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Effect of Rice Husk Ash on Strength Characteristics of Roller Compacted Concrete

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ABSTRACT: *Roller compacted concrete (RCC) is a special dry concrete mix; laid down and compacted like a soil, it is especially used for the construction of massive structures like dams or large horizontal surfaces like road foundation. This paper aims to analyze the possibility of valorizing rice husk ash in roller-compacted concrete pavement (RCCP) mixes as pozzolan. The rice husk ash was added to the mix as partial replacement of the cement by varying percentages of 5% and 10% by dry weight. The experimental approach followed in this research consisted of studying the influence of the rice husk ash on compressive strength and split tensile strength of RCCP. The obtained results show that the incorporation of rubber changes the behavior of RCCP mixes. In presence of rubber, the RCCP became more ductile. The principal disadvantage of rubber incorporation was the decrease in the mechanical properties of RCC. To remedy this problem, the rubber particles were subjected to a treatment and silica fume was added to the mix. The obtained results showed that the performance of RCCP can be improved by the partial replacement of rice husk ash.*
Keywords: *Roller compacted concrete, rice husk ash, compressive strength, split tensile strength*

I. INTRODUCTION

Roller-compacted concrete pavement (RCCP) has the same basic ingredient as ordinary concrete. But unlike conventional concrete, it is a drier mix-stiff enough to be compacted by vibratory rollers (ACI, 1988). With the advantages of low cost, ease of construction, and a high-rate of production, roller-compacted concrete, has been widely used in dam construction. It is now developing as a fast, economical, construction method for the concrete pavement, heavy-duty parking and storage areas, and as a base for conventional pavement. RCC is a stiff, zero slump concrete mixture with more aggregates than ordinary concrete (Delhez et al. 2004; Delhez et al. 2004). Most difficulties for the applications are the rigid behavior of concrete slabs and its easy-to-crack characteristic due to plastic shrinkage, lower tensile strength, and smaller ultimate tension elongation. The plastic cracking can be improved by adding polypropylene fibers or moisture curing (Siddique, R and Naik, T. R., 2004). However, the rigid behavior of RCC remains as an important problem due to its high elastic modulus.
Rice Husk Ash (RHA) is an agricultural industrial waste which is major waste found abundantly in delta regions of A.P, India, which is nearly 5.5 million tons, requires huge quantities of land for its disposal (Vamsi Nagaraju, T and Satyanarayana, P. V. V, 2016). Rice-husk ash is a mineral admixture for cement and concrete (Mehta, P. K, 1992; RELIM, 1988); the behavior of cementitious products varies with the source of RHA (Malhotra and Mehta, 1996; James and Rao, 1986). Most mineral admixtures have a favorable influence on the strength and durability of concrete. In the case of RHA, its chemical effect is related to the fact that when produced by controlled combustion it is a highly pozzolanic material which combines quickly with calcium hydroxide forming a secondary C–S–H; the physical effect is linked to particle size (less than 45 lm on average), which produces a refinement on the pore structure, acts as nucleation point for hydration products, and restricts the growth of crystals generated in the hydration process.

Mehta, P. K, 19979 , has argued that the grinding of RHA to a high degree of fineness should be avoided, since it derives its pozzolanic activity mainly from the internal surface area of the particles; for use in preparation of concrete and mortar products, at least about 75% of RHA particles are in a size range at from about 4 lm to about 75 lm, with a mean particle diameter between 8 lm and 6 lm, and a surface area of at least 20 m2/g (Mehta,1979). And also RHA particles are non-plastic, porous, elongated light weight materials, having low dry densities at high moisture contents and achieved high values of shearing resistance (Vamsi Nagaraju et al. 2016).

This paper not only explores the efficacy of rice husk ash in civil engineering applications. The paper also studies the effect of RHA on strength characteristics of roller compacted concrete.

II. MATERIALS AND METHODS

In this study, preliminary tests were conducted to determine the specifications of the raw materials used, which were then compared against the relevant standards. Once appropriate mix designs had been selected, the main test specimens were manufactured and cured. The 7-day and the 28-day specimens were finally subjected to the compressive strength and spilt-tensile strength tests. Specimens used for the purpose of the present study were manufactured in two varied proportions which are 20% and 30% partial replacement with rice husk ash.

i) Properties of materials

For the purposes of this study, coarse aggregate, sand, cement, and rice husk ash were used to make the concrete specimens. Ordinary Portland Cement OPC 53 Grade was used in the present experimental investigation and satisfying the requirements of IS: 12269-1987 specifications. Locally available river sand passing through 4.75 mm sieve and retained on 75 micron sieve were used. Igneous rock material consisting of granite was crushed into small aggregate was used as coarse aggregate in the Preparation of RCC. The maximum size of aggregate was 20 mm.

