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Impact of Rice Husk Ash on Soil Stability (Including Micro Level Investigation)

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Abstract

Objectives: In this study, the change in behavior of subgrade soil after apply rice husk ash which is an environmental pollutant was observed. **Methods/Statistical Analysis**: Some sample of subgrade soil was taken and mixed with various amount of rice husk ash (1%, 2%, 4%, 6%, 8% and 10%). Did some experimental tests like OMC, MDD, CBR to determine the changes on subgrade strength properties with RHA content also to study its impact in better way, did SEM and EDS tests of untreated soil as well as treated soil. **Findings:** From the experimental works it is observed that addition of rice husk ash shows increase in OMC value whereas decrease in MDD value and Upto 6% rice husk content CBR is increasing after that it start decreasing. In other hand from SEM and EDS test decrease in void ration and breaking of montmorillonite has observed. **Applications/Improvements:** Since mixing of rice husk ash with soil shows improvement in CBR value and reduces the void so it can be use for sub-base construction as it will reduce the thickness and cost of pavement.

Keywords: CBR, EDS, Rice Husk Ash, Scanning Electron Microscopy, Soil Stabilization

1. Introduction

Civil construction project is totally influenced by the soil present in the site, their strength and properties. Quality check of soil should always be the first duty and it has to be strong to support the structure. In order to ensure the quality of the soil we need to have proper information about properties of the soil and also about the influence factors. If the quality of soil is not fair and not able to resist structure, stabilization of the soil is an economical way instead of digging and removing of that soil. Soil stabilization is enhancing the soil properties by mechanical or chemical means. Soil stabilization is widely using in pavement and road constructions. It improves the soil properties like Strength, durability, volume stability and bearing capacity. Cement and lime are the two main stabilizer but they are costly due to increase in labor as well as energy cost. So using of waste material is an economical way for reducing the construction cost. In agricultural country like India abundance of agricultural waste is a big problem as these waste contains minerals and silicate. Rice husk is also one of the agricultural wastes which can be use for many construction purposes. The ashes of rice husk have been potential pozzolanic material[1], it contain more than 80% SIO_2[2]. RHA can also use as a soil stabilizer which reduces the voids and compaction energy.

2. Experimental Investigation

2.1Material

2.1.1 Soil

Soil sample is collected from the river side behind BIRLA INSTITUTE OF TECHNOLOGY, MESRA at RANCHI JHARKHAND (INDIA) at a depth of 1-2 m. Experiments to determine the soil properties are conducted and shown in Table 1. As per IS soil classification of the soil is classified as Organic Clay with low plasticity (OL)[3]. Figure 1 and Figure 2 shows the SEM image of soil at 500 and

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2000 magnification respectively where as Table 2 shows the chemical composition of virgin soil and Figure 3 is the EDS graph of soil specimen.

Table 1. Properties of untreated soil

Sl. No.	Characteristics	Description
1	NATURAL MOISTURE CONTENT (%)	9
2	SPECIFIC GRAVITY	2.62
3	LIQUID LIMIT (%)	30
4	PLASTIC LIMIT (%)	23.2
5	PLASTIC INDEX (%)	6.7
6	SAND (%)	6
7	SILT (%)	32
8	CLAY (%)	62
9	Coefficient of uniformity(Cu)	9.59
10	Coefficient of curvature (Cc)	1.857
11	MAXIMUM DRY DENSITY (gm/cc)	1.765
12	OPTIMUM MOISTURE CONTENT (%)	11
13	CALIFORNIA BEARING RATIO, (UNSOAKED) (%) CALIFORNIA BEARING RATIO, (SOAKED) (%)	8.4 7.15

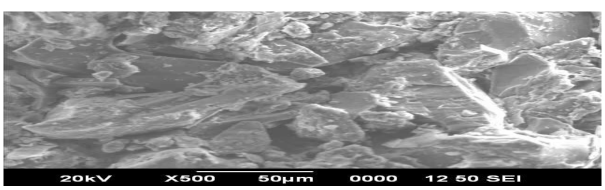


Figure 1. SEM image of untreated soil at 500

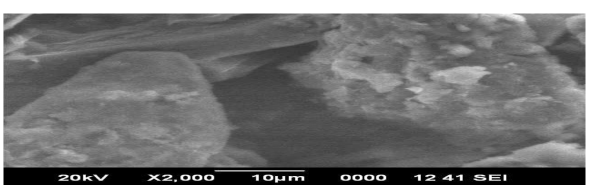


Figure 2. SEM image of unstabilized soil at 2000x.

