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# A Study on Stabilization of Black Cotton Soil using Fly Ash and Rice Husk Ash

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**Abstract**

Stabilization of soil is important to enhance the engineering properties of expansive soil like strength, volume stability and durability the black cotton soil has very low bearing capacity and high swelling and shrinkage characteristics due it has very poor foundation material for civil engineering construction .The main objective of the work is to upgrade the expansive soil as a construction materials by using fly ash and rice husk ash which are waste materials to be used in black cotton soil to stable the soil and to resists from shrinkage or swelling . It can test by using some laboratory test like liquid limit , plastic limit and standard proctor test ( light compaction) , CBR test , Soil sample is mixing of fly ash as percentage of 5% , 10% , 15% , 20%and rice husk ash of 10%, 15% ,20% ,25% and the study of the work was to evaluate the effect of fly ash and rice husk ash to improve the performances of black cotton soil .

**Keywords:** fly ash , rice husk rice , light compaction ,CBR test

## 1. Introduction

Soil stabilization is the process of improving the physical properties of soil to increase its strength, durability, and load-bearing capacity. It is often done to make the soil suitable for construction purposes, such as for building, roads, bridges.

Engineers are often facing the problem of constructing facilities on or with soils, which do not possess sufficient strength to support the loads imposed upon them either during construction or during the service life of the structure. The black cotton soil generally rich in silt, indicates low strength and poor bearing capacity. For better performance of structures built on such on such soils, the performance characteristics of such soils need to be improved.

The black cotton soil absorbs moisture from the surface during monsoon and exudes moisture by means of evaporation during summer season. Due to this property of soil it is recognized as an expansive soil. It is greyish to blackish in colour and contains Montmorillonite clay mineral.Stabilization is a process of changing chemical properties of soil by adding stabilizers to increase the strength and stiffness of expansive (weak) soils.

One method of stabilizing black cotton soil is by using fly ash and rice husk ash. Fly ash is a byproduct of coal combustion, while rice husk ash is a byproduct of burning rice husks. These materials have pozzolanic properties and can react with calcium hydroxide in the presence of water to form cementation compounds, which can improve the strength and durability of the soil.

Fly ash is added to the soil in varying proportions depending on the specific requirements of the project. The soil is first excavated to the desired depth and then mixed with the fly ash using a mixer. Water is then added to the mixture to obtain the desired consistency, and the soil is compacted using rollers or vibrators. Fly ash can be used as a soil stabilizer in a variety of applications, including road construction, embankments, and building foundations. In road construction, fly ash is typically mixed with the soil to improve its strength and stability, while in embankments, it is used to prevent erosion and improve the soil's load-bearing capacity.

Another techniques used for the stabilization of black cotton soil is the use of rice husk ash (RHA). RHA is a byproduct of the burning of rice husks and has been found to be an effective stabilizing agent due to its pozzolanic properties. When mixed with black cotton soil, RHA reacts with the calcium hydroxide in the soil to form cementitious compounds, which helps to reduce the soil's swelling and improve its load-bearing capacity.The process of stabilizing black cotton soil with RHA involves excavating the soil to the desired depth and then mixing it with RHA using a mixer. Water is then added to the mixture to obtain the desired consistency, and the soil is compacted using rollers or vibrators.

The stabilization of black cotton soil using a combination of fly ash and rice husk ash can be an effective method for improving its engineering properties and making it more suitable for construction purposes. However, the effectiveness of this technique depends on the specific properties of the soil and the amount and quality of the ash used. Therefore, it is important to conduct soil tests and consult with a soil engineer or geotechnical expert before using this method .

### 1.2 Objectives of the project

The primary objective of stabilizing black cotton soil using fly ash and rice husk ash is to improve the physical properties of the soil and make it suitable for construction purposes. Black cotton soil is known for its high shrink-swell potential, which can cause damage to structures built on it. The addition of fly ash and rice husk ash can help stabilize the soil and reduce its shrink-swell potential, making it more suitable for construction.

