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A LABORATORY INVESTIGATION ON THE EFFICIENCY OF EXPANSIVE SOIL TREATED WITH RICE HUSK ASH AND FERRIC CHLORIDE AS SUB GRADE FOR FLEXIBLE PAVEMENTS

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Abstract-- Expansive soils are widely distributed approximately one-sixth of the total area of our country. Expansive soil causes great damage to infrastructures is very common. In view, construction of buildings on unsuitable ground is not able to be avoided and making a suitable ground before constructions is real challenging issue for Geotechnical Engineers. To overcome the difficulties experienced by the expansive soil in geotechnical applications on one side and safe disposal of solid wastes on the other side, an attempt is made to investigate the possibilities of utilizing the solid wastes to improve the strength and engineering behaviors of the expansive soil. In this, present investigation the type of solid waste namely Rice Husk Ash for stabilization is selected to study the effects and engineering characteristics of the expansive soil. The present study deals with the strength behavior of the expansive soil collected from Rellugadda nearby Amalapuram, East Godavari district, Andhra Pradesh, India.The rice husk ash is mixed with soil in various proportions like 5%, 10%, 15%, 20%. The various tests are conducted on these proportions of rice husk ash and tests have been carried out and results were reported in this paper.

Key Words—Expansive Soil, Rice Husk Ash, Ferric Chloride, Optimum Moisture Content (OMC) & Maximum Dry Density (MDD), CBR

I. INTRODUCTION

In construction of pavements the subgrade plays major in development of roads for transportation in India. Subgrade is the main constituent of the pavement for caring the loads. It is necessary to check the required properties of subgrade to bear the designed traffic. Otherwise, the service of the pavement gets gradually decreased. To solve this problem, different methods have been developed for improving the characteristics of the subgrade pavement.

In present study, Rice Husk Ash and Ferric chloride are added to expansive soil to evaluate its performances through laboratory tests such as standard proctor test and California bearing ratio strength test,

II. REVIEW OF LITERATURE

Dr.D Koteswara rao et al., (2011) studied the properties of expansive soil before and after treated with vitrified polished waste. K.Divya Krishna et al., (2014) different additives for soft soil and also in soil cement. The effect of sea shell powder on black cotton soil was investigated by K.Mounika et al., (2014). Maheshwari .G.Bisanal et al., (2015) studied the properties of expansive soil treated with sea shell powder. R.Bharathan et al.,(2017) studied about reducing the settlement in clay soil by adding silica fume and cement and improving the soil properties. M.T.S Lakshmayya and G. Aditya (2017) study the stabilization technique is adopted by the usage of phosphogypsum for expansive subgrade soil.

Fig.1 Rice Husk Ash

Fig.2 Ferric Chloride

II. OBJECTIVES OF STUDY

The objectives of the present laboratory investigation are as follows.

- To identify the strategy of techniques to overcome the problems posed by expansive soil with a view to adopt suitable methodology through critical review of literature.
- To determine the properties of the expansive soil and Rice Husk Ash.
- To evaluate the performance of expansive soil treated with optimum percentage of Rice Husk Ash as an admixture percentage variation of Ferric Chloride as an additive.

III. MATERIALS USED

A. Expansive Soil (ES)

The soil used in this study is of expansive in nature, collected from Rellugadda village which is nearby Amalapuram, East Godavari District, Andhra Pradesh at a depth of 1.5m from ground level. The Index and Engineering properties of the expansive soil were determined as per IS codes of practice. The geotechnical properties of the air dried expansive soil, the liquid limit, plastic limit, specific gravity, differential free swell, Compaction, CBR as per IS Codes of practice were determined and the results were tabulated as follows.

Table 1 GEOTECHNICAL PROPERTIES OF THE UNTREATED EXPANSIVE SOIL

SI.NO	**Property**		**Expansive Soil**
1	Gravel	(%)	3
2	Sand	(%)	10
3	Fines (%)	silt	24
		clay	63
4	Liquid limit	(%)	62.06
5	Plastic limit	(%)	29.17
6	Plastic index	(%)	32.89
7	Soil classification		CH
8	Specific gravity		2.56
9	Differential of Free Swell (%)		120
10	O.M.C	(%)	19.88
11	M.D.D	(g/cc)	1.56
12	Cohesion	(KN/m^2)	106
13	CBR	(%)	1.58
14	Angle of shear resistance(ϕ)		5.4^0

B. Rice Husk Ash(RHA)

The rice husk ash was collected from Sri Radha Krishna rice mills Mogalturu, Andhrapradesh. In the form of ash which is a solid wasted which is disposed in the empty barren land as a solid waste. Rice Husk Ash is the by-product material produced from the process of manufacturing puffed rice and contains of large amount of iron oxide and silicate. It has higher density, stay in the top layer and then transported to a water basin with a low temperature for solidification.

