ISSN: 2321-8169
799 – 806

A Study on Economy by Application of Agricultural Waste Materials for Improvement of Sub-grade of Flexible Pavement

Saibal Chakraborty, Lecturer in Civil Engineering, TET&SD Dept, Govt.of West Bengal.

S.P.Mukherjee, Professor in Civil Engineering, Jadavpur University, Kolkata

B.C.Chattopadhyay, Professor in Civil Engineering, Former Professor, IIEST, Shibpur

Abstract:- This paper presents results of an experimental investigation, carried out to study the effects of admixture like rice husk ash (RHA) on the strength properties of a locally available clayey soil with soft consistency. This soil was mixed with different proportions of RHA (3%, 6%, 9% and 12% by weight of dry soil) at corresponding optimum moisture content (OMC) and also at moisture contents 2% and 5% above optimum moisture content (OMC+2%), (OMC+5%). The cost of stabilization may be minimised by using the agricultural waste materials like RHA which also minimises the environmental hazards. The laboratory test results show marked improvement of strength of soil on addition of admixture (RHA) in terms of California Bearing Ratio (CBR). It appear from the experimental results, soaked CBR value of untreated soil is 3.50% and reaches maximum value i.e 16.80% when mixed with 9% RHA at the respective OMC. Further, an attempt has been made to observe the effect of moisture on the strength properties of the original as well as stabilized soil. The paper highlights the use of RHA for sub-grade improvement in case of low cost roads.

Keywords*: Soil, RHA, OMC, OMC+2%, OMC+5%, CBR.*

*****

I. INTRODUCTION

During the last few decades, rapid economic growth in the form of urbanization and industrialization all over the world has resulted in an increase in environmental pollution form different waste materials, which in many cases are discharged directly without any suitable treatment, to the surrounding.

India produces huge amount of different types of waste materials especially as a by-products from agricultural materials. Rice husk is one of the major agricultural waste materials obtained from different rice mills. About 770 million tons of rice husks are produced annually in Asia. In India produces rice husks nearly 120 million tons per year. Now the disposal of the husks is a big problem for the environment and also burning in open place is not desirable which creat a tremendous negative impact on the environment as well as natural ecological system. The proper disposal of these waste materials is very challenging task for the developing country like India. Thus systematic detailed investigation should be undertaken to make possible consumption of rice husk ash (RHA) for beneficial application in weak or soft soils to enhance the quality of such soil for possible cost effective use for constructions of road sectors in subgrade.

The present study had been carried out to investigate the strength improvement of soft soil for the construction of flexible pavement. Sub-grade soil may be mixed with the agricultural waste materials such as rice husk ash in isolation and also in different combinations. The major parameter for determining the strength improvement of soil is California Bearing Ratio (CBR) under soaked and unsoaked conditions at the optimum moisture contents(OMC), and also at water contents 2% and 5% more than optimum moisture contents(OMC+2%),(OMC+5%).

II. MATERIALS

The materials used in the present study were locally available clayey soil and rice husk ash. The physical properties of these materials are summarized one by one as follows:

SOIL

The soil used for this study was collected from Bidhannagar in Kolkata Municipal Corporation area in West Bengal, India at a depth of 2.5 to 3.5 m below the ground level using the method of disturbed sampling. The engineering properties of the soil used in this investigation are given in Table:1. The geotechnical properties of the soil classified as clay with high plasticity (CH) in the IS Soil Classification System.

ISSN: 2321-8169
799 – 806

Table.1: Engineering Properties of Soil

Basic Properties of Soil	Value
Sand (%)	5
Silt (%)	68
Clay (%)	27
Liquid Limit (%)	51
Plastic Limit (%)	28
Plasticity index (%)	23
IS Classification	CH
Specific Gravity	2.65

III. RICE HUSK ASH (RHA)

Rice husk is an agricultural waste material obtained from milling of rice in India. In this study the rice husk ash (RHA) was obtained from local rice mill at the Bashirhat sub division in North 24 Parganas District of West Bengal, India. The Physical properties of RHA are given in Table.2

