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Expansive Soil Modification by the Application of different Waste Materials

Rahul Bhagore[1,] Sumit Raj[2] , Rohit Singh[3] , Rabish Kothana[4], Pallavi Gupta[5]

1Undergraduate, Civil Engineering Dept, IES IPS Academy,Indore,Rahulbhagorekgn@gmail.com
2Undergraduate, Civil Engineering Dept, IES IPS Academy, Indore,raj.sumit59@gmail.com
3Undergraduate, Civil Engineering Dept, IES IPS Academy, Indore,Rohits3888@gmail.com
4Undergraduate, Civil Engineering Dept, IES IPS Academy, Indore rabishkothana@gmail.com
5Assist. Prof. Civil Engineering Dept, IES IPS Academy, Indore,Pallavgupta0390@gmail.com

Abstract*— Usage of marble dust, fly ash, wheat husk ash was investigated for soil stabilization in the scope of utilization of waste material. Geotechnical properties, such as compaction, Atterberg limits, and unconfined compressive strength of the mixtures and changes of these properties with the marble dust fly ash wheat husk ratio were determined. From the test results it is seen that marble dust increases the mechanical properties of soil and application of dust wastes for soil stabilization will be an efficient practice in terms of solid waste management.

Keywords*— Subgrade, Optimum moisture content (OMC), maximum dry density (MDD), California bearing ratio (CBR), Thickness, Section economy, Black cotton (BC)

I. INTRODUCTION

In today's time with increase in requirements of transportation a cost effective road system is needed, for this we have to ensure that the pavement we design should be strong as well as economically suitable .Therefore, for our project we have worked on subgrade of black cotton soil and achieved overall section economy. As we know sub grade is the most thick part of flexible pavement and all the load is ultimately transferred to it we tested it with various waste material combinations in a of 1:4 waste is to soil ratio and calculated optimum moisture content, maximum dry density, and CBR values. By the CBR we have designed pavements and compared their overall prices of pavements with treated subgrade to that with untreated subgrade.

II. LITERATURE REVIEW

- **PAPER BASED ON WHEAT HUSK ASH**

1. **Laxmikant Yadu (2014):** *Comparison of fly ash and wheat husk ash stabilized black cotton soil.* The paper presents the laboratory study of black cotton (BC) soil stabilized with fly ash (FA) and wheat husk ash (WHA). The samples of BC soils were collected from a rural road located in Raipur of Chhattisgarh state. The soil was stabilized with different percentages of FA (i.e., 5, 8, 10, 12, and 15%) and WHA (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 indicate that addition of FA and WHA reduces the plasticity index (PI) and specific gravity of the soil.

2. **Mohammed Y. Fatta (2013):** Improvement of Clayey Soil Characteristics Using Rice Husk Ash .This paper presents the results of experimental study carried out on three different soils improved with different percents of rice husk ash. The testing program conducted on the clayey soil samples mixed with different percentages of rice husk materials, included Atterberg limits, specific gravity, compressibility, unconfined compression test and consolidation test. It was found that the liquid limit of the three soils has been decreased by about (11 - 18) % with the addition of 9% RHA, while the plasticity index decreased by about (32 - 80) %. Treatment with rice husk showed a general reduction in the maximum dry unit weight with increase in the rice husk content to minimum values at 9% rice husk content.

- **PAPER BASED ON MARBLE DUST**

1. **Akshaya Kumar Sabat (2011):** Effect of marble dust on strength and durability of Rice husk ash stabilised expansive soil. This paper presents the results of a laboratory study undertaken to investigate the effect of Marble dusts on strength and durability of an expansive soil stabilized with optimum percentage of Rice Husk ash (RHA). The optimum percentage of RHA was found out be 10% based on Unconfined Compressive Strength (UCS) tests. Marble dust was added to RHA stabilized expansive soil up to 30%, by dry weight of the soil, at an increment of 5%. The Maximum Dry Density(MDD) and Swelling pressure of expansive soil goes on decreasing and Optimum Moisture Content (OMC) goes on increasing irrespective of the percentage of addition of Marble dust to RHA stabilized expansive soil. From the Durability test results it was found that the addition of Marble dust had made the RHA stabilized expansive soil durable. For best stabilization effect the optimum proportion of Soil: Rice husk ash: Marble dust was found to be 70: 10: 20.

2. **Shreekumar V. Babu (2011):** *Stabilization of expansive soils using waste marble dust.* In this paper experimentation of soil is done by mixing different proportions of marble dust (2%,4%,6%,10%) and hence improving the properties of soil.