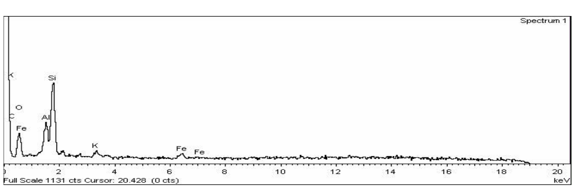


Figure 3. Energy dispersive spectroscopy graph of the soil.

Table 2. Chemical composition of soil

Element	Weight (%)	Atomic (%)
C	18.33	28.12
O	40.87	47.07
Al	8.93	6.10
Si	24.09	15.80
K	2.45	1.15
Fe	5.33	1.76
Totals	100.00	
SI:AL RATIO	2.69	

2.1.2 Rice Husk Ash

Rice husk is a by-product of rice mills, which is mainly used as a fuel for the boiler during pulverization of rice and generates a huge amount of rice husk ash. The rice husk ash (RHA) used in the experiment is brought from BABA RICE MILL at RANCHI where they use incinerator for burning of rice husk ash. The properties and chemical composition of RHA is in Table 3 whereas Figure 4 shows the EDS spectrograph of rice husk ash and Figure 5 shows the SEM image at 150 magnification.

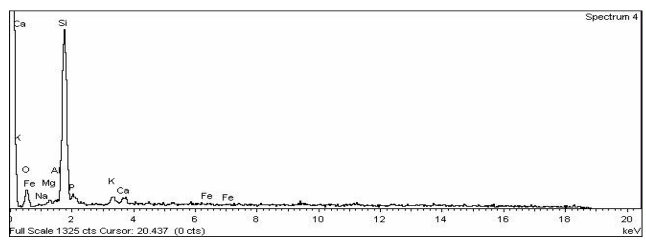


Figure 4. EDS of RHA.

Table 3. Chemical composition of RHA.

Element	Weight%	Atomic%
O	34.07	48.47
Si	51.61	41.82
Ca	3.09	1.76
Na	0.13	0.13
Mg	1.39	1.30
Al	1.21	1.02
P	4.27	3.14
K	3.70	2.15
Fe	0.53	0.22
Totals	100.00	

SPECIFIC GRAVITY 2.12

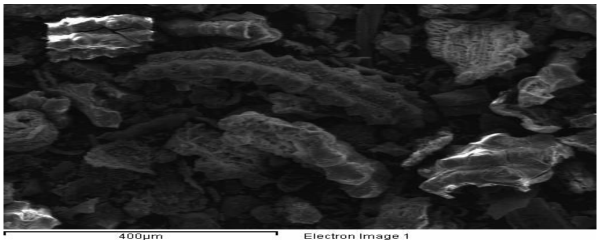


Figure 5. Image of rice husk ash at 150 x.

2.2 Laboratory Tests

2.2.1 Atterberg Limit Test

Atterberg limit test were carried out in accordance with Indian Standard method of test for soil[4]. The soil was sieved by 425 micron IS sieve before testing. Figure 6 shows the flow curve of liquid limit test.

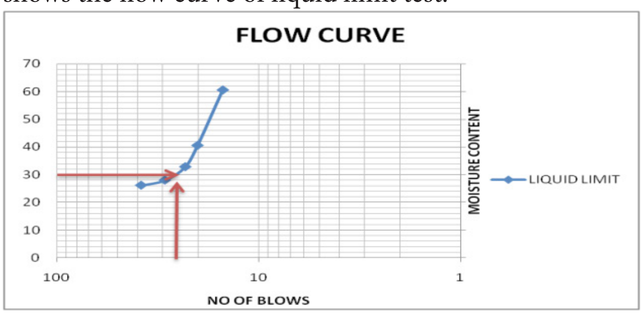


Figure 6. Flow curve of liquid limit test.

2.2.2 Compaction Tests

Optimum Moisture Content (OMC) as well as Maximum Dry Density (MDD) are determined through Standard Proctor compaction test of soil[5]. Compaction test are performed firstly on soil without mixing RHA and mixing with RHA varying proportionally 1%, 2%, 3%, 4% etc.