Table 2: Physical Properties of RHA

Basic Properties of RHA	Value
Liquid Limit (%)	NP
Plastic Limit (%)	NP
Plasticity index (%)	NP
Specific Gravity	1.96
Maximum Dry Density(gm/cc)	0.85
Optimum Moisture Content (%)	32
Angle of internal friction(°)	38
CBR at OMC Unsoaked (%)	8.75
CBR at OMC Soaked (%)	8.15

IV. METHODOLOGY AND TEST PROGRAMME

The laboratory tests specimens of soil with and without admixtures were prepared by thorough mixing the required quantity of soil and stabilizers in pre-selected proportions in dry state and then required quantity of water was added and mixed thoroughly to get a homogeneous and uniform mixture of soil and admixtures. The sample of original and amended soil were tested with the relevant IS codes (IS:2720 part 3 to 16). The tests for original and amended soil include Atterberg limits, Compaction and CBR tests. The California Bearing Ratio (CBR) tests were performed under soaked and unsoaked conditions for the original soil and the stabilized soil at the optimum moisture content (OMC) and 2% more than optimum moisture content (OMC+2%). To study the effect of rice husk ash (RHA) with the addition of original soil in the proportion of 3%, 6%, 9% and 12% similar tests were also performed under the above conditions. The details of mix proportions are presented in Table: 3 and all the tests were carried out on each mix as per the test program presented in Table 5.

Table 3: Soil-RHA Mixes

SAMPLE NO	SOIL (%)	RHA (%)	REMARKS
1	100	0	Only Soil
2	97	3	Soil-RHA Mixes
3	94	6	
4	91	9	
5	88	12	

V. LABORATORY INVESTIGATION AND INTERPRETATION OF RESULTS

The influence of RHA mixed with the original soil individually and also in combinations were investigated by conducting various laboratory tests viz. Atterberg limits, standard proctor tests and CBR tests are presented in Table 4 and table 5.

Table 4: Atterberg limits and Compaction Properties

Sample No	LL (%)	PL (%)	PI (%)	MDD (gm/cc)	OMC (%)
1	51.0	28.0	23.0	1.630	15.92
2	51.6	29.0	22.6	1.552	21.32
3	52.4	30.8	21.6	1.481	22.21
4	53.3	32.4	20.9	1.440	24.2
5	53.5	33.0	20.5	1.378	26.42

Atterberg Limits

When only RHA is added liquid limit and plastic limit both increases and plasticity index decreases with the increase RHA content. This effect is due to the pozzolanic action of RHA. The variation of liquid limit, plastic limit and plasticity index with different percentage of RHA content are presented in Fig.1, Fig. 2 and Fig.3 respectively.