The objective of stabilizing black cotton soil using fly ash and rice husk ash can be stated as follows:

- To reduce the swelling and shrinkage characteristics of black cotton soil, making it more stable for construction purposes.
- To increase the strength and stability of the soil, reducing the risk of deformation and cracking.
- To improve the soil's resistance to water-induced damage by reducing its water absorption and swelling capacity.
- To reduce the soil's compressibility and potential for foundation settlement.
- To a provide a cost-effective and the environmentally friendly solution for improving the soil's quality.
- To enable the use of expansive clay soils in infrastructure development projects.

- To customize the mixture to meet specific geotechnical requirements for different construction projects.
- To evaluate the performance of the stabilized soil using laboratory tests and field trials.
- To provide insights into the potential of using fly ash and rice husk ash to stabilize black cotton soil and improve its geotechnical properties.
- To develop guidelines and standards for the use of this technique in construction projects, contributing to the sustainable and safe development of infrastructure in areas with expansive clay soils.

**1.3 Factors of soil stabilization :-**

- **Road construction:** Soil stabilization is used in road construction to improve the strength and durability of the road base and sub base layers. Stabilization techniques such as cement stabilization, lime stabilization bitumen stabilization are commonly used for road construction
- **Building construction:** Soil stabilization is used in building construction to improve the bearing capacity of soil, which supports the foundation of the building. Various techniques such as chemical stabilization, soil replacement, and deep soil mixing are used for building construction.
- **Landfills:** Soil stabilization is used in landfill construction to improve the stability and load-bearing capacity of the landfill. Stabilization techniques such as geosynthetics and soil reinforcement are used for landfill construction.
- **Erosion control:** Soil stabilization is used in erosion control to prevent soil erosion and improve the stability of slopes and embankments. Stabilization techniques such as vegetation cover, geotextiles, and gabion walls are commonly used for erosion control.
- **Mining:** Soil stabilization is used in mining to stabilize the soil and prevent landslides and soil collapse. Stabilization techniques such as grouting and jet grouting are commonly used for mining.

**1.4 Scope of the work:-**

- The addition of fly ash and rice husk can significantly increase the soil's strength and reduce its compressibility.
- The optimum percentage of fly ash and rice husk required to stabilize the soil depends on several factors such as the type of soil, the type of waste material, and the curing time.
- The use of fly ash and rice husk can also reduce the soil's swell-shrink behavior, there by reducing the risk of damage to infrastructure and buildings.

## 2. Materials

The stabilization of soil is carried out by adding different proportions fly ash and rice husk ash in black cotton soil and test are conducted for studying the variation of different Geotechnical parameters like optimum moisture content maximum dry density and californiabearing ratio, liquid limit .

**2.1. soil :-**

The soil collected at kodavaluru village in north raju palem of depth 1m and the soil is collected in bags then transparent bags.

**Fig 2.1 black cotton soil**

| Sno | Property of soil | values |
|---|---|---|
| 1 | Liquid limit | 51.6 |
| 2 | Plastic limit | 16.3 |
| 3 | Plasticity index | 35.4 |
| 4 | Swell index | 60% |
| 5 | OMC | 18% |
| 6 | MDD | 1.82 gm/cm |
| 7 | CBR value un soaked | 4.4% |
| 8 | CBR value of soaked | 2.2 % |

**2.1 Table for Properties of soil**

**2.2 Fly ash**

Fly ash is collected in kovur cement company and the fly contains some physical and they are followed by

**Physical Properties:**

- ✓**Particle size**: Fly ash particles are generally fine and can range in size from less than 1 micron more than 100 microns.
- ✓**Density:** The density of fly ash can vary depending on its composition and ranges from about 1.0 to 2.6 g/cm³.
- ✓**Color**: Fly ash can be gray, tan, brown, or black depending on the type of coal burned.
- ✓**Shape**: Fly ash particles can be spherical, irregular, or angular in shape.

**2.2 Fig of fly ash**

### 2.3 Rice husk ash

Rice husk ash is collected at rice mill in south raju palem and the rice husk ash contains some physical such as follows :-

**Physical Properties:**

✓**Particle size:** RHA particles are generally fine and can range in size from less than 1 micron to more than 100 microns.