2.2.3 California Bearing Ratio Test

As per[6], methods of test for soils, Part 16, CBR is the ratio expressed in percentage of force per unit area required to penetrate a soil mass with a circular plunger of 50 mm diameter at the rate of 1.25 mm/min to that required for corresponding penetration in a standard material. The ratio is usually determined for penetration of 2.5 and 5 mm. Where the ratio at 5 mm is consistently higher than that at 2.5 mm, the ratio at 5 mm is used, In the first phase of testing CBR value for unsoaked as well as 4 day soaked of the unstabilized soil was determined and in the second phase the soaked CBR value of soil mixed with varying % of RHA (1%, 2%, 3%, 4%, 6%, 8% and 10%) are conducted.

2.2.3 Scanning Electron Microscopy (SEM)

SEM produces images of soil sample by scanning it with focused beam of electron[7]. Images of soil with or without rice husk ash are obtained and observation of void ratio is needed.

2.2.4 Energy Dispersive Spectroscopy (EDS)

The Energy dispersive spectroscopy is use to analyze the composition of sample. In this study soil samples are analyzed, EDS graph gives peak value of silicon, carbon and aluminum.

3. Results and Discussion

3.1 Effect on OMC Values

The effect of RHA on OMC value of soil is shown in Figure 7 which indicates that the OMC increase with increase in amount of RHA. The increase in OMC is probably a consequence of two reasons: 1. The additional water held with the flocculent soil structure resulting from cement interaction, and 2. Exceeding water absorption by RHA as a result of its porous properties[8].

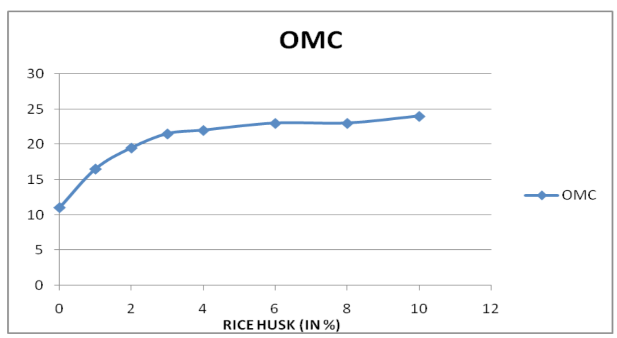


Figure 7. Effect of RHA on OMC.

3.1 Effect on MDD Values

For improvement purpose MDD should increase but since RHA is also a MDD reducing element the value of MDD decrease with increase in RHA (Figure 8). The corresponding value of OMC and MDD is mentioned in Table 4.

Table 4. Values of OMC and MDD with RHA

RICEHUSK (%)	OMC (%)	MDD (gm/cc)
0	11	1.765
1	16.5	1.69
2	19.5	1.65
3	21.5	1.55
4	22	1.58
6	23	1.55
8	23	1.54
10	24	1.51

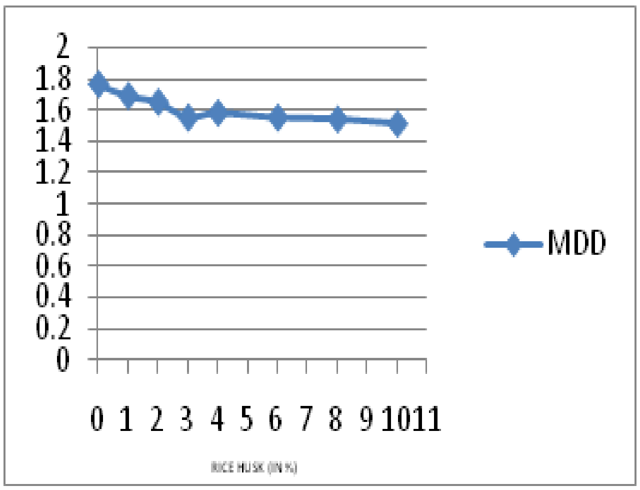


Figure 8. Variations in MDD with rice husk ash.