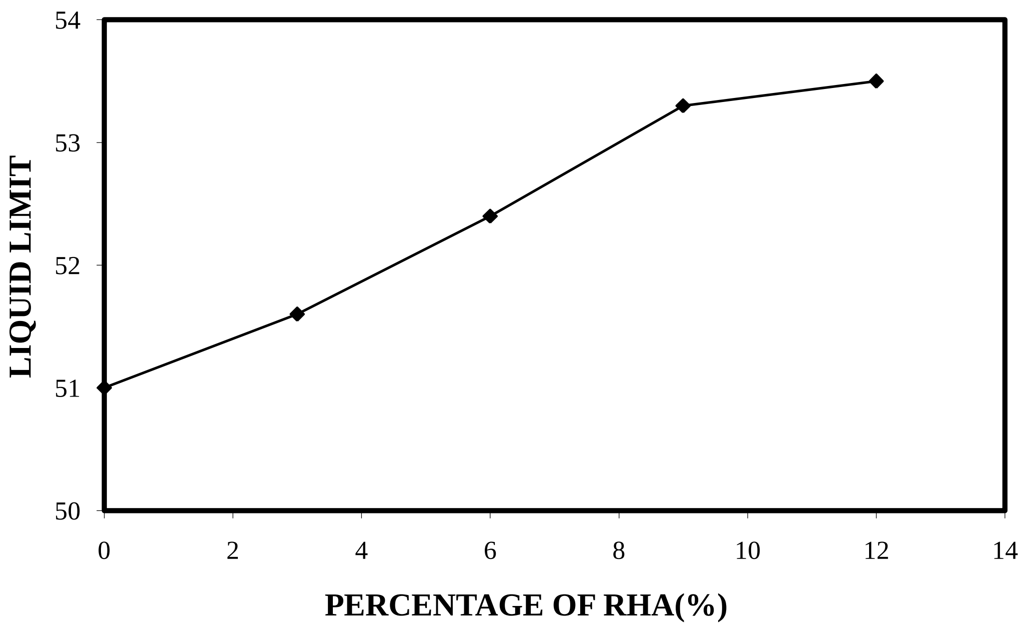


Fig. 1: Variation of Liquid Limit with different percentage of RHA contents

 ISSN: 2321-8169
799 – 806

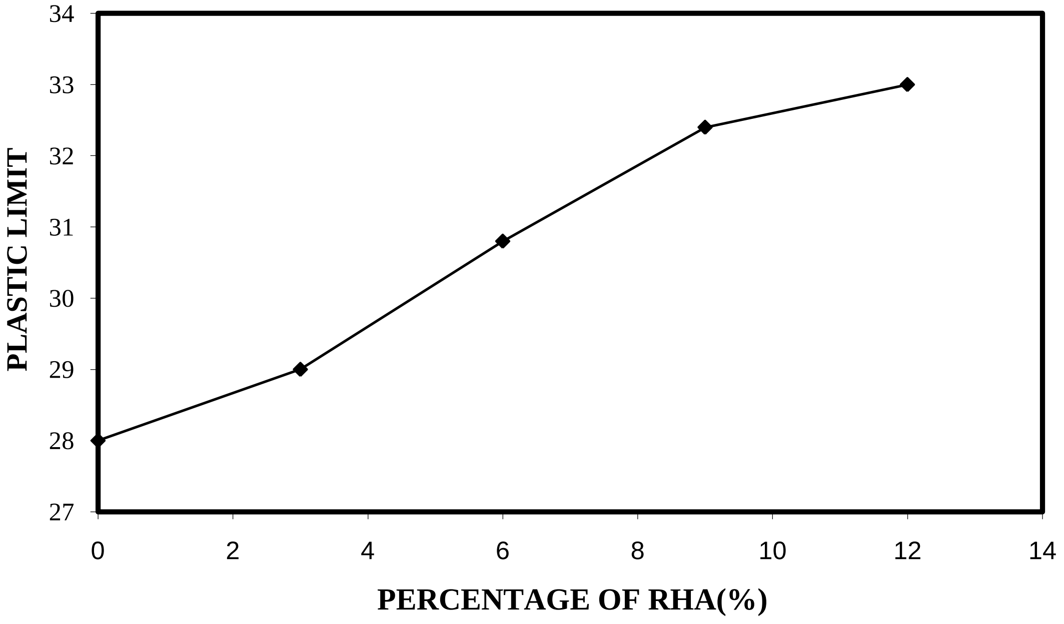


Fig. 2: Variation of Plastic Limit with different percentage of RHA contents

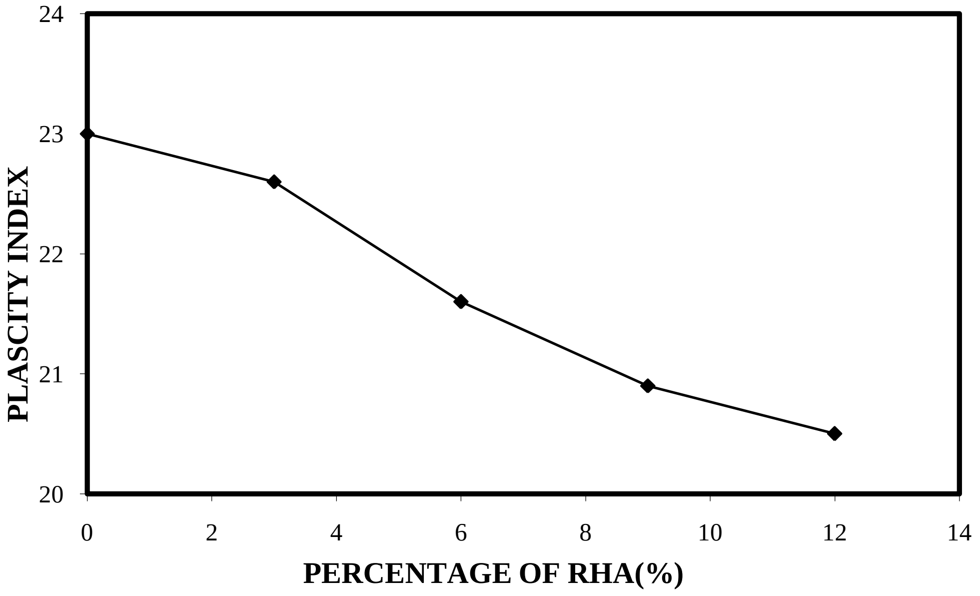


Fig. 3: Variation of Plasticity Index with different percentage of RHA contents

Compaction Characteristics

The variations of maximum dry density (MDD) and optimum moisture content (OMC) with the different percentages of rice husk ash (RHA) are shown in Fig. 4 and Fig.5 respectively. The maximum dry density (MDD) generally decreases, while the optimum moisture content (OMC) increases with increasing the RHA percentage. The decrease in MDD can be attributed by the replacement of soil and RHA mixture and also considering the RHA as filler in the soil voids. This is due to the flocculation and agglomeration of clay particles caused by cation exchange reaction leading to corresponding decrease in dry density. Accordingly, the increase in optimum moisture content (OMC) with the increase in RHA content reduced the surface area is caused by

ISSN: 2321-8169
799 – 806

flocculation and agglomeration. This is due to the addition of RHA, which decreases the amount of free silt and clay fraction and coarser materials with larger surface areas are formed. These processes need water to take place. This implies also that more water is required to compact the soil and RHA mixtures.

