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# EFFECT OF RICE HUSK ASH WITH COCONUT HUSK ASH ON GEOTECHNICAL PROPERTIES OF LATERITIC SOIL

[1](Auwal Dauda, *Department of Civil Engineering, Usman Danfodio University Sokoto, Nigeria*)

[2](Awaisu Shafiu Ibrahim, *Department of Civil Engineering, Federal University, Dutsin-ma, Katsina, Nigeria*)

***Corresponding Author: awaisushafiuibrahim@gmail.com***

[3](Ahmad Idris, *Department of Civil Engineering, Bayero University Kano, Nigeria*)

[4](Zayyan M.A.,*Department of Civil Engineering, Federal University, Dutsin-ma, Katsina, Nigeria*)

***ABSTRACT :*** *This research is aimed at assessing the effect of rice husk ash with coconut husk ash on geotechnical properties of lateritic soil at Makole area, Warawa Local government, Kano state of Nigeria using 0, 2.5%, 5.0% and 7.5% of the combine husk ash by mass of soil sample at different combinations of RHA and CHA in percentage. In order to achieve our research goal, the following laboratory soil tests were carried out on the lateritic soil sample: particle size distribution analysis, Atterberg limit test, compaction test, and California Bearing Ratio in accordance with British Standard 1377 (1990). Chemical composition analysis of the rice husk ash and coconut husk ash was done as well. Chemical analysis of the rice husk ash and coconut husk ash is shown in Table 2 and table 3 respectively. The results obtained show that the increase in combine husk ash content increased the OMC but decreased the MDD. It was also discovered that increase in combine husk ash content, increased plasticity and increased plastic index as well as the strength of the soil. 70%:30% of combine RHA and CHA content was also observed to be the optimum content. The result indicates that combination of rice husk ash and coconut husk ash is suitable for improving the California bearing ratio because this parameter increases with a combination of 70%:30% RHA:CHA combination. Addition of coconut husk ash also increases the plastic limit and increases the plasticity index. Therefore, this study shows that coconut husk ash can be effectively used to improve lateritic soils with low CBR values but not suitable for improving soils with high liquid limit.*

***KEYWORDS**: Rice husk ash, coconut husk ash, lateritic soil, California bearing ratio*

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## I. INTRODUCTION

Wastes either solid or liquid are inevitable products of the greater part of man's activities whether in urban or rural areas. Their type, amount and composition vary with the type of activity which may be domestic, agricultural or industrial in nature.

The waste that comes from domestics, agricultural, industrial, commercial as well as construction activities are composed of a very wide variety of materials such as food wastes, construction waste, paper, plastic and other discarded residual items. The volume of wastes generated in the world over has also increased over the years due to increase in population, socio-economic activities and social development.

Based on the statistical data given in the 1980's, the quantity of municipal solid wastes in the urban center has doubled in size (Ghazali and Kassim, 1994). If it is improperly handled, these wastes will be a cause of land, air, surface water and groundwater pollution. In other to minimize the effects of these wastes, one of the most attractive options of managing such wastes is to look into the possibility of waste minimization and recovery. Coconut husk and rice husk can therefore be seen as an agricultural waste which will result in air and land pollution if not properly managed.

It has been observed that the combustion of many by-products have properties that are beneficial in soil stabilization applications such as soil drying, a soil amendment to enhance sub grade support capacities for pavements and floor slabs, reduction of shrink–swell properties of soils, and a stabilizer in aggregate road base construction and asphalt recycling. It has also been shown by Sear (2005) that Portland cement, by the nature of its chemistry, produces large quantities of CO2 for every ton of its final product which contributes to the melting of the ozone layer covering the Earth's surface.

Coconut husk ash has been categorized as pozzolana, with about 67-70% silica and, approximately 4.9 and 0.95% of aluminum and iron oxides, respectively (Oyetola and Abdullahi, 2006). Therefore, replacing of the Portland cement in soil stabilization with a material like coconut husk ash will reduce the overall environmental impact of the stabilization process. Tejano (1985) stated that several coconut-producing regions have sufficient supply of husks to support the profitable extraction of coir (the fiber from husk of the coconut), yet less than 0.6% of the total husk supply is utilized.

