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Effect of Rice Husk on Flexural Strength of Concrete

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ABSTRACT: 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 compressive strength. Rice husk ash levels of 15 to 20% showed reduction in compressive strength in all ages. The objective of research paper to analysis the M-30 and M-60 grade concrete and find what effect on flexural strength of concrete at 7 days and 28 days.

I. INTRODUCTION

Concrete has continuously posed challenges to architects, engineers, researchers and constructors all these years. While trying to improve certain properties of concrete, the other properties have suffered, hence maintaining a perfect balance between the various requirements of concrete happens to be the key to successfully use this wonderful material in emerging India. So replacement of ordinary Portland cement by pozzolana Portland cement is more efficient in terms of economy in mass construction. Replacement of pozzolana Portland cement by mineral admixtures (slag, silica fume) shows more efficiency in terms of both economy & strength.

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. There are two well -known methods for producing rice husk ash, fluidized bed technology which is practiced in U.S and second method is torbed reactor which was developed recently developed in Egypt, it is found that the rice husk ash produced by the torbed technology is superior than fluidized bed technology. 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. Mauro observed that, when rice husk ash is added to concrete there was 38.7% decrease in water absorption and 25% of increment in compressive strength was obtained when 5% of rice husk ash was added to ordinary Portland cement. Dass and other several investigators have examined the characteristics and properties of rice husk ash as; the Blaine air fineness is around 400 to 600 m^2/kg and its specific gravity is around 2.3. Recycling of such waste into new building materials could be a viable solution not only to the pollution problem, but also to the problem of the high cost of building materials currently facing these nations. Using sawdust ash (SDA) instead of sawdust in its natural form may lead to a cheaper concrete. Rice husk constitute about $1/5^{th}$ of the 300 million metric tons of rice produced annually in the world. Rice husk ash is obtained from agricultural waste rice husk. 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. The presence of silica in RHA was known since 1938 and an extensive literature search highlighted many uses of RHA as silica replacement. Two main industrial uses were identified: as an insulator in the steel industry and as a pozzolan in the cement industry.

RHA is used by the steel industry in the production of high-quality flat steel. Moreover, RHA is an excellent insulator, having low thermal conductivity, high melting point, low bulk density, and high porosity. It is this insulating property that makes it an excellent “tundish powder” that prevents rapid cooling of the steel and ensures uniform solidification in the continuous casting process. In addition, substantial research was carried out on its use in the manufacture of concrete. In particular, there are two areas for which RHA is used: in the manufacture of low cost building blocks and in the production of high quality cement. The addition of RHA to cement enhances the cement properties. Addition of RHA to Portland cement not only improves the early strength of concrete, but also leads to the formation of a calcium silicate hydrate gel around the cement particles, which becomes highly dense and less porous. This may increase the strength of concrete against cracking. In general, concrete made with Portland cement containing RHA has a higher compressive strength.

Burning of rice husk at different temperatures produces different kinds of ashes. Once the rice husk is burned without releasing CO_2 in the atmosphere the end product is rice husk ash. It has many industrial uses. The company uses a patented technology to purify the silica content of the ash up to 99%. The impurities are metallic salts which can be processed as fertilizers in rice production. The purified SiO_2 can be processed further to produce Silicon crystals for the production of microchips and solar cells or photovoltaic panels.

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.

II. MATERIAL AND METHODS

Material. The various material used in the experimental work were cement, fine aggregate, coarse aggregate, mineral admixtures, (namely rice husk ash) superplasticizer and water.

Cement. The cement used in this research work was ordinary Portland cement of 53 grade. Cement was tested for its suitability according to IS 12269:1999.

Fine Aggregates. Sand used, as a fine aggregate in this experimental study was land quarried and locally known as Koilwar, generally used in and around Patna.

Table 1: Properties of cement.

Test Parameter	Value	Permissible Range As per IS:12269:1999
Specific Gravity	3.15	3.10-3.15
Blaine Fineness (m^2/Kg)	307	225
Normal Consistency (%)	32	30-35
Initial setting time (min)	62	30
Final setting time (min)	260	600
Soundness of cement (Le Chatelier expansion value in mm)	2	10
Compressive Strength (MPa) 7 days 28 days	 37 58	 53

Table 2: Sieve analysis of fine aggregate and Zones as per IS:383-1970

Sieve Size (mm)	Passing (%)	(%) Passing		
		Zones as per IS:383-1970		
		1	2	3
10	100	100	100	100
4.75	98.5	90-100	90-100	90-100
2.36	95.5	60-95	75-100	85-100
1.18	87.5	30-70	55-90	75-100
0.600	54	15-34	35-59	60-79
0.300	8	5-20	8-30	12-40
0.150	3.75	0-10	0-10	0-10

The sand used in this experiment falls in Grading zone 2, as per IS: 83:1970.

Coarse Aggregate. Graded crushed stone aggregate with maximum nominal size of 20mm and down was used a coarse aggregate. Type of coarse aggregate was used to have better gradation and higher density of the mix

Rice husk ash. Rice husk ash is obtained from agricultural waste of rice husk. Rice husk used in the experimental study is obtained from a M/S Prakash Rice mill Danapur, Bihar and its specific gravity is 2.06. Bulk density of rice husk ash used was 718 kg/m^3. The particles of rice husk ash used were finer than 45μm.