3.2 Effect on CBR Value

The variation on CBR value with increment in RHA content is mentioned in Table 5. A graph (Figure 9.) is plotted between RHA content and CBR value. It is observed that optimum CBR achieved at 5% RHA. After 6% the CBR value is rapidly decreasing. The decreasing in CBR after 6% is either due to increment in water content or due to decrease in MDD.

Table 5. CBR value with RHA content

Sl. No.	SOIL	RHA	CBR(UNSOKED)	CBR (SOKED)
1	100	0	8.4	7.1
2	99	1	-	7.7
3	98	2	-	9.4
4	97	3	-	9.2
5	96	4	-	10.1
6	94	6	-	10.8
8	92	8	-	3.9
10	90	10	-	1.6

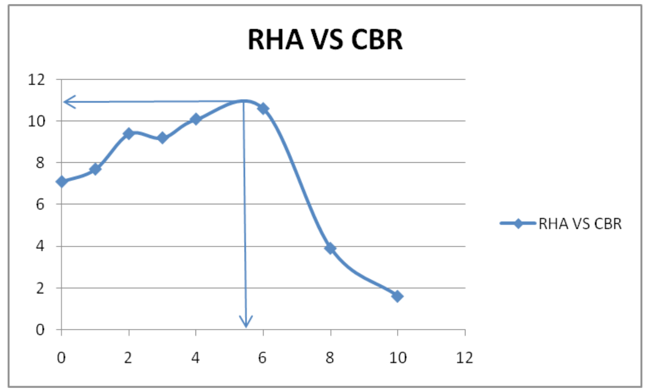


Figure 9. RHA vs CBR graph.

Table 6. Change in void ratio with RHA

RHA Content (%)	Average Void (um)
0	28.24
1	22.4
2	19.8
3	10.9
4	7.56
6	10.41

3.3 Micro Level Study on Effect of RHA

Some air dried sample of in situ soil as well as RHA mixed soil were observed using SEM and also measure voids to further analysis or validate the result using void ratio formula[10]. Figure 11(a) shows the image of untreated soil at the magnification of 2000x while Figure 11(b) represent the SEM image at 500x with measurement of void ratio, we can see that the void decreasing with increasing in RHA, Ref Figure 10 or 12. Table 6 is for average of void ratio measured in SEM of each sample at different RHA contents.

3.3.2 Energy Dispersive Spectrosopy (E.D.S.)

The chemical composition of untreated soil, healed soil with 1% RHA, 2% RHA, 3% RHA and so on was determined by EDS. The Si:Al ratio of untreated soil was found to be 2.69 indicates the presence of Montmorillonite mineral in the soil[9]. Figure below show the EDS spectra of soil with RHA varing from 1 %, 2%, 3%, 4% and so on. The si:al ratio is observed increasing the si containt increse with increse in rice husk. The variation of chemical composition is in Table 7. Figure 13(a) and 13(b) show EDS spectra of treated soil with 1%, 2%, 3%, 4%, 6% RHA repectively.

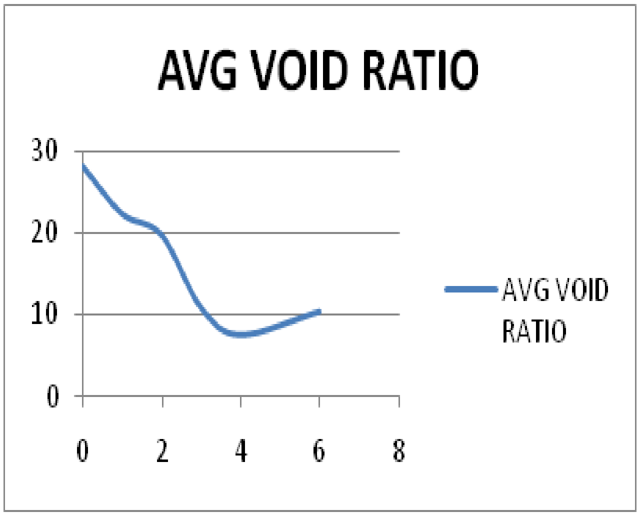
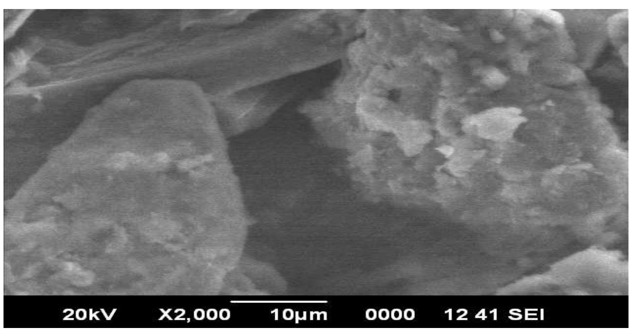
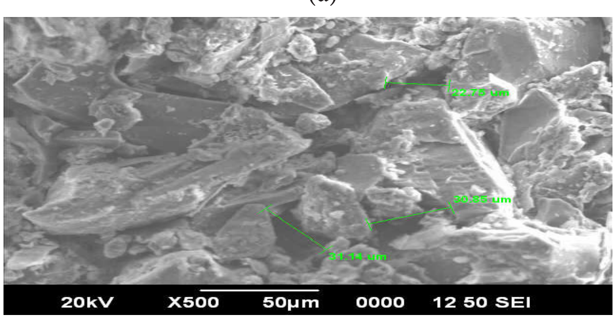


