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A COMPARATIVE STUDY ON FLY ASH, BAGASSE ASH AND RICE HUSK ASH USING AS A SUB-GRADE MATERIAL IN EXPANSIVE SOIL

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ABSTRACT

Expansive soil generally occupy volumetric changes when subjected to variation in moisture content. As the soil is very active and it shrinks and swells with change in moisture contents so low bearing strength and high compressibility behavior of most soils can cause severe damage to subgrade. In this research we evaluate the strength of soil by adding different types of ground improvement materials like as fly ash, bagasse ash and rice husk ash in order to overcome such types of damages. CBR tests were performed with fly ash, bagasse ash and rice husk ash separately at different percentage variations with the increment of 2.5% by weight in order to find out which one is most suitable for stabilization of subgrade material. The results show that initially the California bearing ratio value (CBR) of soil was 6.63% and for addition of fly ash, bagasse ash and rice husk ash separately up to 12.5% it increased up to 15.11%, 13.21% and 18.40% respectively. Initially the CBR value of soil is 6.63%. For addition of bagasse ash up to 7.5% the CBR value of soil has become in increase up to 13.87% and after then for addition of 12.5% bagasse ash it has become in decrease 13.21%. For fly ash the CBR value for 10% is 15.29%, which is larger than the bagasse ash and CBR value for adding 2.5% of rice husk ash is 17.15% and up to adding 10% of rice husk ash it increased up to 18.67% after which in 12.5% CBR value got decreased. So as getting some point of view of making a comparison between the CBR values of Fly ash, Bagasse ash & Rice husk ash the respective highest values are 15.29%, 13.87% & 18.67%.

Keywords: *Expansive Soil, Fly Ash, Bagasse Ash, Rice Husk Ash, Swelling Index, MDD, OMC, CBR.*

1. INTRODUCTION

Expansive soil generally defines as a type of clay soil. Preparation and construction of highways and runways over expansive soils is one of the remarkable civil engineering burning issue over the world considering to the fact expansive soils having the characteristics of shrinking and swelling with variation in moisture content. In monsoon expansive soil generally absorbs water and expands in volume. Similarly, in summer it shrinks because water leaves away (Somaiya, et al., 2013). In semi-arid and arid regions of the globe, expansive soils shows the characteristics of destruction to the nature unless it is treated, causes acute damage to the structure built on it as well as loss of human life (Mohanty, 2015). The properties of soil can be improved by stabilization with admixtures such as lime, cement, fly ash, bagasse ash and rice husk ash are used to improve the qualities of various types of soils such as Lateritic Soil, Clayey soil. In this research fly ash, bagasse ash and rice husk ash are differentially used for the purpose of stabilization of expansive soil.

A waste material extracted from the gases emitting from coal fired furnaces generally called fly ash. Again, fly ash is a waste by product from thermal power plants. The main goal of volcanic ashes in ancient periods were the use of it as hydraulic cements and fly ash carries almost same property to these volcanic ashes. These ashes occupied as one of the best binding agent used in the world. But it requires thousands hectares of farming land for its disposal and also causing both severe health problems and environmental hazards. So, the proper management of this is inevitable for our sound survival. But having both great availability and its low cost, the chances of its usage is investigated here. (Ahmed, 2014; Mohanty, 2015; Anu, et al., 2016)

About 40–45% of the fibrous waste from sugarcane after crushing and extraction of its juice is termed as ‘‘bagasse”. Basically, it is regenerated as fuel in boilers for heat generation which leaves out 8–10% of ash, known as Bagasse Ash, which is treated as residue and unused. Sugarcane bagasse consists of approximately 50% of cellulose, 25% of hemicelluloses and 25% of lignin. Bagasse ash is a non-cohesive material having a low specific gravity. It contains a massive amount of silica and at burnt it behaves as binding material. On the contrary, the disposal of this material is the reason of causing environmental problems around the sugar industries. After realizing the overall facts it can be used as for the stabilization of road subgrade material (Najar, et al. 2017; Murali, et al. 2018).