✓**Density:** The density of RHA is generally low, ranging from 0.5 to 1.3 g/cm³.

✓**Color**: RHA can be gray, tan, or brown depending on the burning process used.

✓**Shape**: RHA particles can be spherical, irregular, or angular in shape.

**2.3 rice husk ash**

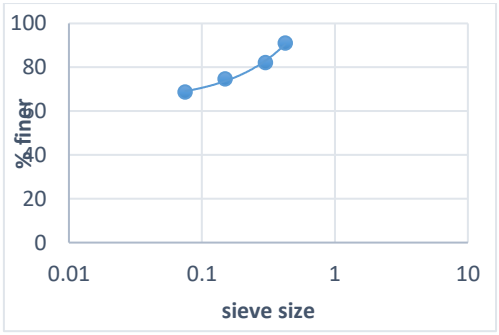
### 3 Methodology

The soil collected at kodavaluru village in north raju palem of depth 1m and the soil is collected in bags then transported to lab and laboratory test are performed they are ,sieve analysis liquid limit , plastic limit ,swell index , standard proctor test , California bearing ratio for only normal soil and by mixing of different mixing of fly ash and rice husk standard proctor test and California bearing ratio test are performed.

### 3.1 Test conduct by only soil

1. sieve analysis
2. liquid limit
3 plastic limit
4 Swell index
5 Standard proctor test
6 CBR

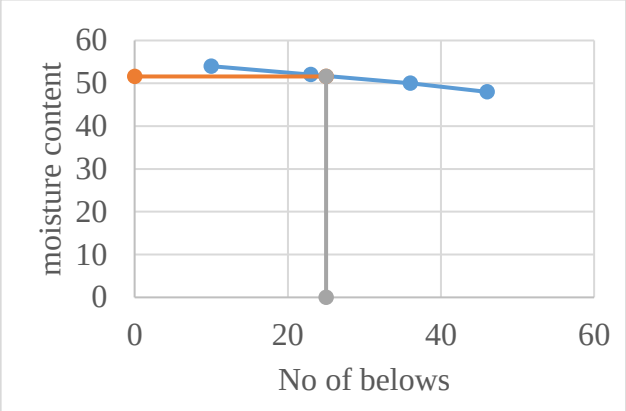
### 3 .1Sieveanalysis



✓ According to the graph the soil is fine grained soil and contains more amount of clay and medium amount of silt
✓ From the graph we analyse that soil is fine grained soil of ( size < 75microns)

**3.2liquid test**

Liquid limit test is determined by casagrande apparatus
the value of liquid limit of soil is 51.1




**3.3 plastic limit**

The value of plastic limit by normal soil is 16.3

**3.4 plasticity index**

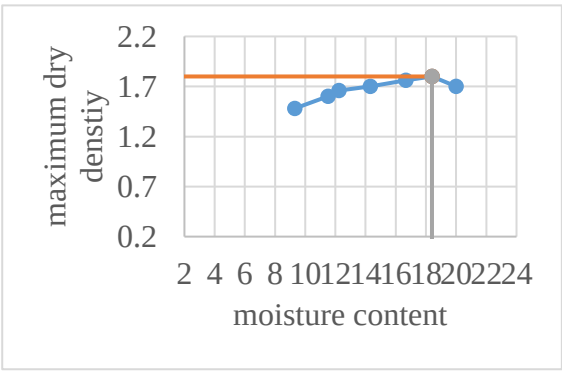
The difference between liquid limit and plastic limit is plasticity index
Plasticity index = 51.12-16.3=35.3%
✓ From the plasticity index chart we conclude the soil is In organic clay of high plasticity.
✓ According to the general property of this soil has poor workability and high compressibility

