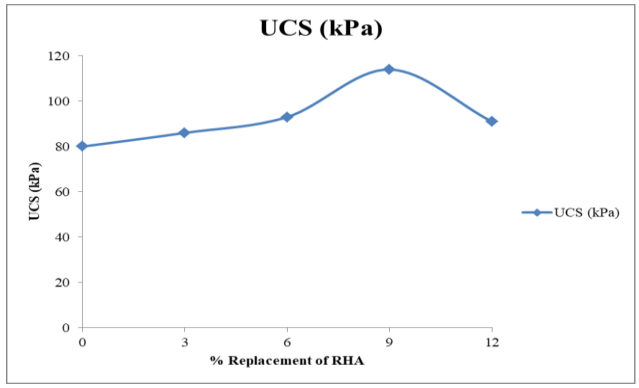


Fig 6.3 Plot showing the Variation in UCS with % percentage replacement of RHA

From the above results, 9 % Rice Husk Ash (RHA) can be considered as Optimum Combination as replacement in improving the various properties of problematic Expansive Soil.

### 6.2 EFFECT OF % ALAKALI ACTIVATED SOLUTION AS BINDER ON THE PROPERTIES OF BLACK COTTON SOIL

The influence of Alkali activated binder on the Index, Compaction, CBR, UCS properties of black cotton soil are clearly presented in the below figures 6.4, 6.5 and 6.6 respectively.

The percentage of Alkali activated binder was varied from 0%, 5%, 10% and 15% by keeping 9% rice husk ash constant for all the mixes. From the above graphs, it was observed that the treatment with 10% Alkali activated binder has moderately improved the black cotton soil.

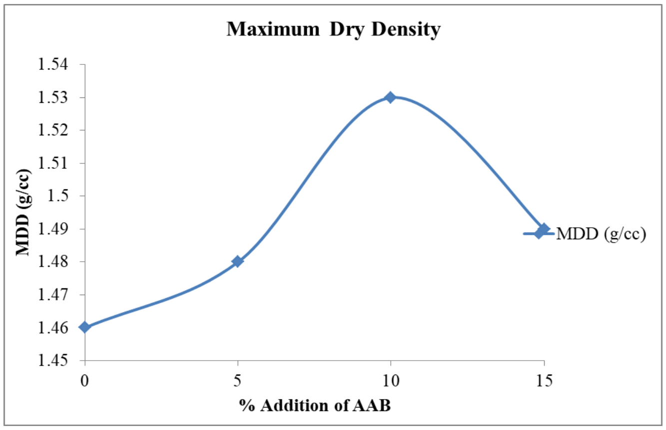


Fig 6.4 Plot showing the Variation in MDD with percentage alkali activated binder

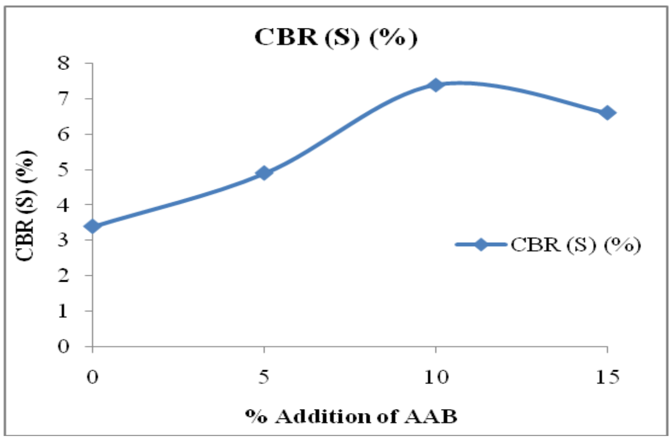


Fig 6.5 Plot showing the Variation in CBR VALUES with percentagealkali activated binder