Rice husk is an agricultural waste obtained from milling of rice. About 108tonnes of rice husk is generated annually in the world. Meanwhile, the ash has been categorized under pozzolana, with about 67-70% silica and about 4.9% and 0.95%, Alumina and iron oxides, respectively (Oyetola and Abdullahi, 2006).

These types of laterites are also common in many tropical regions including Nigeria where in most cases sourcing for alternative soil may prove economically unwise but rather to improve the available soil to meet the desired objective (Osinubi and Bajeh, 1994; Mustapha, 2005).

## II. METHODOLOGY

### A. LATERITIC SOIL

The sample of the lateritic soil was collected from a borrow pit around Makole area, Warawa Local government, Kano state of Nigeria. Some geotechnical experimental tests are carried on the soil which form the basis for comparing the soil in its natural state and when husks are added to it.

### B. HUSKS

The rice husk was collected directly from a local rice milling machine in Karfi area, Kura Local government, Kano state of Nigeria. The husk was air and dried and screened.

The coconut husk was collected from a local coconut seller in Yan Lemu market area, Kumbotso Local government, Kano state of Nigeria. The husk was air and dried and screened.

The screened husks were taken for control burning at (National Research Institute for Chemical Technology (NARICT) at Bassawa area in Zaria Local government, Kaduna state of Nigeria. The husk was first carbonized and was placed in an incinerator with perforation on its two sides to allow inflow of air for combustion. The temperature of the combustion in the incinerator was subjected to a temperature of 650oc for 6 hours for both coconut husk and rice husk.

The husks ash was sieved through B.S sieve No. 200 and a small portion was taken from each husk, to Energy Research Centre (ERC) at Samaru area, in Zaria Local government, Kaduna state of Nigeria for oxide composition analysis. The analysis was carried out by using analytical software (Mini pal 4 version) in use with PW 4030 X-ray Spectrometer.

### C. PREPARATION OF SAMPLE

The combination of rice husk ash and the coconut husk ash was added to the soil sample in 2.5%, 5.0% and 7.5% by weight of the sample, with a ratio of 50%RHA:50%CHA, 60%RHA:40%CHA, 70%RHA:30%CHA, 80%RHA:20%CHA. Plasticity characteristics test and engineering properties (CBR, Compaction) were carried on the samples. It has been noticed that during mixing the husks ash with the soil sample some amount of the husk ash is lost, to encounter this 5% of the husks was assumed to be lost and it was added in the soil sample. The effects of increasing rice husk ash and reduction of coconut husk ash, and the increase in husks ash as stabilizing agent on the sample were thereafter determined.

### D. LABORATORY TEST

The following tests were conducted in this research work to evaluate the engineering properties of the lateritic soil sample (natural) and treated soil samples.

1. *Sieve analysis*
2. *Specific Gravity*
3. *Natural Moisture content*
4. *Atterberg limits*
5. *Compaction*
6. *Soaked and Unsoaked California Bearing Ratio (CBR)*

## III RESULTS AND DISCUSSION

The results of some characteristic of the natural soil sample are shown in Fig.1, Tables 1, 2 and 3 as follow:

