

EFFECT OF FLY ASH AND RICE HUSK ASH ON STRENGTH CHARACTERISTICS OF PAVEMENT QUALITY CONCRETE

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Abstract -The construction of concrete pavement is growing across the country due to its strength, durability, better serviceability & overall economy in long run. The need is to develop better quality pavement sections, which can bear heavy loads. This can be achieved by using high compressive strength concrete (>40MPa) made up of hydraulic cement having fine & course aggregates. In the work embodied construction work is done with the help of wastage from industry. Fly ash is a by-product of burned coal from thermal plants and Rice husk ash is the by-product of burned rice husk from paper plant. Considerably Fly ash and Rice husk ash are used as supplementary cementing materials to improve the properties of cement concrete.

The present study is done to develop pavement quality concrete by partially replacement cement with Fly Ash & Rice Husk Ash. The aim of study is to compare the strength characteristics of pavement concrete which as achieved by concrete mixtures. The work done in this study shows the effects on the behaviour of concrete produced from cement with combination of FA and RHA at different proportions on the mechanical properties of concrete such as compressive strength, flexural strength. The replacement of cement were done at three levels is 10%, 20% and 30% with both Fly ash & Rice husk ash as well as combination of both Fly ash and Rice husk ash. The tests on hardened concrete were destructive in nature which includes compressive test on cube for size (150 x 150 x 150 mm) at 7 and 28 days of curing as per IS: 516 1959, Flexural strength on beam (150 x 150 x700 mm) at 28 days of curing as per IS: 516 1959. The samples were prepared water-cement ratio of 0.40 for flexure design 4.5 MPa. The result so obtained showed that it is possible to achieve saving in cement if replacement is done.

Key words-Compressive strength, Flexural strength, Fly ash, Rice husk ash

I. INTRODUCTION

The excessive global population growth brings high demand for building with higher levels of comforts and to low cost, but it is also generates the need of producing sustainable architecture in order to reduce energy consumption while lowering environmental impact [2]. The growing industries in India leads to the generation of large amount of wastes like rice mills industries generates a by-product known as husk. During milling of paddy about 78% of weight is received as rice, broken rice and bran, rest 22% of the weight of paddy is received as husk [1]. The husk to obtain is used as fuel to generate steam for parboiling process. The husk contain about 75% organic volatile matters and balance 25% of husk is converted into Ash during the firing process known as Rice Husk Ash [5].

Thermal power plants generates fly ash as a by-product waste in large amount which is such a big environmental concern. It has been observed that fly ash is very much similar to volcanic ashes used in production of earliest known pozzolan cement. Fly ash is the best known and one of one of the most commonly used pozzolan in the world. Fly ash being the most notorious waste product causing ill effects on agricultural land, surface & sub-surface waste pollution, soil & air pollution. So researchers have proposed few way to reduce fly ash in a cement replacement. Fly ash particles are mostly spherical in shape & this property is used to property mixed in materials [3].

The present study is conducted by using the waste materials from the both the industries like rice mills & thermal power plant. The study is done on techno-economic analysis for the compressive strength of cement concrete when cement was replaced with fly ash and rice husk ash in different ratio. This research is to find environmental reuse of waste product also to find a substitute of cement where these industries are located so that in nearby areas these products could not cause pollution, water logging and diseases to mankind [4].

II. MATERIALS

In this paper the experimental investigation of pavement quality concrete produced from partial replacement of cement with RHA and FA is presented. The properties of RHA, FA and OPC were investigated. Mixing of RHA and FA were done with different ratio of flexural design of 4.5 Mpa with 0.4 water cement ratio. The effect of RHA and FA on concrete properties were studied by means of mechanical properties of concrete i.e. compressive strength and flexural strength.

A. Cement

The cement used was Ordinary Portland Cement of 43 grade. The properties obtained experimentally and as per IS 8112:1989 [12] shown in following table:

Sr. No.	Characteristics	Values Obtained Experimentally	Values Specified By IS 8112:1989
1	Specific Gravity	3.10	-
2	Standard Consistency	27%	-
3	Initial Setting Time, minutes	149	30 minutes (minimum)
4	Final Setting Time, minutes	257	600 minutes (maximum)
5	Compressive Strength		
	3 days	27.8 N/mm ²	23 N/mm ²
	7 days	36.5 N/mm ²	33 N/mm ²
	28 days	48.6 N/mm ²	43 N/mm ²

Table 1: Showing characteristics of Ordinary Portland cement

B. Aggregates

The coarse aggregate used were a mixture of two locally available crushed stone of 20 mm and 10 mm size in 70:30 proportion. The specific gravity of coarse aggregates is 2.73 the aggregates were washed to remove dirt, dust and then dried to surface dry condition [9]. In this experimental program, fine aggregates (stone dust) were collected from Jhelum Stone Crusher, Mirthal, Pathankot and conforming to grading zone II. It was coarse sand light grey in color.

