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# Utilization of Waste Materials in Soil Stabilization

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***Abstract:*** ***Soil strength plays a vital role in the construction field. The main purpose of this project is to stabilize red soil with the help of various waste materials. The waste materials used are rice husk ash, lime, ground granulated blast furnace slag and coconut coir fiber. These waste materials have been mixed with the soil in the ratio 10%, 20% and 30% and subjected to various tests Specific Gravity Test, Sieve Analysis Test, Plasticity Index Test, Standard Proctor Test, Unconfined Compression test and California Bearing ratio test. A comparative increase in soil strength was found with all the waste materials. Thus, ultimately the soil is stabilized with the help of these waste materials.***

***Keywords: Soil, Stabilization, waste materials, rice husk ash, lime, GGBS, Coir fiber***

## I. INTRODUCTION

Soil stabilization is the process of increasing the bearing capacity of the soil to support pavements and foundation of structures. Soil is a complex as well as a variable material. It is universally available and because of its low cost, it contributes to more use as an engineered material. At any particular location, the soil may be unsuited or partially suited to meet the requirements of construction engineers. In such case, the properties of soil should be altered so as to meet the requirements. The most important properties of soil about which the construction engineer will be more concerned about are strength, permeability and durability. There are two methods of soil stabilization viz., improving the soil strength without addition of admixtures and improving the soil strength with the help of admixtures.

## II. MATERIALS & METHODS

The materials required for this study includes Red Soil, RHA, Lime, GGBS and Coconut Coir. Each of them will be tested separately with the addition to these waste materials to the soil in the ratio of 10% 20% and 30%. The various tests conducted are specific gravity, sieve analysis, standard proctor test and plasticity index.

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The strength test such as unconfined compression test and CBR test is also conducted.

## III. RESULT & DISCUSSIONS

The various tests performed are discussed below:

### A. Sieve Analysis

Initially sieve analysis has been carried out for red soil in addition with 10%, 20% and 30% of waste materials viz., rice husk ash, lime, GGBS and coconut coir. The results are discussed in the below table.

Fig 1. Sieve analysis

**Table-I: Fineness of soil**

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % Fineness | Soil with 30% fiber | 0 | 0 | 0 | 0 | 9.2 | 36.2 | 56.6 | 77.8 | 84.6 | 93 | 100 |
| | Soil with 20% fiber | 0 | 0 | 0.6 | 1.4 | 9.6 | 36.6 | 49.8 | 67.8 | 71 | 77.8 | 100 |
| | Soil with 10% fiber | 0 | 2.2 | 6.4 | 8 | 40 | 71.2 | 78.4 | 81.2 | 85 | 92.4 | 100 |
| | Soil with 30% GGBS | 0 | 14.6 | 32 | 33.8 | 70.4 | 72.2 | 77.6 | 80.8 | 85.4 | 87.8 | 100 |
| | Soil with 20% GGBS | 0 | 11.8 | 20 | 28.4 | 59.8 | 68.2 | 73.8 | 76.4 | 81.6 | 93.8 | 100 |
| | Soil with 10% GGBS | 0 | 13 | 19.2 | 25.6 | 71.6 | 78.6 | 81.2 | 81.5 | 87.3 | 98.8 | 100 |
| | Soil with 30% Lime | 0 | 2.2 | 5.4 | 10 | 11.6 | 62.6 | 69.4 | 73 | 77.2 | 90.4 | 100 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Soil with 20% Lime | 0 | 1.6 | 4.6 | 9.2 | 14.8 | 63.2 | 67.8 | 70.8 | 76.2 | 89.4 | 100 |
| | Soil with 10% Lime | 0 | 2.6 | 11.4 | 24.2 | 31.4 | 63.6 | 69.4 | 73.2 | 77.8 | 92.6 | 100 |
| | Soil with 30% RHA | 0 | 0 | 0.6 | 9.2 | 24.8 | 77.4 | 82.6 | 84.6 | 90 | 91.4 | 100 |
| | Soil with 20% RHA | 0 | 0 | 0 | 9 | 19.6 | 60.8 | 66.4 | 68.2 | 74.2 | 76 | 100 |
| | Soil with 10% RHA | 0 | 0 | 0 | 0.6 | 2.2 | 40.8 | 54 | 60.4 | 75 | 77.2 | 100 |
| | Soil | 0 | 0 | 2 | 9.2 | 18.8 | 61 | 67.6 | 70.8 | 76.8 | 90 | 100 |
| | Sieve size | 0 | 0.075 | 0.15 | 0.3 | 0.6 | 1.2 | 1.46 | 2.4 | 3.36 | 4 | 4.75 |