Many researches have showed in the recent past years on the use of fly ash and sugarcane bagasse ash in the development of road subgrade. Goliya, H. S., Faraz, M. I. and Singune, V. (2018) reviewed various papers where researcher are used various stabilizer. In which some mixtures are expensive and some mixtures are economical. Cement, chemical, bituminous mixtures are expensive and saw dust, fly ash, rice husk, bagasse ash are cheaper. So the cheap stabilizer are used to minimize the project cost and the result will come in the form of improvement in active or black cotton soil properties, CBR value, stability and bearing capacity of soil value will be increased. The characteristics of an expansive soil can be found by using fly ash stabilization. Phanikumar and Sharma (2004) showed that by using 20% fly ash the plasticity of soil reduced by 50%. Also optimum moisture content is increased with the addition of ash in the compaction tests by increasing the soil great specific surface and decreasing the maximum dry density because of a lower specific weight. Ahmed also indicates that the fly ash can be applied in soils containing a high percentage of moisture resulting in greater compaction because of the evaporation of a considerable quantity of the contained moisture (Ahmed, 2014). Another paper showed that maximum dry density obtained from modified Proctor test decreases with increasing fly ash content and there is no consistent variation in optimum moisture content with increasing fly ash content (Ozdemir, 2016).

Rice Husk Ash (RHA) is the by-product of the burning of rice husk. By weight, 10% of the rice grain is rice husk. On burning the rice husk, about 20% becomes RHA. This RHA contains around 85% to 90% amorphous silica. Rice husk ash is basically termed as the agricultural waste products obtained from the rice milling. Rice husk ash is used in many application due to its versatile properties. Rice husk ash is used in different applications such as building and construction, steel, ceramic and refractory, silica manufacturing and others. Use of RHA in building and construction industry governs the market with more than 40% in period of applications. Also, RHA is widely applied in production of high strength concrete by replacing silica fume, in term of mineral admixture. RHA to be used in powder form as an admixture in soil. Bhasin et al. (1988), made a laboratory research work on the stabilization of black cotton soil as a pavement material using RHA, along with other industrial by-product wastes like fly ash, bagasse ash, lime sludge, black sulphite liquor independently. The RHA causes greater improvement rather than other wastes due to presence of higher percentage of reactive silica in chemical formation. In combination with lime, RHA improved the properties of black cotton soil effectively. Ms. Aparna (2014), has presented a research work delineates information about soil which is stabilized with different percentages of Rice Husk Ash and a small amount of cement. This application showed that the increase in RHA content increases the Optimum Moisture Content but decreases the Maximum Dry Density in quantity. Also, the CBR value and Unconfined Compressive Strength of soil are considerably developed with the Rice Husk Ash content.

2. METHODOLOGY

2.1 Materials and Methods

The expansive soil used in this research work was collected from Godagari Upazila in the district of Rajshahi in Bangladesh. The soil sample was collected about 5 feet below from the surface level. The admixtures utilized in this research are fly ash, bagasse ash and rice husk ash. Fly ash sample was accumulated from the Bangladesh Barapukuria Power Station and sugarcane bagasse ash sample was accumulated from Rajshahi Sugar Mill. Alongside the Rice Husk Ash sample was accumulated from the Haque Auto Rice Mill, Cantonment road, Rajshahi. After that the collecting samples were dried for 24 hours for the laboratory works. Then the sample was prepared and subjected to various laboratory tests including specific gravity test, liquid limit test, plastic limit test, shrinkage limit test, modified proctor test and California bearing ratio (CBR) test to find out the engineering properties of the samples. California Bearing Ratio (CBR) value of sub grade is used for design of flexible pavements and determination the stability of subgrade soil by adding mixtures. AASHTO and ASTM standards are projected in order to determine and evaluate the engineering properties of soil. The Soil sample is adulterated and compounded with various percentages of fly ash and bagasse ash and rice husk ash separately and subjected to modified proctor test to get the optimum moisture content and maximum dry density of soil sample pros and cons mixing with admixtures. Then CBR test is supervised in unsoaked condition. The soil sample is concocted with its optimum moisture content and compacted and condensed in 5 layers by giving 56 blows to each layer by 4.89 kg hammer. After then it is assigned on the penetration test machine to find out the CBR value.

2.2 Properties of expansive soil sample

The soil sample was fully oven dried, weighed and placed in room temperature for storing. After that, the general properties and prominences of the soil were experienced in the laboratory. Then the soil sample was tested for liquid limit, shrinkage limit, plastic limit, plasticity index, optimum moisture content, maximum dry density and finally CBR test delineated in Table 1.