C. Fly Ash

Fly ash used in the study was obtained from Guru Nanak Dev Thermal Power Plant, Bathinda. The fly ash, also known as pulverized fuel ash, Coal Fly ash (FA) is a by-product of the combustion of pulverized coal in thermal power plants. It is removed by the dust collection systems from the exhaust gases of fossil fuel power plants as very fine, predominantly spherical glassy particles from the combustion gases before they are discharged into atmosphere. The size of particles is largely dependent on the type of dust collection equipment. Diameter of fly ash particles ranges from less than 1 µm to 150 µm [6]. It is generally finer than Portland cement.

Constituent	Component in %
Silica (SiO ₂)	46.8
Alumina (Al ₂ O ₃)	23.7
Ferric Oxide (Fe ₂ O ₃)	13.2
Calcium Oxide (CaO)	1.2
Magnesia (MgO)	1.0
Loss on Ignition (LOI)	6.9
Specific gravity	2.10
Fineness	2840 cm ² /gm

Table 2: Showing properties of Fly Ash

D. Rice Husk Ash

Rice husk ash used in this study obtained from Rice mill plant located in Rajpura, Punjab, India. Rice husk is one of the main agricultural residues obtained from the outer covering of rice grains during the milling process. It constitutes 20% of the 500 million tons of paddy produced in the world. IS 456-2000 [13], recommends use of RHA in concrete but does not specify quantities. The rice husk ash had no useful application and had usually been dumped into water streams and caused pollution and contamination of springs until it was known to be a useful mineral admixture for concrete. Various experiments were carried out to determine properties of concretes incorporating optimum RHA. Tests include compressive strength, splitting tensile strength, workability, water permeability and flexural strength. In the case of RHA, the compressive strength of blended concrete structures has been shown to be enhanced and water permeability to be decreased chemically and physically.

Property	Value
Colour	Grey with slight black
Bulk density	104.9 kg/m ³
Specific gravity	1.96
fineness	2775 cm ² /gm
Avg particle size	150.47µm
Component	%
Silica	92.1
Alumina	0.51
Iron oxide	0.40
Calcium oxide	0.55

Potassium oxide	1.53
Titanium di oxide	0.02
Manganese oxide	0.08
Phosphorous penta oxide	0.08
Sulphur tri oxide	0.12

Table: 3: Showing properties of Rice Husk Ash

E. Superplasticizer

The superplasticizer “GLENIUM™ B233” procured from SIKA India Pvt. Limited was used in this study. The dosage of superplasticizer recommended is 0.6% to 2% by weight of cementitious material. 1% superplasticizer by weight of cementitious material was selected in this study to get the medium range of workability [7]. The technical data provided by manufacturer is given in Table:

Sr. No.	Characteristics	Values
1	Type	Poly carboxylic ether (PCE)
2	Form	Liquid
3	Colour	Light Brown
4	Specific Gravity	1.09
5	Relative density	1.09 ± 0.01 at 25°C
6	PH Content	> 6
7	Setting Time	There may be mild extension of initial or final set

Table: 4: Showing properties of Superplasticizer

III. RESULTS AND DISCUSSION

Test specimens of size 150x150x150 mm were prepared for testing the compressive strength and specimen of size 150x150x700 mm for flexure strength with different ratios of materials of water cement ratio 0.40. The compressive strength were tested for curing period of 7 and 28 days and flexure strength were tested for curing period of 28 days as per IS: 516-1959 [10]. Proper vibration was given to the mould with the help of table vibrator for removing voids in concrete cubes. For testing in compression, no cushioning material was placed between the specimen and the plates of the machine. The load was applied axially without shock till the specimen was crushed.

A. Different Proportion of Cement, RHA and FA for testing:-

In this experimentation the replacement of cement were done at three levels is 10%, 20% and 30% with both Fly ash & Rice husk ash as well as combination of both Fly ash and Rice husk ash.

