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ABSTRACT: Over the past years, there has been seen an increasing number of research on the use and utilization of industrial, agricultural and thermoelectric plants residue in the production of concrete. Different materials with pozzolanic properties such as fly ash, condensed silica fume, blast furnace slag and rice husk ash have played an important part in the production of high performance concrete. During the late 20th century, there has been an increase in the consumption of mineral admixture by the cement and concrete industries. The rate is expected to increase. The increasing demand for cement and concrete is met by the partial cement replacement. Substantial energy and cost savings can result when industrial by-products are used as a partial replacement for the energy intensive Portland cement. The presence of mineral admixture and mineral admixtures in concrete is known to impart significant improvement in workability and durability. Among the different existing residues and by products, the possibility of using rice husk ash in the production of structural concrete is very important for India. India is the second largest rice paddy cultivating country in the world. Both the technical advantages offered by structural concrete containing rice husk ash and the social benefits related to the decrease in number of problems of ash disposal in the environment have simulated the development of research into the potentialities of this material.
The objective of the present investigation is to evaluate one type of commercially available RHA as supplementary cementitious material for cement and to evaluate the threshold limit of replacement of cement. The main aim of this work is to determine the optimum percentage (0, 5, 10, 15 & 20%) of RHA as a partial replacement of cement for M30 and M60 grade of concrete and also the effect of super plasticizer on mechanical properties. The physical properties of cement have to be determined and will be tabulated as given below.
Ordinary Portland cement (OPC) of 53 grade obtained from single source is to be used in this investigation. The properties of cement tested as per IS:4031-1988 are given in table 2 and is found to conform to various specifications of IS:12269:1987. Locally river sand is to be used as fine aggregate and also determine its specific gravity and fineness. Tests determining the Mechanical properties of concrete are to be determined using rice husk ash with different percentages.

KEY WORDS: Pozzolanic; Mechanical Properties; Cement Replacement; Workability and Durability.

1. INTRODUCTION

Concrete is no longer made of aggregates, Portland cement and water only. Often, if not always it has to incorporate at least one of the additional ingredients such as admixtures, supplementary cementious material or fibers to enhance its strength and durability. During last few decades requirement of high performance and highly durable concrete has been on rise. The use of mineral admixture in combination with chemical admixture has allowed the concrete technologists to tailor the concrete for many specific requirements. Amongst the mineral admixture, silica fume, because of its finely divided state and very high percentage of amorphous silica, proved to be most useful, if not essential for the development of very high strength concretes and concrete of very high durability i.e. high performance concrete. Therefore it is being used on a worldwide scale in concrete, for the making of high performance concrete. In spite of its numerous advantages silica fume suffers from one major disadvantage that it is imported therefore, very costly. In this work an attempt has made to find a suitable alternate of rice husk ash.

2. RICE HUSK ASH

Rice husks are shells produced during the de husking of paddy rice.1000 Kg of paddy rice can produce about 200 Kg of husk, which on combustion produces about 40 Kg of ash[7]. Rice husk constitute about 1/5th of the 300 million metric tons of rice produced annually in the world. According to the report by Mehta[8], the current yearly production paddy rice is approximately 500 million tones that gives about 100 million tones of rice husk as a waste product from the milling. Rice husk is also not used for feeding animals since it is less nutritional properties and its irregular abrasive surface is not naturally degraded and can cause serious accumulation problems. Controlled burning of rice husk between 500 and 600^{o} C for short duration of about 2hrs yields ash with low un-burnt carbon and anamorphous silica. When rice husk is burnt in an uncontrolled manner, the ash, which is essentially silica, is converted to crystalline forms and is less reactive. Both the crystalline and amorphous rice husk ash is used to manufacture a lime- rice husk ash mix or a Portland rice husk ash cement or the rice husk ash can be used as a Portland cement replacement in concrete. Research in

India and the United States has found that if the hulls or straw are burned at a controlled low temperature, the ash collected can be ground to produce a pozzolan very similar to (and in some ways superior to) silica fume and heat produced during burning can beneficially used in power production, by doing so not only crop waste can effectively disposed, but also can generate electricity for the area, and provide high quality cement. The characteristics of the typical rice husk produce in India has organic amorphous silica (made of rice husk ash) with silica content of above 85%, in very small particle size of less than 25 microns, which is used for making green concrete, high performance concrete, refectories, insulators, flame retardants etc.