- **PAPER BASED ON FLY ASH**

1. **Dr. Robert M. Brooks(2009) :** Objective of this paper is to upgrade expansive soil as a construction material using rice husk ash (RHA) and flyash, which are waste materials Stress strain behavior of unconfined compressive strength showed that failure stress and strains increased by 106% and 50% respectively when the flyash content wa increased from 0 to 25%. When the RHA content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97% while CBR improved by 47%. Therefore, an RHA content of 12% and a flyash content of 25% are recommended for strengthening the expansive subgrade soil. A flyash content of 15% is recommended for blending into RHA for forming a swell reduction layer because of its satisfactory performance in the laboratory tests.

2. **S. Bhuvaneshwari (2005) :** Stabilization of expansive soils using fly ash. The paper describes a method adopted for placing this material in layer of required thickness and operating a disc harrow. A trial thickness of 30 m length by 6 m width and .6 m height was successfully constructed and the in situ test carried out proved its suitability for const. of embankment ash dykes,filling low level areas etc.

III. CRITIQUE

- In above papers various techniques of improving black cotton soil were explained by authors. They explained by research papers that adding different proportion of admixtures, chemicals such as lime, cement, fly ash, plastic; fibers can increase the geotechnical properties of Black cotton soil to certain extent so that sub grade soil can be improved.
- In our project we will be studies showing properties of soil with any one of these waste material so we used combination of these materials and studied change in their properties

IV. OBJECTIVE

- To determine the Geotechnical properties of Black Cotton soil.
- To determine the effect of adding Fly ash, Marble dust, Wheat Husk Ash to BC soil on its properties.
- To determine the change in mechanical & engineering properties associated with addition of different percentage of Fly ash, Marble dust, Wheat Husk Ash.
- To design an economical pavement using IRC-37-2012.

V. MATERIAL USED

- Black cotton soil
- Fly Ash
- Wheat Husk Ash
- Marble Dust

- **Black cotton soil**: Black cotton soils are expansive clays with high potential for shrinking or swelling as a result of changing moisture content. Due to intensive shrink-swell processes, surface cracks resulting in openings during dry seasons. These openings are usually more than 50mm wide and several millimeters deep. Cracks disappear during wet season but an uneven soil surface stays as a result of irregular swelling and heaving. The black cotton soils have low strength and are susceptible to excessive volume changes, making their use for construction purposes very difficult. Instability of these soils cause more damage to structures, than any other natural hazard, including earthquakes and floods, unless proper black cotton soil stabilization performed.

Table 1 Property of soil

Liquid limit	60.5
Plastic limit	28
Plasticity index	32.5
Shrinkage	8.225
OMC	18%
MDD	1.6
Free swell	40%

- **Fly ash** : Fly ash is a peculiar material generated from burning pulverized coal in electric power generating plants some waste materials such Fly Ash may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are CBR value, shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity etc.

Table 2 Chemical property

Compounds	**(mass percent)**
SiO_2	40
Al_20_3	17
Fe_2O_3	6
Coo (Lime)	24
MgO	5
SO_3	3

- **Marble dust**: Marble is a non-foliated metamorphic rock composed of re-crystallized carbonate minerals, most commonly calcite or dolomite. Geologists use the term "marble" to refer to metamorphosed limestone; however, stonemasons use the term more broadly to encompass un-metamorphosed limestone Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color and appearance: it is white if the limestone is composed solely of calcite (100% CaCO3). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand.

Chemical Property of marble dust Table 3

Compounds	**Composition**
SiO_2	3.89
Al_20_3	2.785
Fe_2O_3	0.603
CaO (Lime)	62.94
MgO	22.13
Other compounds	7.652

- **Wheat Husk Ash:** Wheat is planted to a limited extent as a forage crop for livestock and the straw can be used as fodder for livestock or as a construction material for roofing thatch. Wheat husk is a lingo cellulosic waste product which is about 15–20% of wheat and some extents of wheat husk uses as cattle food and fuel

Table 4 Chemical Property of Wheat husk ash

Compound	Value
SiO_2	43.22
K_2O	11.3
MgO	0.99
Fe_2O_3	0.84
Na_2O	0.16
MnO_2	0.02
Cr_2O_3	0.0004
CaO	5.46