Table 2 PHYSICAL COMPOSITION OF RICE HUSK ASH

Physical composition	**Percentage %**
Colour	Gray
Shape Texture	Irregular
Mineralogy	Non Crystalline
Praticle size	< 45micron
Odour	Odourless
Specific gravity	2.3
Appearance	Very fine

Table 3CHEMICAL COMPOSITION OF RICE HUSK ASH

Chemical composition	**Percentage %**
SiO_2	76.30
Al_2O_3	2.90
CaO	2.36
Fe_2O_3	1.67
MgO	0.31
Loss in ignition	4.87

(Courtesy :Sri Radhakrishna Rice Mills, AP**)**

Table 4 CHEMICAL COMPOSITION OF FERRIC CHLORIDE

Chemical composition	**Percentage %**
CaO	0.55
SiO_2	87.20
SO_3	0.24
MgO	1.81

(Courtesy: Andhra Scientifics and Chemicals, Kakinada)

V.LABORATORY INVESTIGATION

The laboratory studies were carried out on the Expansive soil, Expansive soil with percentage variation of Rice Husk Ash for obtaining the optimum mix and soil with optimum percentage of Rice Husk Ash with percentage variation of Ferric Chloride.

A. Liquid limit

The Liquid limit test was conducted on Expansive soil, Expansive soil+15% RHA, expansive soil+15% RHA and 1.5% Ferric Chloride mixes using Casagrande’s liquid limit apparatus as per the procedures given in the IS: 2720 part 4 (1970).

B. Plastic limit

Similarly the Plastic limit test was conducted, Expansive soil, expansive soil with optimum of RHA and expansive soil with optimums of RHA and Ferric Chloride as per the producers given in the IS: 2720 part 4 (1970).

C. Differential Free Swell:

Differential Free Swell (DFS) is a parameter used for the identification of the expansiveness of the soil. To determine the free swell of a soil, 20g of oven dry soil passing through 425µ size sieve is taken. One sample of l0g is taken into a l00cc capacity graduated cylinder containing water, and the other sample of 10g is taken into a l00cc capacity graduated cylinder containing kerosene oil.

$$\text{Differential Free Swell (\%)} = \frac{vd-vk}{vk} * 100$$

Where,

V_d = volume of soil specimen read from the graduated cylinder containing distilled water.

V_k = volume of soil specimen read from the graduated cylinder containing kerosene.

Because kerosene is a non-polar liquid, it does not cause any swell of the soil IS: 2720 (Part III- l980) gives degree of expansion of a soil depending upon its differential free swell as under.

Table 5 RANGE OF DIFFERENTIAL FREE SWELL

S. No	Differential Free Swell	DFS
1	Low	<20%
2	Moderate	20-35%
3	High	35-50%
4	Very High	>50%

D. Modified proctor compaction Test

The expansive soil was treated with different percentages of admixture i.e., the RHA. Rice Husk Ash was replaced with the expansive soil in different percentages varying from 5% to 20% to improve the properties of the soil. table 5 represents the OMC and MDD values of untreated expansive soil and also treated expansive soil with percentage variation of RHA.

E. Specific Gravity Test

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at the stranded temperature both the weights are taken in air. Specific gravity test was carried out by Pycnometer as per IS 2720 Part 3 (1980).

F. California Bearing Ratio Test

The California bearing ratio test was conducted on the soil sample with 4 varying percentages of RHA. Rice Husk Ash added to soil in varying percentages (5%,10%,15%,20%) respectively. CBR value increases up to 15 % addition of Rice Husk Ash, by further adding RHA the CBR value of soil decreases. The maximum value of CBR for 15 % addition of RHA was obtained as 6.13%. The CBR value showed an Increase from 1.58% to 6.13% at 15% addition of RHA. Further on addition of 5% FC to soil and 15% RHA the CBR increased from 6.13% to 8.58%. The test was penetration test in which a standard piston, with a diameter of 50mm is used to penetration the soil at a standard rate of 1.25mm/min. The proving ring reading is noted for 50 divisions, and loading was continued until 3 (or) more readings and take decreasing (or) constant values. The test was conducted at Optimum moisture content. The samples were tested in soaked condition.