3. SCOPE OF WORK

The main and foremost objective of the present investigation is to evaluate the threshold limit of replacement of cement. This investigation targets to determine the optimum percentage (0, 5, 10, 15 and 20%) of RHA as a partial replacement of cement for M30 and M60 grade of concrete.

Table 1 Physical Properties of cement

Property	Result
Normal Consistency	32%
Setting times Initial setting time Final setting time	 62 mins. 260 mins.
Specific gravity	3.15
Fineness of cement (By 90 micron sieve)	 5% retained
Soundness of cement	2 mm
Compressive strength	
7 days 28 days	37 N/mm^2 58 N/mm^2

4. EXPERIMENTAL WORK

4.1 Materials

Ordinary Portland cement (OPC) of 53 grade obtained from a single source was used in this investigation. The properties of cement tested as per IS: 4031-1988 are given in Table-1 and is found to conform to various specifications of IS: 12269-1987. Locally available river sand with a specific gravity of 2.66 and fineness modulus 2.5 was used as a fine aggregate. The compacted bulk density value is 1614 Kg/m^3. The crushed stone aggregate with a maximum size of 20mm having specific gravity and fineness modulus 2.68 and 6.7, respectively was used .The commercially available rice husk procured from M/S Prakash Rice mill Danapur, Bihar with specific gravity of 2.06 was used as a cement replacement material. The chemical composition and physical properties of the rice husk ash is presented in Table -2. Potable water was used for the preparation of concrete mixes.

Table 2 Physical and Chemical Analysis of Rice Husk Ash Used

Parameters	Values
Fineness passing 45 micron	96%
Specific gravity Bulk Density Silicon Dioxide (SiO_2)	2.06 718 Kg/m^3 87.20%
Aluminium oxide (Al_2O_3)	0.15%
Ferric oxide (Fe_2O_3) Calcium oxide (CaO)	0.16% 0.55%
Magnesium oxide (MgO)	0.35%
Sulphur trioxide (SO_3)	0.24%
Carbon (C) Loss on Ignition	5.91% 5.44%

4.2 Mix Proportions

The mix proportion of M30 and M60 grade concrete mixes were designed based on the recommendations of IS: 10262-1982 without rice husk ash and super plasticizer. The identification of mix proportions and quantity of materials taken for one metre cube of concrete mixes are given in Table-3 and Table-4. Concrete mixes were prepared with cement replacement levels of 0, 5, 10, 15 & 20% by rice husk ash.

4.3 Preparation of test specimen

The ingredients for various mixes were weighed and mixes prepared by using a tilting drum type concrete mixes machine. Precautions were taken to ensure uniform mixing of ingredients. The specimen were cast in steel mould and compacted on a table vibrator. The specimens of 150x150x150 mm size of cube, 150mm diameter x300 mm high cylinder specimens, 100x100x700 mm size of prisms were cast for different tests.

Table 3- Mix proportion for M30 grade mixture

Mix Designation	BC	BC1	BC2	BC3	BC4
Rice Husk Ash Present %	0	5	10	15	20
w/c Ratio	0.43	0.43	0.43	0.43	0.43
Cement (Kg/m^3)	420	399	378	357	336
Rice Husk ash (Kg/m^3)	0	21	42	63	84
Sand (Kg/m^3)	621.6	582.1 8	542. 88	503.5	464. 2
Coarse Aggregate (Kg/m^3)	1108.8	1108. 8	1108 .8	1108. 80	1108 .80
Water (lit/m^3)	180.6	180.6 0	180. 60	180.6	180. 6

Note: BC-Control concrete, BC1-5% rice husk ash BC2-10% rice husk ash, BC3- 15% rice husk ash BC4-20% rice husk ash.

Table 4- Mix proportion for M60 grade mixture

Mix Designation	CC	CC1	CC2	CC3	CC4
Rice Husk Ash Present %	0	5	10	15	20
w/c Ratio	0.35	0.35	0.35	0.35	0.35
Cement (Kg/m^3)	474	450.3	426.6	402.9	379.2
Rice Husk ash (Kg/m^3)	0	23.7	47.4	71.1	94.8
Sand (Kg/m^3)	636	585.1	535.6	483.2	433.7
Coarse Aggregate (Kg/m^3)	1113	1113	1113	1113	1113
Water (lit/m^3)	166	166	166	166	166

Note: CC-Control concrete, CC1-5% rice husk ash CC2-10% rice husk ash, CC3- 15% rice husk ash CC4-20% rice husk ash.