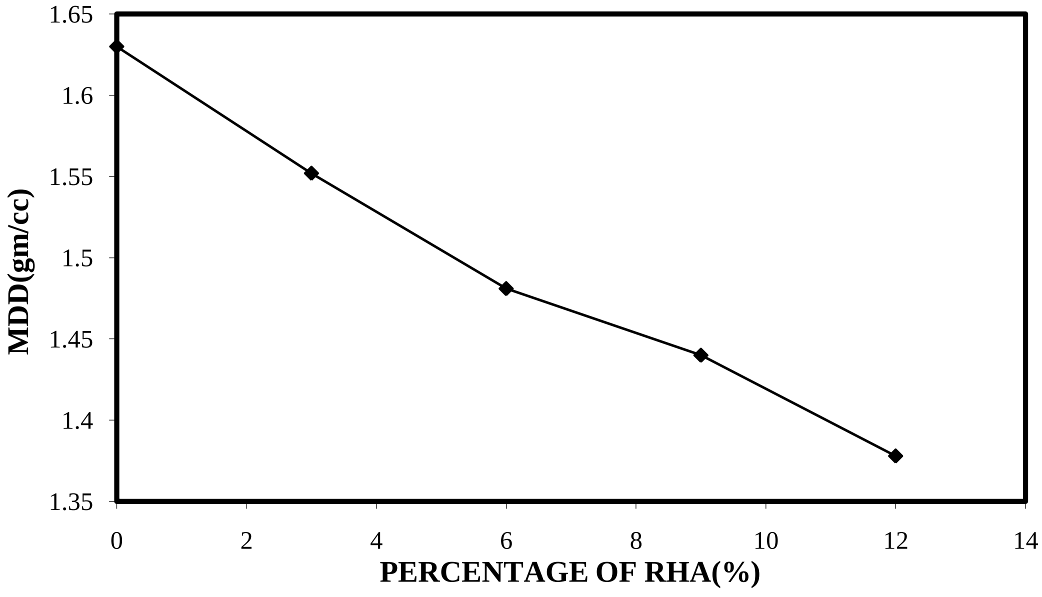


Fig. 4: Variation of Maximum Dry Density with different percentage of RHA

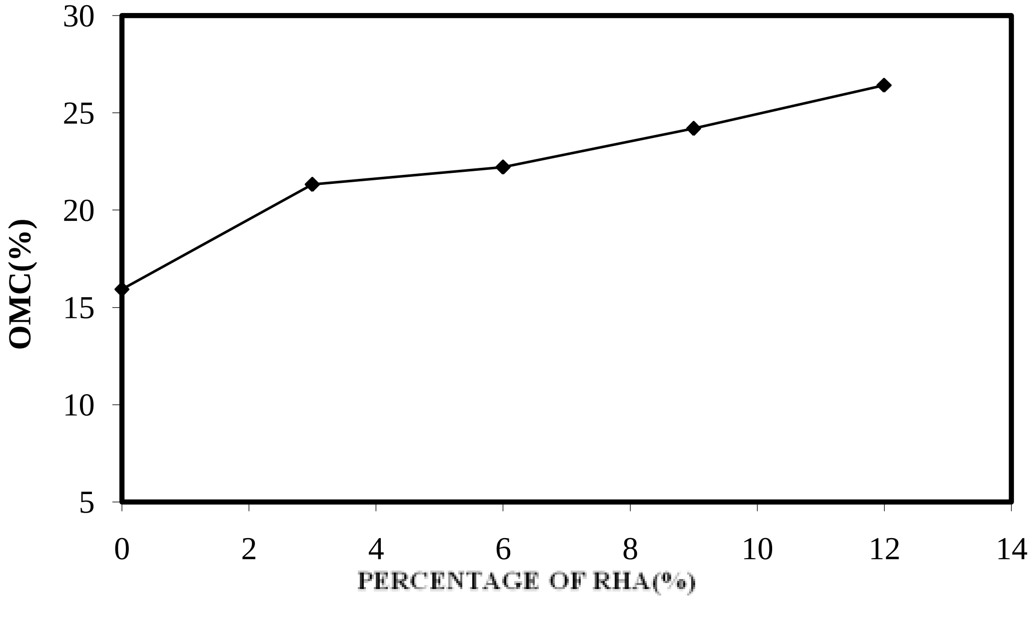


Fig. 5: Variation of Optimum Moisture Content with different percentage of RHA

Table 5: CBR at different moisture contents

Sample No	CBR AT OMC (%)		CBR AT W.C of OMC+ 2(%)		CBR AT W.C of OMC+ 5(%)	
	UCBR	SCBR	UCBR	SCBR	UCBR	SCBR
100% Soil	4.25	3.50	2.40	2.15	2.20	1.98

97% Soil+ 3% RHA	10.2	12.65	8.20	9.75	6.92	8.17
94% Soil+ 6% RHA	12.85	15.75	9.60	10.85	7.74	9.33
91% Soil+ 9% RHA	14.30	16.80	9.25	10.15	7.11	8.82
88% Soil+ 12% RHA	11.90	13.20	5.15	8.60	6.72	7.47