G. Modified Compaction Test Results

Table 6 OMC AND MDD VALUES OF UNTREATED & TREATED EXPANSIVE SOIL WITH PERCENTAGE VARIATION OF RICE HUSK ASH

Expansive soil with % variation of RHA	MDD (gm/cc)	OMC (%)
Soil	1.575	19.88
Soil+5%RHA	1.577	19.53
Soil+10%RHA	1.592	18.94
Soil+15%RHA	1.652	18.48
Soil+20%RHA	1.606	18.15

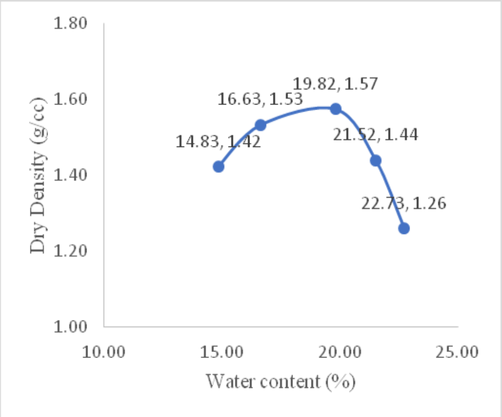

Fig.3 OMC & MDD soil treated with 5% RHA

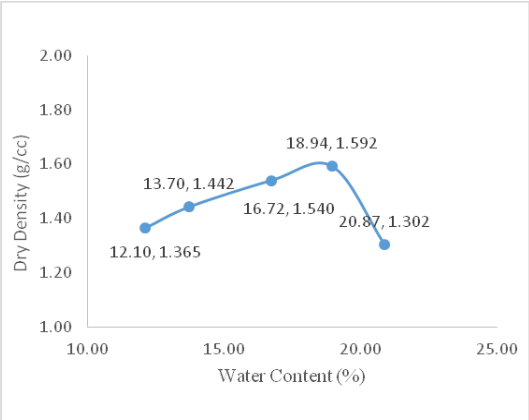

Fig.4 OMC & MDD soil treated with 10% RHA

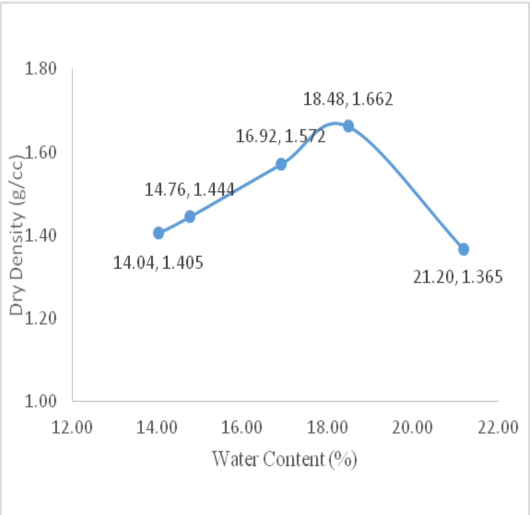

Fig.5 OMC & MDD soil treated with 15% RHA

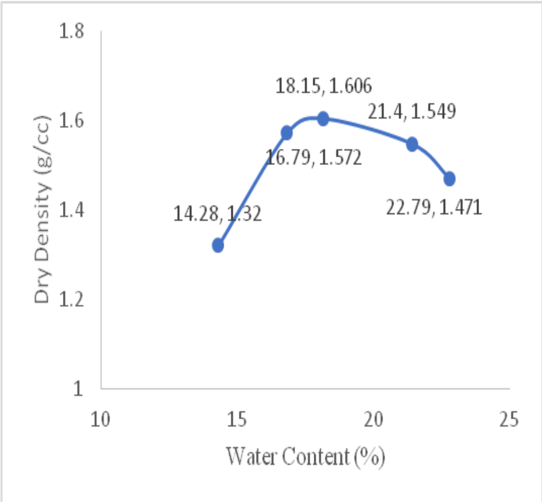

Fig.6 OMC & MDD soil treated with 20% RHA