Figure 10. Graph between void ratio and rha contant.

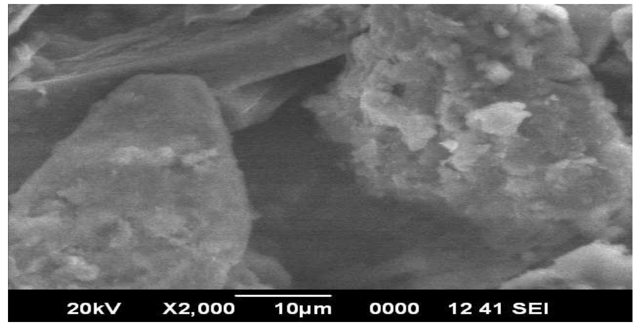


(a)

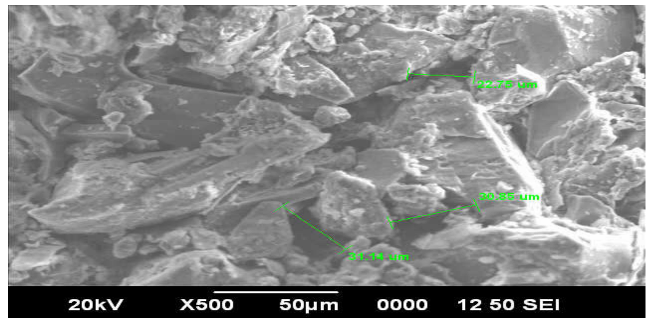


(b)

Figure 11. (a) SEM Image of Untreated soil at 2000x. (b) SEM image of untreated soil with void measurement at 500x.



(a)



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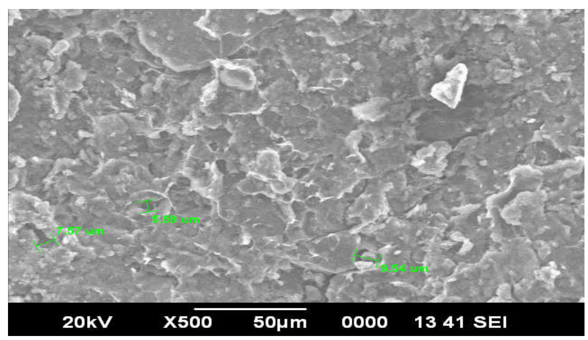