Table 1: Fundamental engineering properties of expansive soil

Properties	Value
Textural classification	Loam
Sand content (%)	35
Silt content (%)	40
Clay content (%)	25
Specific gravity	2.65
Liquid limit (%)	58.43
Plastic limit (%)	30.21
Shrinkage limit (%)	17.36
Plasticity index (%)	28.22
Optimum moisture content (%)	13.5
Maximum dry density (gm/cm^3)	1.88
California bearing ratio (%)	6.63

Kinjal, S., Desai, A. K., and Solanki, C. H. (2012).studied, the expansive soil contains a lot of percentage of clay content as well as silt content for the strong hydrophilic properties. Again the liquid limit of the expansive soil should be more than 40% and plasticity index of expansive soil should be higher than 20. So, our test soil sample can be classified as expansive soil containing liquid limit 58.43% and plasticity index 28.22%.

2.2 Preparation of Admixtures

The above considered materials such as expansive soil, fly ash, bagasse ash and rice husk ash was collected. After collecting the fly ash it was dried in the oven. Alongside Sugarcane Bagasse ash and Rice Husk Ash was dried in air for 3-4 days. Then the admixtures were sieved through IS Sieve No.200 (75µ) in order to achieve a uniform powdery for identifying the variations.

Table 2: Chemical composition of Fly Ash

Oxide	Percentage
SiO_2	54.4
Al_2O_3	35.6
Fe_2O_3	2.9
TiO_2	3.2
Mn_3O_4	0.11
CaO	0.56
K_2O	0.66
Na_2O	0.06
MgO	0.18
P_2O_5	0.46
SO_3	0.13
Wardell Armstrong (1991)	

Table 3: Chemical composition of Bagasse Ash

Oxide	Percentage
SiO_2	78.34
Al_2O_3	8.55
Fe_2O_3	3.61
CaO	2.15
Na_2O	0.12
MnO	0.13
TiO_2	0.50
MgO	1.65
P_2O_5	1.07
K_2O	3.46
Corderio, et al. (2004)	

Table 4: Chemical composition of Rice Husk Ash

Constituent	%
SiO_2	90.23
Al_2O_3	2.54
C	2.23
CaO	1.58
MgO	0.53
KaO	0.39
Fe_2O_3	0.21

3. RESULTS

The subsequent grain size distribution curve is established by using the data acquired from sieve analysis and hydrometer analysis of soil delineated in Figure 1 showing silt content 40% and clay content 25%