Following table shows the percentage variation of cement, fly ash and rice husk ash:

S. No.	Mould ID	Cement %	Fly Ash %	Rice Husk Ash %
1	FR00	100	0	0
2	FR10	90	10	0
3	FR20	80	20	0
4	FR30	70	30	0
5	FR01	90	0	10
6	FR02	80	0	20
7	FR03	70	0	30
8	FR11	80	10	10
9	FR21	70	20	10
10	FR12	70	10	20

Table: 5: Shows the percentage variation of cement, fly ash and rice husk ash in specimens

B. Test on Fresh Concrete

i). Compressive strength

For compressive strength test, cube specimens of dimensions 150x150x150 mm were cast for flexural design of 4.5 Mpa with w/c ratio of 0.4. The mould were prepared with different ratio of cement, RHA & FA. Vibration was given to moulds using table vibrator. After 24 hours the specimens were demoulded and were transferred to curing tank to cure for 7 and 28 days. After curing, these cubes were tested on digital compression testing machine as per IS 516-1959 [10]. The failure load was noted.

W/C = 0.40	7-Days	28-days	% increase
FR00	37.92	51.22	35.074
FR10	37.54	47.84	27.437
FR20	34.4524	45.36	31.660
FR30	28.3268	40.9826	44.678
FR01	22.55	32.44	43.858
FR02	19.7522	28.4137	43.851
FR03	15.8511	24.8955	57.059
FR11	20.7667	31.7525	52.901
FR21	16.45	26.9688	63.944
FR12	15.47	25.79	66.710

Table: 6: Compressive strength of 4.5 MPa flexure design (w/c = 0.4)

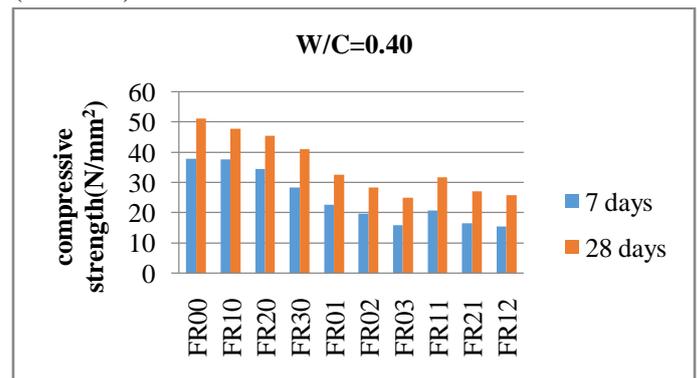


Fig. 1: 7-day and 28-day compressive strengths with w/c = 0.40

ii). *Flexural Strength*

Test specimens of beam size 150×150×700 mm were prepared for testing the flexural strength of unreinforced beams. The beam moulds containing the test specimens were placed in moist air for at least 90% relative humidity and a temperature of $27^0 \pm 2^0$ C for 24 hours $\pm 1/2$ hour from the time of addition of water to the dry ingredients. After this the specimens were removed from the moulds and placed in clean fresh water at a temperature of $27^0 \pm 2^0$ C for 28 days curing. After 28 days of curing the specimens were tested in flexure on a Universal Testing Machine [8]. Loads were applied at the one third points at a constant rate of 30 kg/minute. The distance between the centres of two rollers was kept 20cm. If the fracture occurred within the central one-third of the beam, the flexural strength was calculated on the basis of ordinary elastic theory.

W/C = 0.40	F.S (N/mm ²)	% variation in flexural strength relative to that of control specimen	% variation in flexural strength relative to the minimum design strength (as per MORTH standard for PQC) of 4.5MPa
FR00	5.362	0.0	19.15556
FR10	5.179	-3.4	15.08889
FR20	5.097	-4.9	13.26667
FR30	4.572	-14.7	1.6
FR01	4.481	-16.4	-0.42222
FR02	3.487	-35.0	-22.5111
FR03	3.016	-43.8	-32.9778
FR11	3.562	-33.6	-20.8444
FR21	3.463	-35.4	-23.0444
FR12	3.032	-43.5	-32.6222

Table: 7: Flexural strength of 4.5 MPa flexure design (w/c = 0.4)