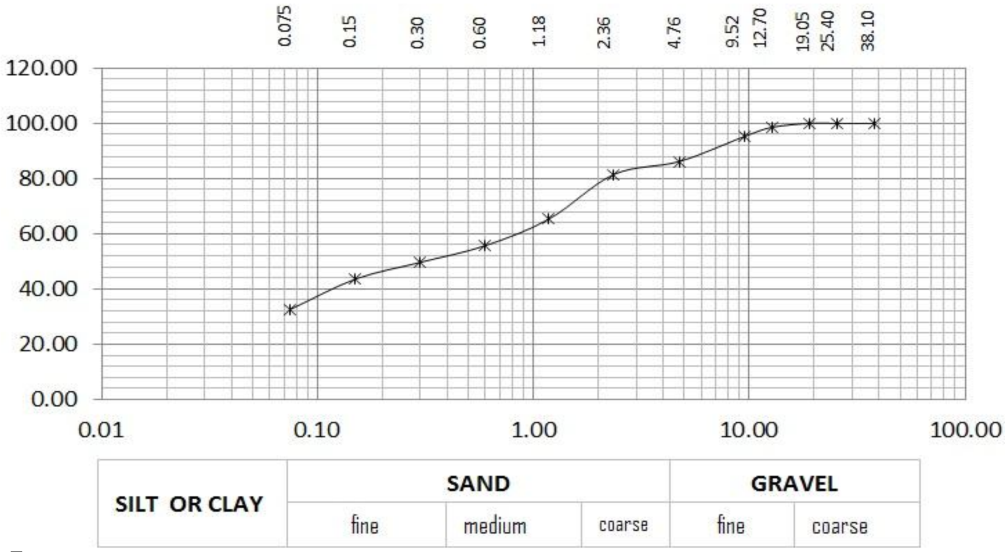


**Fig.1: Particle Size Distribution for the natural soil**

**Table 1: Characteristics of the Natural Soil**

| Characteristics | Description |
|---|---|
| Natural moisture content (%) | 11.73 |
| Percent passing B.S Sieve NO. 200 | 32.66 |
| Liquid Limit (%) | 23.25 |
| Plastic Limit (%) | 14.38 |
| Plasticity Index (%) | 8.87 0 |
| Group Index | |
| AASHTO Classification | A-2-4 |
| Maximum Dry Density ($g/cm^3$) | 2.03 |
| Optimum Moisture Content (%) | 9.50 |
| California Bearing Ratio Soaked (%) | 9.02 |
| California Bearing Ratio Unsoaked (%) | 14.03 |
| Specific Gravity | 2.50 |
| Colour | Reddish:brown |

The oxide composition of the RHA and CHA is shown in table 2 and 3.

**Table 2: Rice husk ash oxide composition**

| **Compound** | **$SiO_2$** | **$K_2O$** | **CaO** | **$Fe_2O_3$** | **$SO_3$** | **P2O5** |
|---|---|---|---|---|---|---|
| **Composition** | 72.72% | 7.18% | 2.40% | 3.01% | 0.86% | 13.00% |

**Table 3: Coconut husk ash oxide composition**

| **Compound** | **$SiO_2$** | **$K_2O$** | **CaO** | **$Fe_2O_3$** | **$Al_2O_3$** | **$SO_3$** | **P2O5** | **Cl** | **$TiO_2$** |
|---|---|---|---|---|---|---|---|---|---|
| **Composition** | 39.30% | 20.34% | 15.00% | 10.10% | 5.30% | 2.92% | 2.35% | 2.23% | 1.08% |

### A, ATTERBERG'S LIMIT LIQUID LIMIT TEST

The liquid limit result for the un-stabilized soil sample 23.25%, the liquid limit results for soil combine husk of different percentages is plotted in Fig. 2.

Generally, there is increase in liquid limit with increase in RHA content and decrease in CHA, at different percentage for soil-combine husk. Also the liquid limit increases with increase in percentage of combined husk in the sample. The liquid limit increases at 60%RHA: 40%CHA combination for 2.5% combine husk ash and at 80%RHA: 20%CHA for 5.0% combine husk ash.

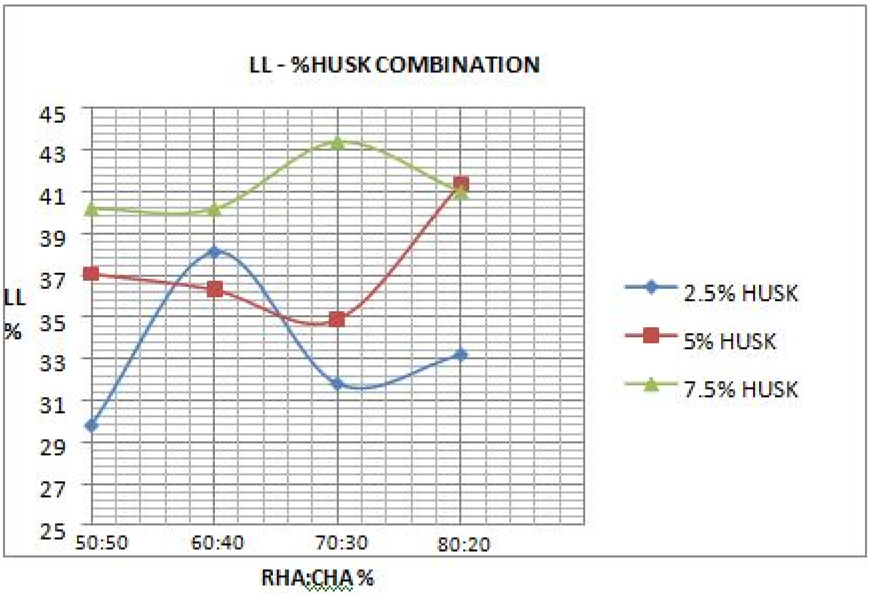


*Fig 2: Liquid Limit Chart*

The increase in liquid limit indicates that the soil when mixed with combination of RHA and CHA expand with increasing moisture which is due to the presence of large amount of very fine particles of the RHA and CHA in the mixture. This shows that RHA in combination with CHA increase the liquid limit of a natural soil.