VI. METHODOLOGY

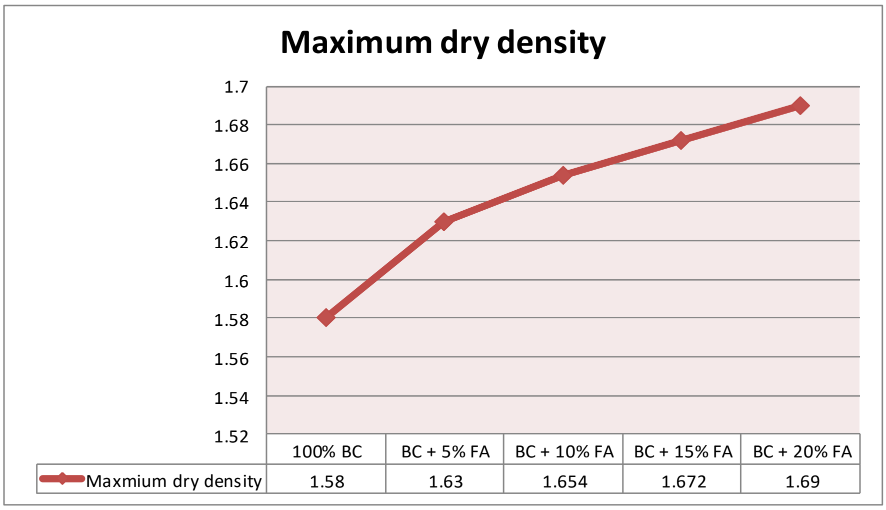
- First exiting Black Cotton soil brought to laboratry from field then various test will be perform on untreated soil.The following test will be perform on vergin soil.
  1. Grain size distribution
  2. Liquid limit test
  3. Plastic limit test
  4. Compaction test
  5. CBR test
- Black cotton soil will be mixed with different proportion of flyash , Marble dust and wheat Husk Ash composition as 0% to 20 %, to soil. Follwing test will be conducted on treated soil:
  1. Compaction test
  2. CBR test
- Black cotton soil will be mixed (10% of flyash with 10% Marble dust) and (10% of flyash with 10% wheat Husk Ash). Follwing test will be conducted on treated soil:
  1. Compaction test
  2. CBR test
- Change in soil properties will be observed on treated & untreated soil.

VII. RESULT AND OBSERVATIONS

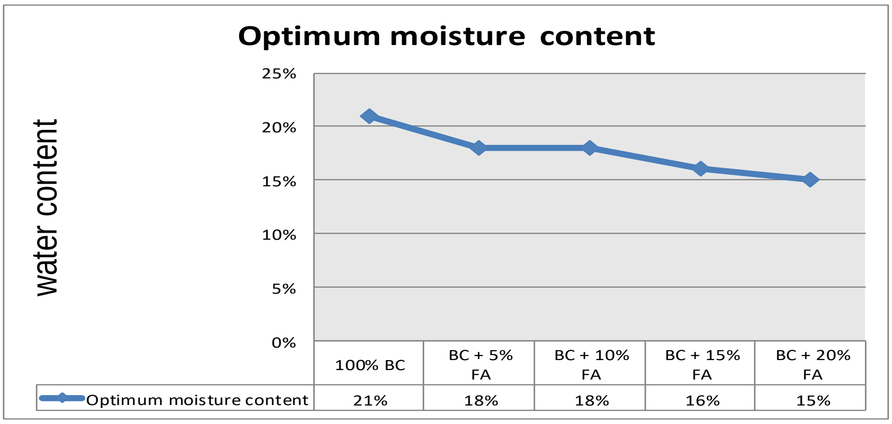
- **Result on flash**: The table 6 shows the variation of OMC MDD and CBR with the variation of flash at different percent in soil. It was found that the maximum CBR is obtain at 20% Fly ash having OMC 18% and MDD 1.69

Table 5 Combination BC soil and Fly ash

Combination	OMC	MDD	CBR(Soaked)
BC soil	21%	1.58	1.48
BC soil + 5% FA	18%	1.63	2.01
BC soil + 10% FA	18%	1.654	2.42
BC soil + 15% FA	16%	1.672	2.61
BC soil + 20% FA	15%	1.69	2.83