Water. Potable water was used in the experiment, whose Ph value is greater than 6.

Mix Proportions. Water/cementious material ratio is kept around 0.43 and 0.35. M30 M60 grades concrete are used throughout the experimental study. A total of 10 concrete mixes were used for this study. Concrete mixes were made with 5%, 10%, 15% and 20% replacement of cement with rice husk ash.

Specimen Preparation. Concrete specimens are prepared by proper mixing of ingredients in proportions as mentioned. First of all small amount of water is poured into tilting drum mixer then coarse aggregate, fine aggregate, cement and mineral admixture are fed, thereafter the ingredients are mixed dry in the mixer for about 30 seconds, then water was added and mixing was continued till the concrete attained the uniform colour and consistency, then mixer was stopped for about two minutes.

Table 3: Mix Proportions for M30 grade concrete Mixtures.

Mix Designations	**BC**	**BR1**	**BR2**	**BR3**	**BR4**
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)	621.60	582.18	542.88	503.59	464.29
Coarse Aggregate (Kg/m^3)	1108.80	1108.80	1108.80	1108.80	1108.80
Water (lit/m^3)	180.60	180.60	180.60	180.60	180.60

Table 4: Mix Proportions for M60 grade concrete Mixtures.

Mix Designations	**CC**	**CR1**	**CR2**	**CR3**	**CR4**
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	585.10	535.61	483.21	433.72
Coarse Aggregate (Kg/m^3)	1113	1113	1113	1113	1113
Water (lit/m^3)	166	166	166	166	166

Slump was measured. Then compaction factor test was conducted. Specimens were compacted by placing them on the vibrating table. Density and temperature were measured subsequently. Total numbers and types of specimen cast for each mix are given in. The Compression Test had been carried out at different ages of 7 and 28 days. Splitting Tensile Test had been carried out at ages of 7 and 28 days. Flexural strength Test is conducted at age of 28 days.

Curing Conditions. After 24 hours of casting, specimens were de-moulded and marked and immediately submerged in the curing tank of fresh water. They were cured continuously in water tank till testing.

III. EXPERIMENT

Flexural Strength Test. The determination of flexural tensile strength or modulus of rupture is essential to estimate the load at which the concrete member may crack. Its knowledge is useful in the design of pavement slabs and airfield runway as flexural tension is critical in these cases. Specimen of standard dimension of 100mm × 100mm500mm over a span of 400mm, under symmetrical one-point loading is used to produce a constant bending moment between load points so that the span is subjected to the maximum stress, and therefore it is there that cracking is likely to take place. The specimen was placed in the Universal testing machine such that the load was applied to the upper most surface as cast in the mould, along two lines spaced 13.3cm apart. The load was applied without shock and increased continuously at rate of 180kg/min, until the specimen fails, as shown in Fig-8. The test was conducted at the age of 28 days and the average of three specimens was taken as the representative flexural strength of the concrete. The flexural strength of specimen is calculated by PL/bd^2, when „a‟ is greater than 13.3cm. If "a" is between 13.3 and 10 cm, it is calculated as 3Pa/bd. And if „a‟ is less than 10cm the result of test is discarded.

Fig. 1.

RESULTS AND DISCUSSIONS

Flexural Strength of M30 and M60 Grade RHA

The tests for flexural strength of concrete were conducted for different concrete mixes i.e. M30 and M60 grade with different rice hush ash content i.e. 0%, 5%, 10%, 15% and 20% at the selected age i.e. 28 days.The results are complied in the given below. 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.

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.

Table 5: Flexural Strength of M30 Grade RHA Concrete.

S.No.	**Mix designation**	**RHA content (%)**	**Flexural Strength in MPa for 28 days**
1.	BC	0%	4.95
2.	BR1	5%	5.25
3.	BR2	10%	5.39
4.	BR3	15%	4.98
5.	BR4	20%	4.93

Table 6: Flexural Strength of M60 Grade RHA Concrete.

S.No.	Mix designation	RHA content (%)	Flexural Strength in MPa for 28 days
1.	CC	0%	5.94
2.	CR1	5%	5.98
3.	CR2	10%	6.05
4.	CR3	15%	5.96
5.	CR4	20%	5.88

Table 7: Change in Flexural strength of M30 Grade of Concrete compared with Control Concrete in respective ages.

S.No.	Mix designation	RHA content (%)	Change in Flexural Strength in MPa for 28 days
1.	BC	0%	-
2.	BR1	5%	5.25 (Increased by 6.06 times)
3.	BR2	10%	5.39 (Increased by 8.88 times)
4.	BR3	15%	4.98 (Increased by 0.6 times)
5.	BR4	20%	4.93 (Decreased by 0.4 times)

Table 8 : Change in Flexural strength of M60 Grade of Concrete compared with Control Concrete in respective ages.

S.No.	Mix designation	RHA content (%)	Change in Flexural Strength in MPa for 28 days
1.	CC	0%	-
2.	CR1	5%	5.98 (Increased by 0.6 times)
3.	CR2	10%	6.05 (Increased by 1.85 times)
4.	CR3	15%	5.96 (Increased by 0.3 times)
5.	CR4	20%	5.88 (Decreasedby1.01times)

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