Table. 1 Index and engineering properties of sand

Property	Values
Gravel (%)	3
Sand (%)	95
Silt(%)	2
I.S Classification	SP
Specific gravity	2.64
Optimum moisture content (OMC) (%)	6
Maximum dry density (MDD) (g/cc)	1.75
Density in loosest condition (g/cc)	1.70
Density in compacted condition (g/cc)	1.42
Angle of Shearing Resistance, degrees	34
California Bearing Ratio, CBR (%)	6.0
Coefficient of uniformity, Cu	2.07
Coefficient of curvature, Cc	1.41

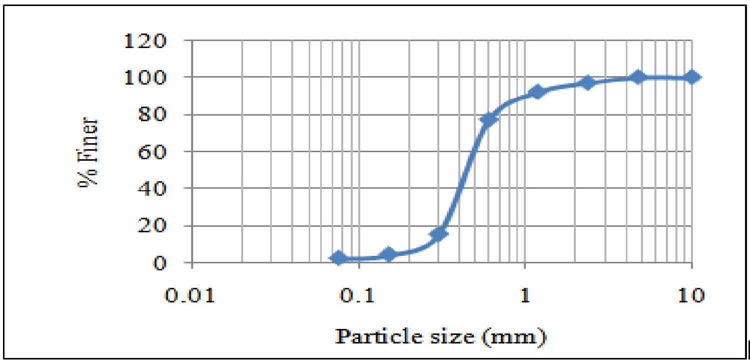
ii) Specimens

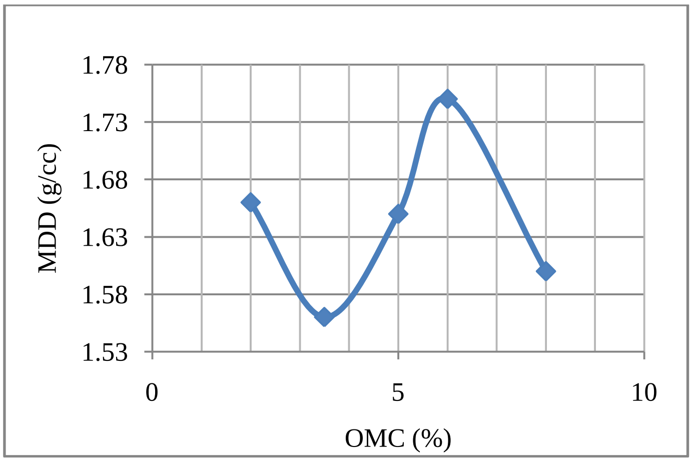
Concrete cylinders of diameter 150mm X height 300mm of 46 numbers were cast to study compressive strength and split tensile strength. Out of 46 cylinders 28 numbers were 20% replacement of RHA and the remaining was with 30% replacement of RHA. The cylinders of 28 numbers were divided in to 2 sets, as 14 in each set. 1st set is for compressive strength test and the 2nd set is for split tensile strength test. These specimens were tested under CTM as per IS 516: 1959 and strengths were calculated for 7days and 28 days, and the results were tabled.

III. RESULTS AND DISCUSSION

3.1. Compaction and optimum moisture tests

Immediately after the specimens were molded, they were weighed and the volumetric dry weight of each was calculated. Optimum moisture contents and maximum dry densities were obtained by IS heavy compaction test. The test results were mentioned below figures.





3.2. Strength characteristics

Table 2 shows the test results including compressive strength and split tensile strength which was obtained by using cylinder specimen (diameter 150mm x height 300 mm). All of them were measured at the age of 7-days and 28-days.