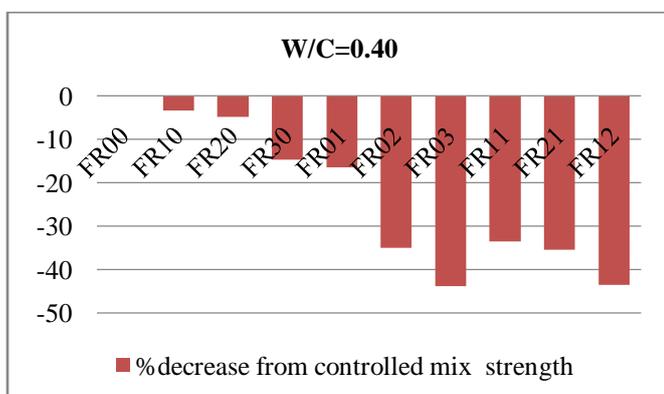


Fig: 2: Percentage decrease in Flexural strength relative to controlled mix strength W/C = 0.40

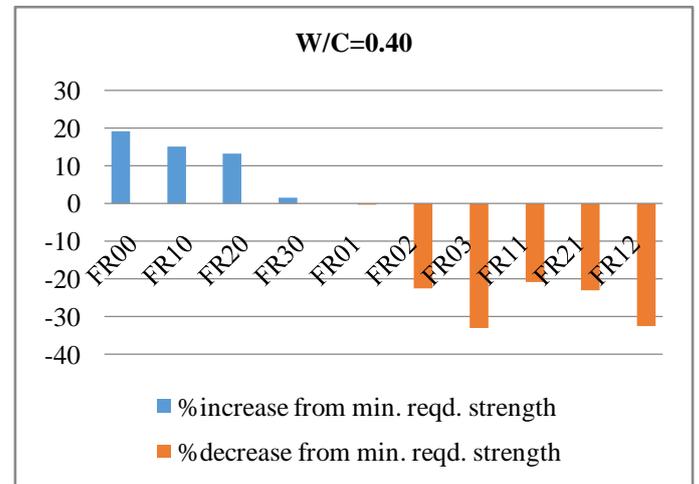


Fig: 3: Percentage change of flexural strengths relative to target strength at W/C = 0.40

IV. CONCLUSIONS

A. *Compressive strength*

1. The mixes with only fly ash replacement has a lesser rate of increase in strength from 7 days to 28 days despite the fact that they have high initial strength, than the mixes with rice husk ash replacement only. The mixes with the inclusion of both rice husk ash and fly ash as replacement material show the highest rate of increase of compressive strength for all water to cement ratios which indicates that pozzolanic activity initiates early for such mixes.
2. Concrete mix with up to 20% percent replacement of cement with fly ash for 0.40 w/c ratio have higher compressive strengths than minimum required as per MoRT&H specifications.
3. Concrete mixes with replacement of rice husk ash have lesser compressive strengths than minimum required as per MoRT&H specifications.
4. Combined replacement of fly ash and rice husk ash showed higher compressive strengths than only replacement of concrete mixes with rice husk ash.
5. Concrete mixes with combined replacement of fly ash and rice husk ash have lesser compressive strengths than minimum required as per MoRT&H specifications.

B. *Flexural strength*

1. The mixes containing only fly ash could achieve 85 to 95% of the control strength, whereas, the mixes containing only 30% rice husk as replacement achieved only 55% of the target controlled strength.

2. Fly ash up to 10 to 25% replacement for all the water-cement ratios showed higher flexural strengths than minimum required flexural strengths as per PQC design standards. Thus, cement replacement by fly ash can be used in designing pavement quality concrete mixes with significant saving in cost.
3. Partial replacement of cement along with rice husk ash does not significantly contribute to gain in flexural strengths for all the replacement levels.
4. Mixes with combination of fly ash and rice husk ash were unable to achieve desired flexural strengths.

V. FUTURE PROSPECTS

1. Rice husk ash is showing lesser compressive strength than fly ash, industrial waste it can further be utilized as strength material of sub grade soil in highway pavements.
2. The result so obtained proves that fly ash is providing more strength than rice husk ash but lesser than cement, so it can be utilized as supplementary cementing material in pavement concrete of less traffic load.
3. The industrial waste, if left unutilized cause environmental problems like burning cause pollution, mixing with water causes choking & blockage. It is better to use waste in an effective & environmentally sound manners.
4. Partial replacement of FA & RHA reduces the environmental effects, produces economical & eco-friendly concrete.

VI. References

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