California Bearing Ratio (CBR) at optimum moisture content

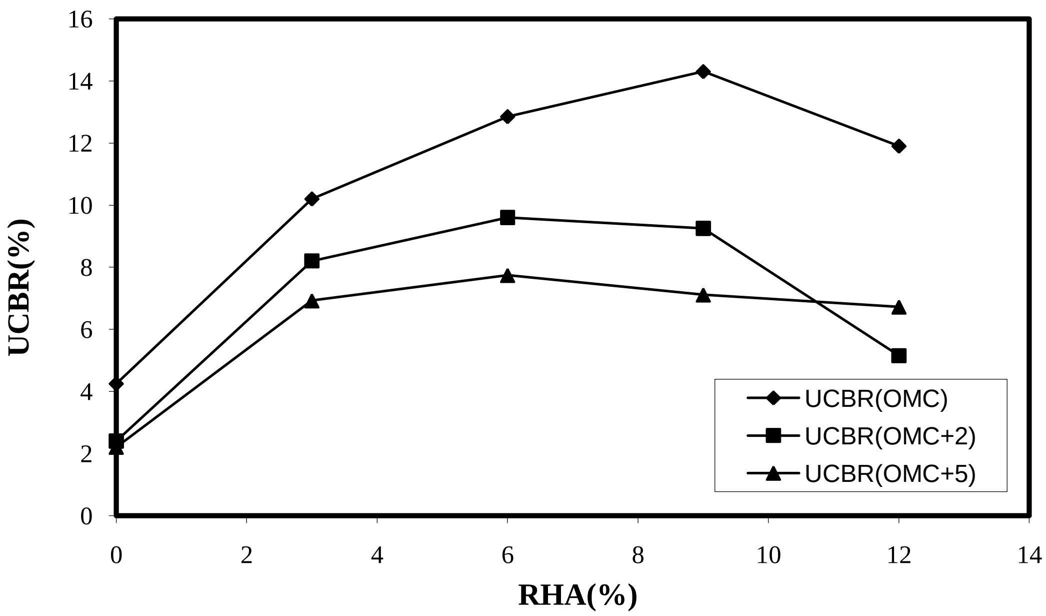
The laboratory test results for CBR at unsoaked and soaked conditions are presented in table 5. The variations of California Bearing Ratio (CBR) with different percentage of rice husk ash in soaked and unsoaked conditions at the different moisture content are presented in Fig. 6 and Fig.7 respectively. This plots shows that the California Bearing Ratio (CBR) value increases with increase of rice husk ash (RHA) content up to certain limits and further the CBR value is slightly decreased for 12% RHA content. This decrease in CBR may be due to extra RHA that could not mobilized for the reaction which occupies the space within the sample. The maximum California Bearing Ratio (CBR) value of 14.30% and 16.80% are found to occur with 9% rice husk ash (RHA) contents under un-soaked and soaked conditions at OMC.

The CBR value is increased by more than for both 100% for unsoaked and soaked samples for 9% RHA content. The soaked CBR value increases with the increase in RHA content at a higher rate than unsoaked CBR. The excess RHA occupies space within the specimen and reduces the clay and silt content in soil which reduces the cohesion in the soil RHA mixture.

California Bearing Ratio (CBR) at the moisture content more than OMC

The variation of California Bearing Ratio (CBR) with rice husk ash at the water content of the 2% and 5% above the optimum moisture contents (OMC) are shown in table for soaked and unsoaked conditions. The maximum California Bearing Ratio (CBR) value of 9.60% and 10.85% are found to occur with 6% rice husk ash (RHA) contents at OMC+2% and of 7.74% and 9.33% are also found to occur with 6% rice husk ash (RHA) at OMC+5% under un-soaked and soaked conditions.

It is observed that with increase of water content from optimum, the maximum California Bearing Ratio (CBR) values also drops as compared with the relevant values corresponding to tests done at optimum moisture contents (OMC). This is probably due to the mechanism of compaction which does not permit of water into the sample beyond OMC and rather than compaction energy is utilized in overcoming large shear strain.



ISSN: 2321-8169
799 – 806

Fig. 6: Variation of California Bearing Ratio with different percentage of RHA in unsoaked condition