**3.5 Swell index**

Free swell index of a soil is given by 60 %

**3.6 standard proctor test**

✓ Maximum dry density of a soil =1.8gm/cm$^3$ Maximum optimum content = 18%



**3.7California bearing ratio**

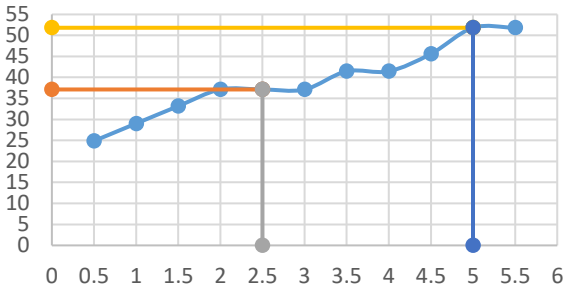
**This can be determined by two type**

1 un soaked CBR

2 soaked CBR

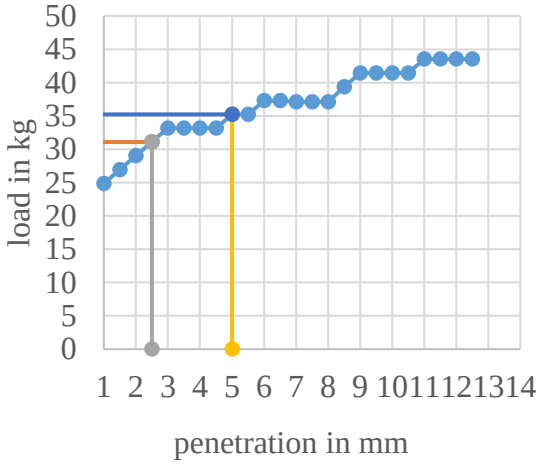
**1 . Un soaked CBR**

- For un soaked CBR value for 2.5 mm penetration value =2.71%
- For un soaked CBR value for 5 mm penetration value =2.5%




**2.Soaked CBR**

- For soaked CBR value for 2.5 mm penetration value =22.6%
- For soaked CBR value for 5 mm penetration value =1.71%