The sample stabilized with 7.5% combined husk ash for 70%RHA: 30%CHA recorded the highest liquid limit value of 43.4%. The stabilized soil could be used for engineering construction as a sub-grade material base on the Nigerian general roads and bridges specification (2007) which recommend ≤55% liquid limit for subgrade material.

**B, PLASTIC LIMIT TEST**

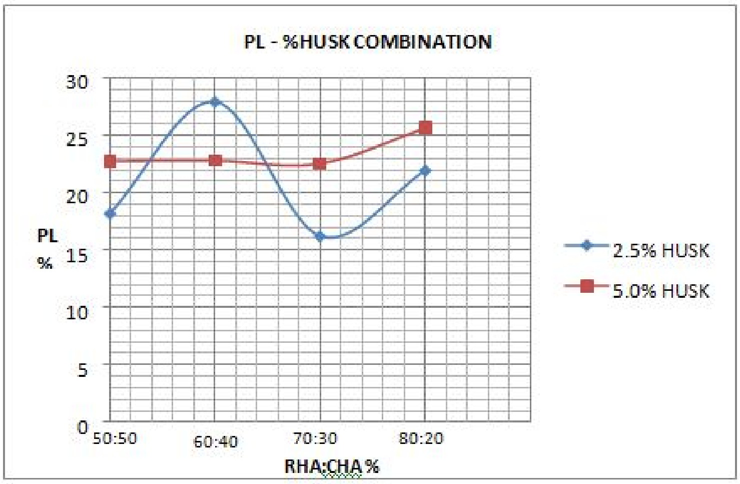


*Fig. 3: Plastic Limit Chart*

As shown in Fig. 3, there is a general increase in plastic limit, all the points in the figure are exceeding 14.38% which is the plastic limit of the natural soil, with the exception of 50%RHA:50%CHA and 80%RHA:20%CHA at 7.5% combined husk ash which a non-plastic result was recorded. For 50%RHA:50%CHA and 80%RHA:20%CHA combination when there is increase in combined husk ash percentage the soil will turn into non-plastic. This indicates that, the increase in percentage of RHA and decrease in the percentage of CHA in the combination, reduce the tensile strength of the soil, similarly increase in the combined husk ash.

### C, PLASTIC INDEX

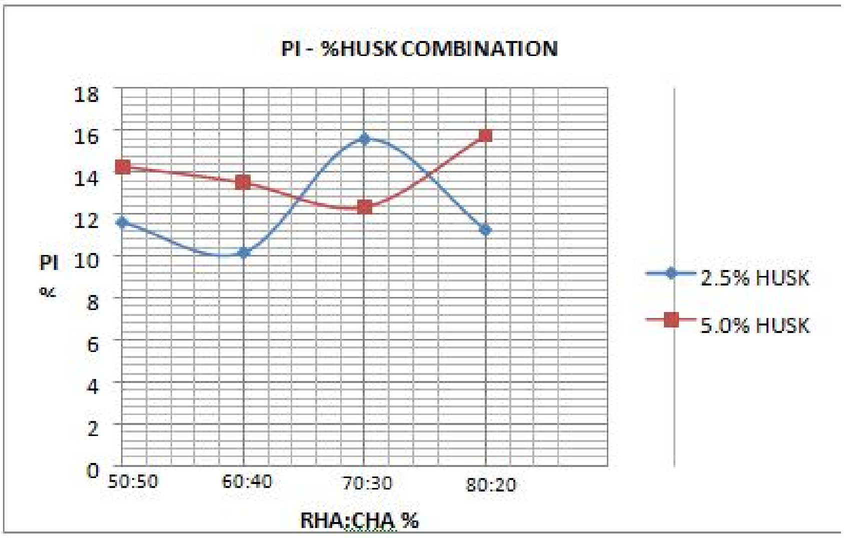


***Fig.4: Plastic Index Chart***

From the Fig.4, generally there are increases in plasticity index. At 50%RHA:50%CHA and 80%RHA:20%CHA combinations, there is an increase in plasticity index to an optimum value of 15.76% at 5.0% combined husk ash, in which any percentage increase in combine husk ash, the soil will turn out to be non-plastic.