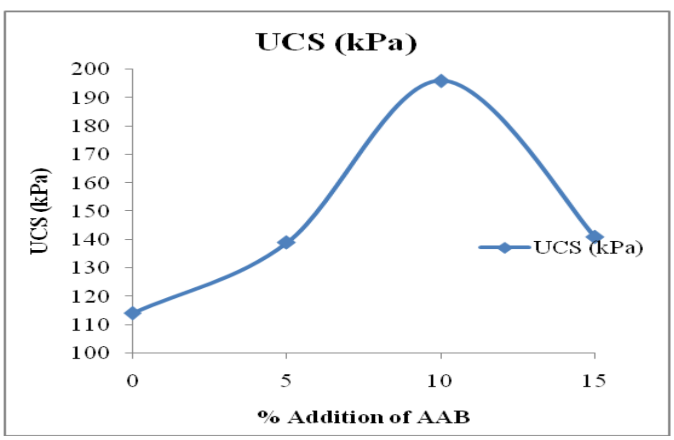


Fig 6.6 Plot showing the Variation in UCS with percentage alkali activated binder

**6.3 EFFECT OF POLYPROPYLENE FIBRE ON SAMPLES PREPARED WITH 9% RICE HUSK ASH (RHA) + 10% AAB AS REPLACEMENT OF BLACK COTTON SOIL**

The influence of polypropylene fibre on the Index, Compaction, CBR, UCS properties of black cotton soil are clearly presented in the below figures 6.7, 6.8, 6.9 and 6.10 respectively.

The percentage of polypropylene fibre was varied from 0%, 0.5%, 1%, 1.5% and 2% by keeping 9% rice husk ash and 10% AAB as constant for all the mixes.

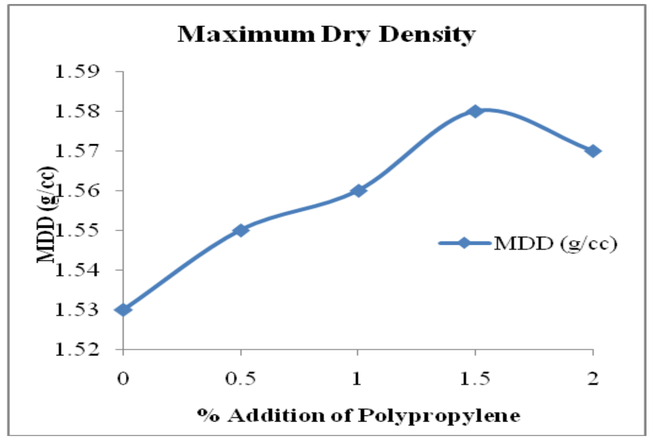


Fig 6.7 Plot showing the Variation in MDD with % Addition of Polypropylene

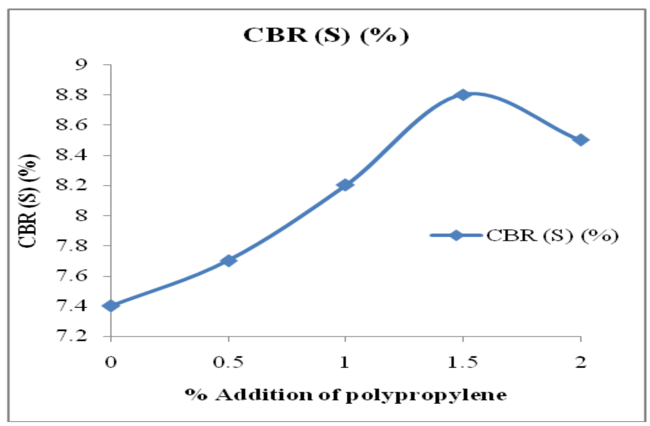


Fig 6.8 Plot showing the Variation in CBR with % addition of Polypropylene

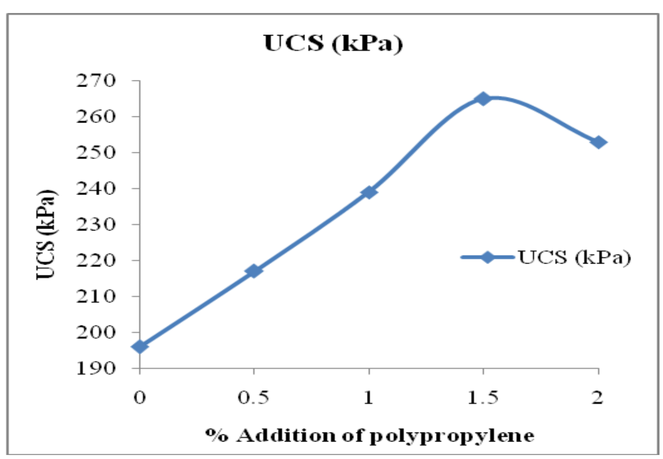

Fig 6.9 Plot showing the Variation in UCS with % addition of Polypropylene

It can be inferred from the above results the optimum content of polypropylene fibre (PPF) with 9% 9% rice husk ash + 10% alkali activated binder with black cotton soil is 1.5%.