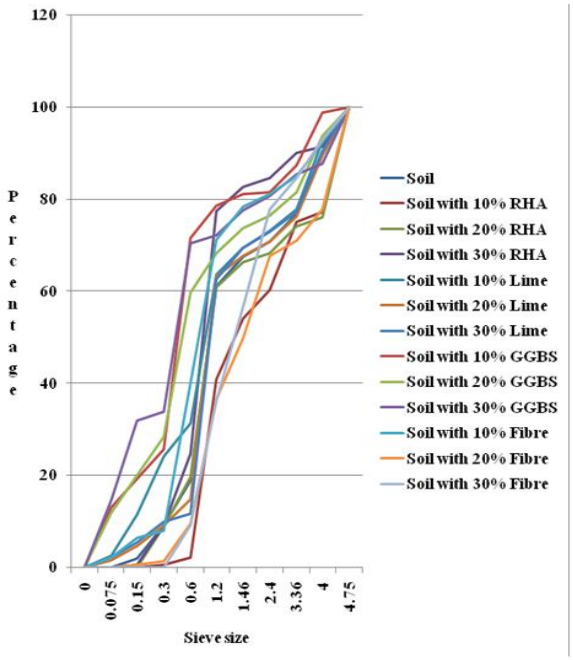


**Fig 2.Sieve analysis test result**

## B. Specific Gravity

This test helps in determining density of material to that of unit weight of water. The test is done as per IS specification using a pycnometer in laboratory. The Specific Gravity goes on decreasing for increasing ratio in Rice Husk Ash, Lime and Fibre while increases for increase in ratio in GGBS.

Fig 3. Specfic gravity test

**Table-II: Specific gravity soil**

| Soil Type | Specific Gravity |
|---|---|
| Soil | 2.86 |
| Soil with 10% RHA | 2.22 |
| Soil with 20% RHA | 2 |
| Soil with 30% RHA | 1.82 |
| Soil with 10% Lime | 2.44 |
| Soil with 20% Lime | 2.33 |
| Soil with 30% Lime | 2.22 |
| Soil with 10% GGBS | 2.44 |
| Soil with 20% GGBS | 2.5 |
| Soil with 30% GGBS | 2.564 |
| Soil with 10% Coir Fibre | 1.92 |
| Soil with 20% Coir Fibre | 1.69 |
| Soil with 30% coir Fibre | 1.67 |

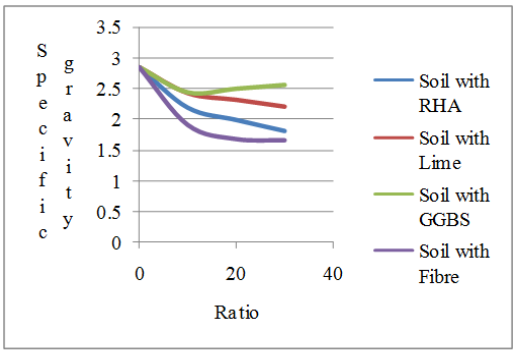


Fig 4.Specific gravity test results

## C. Standard Proctor Test

The standard proctor test helps to determine the optimum moisture content (OMC) in the soil an also its maximum dry density. With the help of this test the soil ability to with shear is determined. The Optimum Moisture Content increases for increase in ratio in Rice Husk Ash, Lime while decreases for increase in ratio in GGBS and Fibre.

Fig 5.Standard proctor test

Fig 7. Liquid limit apparatus

**Table III: Optimum mositure conntent and maximum dry density in soil**

| Soil Type | OMC (%) | Maximum Dry Density (kg/cm3) |
|---|---|---|
| Soil | 8 | 1.75 |
| Soil with 10% RHA | 8 | 1.67 |
| Soil with 20% RHA | 12 | 1.57 |
| Soil with 30% RHA | 20 | 1.4 |
| Soil with 10% Lime | 8 | 1.82 |
| Soil with 20% Lime | 12 | 1.73 |
| Soil with 30% Lime | 16 | 1.64 |
| Soil with 10% GGBS | 16 | 1.8 |
| Soil with 20% GGBS | 12 | 1.88 |
| Soil with 30% GGBS | 12 | 1.73 |
| Soil with 10% Coir Fibre | 12 | 1.63 |
| Soil with 20% Coir Fibre | 8 | 1.48 |
| Soil with 30% Coir Fibre | 8 | 1.34 |

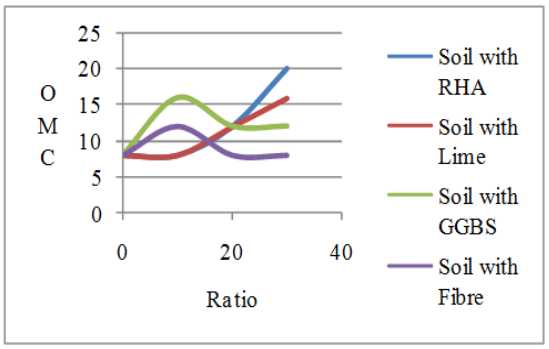


Fig 6. Standard proctor test result

## D. Plasticity Index

It is the measure of plasticity of soil and it is the difference between the liquid limit and plastic limit of the soil. By using the casagrande plasticity chart the soil is categorized. The Plasticity Index goes on decreasing for increase in ratio in Rice Husk Ash, Lime, GGBS while increases for increase in ratio in Fibre.