The maximum value of plasticity index recorded was 15.76% at 5.0% combined husk ash for

80%RHA: 20%CHA combination. When compared with conventional specifications ≤30% from Federal Ministry of Works and Housing (FMW&H), most values recorded for the plasticity index are suitable for use as a sub-grade.

### D. COMPACTION CHARACTERISTICS Optimum moisture content (OMC)

For the soil – combined husk at 2.5% husk, 5%husk and 7.5% husk, generally the OMC increases with increasing combined husk content, likewise the OMC also increase generally with decrease of CHA and Increase of RHA content in the combined husk ash content. With soil – combined husk ash mixture at 2.5% there was an increase of OMC for 50%RHA: 50%CHA but huge decrease was observed at 7.5% for 70%RHA: 30%CHA combination.

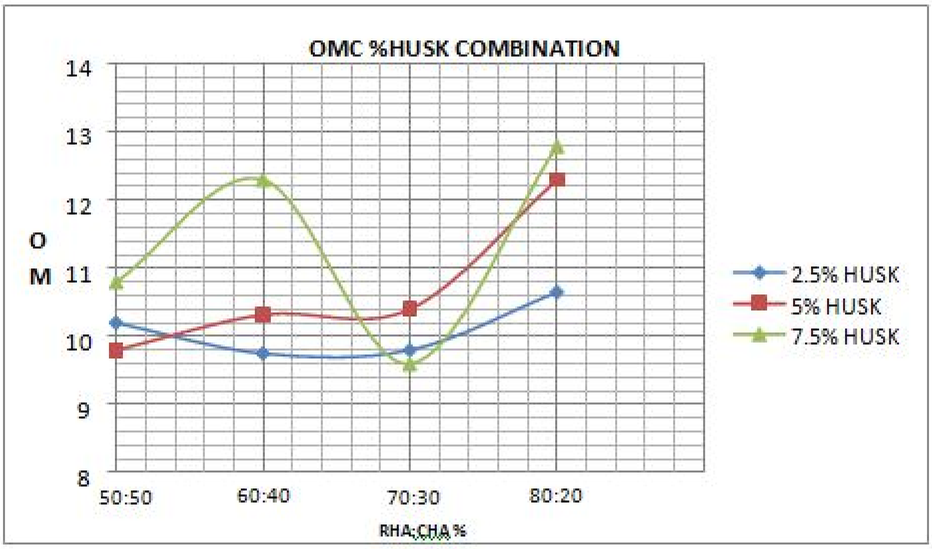


*Fig. 5. Optimum moisture content Chart*

As shown in Fig.5, the increase in OMC is due to the additional fine contents to the natural soil sample which requires more water for pozzolanic reaction to take place than the CHA. The increase of OMC with decrease of CHA and increase of RHA in the combined husk ash contents indicates that RHA requires more water for pozzolanic reaction to take place than the CHA.

**a. Maximum Dry Density (MDD)**

The maximum dry density (MDD) for un-stabilized soil sample was 2.03 g/cm$^3$ recorded as the highest MDD. The MDD generally decreases with increase in combined husk percentage and also decreases with increase in RHA and decrease of CHA content in the mixture.