**4.Test conducted by different percentage of fly ash and rice husk ash**

1 soil + 5% fly ash + 10% rice husk ash

2 soil + 10% fly ash + 15% rice husk ash

3 soil + 15% fly ash + 20% rice husk ash

4 soil + 20% fly ash + 25% rice husk ash

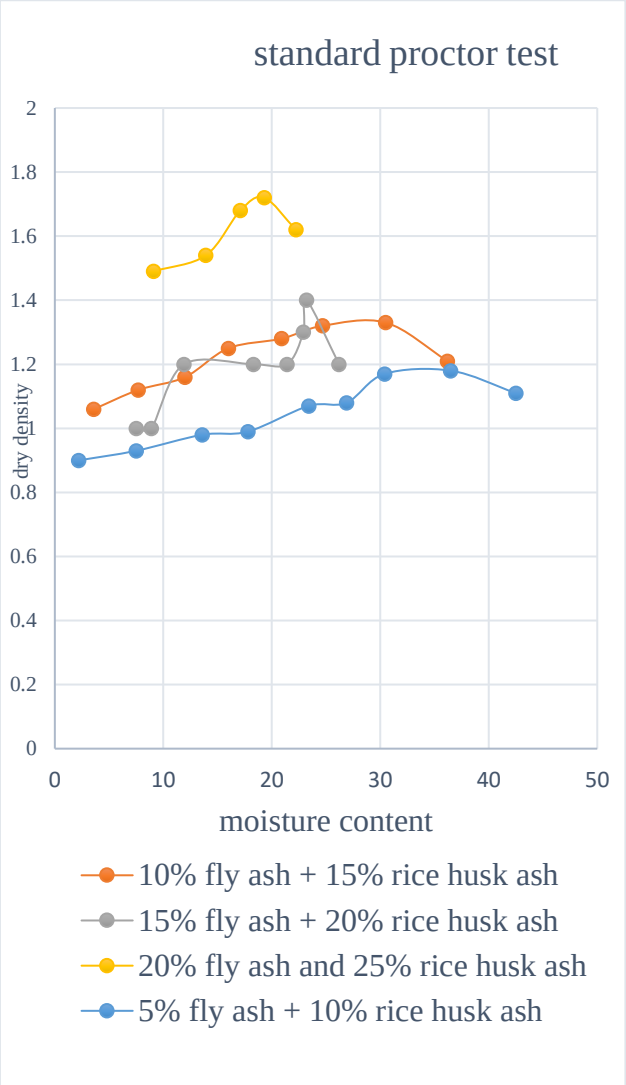
**4.1.Standard proctor test**

The test conduct on mixing of fly ash and rice husk ash in soil by different percentage.We conclude that dry density of soil is decrease and moisture content increases as 5% of fly ash and 10 % of rice husk ash has 1. 72 gm\cm $^3$ dry density is decreases and moisture content is increase has 19.3 and10% fly ash and 15% rice husk ash dry density is 1.4gm\cm $^3$ and moisture content is 23.2% and 15% fly ash and 20% rice husk ash dry density is 1.33 gm\cm $^3$ and moisture content is 30% is increase and for 20% fly

ash and 25% rice husk ash has dry density is 1.18 gm\cm $^3$and moisture content is 36.2% is decrease as compare to the soil only is 1.8 dry density and moisture content is 18% for this we analyze that dry density decrease .

**4.1Table for standard proctor test by mixing of fly ash and rice husk of different ratio**

**4.1 Graph shows various percentage of fly ash and rice husk ash**




| Sno | Mixing of soil+ fly ash+rice husk ash ratio | MDD | OMC |
|---|---|---|---|
| 1 | Soil only | 1.8 gm/cm$^3$ | 18.6% |
| 2 | Soil+5% fly ash +10% rice husk ash | 1.72 gm/cm$^3$ | 19.3% |
| 3 | Soil+10% fly ash +14% rice husk ash | 1.4 gm/cm | 23.2% |
| 4 | Soil+15% fly ash +20% rice husk ash | 1.33 gm/cm | 30% |
| 5 | Soil+20% fly ash +25% rice husk ash | 1.18 gm/cm | 36.2% |

**5.California bearing ratio** :

They are two types test that are conduct in CBR

They are given below

1 un soaked CBR

2 soaked CBR

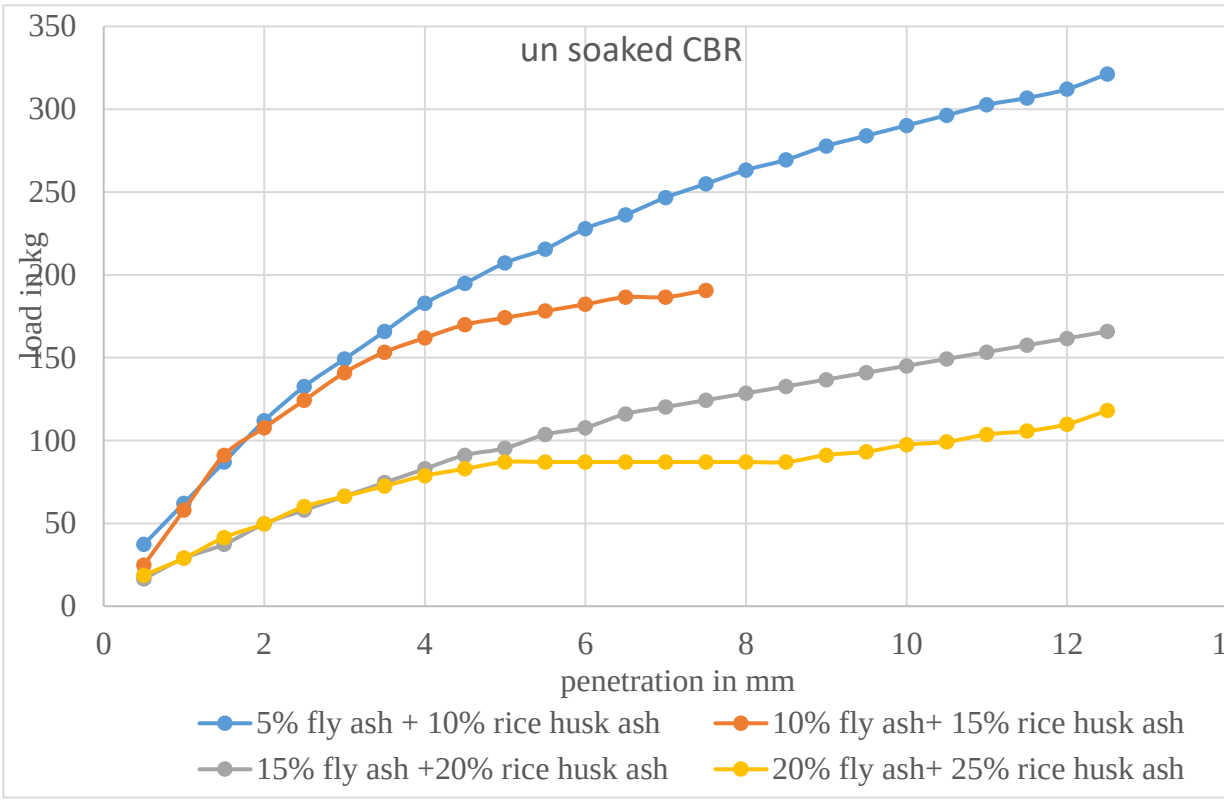
● The test conduct on mixing of fly ash and rice husk ash in soil by different percentage