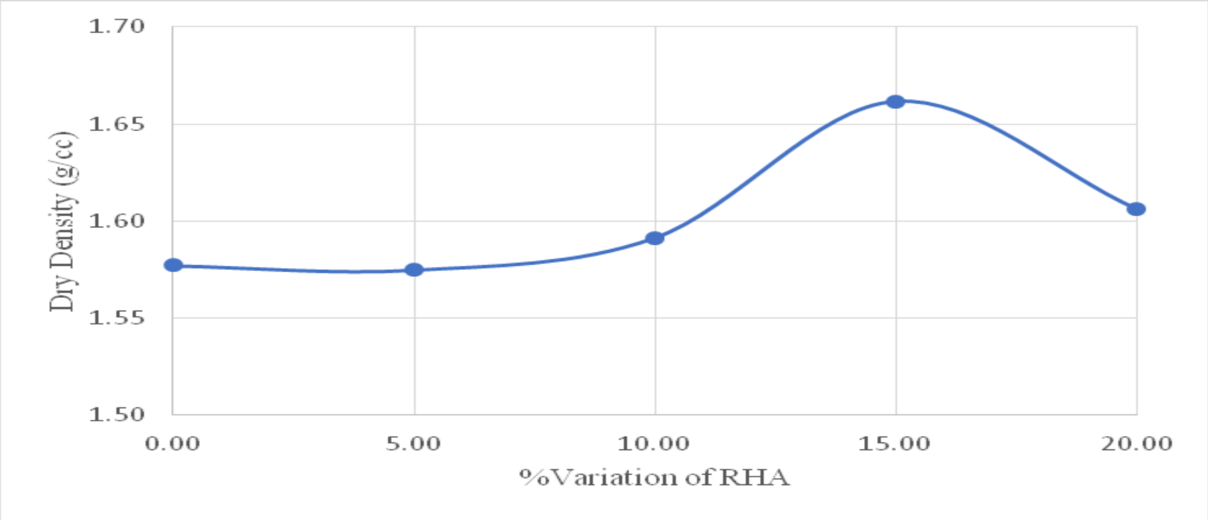

Fig.7 MDD of the soil treated with % variation of RHA

H. CBR TEST RESUTLS

The soaked CBR values of various mixes of Expansive Soil and RHA using OMC obtained from compaction are determined. The CBR specimen in the mould is soaked in the water for four days, and fully saturation is likely to occur, is also determined. Variation of CBR with % variation in Rice Husk Ash (RHA) is presented.

Table 7 CBR VALUES OF UNTREATED & SOIL TREATED WITH % VARIATION OF RHA

Soil treated with % variation of RHA	**Soaked CBR (%)**
Soil	1.58
Soil+5%RHA	1.80
Soil+10%RHA	2.24
Soil+15%RHA	**6.13**
Soil+20%RHA	2.55