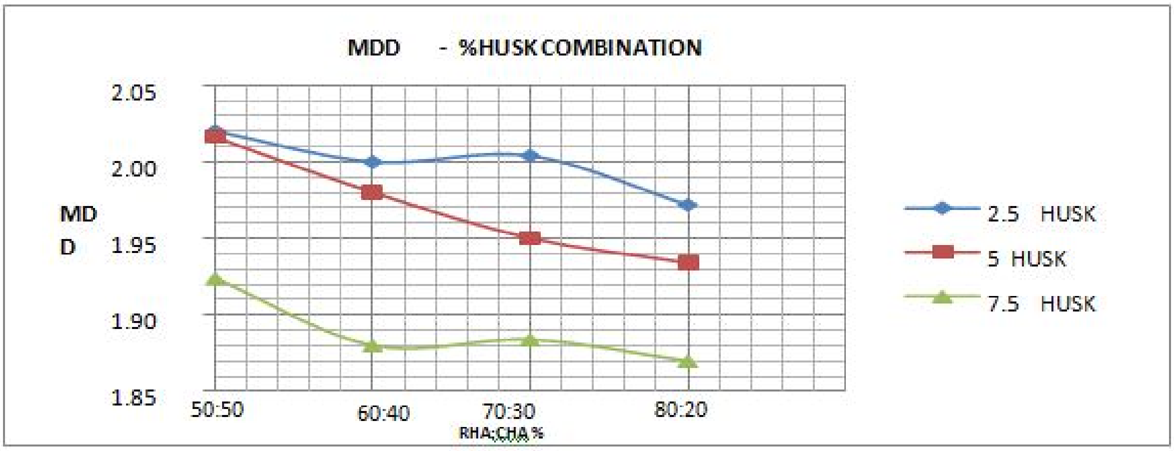


*Fig.6: Maximum Dry Density Chart*

With soil – combined husk ash mixture, at 2.5% husk and 7.5% husk, a little increase in MDD was observed for 70%RHA: 30%CHA combination on both (2.5% and 7.5%) combined husk ash as shown in Fig.6. The reduction of MDD with increase in RHA is due to the RHA having a higher percentage than the CHA in the mixture of the husk. The reduction of MDD is attributed to the specific gravity of the rice husk ash 2.14 (Sathish Kumar, 2012) and coconut husk ash 1.83 (L.O Ettu et al., 2013) which are both lower than that of the natural soil, therefore the lighter particles fills the voids of the flocculated soil matrix to give a less dense matrix.

With reference to OMC soil – combined husks curve, this trend is in order and agrees with the usual increasing OMC/decreasing MDD and decreasing OMC/increasing MDD pattern and is in agreement with Ladd et al (1960) as well as Halliburton (1970).

Decrease in dry density indicates that it need low compative energy than the natural soil, to attain its maximum dry density as a result the cost of compaction will be economical (Muntohar and Hantoro, 2000).

## E. CALIFORNIA BEARING RATIO (CBR)

### a. Unsoaked CBR

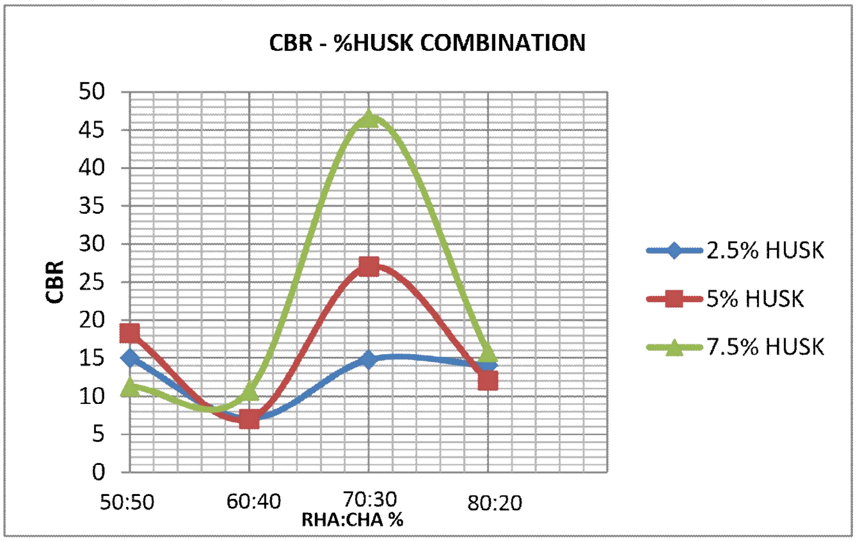


***Fig. 7: Unsoaked CBR Chart***

From Fig.7, the un-soaked CBR for the soil – combined husk of varying combination, generally, increases with increase in combined husk percentage, a little increase in CBR was observed at soil – combined husk ash of 7.5% husk for 80%RHA: 20%CHA combination, also a decrease in CBR at soil – combined husk ash at 2.5% and 7.5% husk for 50%RHA: 50%CHA combination and a general decrease at 60%RHA: 40%CHA combination. Mostly, the CBR increases at 70%RHA: 30%CHA, the maximum value of CBR was recorded at 70%RHA: 30%CHA combination for all percentage of soil – combined husk ash. The peak CBR value is 46.59% at 7.5% soil - combined husk ash for 70%RHA: 30%CHA combination.