**6.4 Results of Durability Studies (Curing) on samples prepared with 9% rice husk ash + 10% AAB and 1.5% polypropylene fibre as reinforcement**

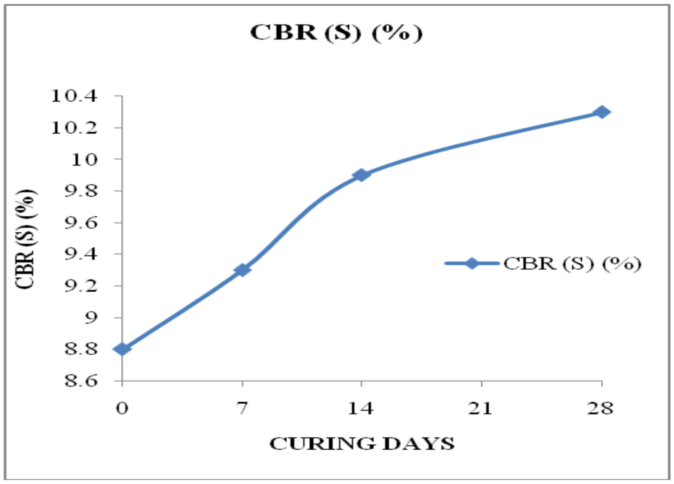


Fig 6.10 Plot showing the Variation in CBR at different curing periods

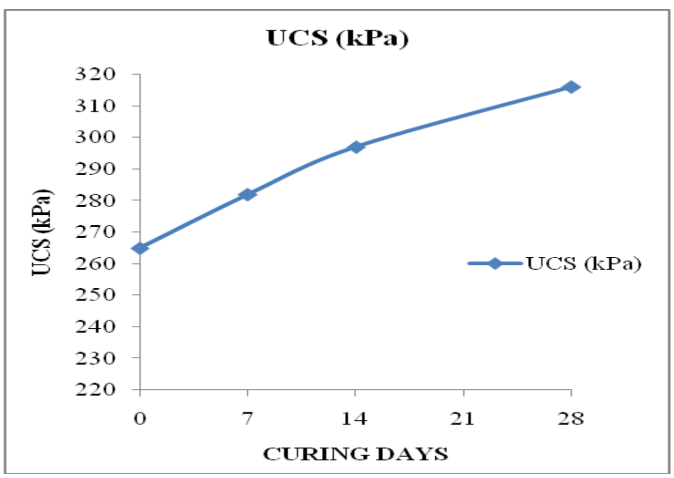


Fig 6.11 Plot showing the Variation in UCS at different curing periods

## 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 black cotton soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the individual treatment with 9% of rice husk ash 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 11.25 %. Also maximum dry density is improved by an amount of 3.55 % and it was about 29.82 % for UCS and 50% for Soaked CBR respectively.
- With the addition of alkali activated binder by keeping 9% rice husk ash as constant at a percentage increment of 5% up to 20% strength parameters more improved and maximum dry density is improved by an amount of 4.8 % and it was about 71.92 % for UCS and 117% for Soaked CBR respectively.
- On being reinforced with polypropylene fibers, maximum dry density increased as fiber content increases.There is an improvement in Strength characteristics with an increase in the polypropylene fibre from 0% to 2% with an improvement of 0.5% .There is an improvement by an amount of 35.20 % for UCS and 18.91% for Soaked CBR respectively.
- It is evident that the replacement of Rice Husk Ash individually to the virgin black cotton soil showed an improvement in properties to some extent and on further addition of alkali activated binder and polypropylene fibre, the improvement was more pronounced.
- Finally it can be summarized that the materials Rice Husk Ash and polypropylene fibre had shown promising influence on the properties of black cotton soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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