Graph 1: shows the relationship between MDD at different percentage of flyash



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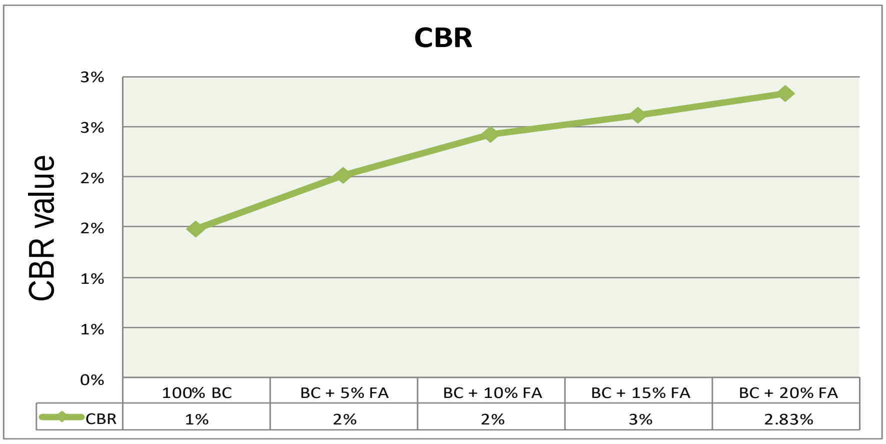
Graph 2 shows the relationship between OMC at different percentage of flyash

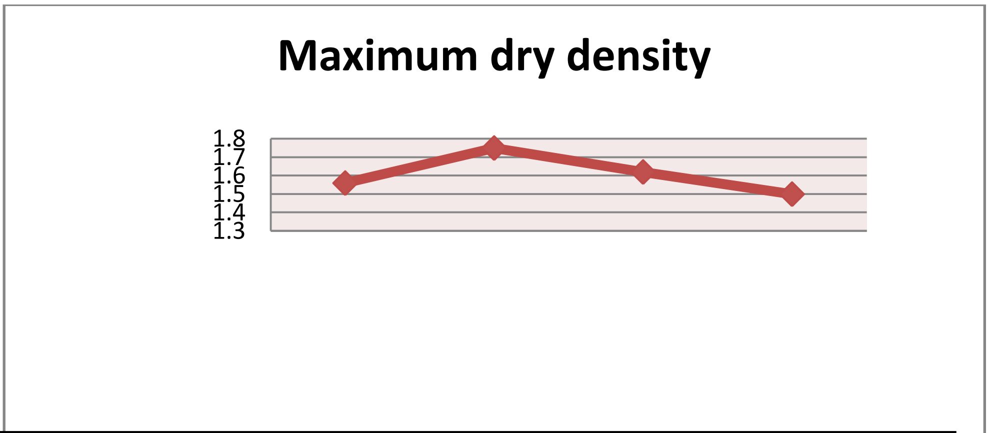


Graph 3: shows the relationship between CBR at different percentage of flyash

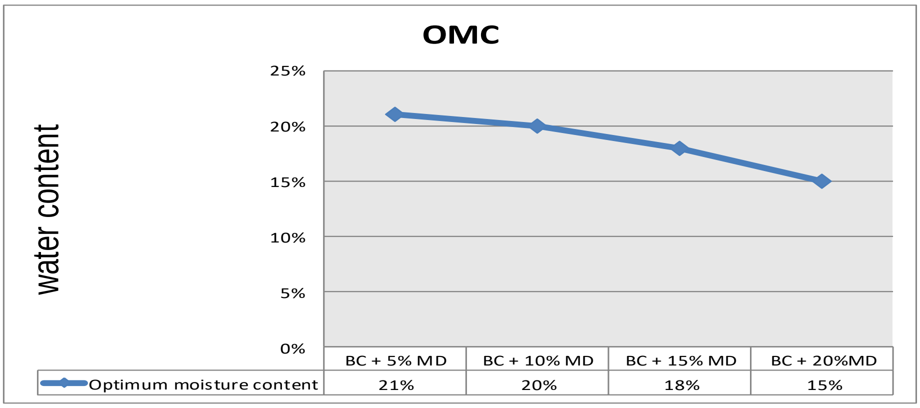
- **Result on Marble Dust**: The table 7 shows the variation of OMC MDD and CBR with the variation of Marble dust at different percent in soil. It was found that the maximum CBR is obtain at 15% Marble dust having OMC 18% and MDD 1.62.