**b, Soaked CBR**

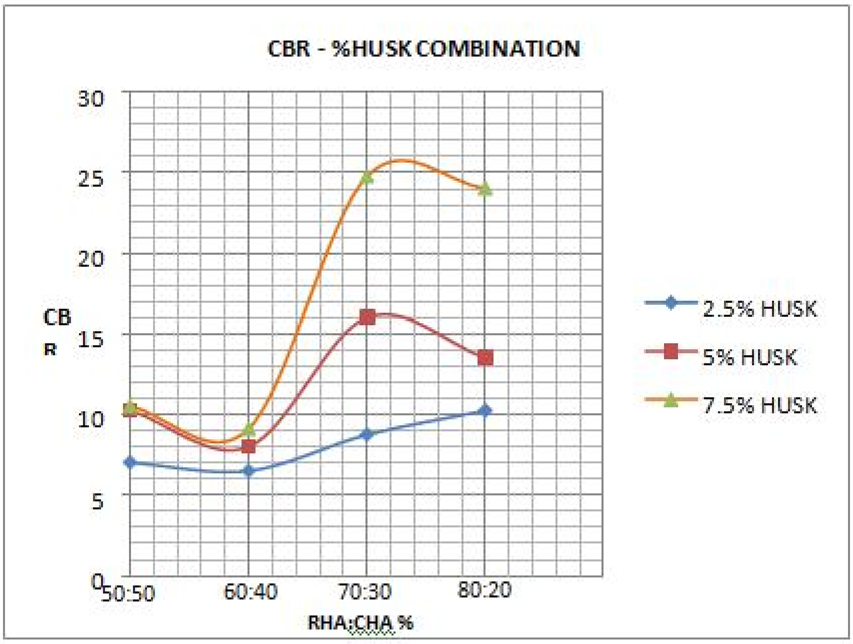


***Fig. 8 Soaked CBR chart***

From Fig. 8, for the soaked CBR, the CBR increases with increase in percentage husk. There was a general decrease in CBR at 60%RHA: 40%CHA and increase to the peak at 70%RHA: 30%CHA with a subsequent decrease in CBR for each soil – combined husk ash with exception of 2.5% soil – combined husk.

From the Figs 7 and 8, the result shows that the sample attains its maximum CBR at 70%RHA: 30%CHA combination for all the soil – combined husk ash with exception of the 2.5% combined husk ash for a soaked CBR. This shows that from this point any reduction of CHA and increase of RHA contents may reduce the CBR of the sample. With this reason it's suggested that 70%RHA: 30%CHA combination can be used to increase CBR of the sample with appropriate percentage of the combined husks (RHA & CHA) in the sample.

## IV. CONCLUSION

1. Particle size distribution revealed that the natural sample was predominantly sand of 54% and clay of 32% with traces of fine gravel of 14%. Generally, there is increase in liquid limit with increase in combined husk ash. Also the liquid limit increases with increase in RHA and decrease in CHA content at different percentage for soil combine husk, which shows the presence of large amount of fine particles. Most values recorded for plasticity index are suitable for use as subgrade or fill material, But 70%RHA; 30%CHA combination is more preferable because the plasticity index decreases with increase combined husk ash percentage.

   The compaction of the natural sample exhibits a high maximum dry density of 2.03g/cm3. The MDD decreases with increase in RHA and decreases in CHA and also the MDD decreases with increase in combined hush ash. While the OMC of the stabilized soil increases with increase in RHA and decrease in CHA contents and also the OMC increases with increase in combined husk ash due to the presence of fine particles of the combined husk ash content which results in the absorption of water.

   With addition of RHA and CHA at varying percentage improved CBR values were observed.

Peak value of 47% un-soaked CBR and 26% soaked CBR were obtained at 70%RHA; 30%CHA for 7.5% husk combination.

2. From the result 70%RHA; 30%CHA is more suitable combination of rice husk ash and coconut husk ash to be used in improving soil with low CBR, low Plastic Limit and low liquid limit.

3. The use of RHA and CHA in improving soil can be a safer way of disposing rice husk and coconut husk.

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