**5.1. Un soaked CBR**

The CBR value increase fro 5% fly ash and 10% of rice husk ash of 5mm penetration is (10.6 % )and for 10% fly ash and 15% rice

husk ash of 5mm penetration is (8.27%) and for
and for 15% fly ash and 20% rice husk ash 5mm penetration is (4.6%) and 20% fly ash and25% rice husk ash of 5mm penetration is (4.23%) then compare to the soil is 5mm penetration is (2.5%) is increase by mixing of fly ash and rice husk ash.

**5.1 Fig show various percentage of fly ash and rice husk ash of un soaked CBR**




**5.1Table value of un soaked CBR for different percentage of fly ash and rice husk ash**

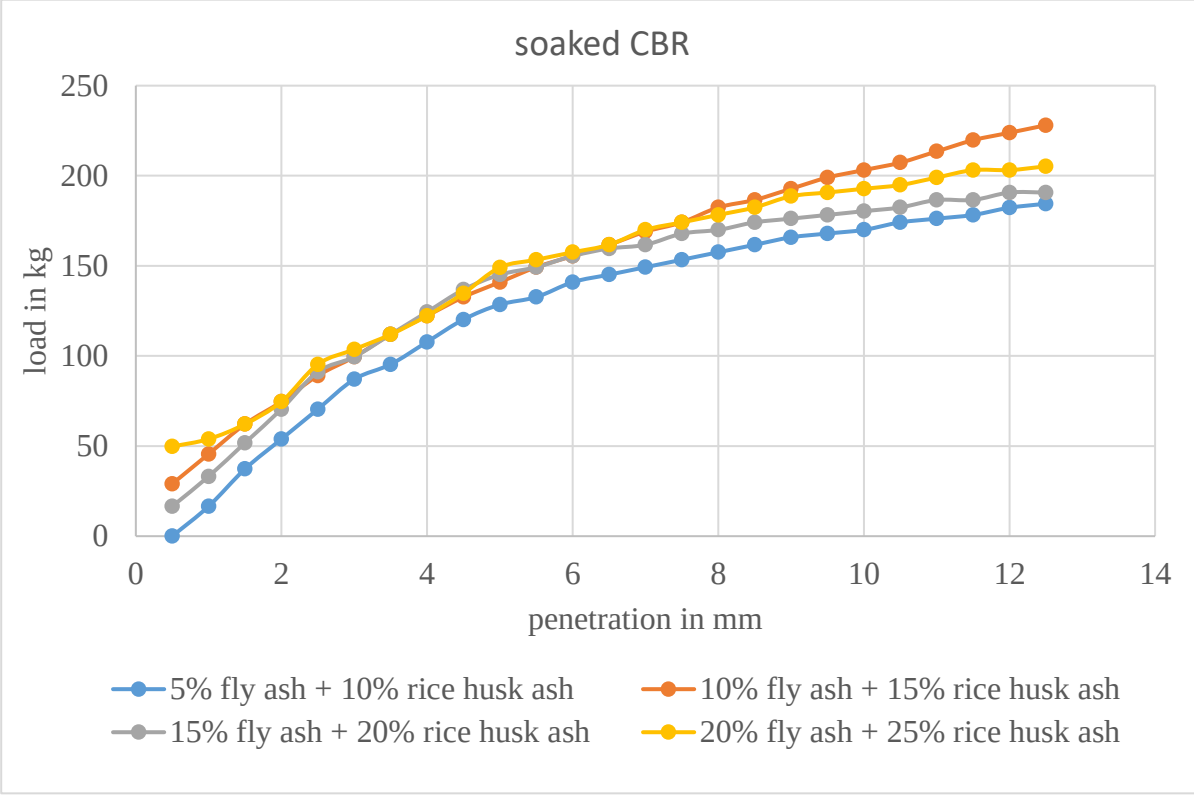
| Sno | Mixing of soil+ Fly ash +rice husk ash | CBR value of 2,5mm | CBR value of 5mm |
|---|---|---|---|
| 1 | Soil only | 2.7% | 2.5% |
| 2 | Soil+5% fly ash +10% rice husk ash | 9.36% | 10.08% |
| 3 | Soil+10% fly ash +14% rice husk ash | 7.86% | 8.27% |
| 4 | Soil+15% fly ash +20% rice husk ash | 4.2% | 4.6% |
| 5 | Soil+20% fly | 4.38% | 4.23% |