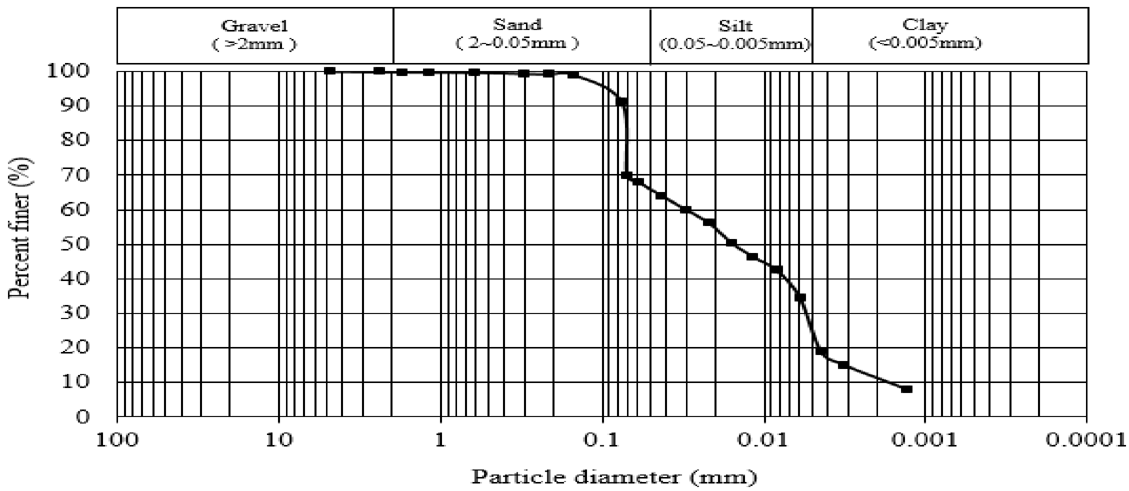


Figure 1: Grain Size Distribution Curve

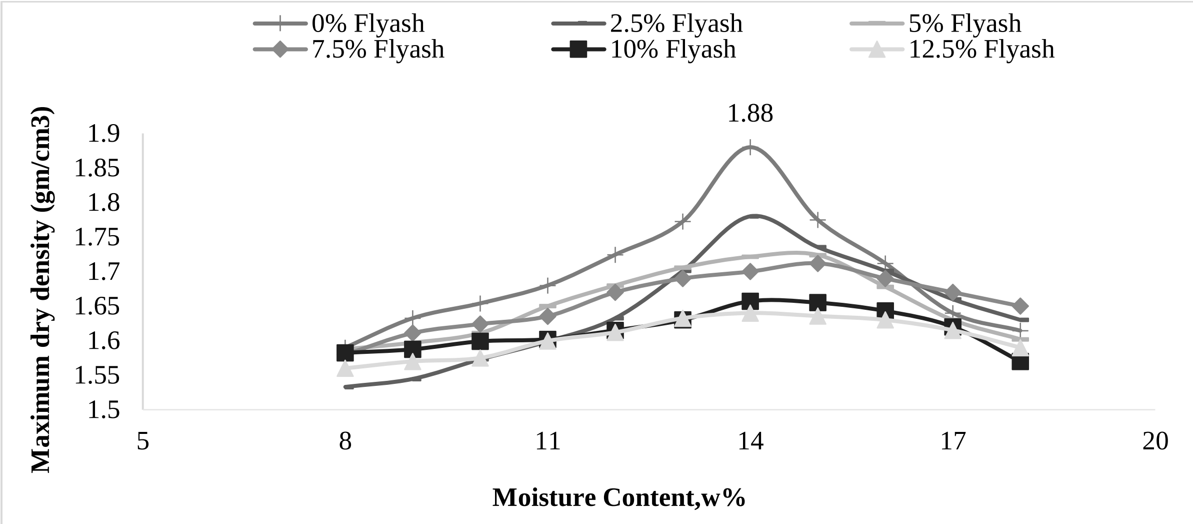


Figure 2: Moisture Content & Maximum Dry density of soil with different percentage of Fly Ash

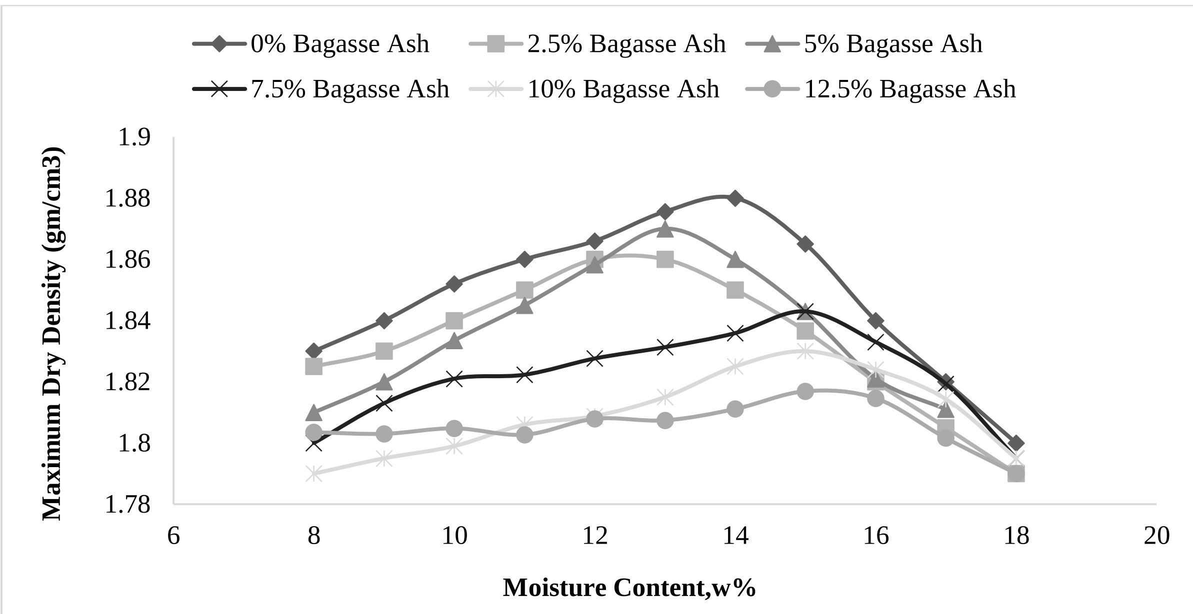


Figure 3: Moisture Content & Maximum Dry density of soil with different percentage of Bagasse Ash