Table 6 Combination BC soil and Marble Dust

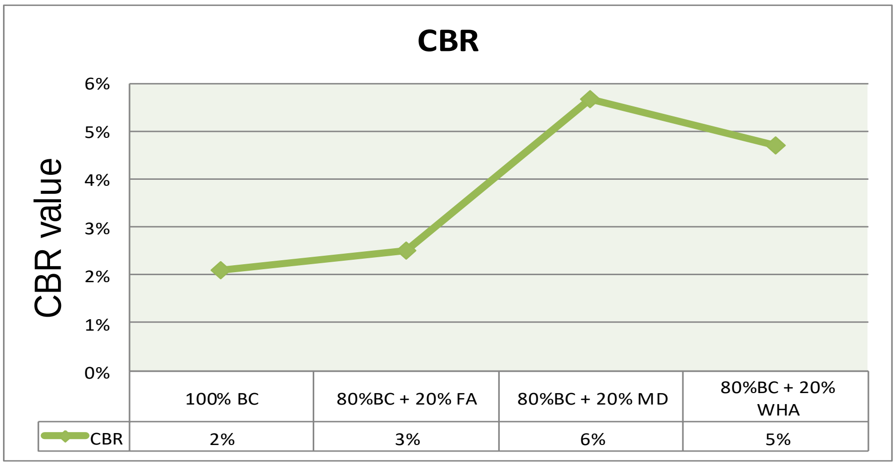
Combination	OMC	MDD	CBR(Soaked)
BC soil + 5% MD	21%	1.56	2.1
BC soil + 10% MD	20%	1.75	2.52
BC soil + 15% MD	18%	1.62	5.67
BC soil + 20% MD	15%	1.5	4.7



Graph 4 shows the relationship between MDDat different percentageof Marble dust



Graph 5 shows the relationship between OMCat different percentages of Marble Dust

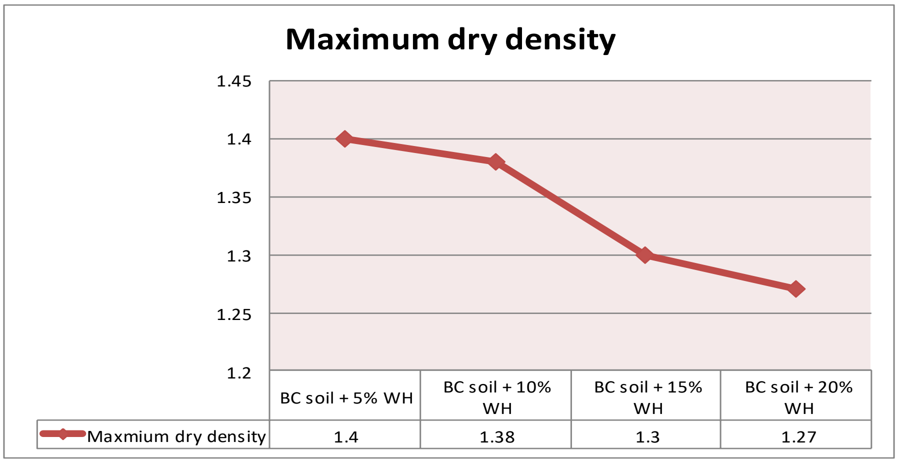


Graph 6 shows the relationship between CBR at different percentage of Waste material

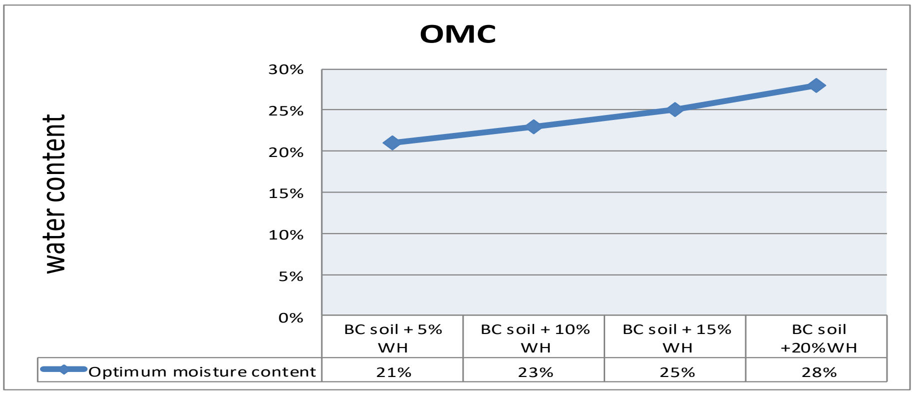
- **Result on Wheat husk ash:** The table 8 shows the variation of OMC MDD and CBR with the variation of wheat husk at different percent in soil.It was found that the maximum CBR is obtain at 3.15% Wheat husk ash having OMC 23% and MDD 1.38.