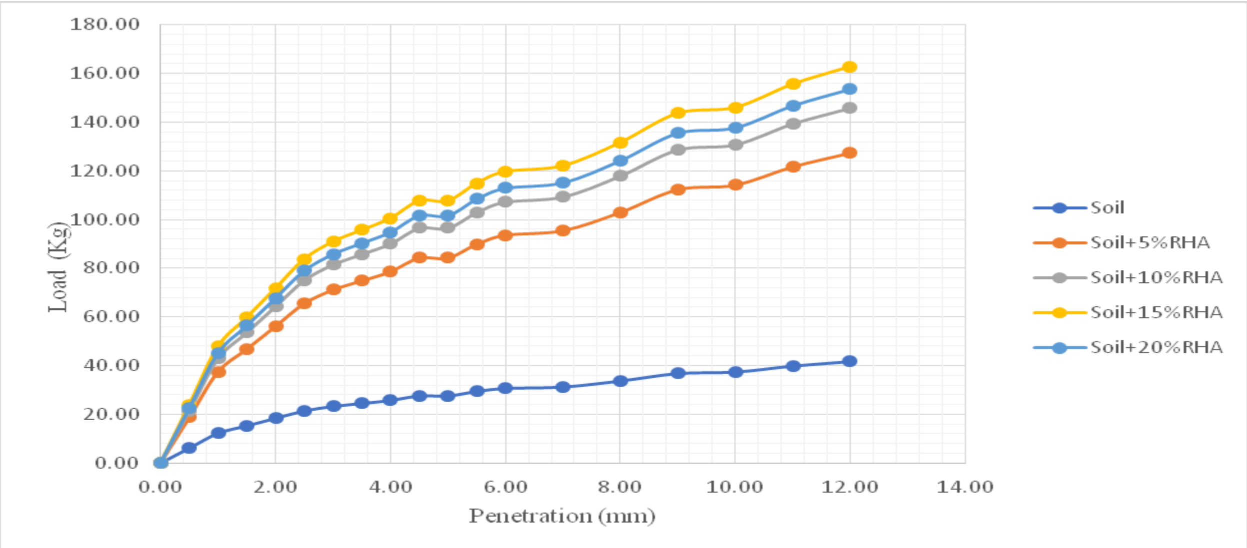

Fig.8 CBR values of untreated & expansive soil treated with % variation of RHA

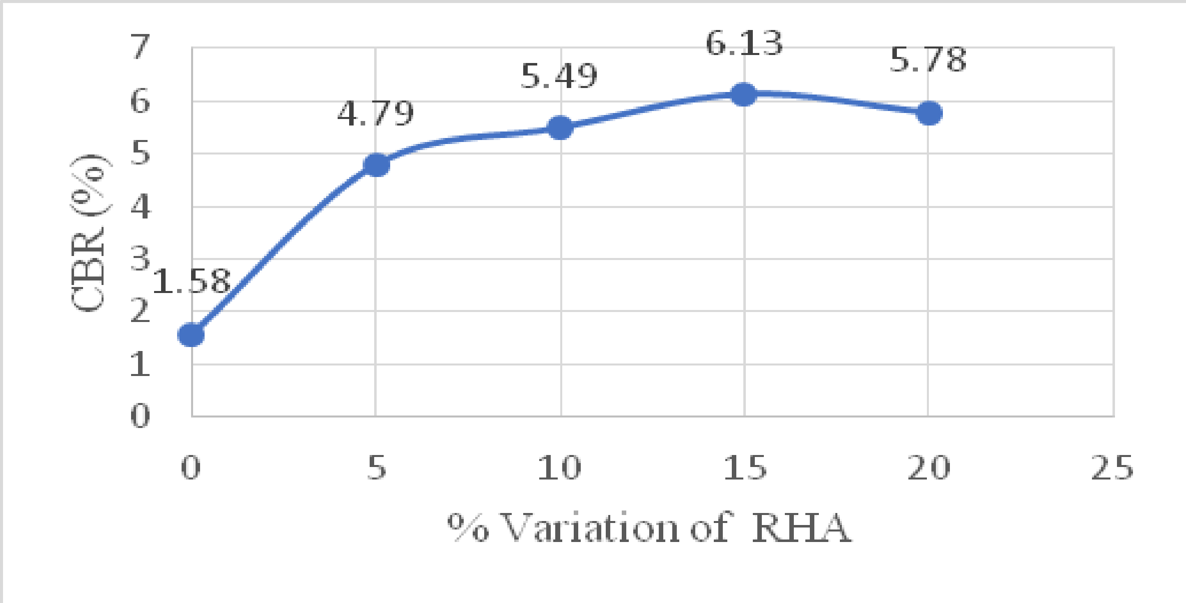

Fig.9 CBR Values of Expansive Soil with % Variation of Rice Husk Ash

DISCUSSION-1

It was observed from the laboratory test results that expansive soil treated with an optimum of 15% of RHA has exhibited the CBR value of 6.13% which is less as per IS codes of practice to use this treated expansive soil as sub grade for flexible pavements. Hence it is essential to improve this treated expansive soil by taking an attempt with the addition of suitable chemical for further improving the CBR value to suit this treated soil as subgrade for flexible pavements as per IS-2720 (Part-16) and IRC:37-2012, pp:10. In the present study Ferric Chloride was used for further improvement in CBR value of the expansive soil treated with an optimum percentage of RHA.

Initially, the OMC, MDD and CBR values were determined for the treated expansive soil with percentage variation of Ferric Chloride and the results were shown in tables 7&8 respectively.