| | | | |
|---|---|---|---|
| | ash +25% rice husk ash | | |

**5.2 Soaked CBR**

The CBR value increase fro 5% fly ash and 10% of rice husk ash of 5mm penetration is (6.25% )and for 10% fly ash and 15% rice husk ash of 5mm penetration is (6.85%) and for and for 15% fly ash and 20% rice husk ash 5mm penetration is (7.06%) and 20% fly ash and 25% rice husk ash of 5mm penetration is (7.25%) then compare to the soil is 5mm penetration is (1.71%) is increase by mixing of fly ash and rice husk ash .

The soaked CBR value of 2mm penetration is also increase from 2,26 to 6.925 by adding soil+20% fly ash + 25%rice husk ash of percentage




**5.2 5.2Fig show various percentage of fly ash and rice husk ash of soaked CBR**

| Sno | Mixing of soil+ Fly ash +rice husk ash | CBR value of 2,5mm | CBR value of 5mm |
|---|---|---|---|
| 1 | Soil only | 2.26% | 1.71 |
| 2 | Soil+5% fly ash +10% rice husk ash | 5.14% | 6.25% |
| 3 | Soil+10% fly ash +14% rice | 6.50% | 6.85% |

| | | | |
|---|---|---|---|
| | husk ash | | |
| 4 | Soil+15% fly ash +20% rice husk ash | 6.6% | 7.06% |
| 5 | Soil+20% fly ash +25% rice husk ash | 6.95% | 7.25% |

**6.Analysis and results**

As we found performance of soil and fly ash (5%,10%. 15% 20%)& rice husk ash (10%,15%,20%,25%) by conducting laboratory test and the results are included as

- ✓ The moisture content of soil + fly ash + rice husk ash increase from (18 % to 36.5 %)and dry density of soil+fly ash +rice husk ash decrease from (1.8 gm/cm to 1.18 gm /cm)
- ✓ CBR value of normal soil is less when camper to soil+fly ash+ rice husk ash combined
- ✓ Un soaked CBR 5% of fly ash and 10fly ash and 10% rice husk ash is increase of 10.6 % when compared to the normal soil CBR value of 4.4 %.
- ✓ soaked CBR value of 20% fly ash and 25%rice husk is increase of 7.2 % when compared to the normal soil of CBR value of 2.2 %

Based on the above results the increase un soaked and CBR of percentage (5%,10%)and soaked CBR of percentage(20% ,25%) of both fly ash and rice husk ash improve the soil property hence we consider that fly ash and rice husk ash are used soil stabilizers

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