Combination BC soil and Wheat husk ash Table 8

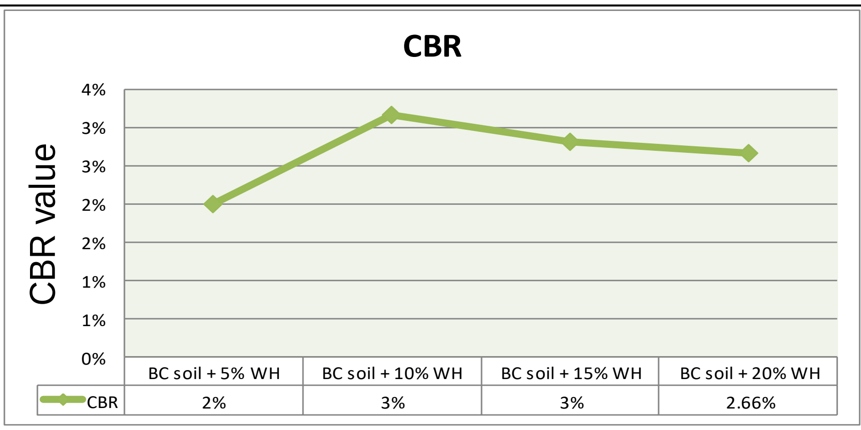
Combination	OMC	MDD	CBR(Soaked)
BC soil	21	1.58	1.48
BC soil + 5% WH	21%	1.4	2
BC soil + 10% WH	23%	1.38	3.15
BC soil + 15% WH	25%	1.3	2.8
BC soil + 20% WH	28%	1.27	2.66



Graph 7 shows the relationship between MDD at different percentage of wheat husk ash



Graph 8 shows the relationship between water content at different percentage of flyash



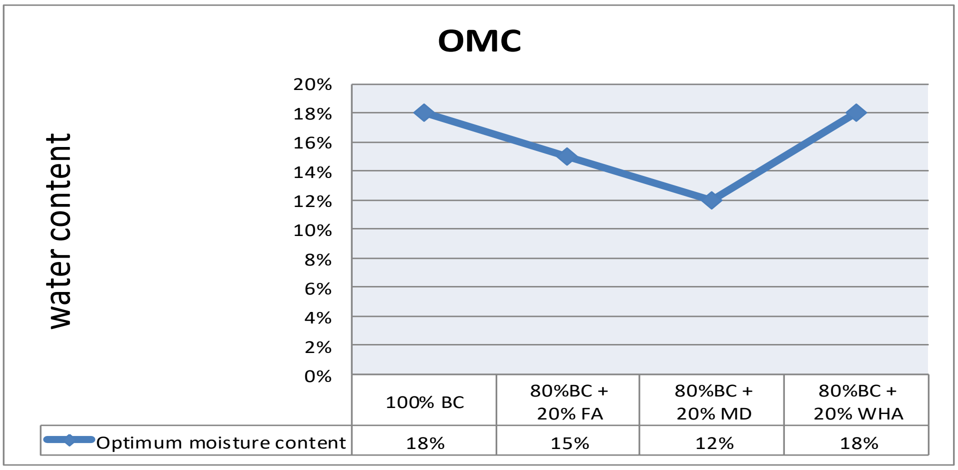
Graph 9 shows the relationship between CBR at different percentage of WH

Table 9 Combination BC soil, Fly ash and Wheat husk ash

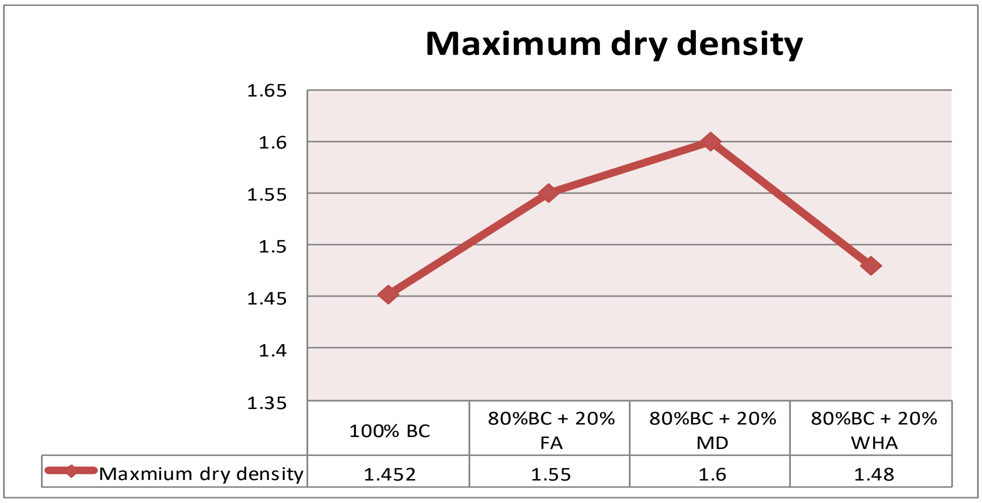
Soil Combination	OMC	Max. Dry Density	CBR Value
Pure B.C. Soil	14%	1.455	3%
B.C. Soil + 20% Fly Ash	15%	1.55	3.9%
B.C. Soil + 20% Marble Dust	12%	1.6	5.8%
B.C. Soil + 20% Wheat Husk Ash	18%	1.48	3.3%
B.C. Soil + 10% Fly Ash + 10% Marble Dust	13%	1.65	6%
B.C. Soil + 10% Fly Ash + 10% Wheat Husk Ash	18%	1.58	5.5%