Table 8

OMC & MDD VALUES OF THE EXPANSIVE SOIL TREATED WITH AN OPTIMUM OF 15% RHA AND ON ADDITION OF PERCENTAGE VARIATION OF FERRIC CHLORIDE

1) OMC & MDD VALUES

RHA treated expansive soil with percentage variation of Ferric Chloride	**MDD (g/cc)**	**OMC (%)**
Soil+15%RHA+0.50%**$FeCl_3$**	1.563	17.486
Soil+15%RHA+1%**$FeCl_3$**	1.565	17.41
Soil+15%RHA+1.5%$FeCl_3$	**1.661**	**16.277**
Soil+15%RHA+2%**$FeCl_3$**	1.604	16.693

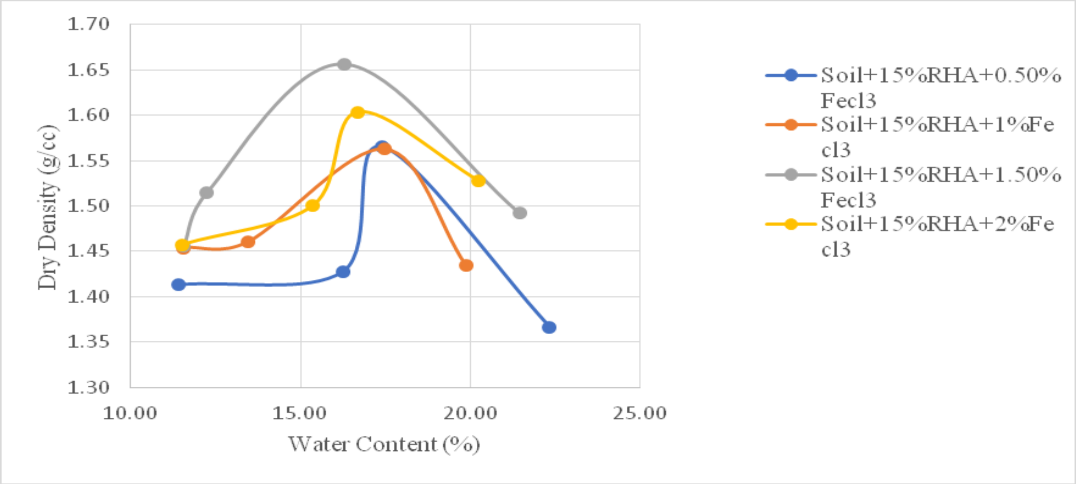

Fig.10 OMC&MDD values of soil treated with an optimum of 15% RHA upon adding percentage variation of Fecl$_3$

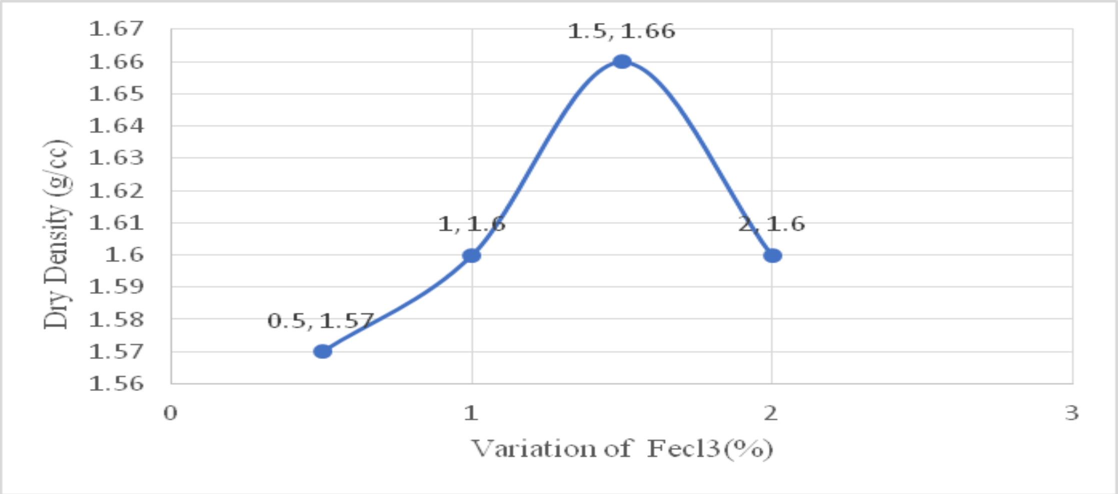

Fig.11 Present the MDD values of Soil+15%RHA+ % Variation of Fecl$_3$

Table 9 CBR VALUES OF THE SOIL TREATED WITH AN OPTIMUM OF RHA UPON ADDING PERCENTAGE VARIATION OF Fecl$_3$

RHA treated expansive soil with percentage variation of Fecl$_3$	**CBR (%)**
94.50%Soil+5%RHA+0.5%**Fecl$_3$**	1.661
89%Soil+10%RHA+1%**Fecl$_3$**	4.355
83.50%Soil+15%RHA+1.5%Fecl$_3$	**8.581**
78%Soil+20%RHA+2%**Fecl$_3$**	7.074