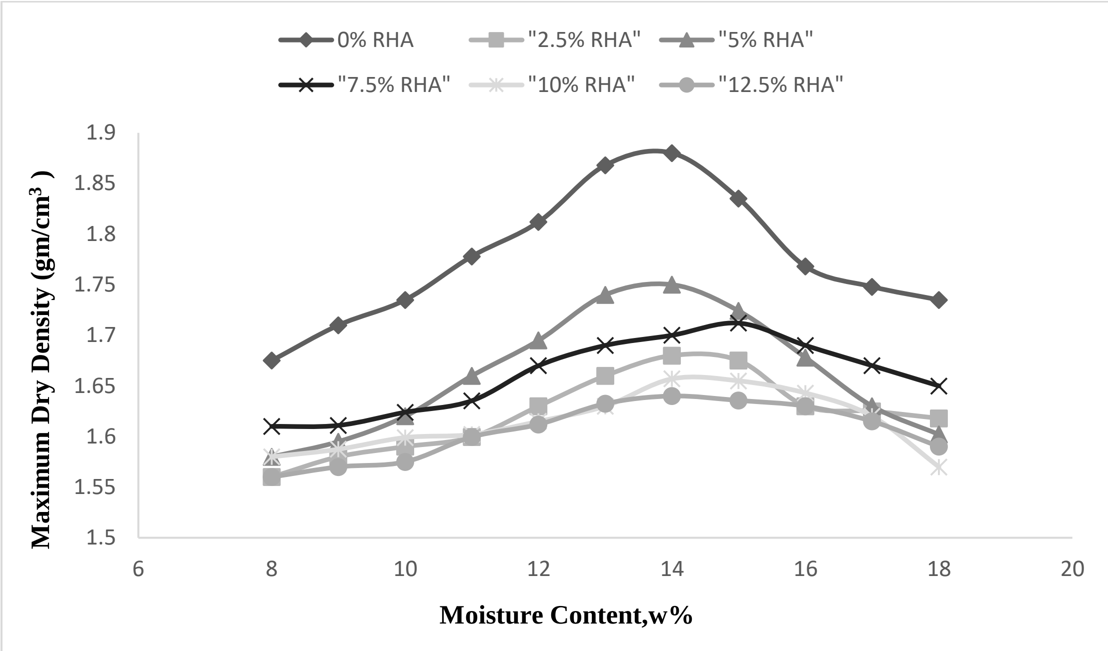
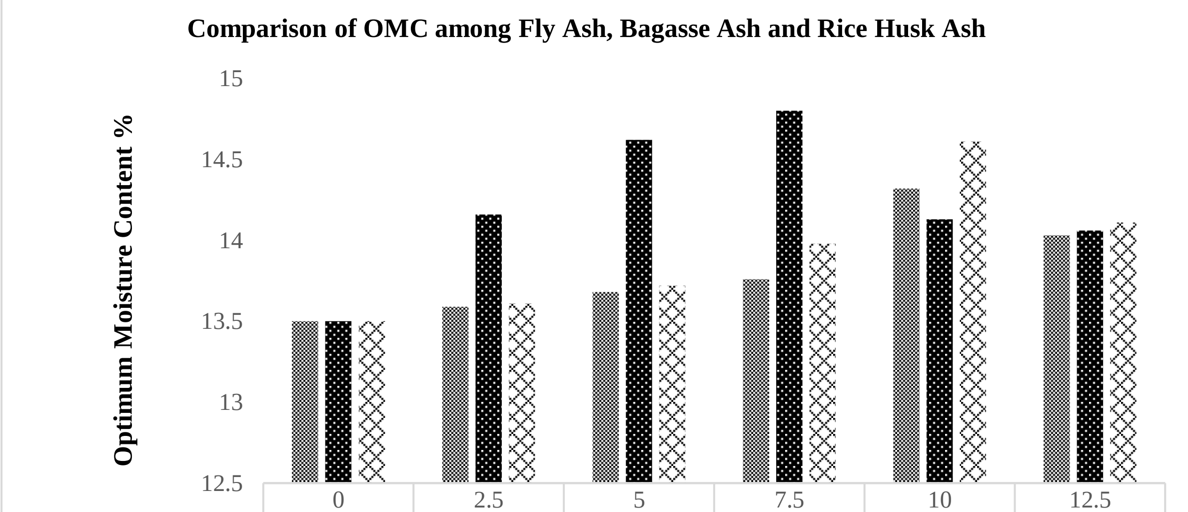
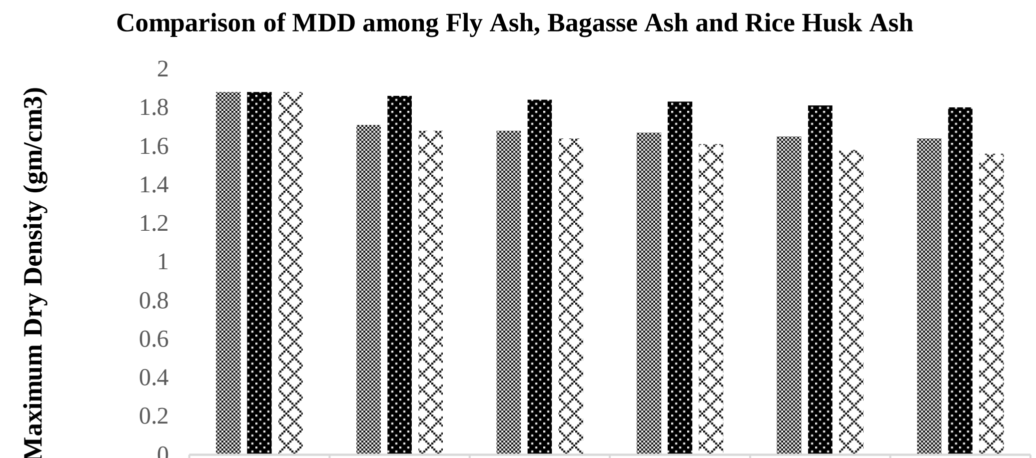