Table. 2 Effect of rice husk ash on strength characteristics

Cement (%)	Compressive strength (MPa)		Split tensile strength (MPa)	
	7 days	28 days	7days	28days
10% RHA				
5	6	8.5	1.21	1.72
8	7	9.4	1.33	2
10	7.8	11.2	1.5	2.46
12	9	13.2	1.75	2.98
15	10.2	15	2.02	3.46
18	11.8	16.8	2.3	3.96
20	13.6	18.6	2.64	4.38
20% RHA				
5	6.15	9	1.27	1.66
8	7.45	10.5	1.38	2.2
10	8.5	13	1.62	2.56
12	10	14	1.76	3.2
15	10.85	15.5	2.18	3.65
18	13	18	2.46	4.05
20	14.5	20.5	2.78	4.55

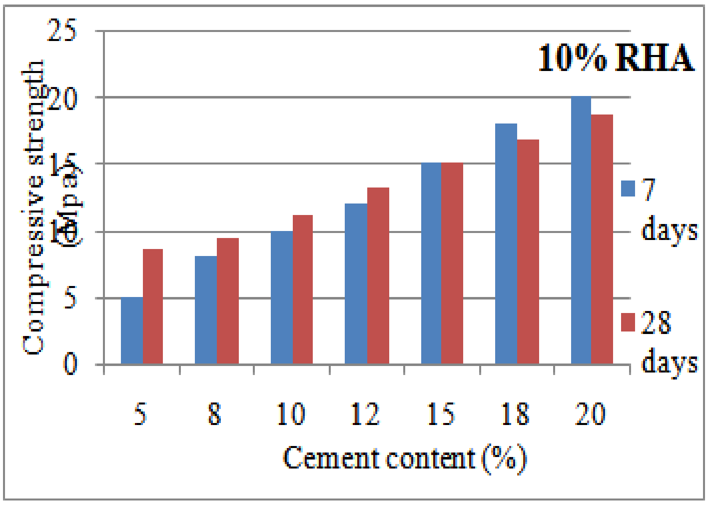


Fig.1 Effect of cement content + 10% RHA on compressive strength

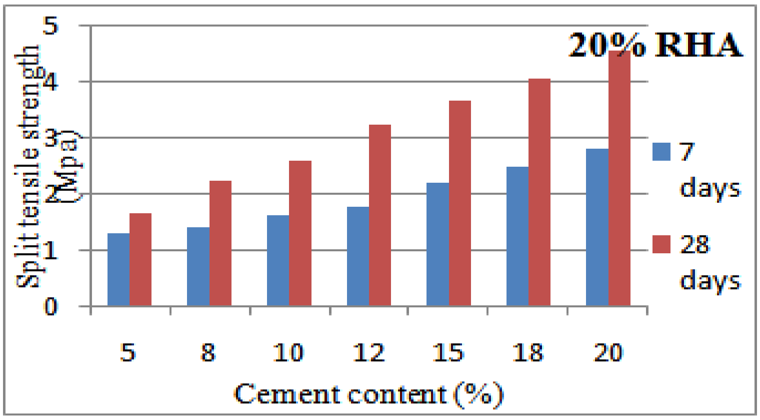


Fig. 2 Effect of cement content + 20% RHA on split-tensile strength

The compressive strength is a fundamental property in the characterization process of cementitious materials. Figure 1 shows the variations of compressive strength according to the cement content keeping the 10% RHA in the mix. It is clearly appeared that the compressive strength increased with increase in 10% RHA + cement content when the curing period increased to 7-days and 28-days. Further, for a given additive content, the compressive strength for 28-days was higher than that for 7-days. This can be attributed to increased pozzolanic reaction with increasing additive content and curing period. Figure 2 shows the variations of split tensile strength according to the cement content keeping the 20% RHA in the mix. The compressive strength increased with increase in 20% RHA + cement content when the curing period increased to 7-days and 28-days. Further, for a given additive content, the split tensile strength for 28-days was higher than that for 7-days. This can be attributed to increased pozzolanic reaction with increasing additive content and curing period.

IV. CONCLUSIONS

This study investigated the effects of rice husk ash (RHA) on compaction characteristics; compressive strength and split tensile strength in roller compacted concrete (RCC). The results obtained may be summarized as follows:

1) MDD decreased with increasing RHA content, OMC of mix increased with RHA content.
2) Compressive strength of the RRCS increased with increase in additive content when the samples were cured for 7-days and 28-days. For a given additive content, compressive strength period of the mix was higher for 28-days than that of the 7-days curing period.
3) RHA can be used in bulk quantities in roller compacted concrete.

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