Comparative Graphs

1. For different proportions of material with B.C. soil



Graph 10 shows the relationship between OMC at different percentage of waste material



Graph 11 shows the relationship between MDD at different percentage of waste material

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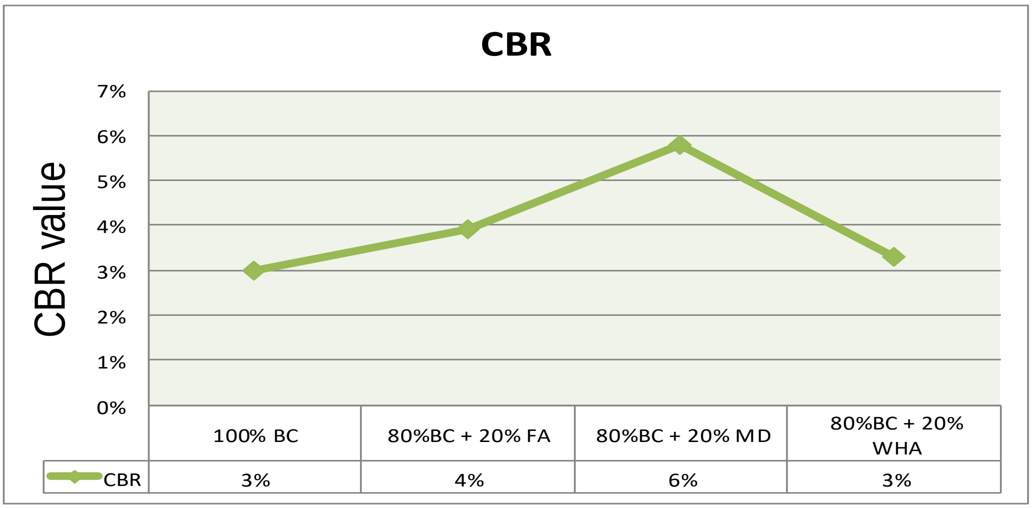
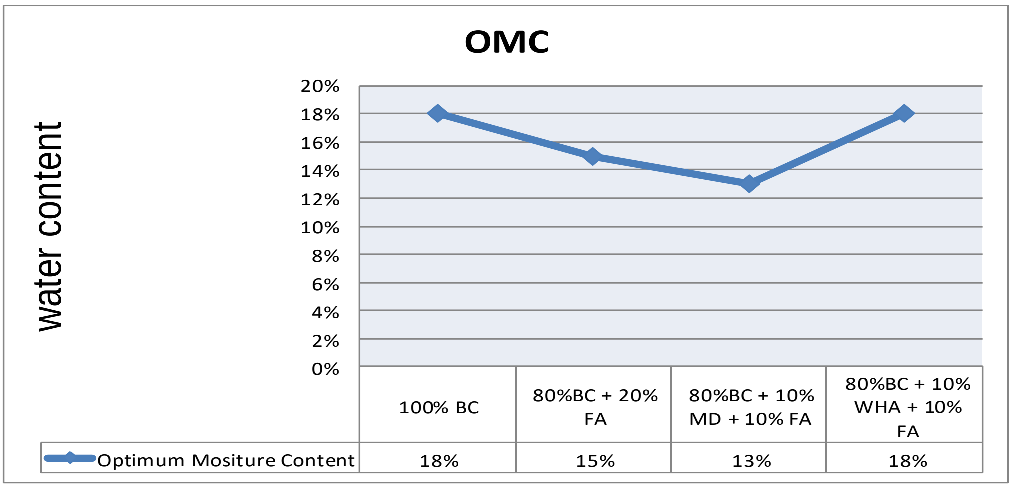
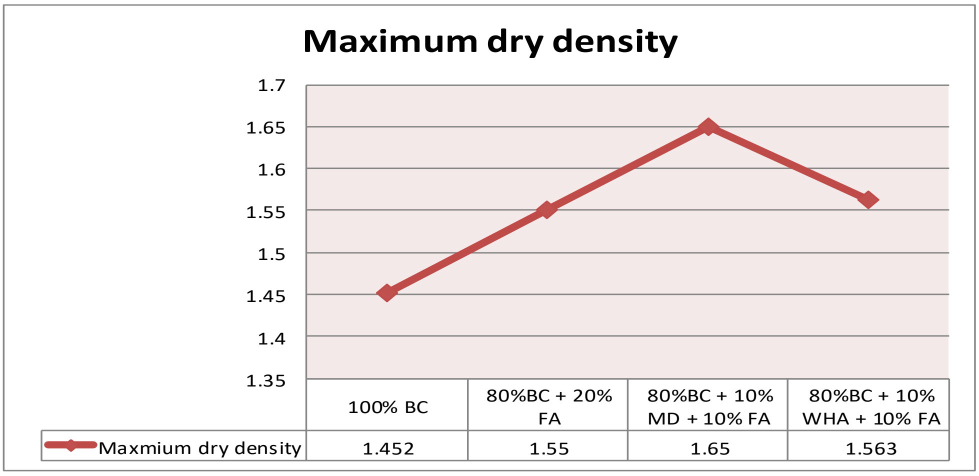