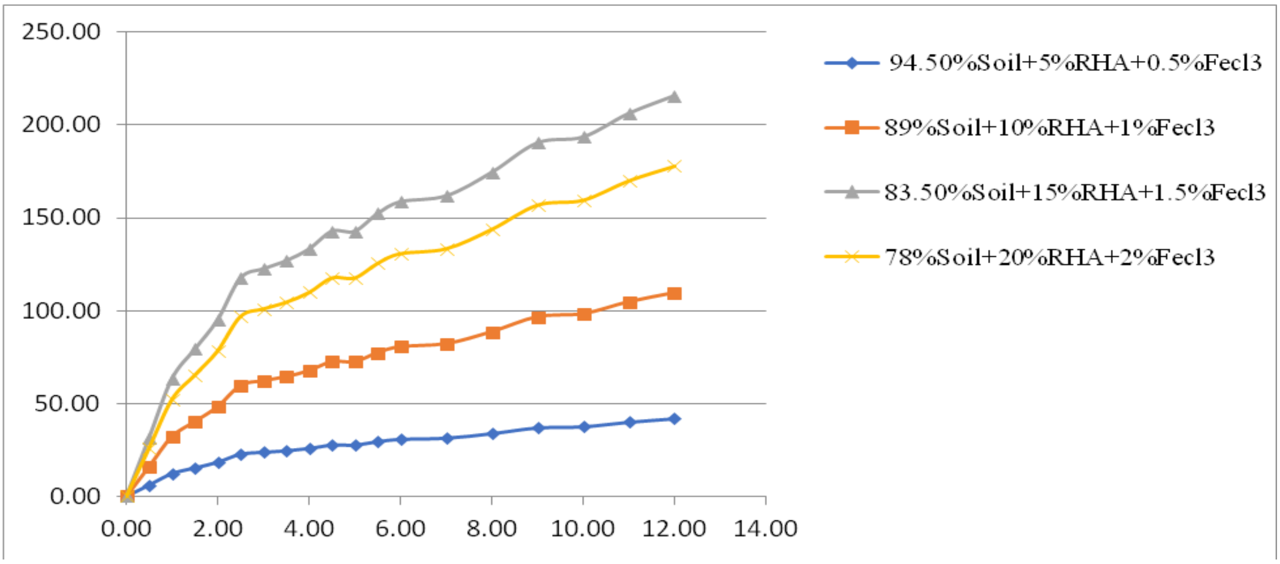

Fig.12 CBR test results of expansive soil treated with an optimum of RHA upon adding percentage variation of $FeCl_3$