Figure 4: Moisture Content & Maximum Dry density of soil with different percentage of Rice Husk Ash (RHA)



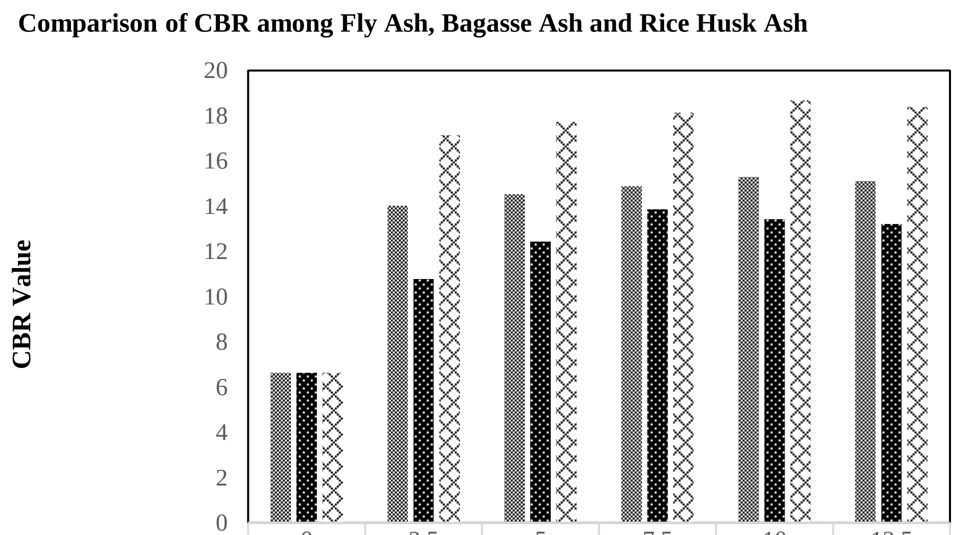
	0	2.5	5	7.5	10	12.5
For Fly Ash	13.5	13.59	13.68	13.76	14.32	14.03
For Bagasse Ash	13.5	14.16	14.62	14.80	14.13	14.06
For Rice Husk Ash	13.5	13.61	13.72	13.98	14.61	14.11

Figure 5: Optimum moisture content of soil with various percentages of Fly Ash, Bagasse ash and Rice Husk Ash



	0	2.5	5	7.5	10	12.5
for Fly Ash	1.88	1.71	1.68	1.67	1.65	1.64
For Bagasse ash	1.88	1.86	1.84	1.83	1.81	1.8
For Rice Husk Ash	1.88	1.68	1.64	1.61	1.58	1.56

Figure 6: Maximum Dry Density of soil with various percentages of Fly Ash and Bagasse ash and Rice Husk Ash