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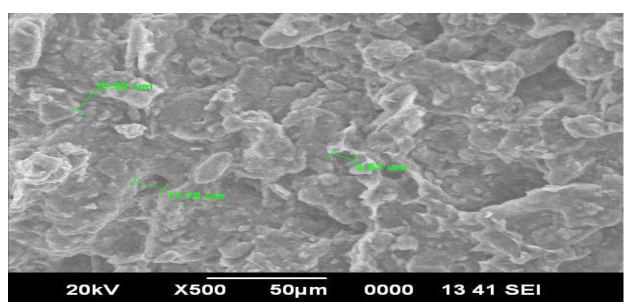
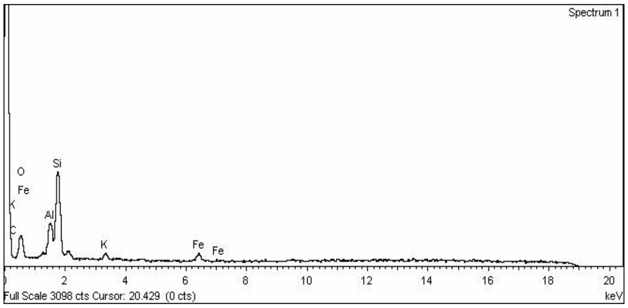
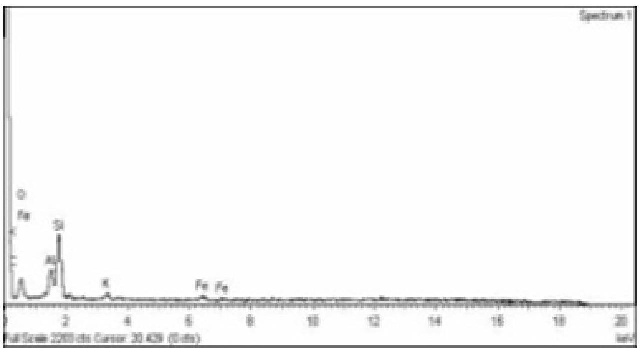


(d)

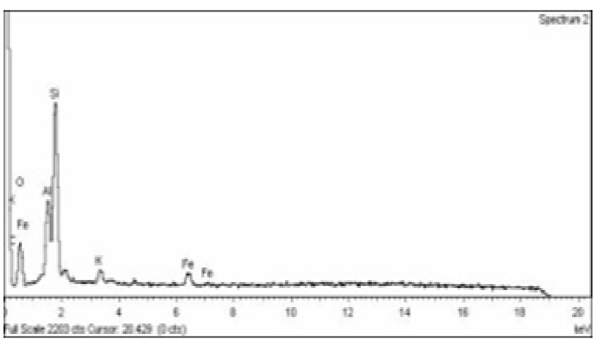
Figure 12. SEM image with void measurement. (a) 1% RHA. (b) 2% RHA. (c) 3% RHA. (d) 4% RHA. (e) 6% RHA.



(a)



(b)



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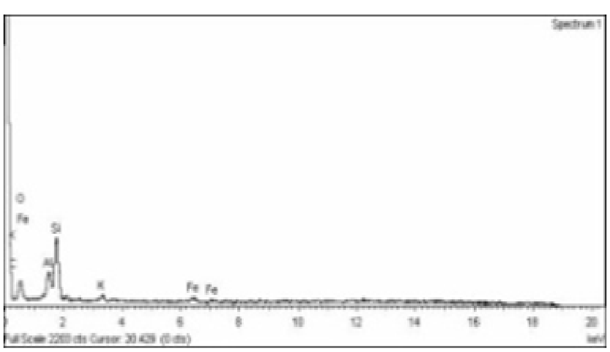

(d)

Figure 13 (a) EDS spectra of soil with RHA 1%. (b) EDS spectra of soil with RHA 2%, 3%, 4%, 6 % respectively.

Table 7. Variation in chemical composition of treated soil with RHA

Element	Untreated Soil	Soil With RHA 1%	Soil with RHA 2%	Soil with RHA 3%	Soil with RHA 4%	Soil with RHA 6%
C	18.33	18.91	15.66	17.14	19.5	8.77
O	40.87	37.8	39.52	35.87	30.9	38.47
Al	8.93	8.82	8.45	9.31	9.78	9.03
Si	24.09	25.58	27.11	29.71	31.6	32.72
K	2.45	2.44	2.01	2.89	2.55	2.71
Fe	5.33	6.44	7.25	5.09	5.67	7.56
Totals	100	100	100	100	100	100
Si:Al ratio	2.69	2.9	3.2	3.2	3.23	3.6

4. Conclusion

Rice husk ash is the by-product of rice mills and is an environmental pollutant. It contributes to air and water pollution. If this pollutant can be effectively used, the problems relating to its disposal can be minimized. One such method is using rice husk ash as stabilizing agent in pavement construction. Rice husk ash is added at different percentage to natural soil and its maximum dry density, optimum moisture content and CBR value, which reduces the overall thickness of pavement. Apart from reducing the cost of pavement construction, it serves as safe method of using the agro-waste.

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