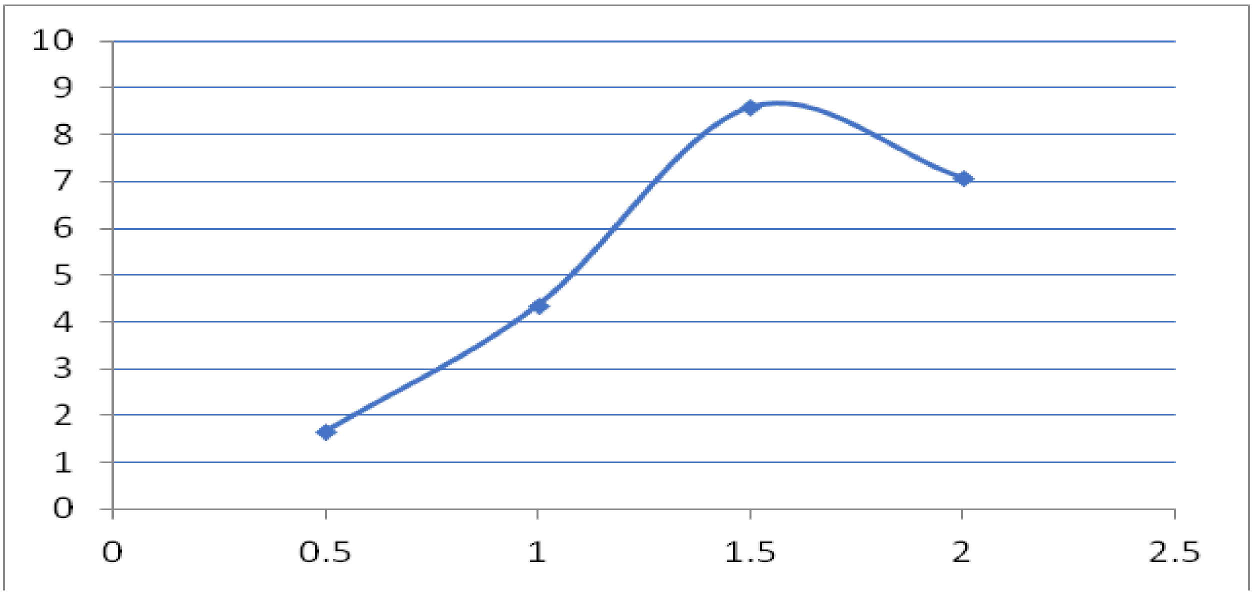

Fig.13 The Variation of CBR with the Percentage variation of Ferric Chloride

DICUSSION-2

It was observed from the laboratory test results that the expansive soil treated with an optimum of 15% RHA and 1.5% Ferric Chloride has exhibited the CBR value of 8.581% which is acceptable as per IS Codes of practice to use this treated expansive soil as subgrade for flexible pavements.

Hence the laboratory tests viz Liquid limit, Plastic limit, Plasticity Index, Compaction, CBR, Specific gravity, Differential Free Swell, Cohesion, angle of shear resistance was conducted on the expansive soil treated with the optimum percentage of RHA and Ferric Chloride. The results were present in the following table.

Table 10 LABORATORY TEST RESULTS OF THE UNTREATED AND TREATED EXPANSIVE SOIL

Si.No	Property	Untreated expansive soil	Expansive soil treated with 15% of RHA	Expansive soil treated with optimum percentages of 15% RHA and 1.5% $FeCl_3$
1	Liquid limit (%)	62.06	50.15	38.25
2	Plastic limit (%)	25.13	26.13	27.92
3	Plastic index (%)	36.93	24.02	10.33
4	Soil classification	CH	CH	CH
5	Specific gravity	2.55	2.65	2.73
6	D. F.S (%)	120	92	48
7	O.M.C	19.88	18.48	16.27
8	M.D.D (g/cc)	1.57	1.65	1.66
9	Cohesion (KN/m^2)	106	75	68
10	Angle of shear resistance(ϕ)	5.4^0	15^0	17^0
11	CBR (%)	1.58	6.13	8.58

VI. CONCLUSIONS

1) It is observed that the liquid limit of Expansive Soil has been decreased by 19.19% on addition of 15% Rice Husk Ash and it has been further decreased by 38.36% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
2) It is observed that the plasticity index of the Expansive Soil has been decreased by 34.95% on addition of 15% Rice Husk Ash and it has been further decreased by 72.02% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
3) It is noticed that the cohesion of Expansive Soil has been decreased by 29.24% on addition of 15% Rice Husk Ash and it has been further decreased by 35.84% on addition 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
4) It is noticed that the angle internal friction of Expansive Soil has been improved by 177.77% on addition of 15% Rice Husk Ash and it has been further improved by 214.81% on addition 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
5) It is found that the O.M.C of the Expansive Soil has been decreased by 7.04% on addition of 15% Rice Husk Ash and it has been further decreased by 18.15% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
6) It is found that the M.D.D of the Expansive Soil has been improved by 5.09% on addition of 15%, Rice Husk Ash and it has been improved by 5.73% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
7) It is observed that the C.B.R value of the Expansive Soil has been increased by 287.97% on addition of 15% Rice Husk Ash and it has been further improved by 443.03% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.
8) It is observed that the DFS value of the Expansive Soil, has been decreased by 23.33% on addition of 15% Rice Husk Ash and it has been further decreased by 60.00% on addition of 1.5% $Fecl_3$ as on optimum when compared with the untreated expansive soil.

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