**Table-IV: Soil category based on plasticity index**

| Soil Type | Plasticity Index | Soil Category |
|---|---|---|
| Soil | 11.26 | MH (or) OH |
| Soil with 10% RHA | 31.56 | CH |
| Soil with 20% RHA | 14.29 | MI (or) OI |
| Soil with 30% RHA | 7.73 | MI (or) OI |
| Soil with 10% Lime | 23.05 | CL |
| Soil with 20% Lime | 17.13 | CL |
| Soil with 30% Lime | 15.22 | CL |
| Soil with 10% GGBS | 13.68 | MH (or) OH |
| Soil with 20% GGBS | 12.29 | MH (or) OH |
| Soil with 30% GGBS | 11.91 | MI (or) OI |
| Soil with 10% Coir Fibre | 15.61 | MI (or) OI |
| Soil with 20% Coir Fibre | 45.83 | CI |
| Soil with 30% Coir Fibre | 51.59 | CH |

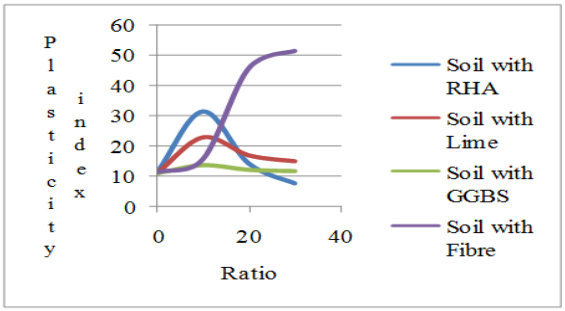


Fig 8. Plasticity index test result

## E. Unconfined Compression Test

The test is used to determine the soil ability to withstand loading and it deformation under each point of loading. Based on the data obtained the soil along with the various waste materials ultimate compressive strength is determined. The UCS goes on increasing for increase in ratio for all the materials.

**Table-V: Ultimate compression strength of soil**

| Soil Type | Ultimate Compression Strength (Kg/cm$^2$) |
|---|---|
| Soil | 1.02 |
| Soil with 10% RHA | 1.07 |
| Soil with 20% RHA | 1.18 |
| Soil with 30% RHA | 1.23 |
| Soil with 10% Lime | 1.14 |
| Soil with 20% Lime | 1.28 |
| Soil with 30% Lime | 1.34 |
| Soil with 10% GGBS | 1.1 |
| Soil with 20% GGBS | 1.25 |
| Soil with 30% GGBS | 1.3 |
| Soil with 10% Coir Fibre | 1.34 |
| Soil with 20% Coir Fibre | 1.4 |
| Soil with 30% Coir Fibre | 1.47 |

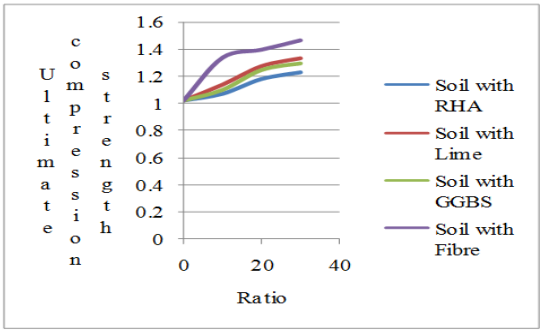


Fig 9. UCC test result

### F. California Bearing Ratio Test

The California bearing ratio test also known as CBR test is used to find out the bearing capacity of given soil and is ability to withstand penetration under loading. The load at standard depths of penetration in soil is determined based on which the CBR value of soil is found out. The CBR goes on increasing for increase in ratio for all the materials.

Table-VI: CBR value of soil

| Soil Type | CBR Value |
|---|---|
| Soil | 3.12 |
| Soil with 10% RHA | 3.29 |
| Soil with 20% RHA | 3.38 |
| Soil with 30% RHA | 3.47 |
| Soil with 10% Lime | 3.38 |
| Soil with 20% Lime | 3.56 |
| Soil with 30% Lime | 3.83 |
| Soil with 10% GGBS | 3.21 |
| Soil with 20% GGBS | 3.38 |
| Soil with 30% GGBS | 3.56 |
| Soil with 10% Coir Fibre | 3.83 |
| Soil with 20% Coir Fibre | 4.19 |
| Soil with 30% Coir Fibre | 4.45 |

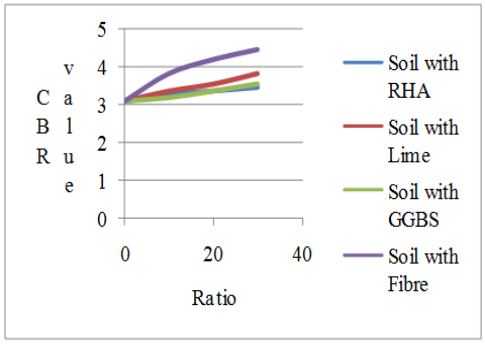


Fig 10.CBR test results

## IV. CONCULSION

The red soil along with the materials is tested and results were compared. It is known that the soil strength has apparently increased for all the materials. Through this not only the quality of the soil is improved but also the waste content in the area can be effectively reduced. This does not harm the environment and makes the soil easy for the civil engineers to work with.

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