	0	2.5	5	7.5	10	12.5
CBR of soil using Fly Ash	6.63	14.02	14.53	14.88	15.29	15.11
CBR of soil using Bagasse Ash	6.63	10.78	12.44	13.87	13.42	13.21
CBR of soil using Rice Husk Ash	6.63	17.15	17.73	18.14	18.67	18.4

Figure 7: CBR values of soil with various percentages of Fly Ash, Bagasse ash and Rice Husk Ash

4. DISCUSSIONS

Corresponding to Textural classification (U.S. Bureau of Soil and Public Road Administration (PRA) classification) from grain size distribution curve describes as the following soil sample is clay loam. And from the plasticity chart the liquid limit of soil is 58.43% and resembling plasticity index is 28.22%, so it has been identified that it is a medium plastic soil.

From the Figure 2, Figure 3 & Figure 4 the addition of fly ash, bagasse ash and rice husk ash separately by weight (0%, 2.5%, 5%, 7.5%, 10% and 12.5%) to the soil sample caused an increase in the optimum moisture content and caused a decrease in maximum dry density. But for Rice Husk Ash the rate of increment of OMC is relatively higher than the others. In case of maximum dry density for different percentages of mixing admixtures, bagasse ash gives the greater value compared to the fly ash and rice husk ash.

In Figure 5 it is stated that after applying the various percentage of ashes the OMC value of soil slightly got increased up to an optimum value. As early it was 13.5 and by adding 10% of fly ash it got increased up to 14.32 and after 10% of fly ash it tends to decrease. Bagasse ash shows an increment up to adding 7.5% of ash and the OMC value is 14.80 after which it is going to be decreased. In case of rice husk ash the optimum value of OMC is got 14.61 for 10% of product. So here the optimum value for rice husk and fly ash is 10% whereas the most OMC is got for bagasse ash in 7.5%.

In Figure 6 the histograph representation showing a clear indication that with increasing the various percentages of Fly ash, Bagasse ash and Rice husk ash the corresponding MDD value got decreased as well. And the decrement of MDD value is higher for Rice husk ash than the other by products. In addition of 12.5% of admixtures the MDD value is 1.56% which is certainly the lowest value among all the corresponding values. On the contrary in case of MDD value the lowest value for Fly ash is 1.64% and for Bagasse ash is 1.8% for same amount of 12.5% subgrade materials addition. From the Figure 7 it has been identified that the addition of Rice Husk Ash gives better CBR value than the fly ash and bagasse ash. With the increasing percentages of Rice Husk Ash and Fly ash CBR value is continuously increasing up to 10% after that it tends to reduce. And after 7.5 % addition of bagasse ash the CBR value starts to decrease also. For that reason, 7.5% is the optimum percentage value for bagasse ash. On the contrary, for fly ash the optimum percentage is about 10% up to which CBR value got improved.

And in the case of rice husk ash the CBR value of the expansive soil for 2.5% of admixture is 17.15% which got increased up to 18.67% for adding the rice husk ash 10% after which it is to be reduced. On the contrary the value of MDD got a decrement of 0.32% which is 1.88% to 1.56%. and in the term of the governing factor that is CBR value for adding 2.5% of Fly Ash is 14.02% and up to adding 10% of fly ash it increased up to 15.29% and after which it is also got decreased. In case of Bagasse Ash CBR value shows variation from 10.78% to 13.87% for respectively 2.5% to 7.5% where the CBR value shows reduction in 10% and in 12.5% mix. So as getting some concerned of making a comparison between the CBR values of Fly ash, Bagasse ash & Rice husk ash the respective highest values are 15.29%, 13.87% & 18.67%.

In terms of choosing subgrade material based on CBR value Rice Husk Ash (RHA) is just ahead of Fly Ash (FA) and Bagasse Ash (BA).

5.CONCLUSIONS

All Fly ash, Bagasse ash and Rice husk ash are suitable for expansive soil stabilization. And Rice husk ash is more suitable than the Bagasse ash and Fly ash for soil stabilization. With the increasing percentages of fly ash, rice husk ash the governing factor CBR value is continuously increasing up to 10% after which is shows reduction. The research work shows the optimum percentages for Bagasse Ash is 7.5%. For Fly ash and Rice husk ash it is 10%. For same percentage the CBR value for Rice husk ash is slightly improved than others. That shows a clear statement that the most suitable sub grade material for same percentage of admixtures is Rice husk ash rather than the Fly ash and Bagasse ash.

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