Graph 12 shows the relationship between CBR at different percentage of waste material

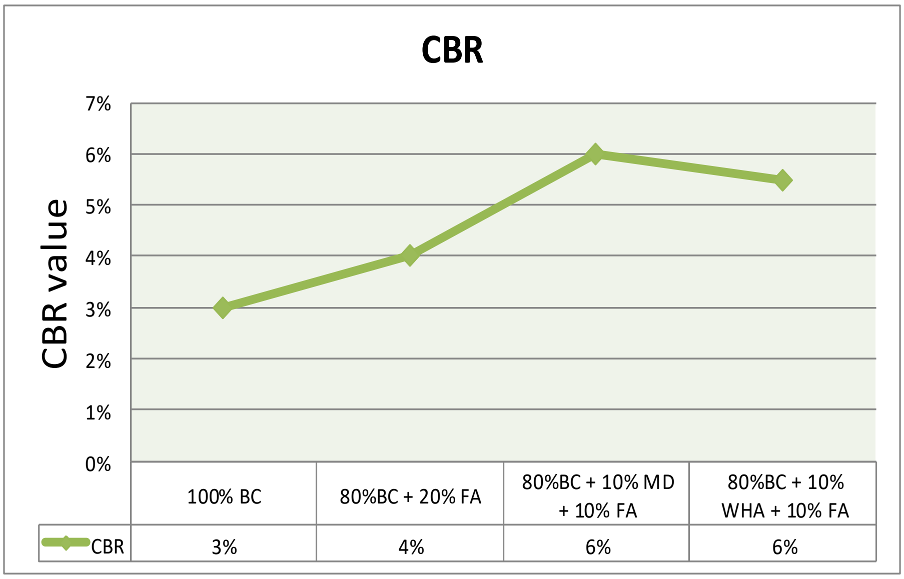
2. For combination of different material with B.C. soil



Graph 13 shows the relationship between water content at different percentage of Waste Material



Graph 14 shows the relationship between MDD at different percentage of flyash



Graph 15 shows the relationship between CBRat different percentage of flyash

VIII. COMPUTATION OF DESIGN TRAFFIC

As Per IRC 37 2012

Thicknesses of different crust of flexible pavement are as follows:-

- For CBR value 3% (Pure B.C. Soil)
  - Granular Sub-base = 300mm.
  - Granular base = 250 mm.
  - Dense bituminous macadam = 115mm.
  - Bituminous concrete = 40 mm.

Table 10 Computation of design traffic

Layers	CBR (5.67)	CBR (6.5)
Granular sub base	276	245
Granular base	250	250
Dense bitumen macadam	111.65	122.5
Bituminous concrete	40	50

IX. CONCLUSIONS

- By our study we conclude that the mixture of black cotton soil with 10% fly ash and 10% marble dust has most MDD and greatest CBR value. Furthermore the pavement designed by this value is most economical.
- It was found that by adding of 20% fly ash increases highest CBR value as well as MDD of the soil.
- It was found that by adding of 15% Marble dust increases highest CBR value as well as MDD of the soil.
- It was found that by adding of 10% of wheat husk ash increases highest CBR value as well as MDD of the soil.
- The Comparative growths of properties are given in table & graphs above.

X. REFERENCES

[1] Laxmikant Yadu (2014): Comparison of fly ash and wheat husk ash stabilized black cotton soil.
[2] Mohammed Y. Fatta (2013): Improvement of Clayey Soil Characteristics Using Rice Husk Ash
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