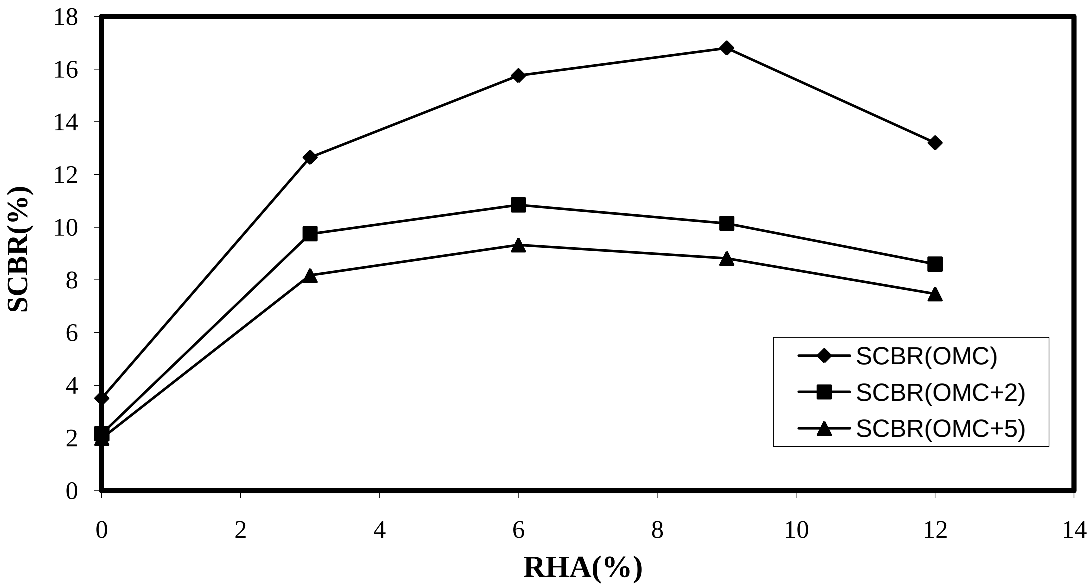


Fig. 7: Variation of California Bearing Ratio with different percentage of RHA in soaked condition at different Optimum Moisture Content

DESIGN OF PAVEMENT THICKNESS

The construction of road by treating sub-grade soil with RHA is suitable in locally area. This is illustrated with design of road as per IRC: 37-2001. The data considered for design of single lane pavement is given below:

i. Initial traffic in the year of completion of construction = 350CV/day
ii. Traffic growth rate (r) = 7.5%
iii. Design life(n) = 15 years
iv. Vehicle damage factor(VDF) = 3.10
v. CBR of sub-grade = 3.50%
vi. Design traffic = 8.0 msa (approx)

For the sub-grade soil treated with RHA, the CBR value increased to 16.80% from 3.50% for the proportion of 9% RHA. The details of the pavement thickness are shown in Table:6.

Table:6 Design of Pavement Thickness

Proportion	**Soaked CBR(%) at OMC**	**Thickness (mm)**	**Reduction in thickness (mm)**
100% Soil	3.50	700	-
9% RHA	16.80	480	220

CONCLUSION

In the present study the performance of RHA used as a stabilizing materials for the construction of flexible pavement. The various tests like LL, PL, proctor and CBR were conducted. The following conclusions may be drawn from the present investigation

ISSN: 2321-8169
799 – 806

i. The treatment of soil with addition of admixtures such as RHA has a general trend of increase in liquid limit and plastic limit and decrease of plasticity index.
ii. The addition of RHA with the soft sub-grade decreases the Maximum Dry Density and increases the Optimum Moisture content. The maximum dry density is generally reduced with the increase of rice husk ash contents.
iii. The strength characteristics in terms of CBR value is found to increase appreciably with addition of RHA as compared to the original soil. This is due to the pozzolanic action of RHA.
iv. Soil, when mixed with RHA the CBR values increases appreciably both under soaked and un-soaked conditions.
v. The maximum CBR value of 28.25% is found to occur with the combination of 6% of lime and 9% RHA contents under un-soaked condition and this value increases up to 29.82% for 6% of lime and 6% RHA combination under soaked condition at the optimum moisture content.
vi. As per IRC 37:2001 pavement thickness for flexible pavement by conventional method of 3.50% CBR value is 700 mm and for RHA stabilized road of 16.80% CBR value is 480 mm, which reduces the cost of construction.
vii. For maximum improvement in strength of soft sub-grade soil by using 9% RHA is recommended as optimum amount for practical purposes.
viii. The utilization of Agricultural wastes is economical for local area and it is also environmental friendly.

References:

[1] Chakraborty S (2015), Application of suitable admixtures (Lime and RHA) for improvement of pavement subgrade. International journal of geological and geotechnical engineering, vol-1, issue 1, P-19-36.
[2] I.S:2720 Part-3(1980): Determination of Specific gravity.
[3] I.S:2720 Part-4(1985): Determination of Grain size analysis.
[4] I.S:2720 Part-4(1985): Determination of Water content.
[5] I.S:2720 Part-5(1985): Determination of liquid limit and plastic limit.
[6] I.S:2720 Part-6(1985): Determination of Dry density and Optimum moisture content.
[7] I.S:2720 Part-16(1979): Determination of California bearing ratio.