5. TEST RESULTS AND DISCUSSIONS

5.1 Workability

The workability of RHA concrete has found to decrease with increase in RHA replacement.

Table 5- Workability results for different mixes

Mix	C.F	Mix	C.F
BC	0.92	CC	0.82
BC1	0.83	CC1	0.73
BC2	0.82	CC2	0.68
BC3	0.80	CC3	0.60
BC4	0.77	CC4	0.56

C.F- Compaction Factor

5.2 Compressive Strength

Replacement of cement by rice husk ash showed in M30 grade concrete compressive strength improvement up to the replacement of 10% in all ages. Both concrete mixes at 10% rice husk ash level showed 3 to 10% increase in compressive strength. Rice husk ash levels of 15 to 20% showed reduction in compressive strength in all ages as presented in Table-6 and Table- 7.

Table 6- % Change in Compressive strength of M30 Grade of Concrete compared with Control Concrete respective ages.

Mix	7 days	28 days
BC	-	-
BC1	4.68	3.37
BC2	10.93	6.74
BC3	-6.25	13.48
BC4	-14.06	-17.97

Note- Negative sign shows decrease in strength.

Table 7- % Change in Compressive strength of M60 Grade of Concrete compared with Control Concrete respective ages.

Mix	7 days	28 days
CC	-	-
CC1	2.88	4.87
CC2	4.23	6.50
CC3	-4.80	0.80
CC4	-8.65	-5.69

Note- Negative sign shows decrease in strength.

5.3 Flexural Strength

Replacement of cement by rice husk ash showed in M30 and M60 grade concrete flexural strength improvement up to the replacement of 10% in all ages. Both concrete mixes at 10% rice husk ash level showed 0.6% to 8% increase in flexural strength. Rice husk ash levels of 15 to 20% showed reduction in flexural strength in all ages as presented in Table-8.

Table 8- % Change in Flexural strength of M30 and M60 Grade of Concrete compared with Control Concrete respective ages.

Mix	28 days	Mix	28 days
BC	-	CC	-
BC1	6.06	CC1	0.60
BC2	8.88	CC2	1.85
BC3	0.60	CC3	0.30
BC4	-0.40	CC4	-1.01

Note- Negative sign shows decrease in strength.

5.4 Split tensile Strength

From the experiments of split tensile strength we observed that there was reduction in split tensile strength in both the concrete mixes. It varies from 9.77 to 26.69% and 6.62 to 26.90% at 28 days for the variation for rice husk content 5 to 20% for M30 and M60 grade concrete respectively. The trend is presented in Table-9.

Table 9- % Change in Split tensile strength of M30 and M60 Grade of Concrete compared with Control Concrete respective ages.

Mix	28 days	Mix	28 days
BC	-	CC	-
BC1	-6.62	CC1	-9.7
BC2	-16.40	CC2	-11.60
BC3	-21.20	CC3	-22.93
BC4	-26.90	CC4	-26.60

6. CONCLUSIONS

The numerous tests performed to check the performance of rice husk ash as a cement replacement material can be concluded by the following points:

1. There was a significant improvement in Compressive strength of the Concrete with rice husk ash content of 10% for different grades namely M30 and M60 and at different ages i.e. 7 days and 28 days.
2. The increase in Compressive strength was of the order of 4.23% to 10.93% for different grades and at different ages.
3. There was also significant improvement in Flexural strength of the Concrete with rice husk ash content of 10% for different grades namely M30 and M60 and at the age of 28 days.
4. There increase in Flexural strength was of the order of 1.85% to 8.88% for different grades and at the age of 28 days.
5. There was reduction in Split tensile strength for 28 days at every rice husk content. There was enormous reduction in split tensile strength as the percentage of rice husk ash increased strength decreased enormously from 6% to 26% for both the grades and at the age of 28 days. As the concrete is a brittle material and cannot handle tensile stress as per IS: 456-2000 proved to be right and that is why as the percentage of rice husk ash increased strength decreased. So it can be concluded that Split tensile strength test has a little importance for design aspects

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