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Mechanical properties of cement replaced concrete with Rice Husk Ash and Addition of polypropylene fibres

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Abstract: *Sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural waste components. Cement is the most important ingredient in the production of the concrete but Production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenh ouse effect and the global warming. Rice husk is a agro-waste material and by burring it, rice husk ash is obtained which is highly pozzalonic in nature. RHA and fibres are used in this study to enhance properties of concrete. This study was conducted to investigate the strength and durability properties of rice husk ash concrete reinforced with polypropylene fibre. The properties included are the workability, compressive strength, and RCPTF or compressive strength, the addition of RHA in concrete mix was found to increase the compressive strength at 10% replacement as compared to control mix whereas further addition of RHA at 15% and 20% decreases the compressive strength and addition of fibres increases compressive strength at 0.5% fibre content and decrease at 0.75% and 1% fibre content for all concrete mix A concrete mix at 10% RHA replacement is found to be the most appropriate mix based on results of compressive strength,, flexural strength,*

Key words: *concrete, Rice husk ash, polypropylene fibre, compressive strength ,flexure strength, etc…*

1.INTRODUCTION

Concrete as is well known is a heterogeneous mix of cement, water and aggregates. The admixtures may be added in concrete in order to enhance some of the properties desired specially. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk, and admixture to obtain concrete of desired property. Production of cement involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. The use of supplementary cementitious materials (SCMs) such as fly ash, ground granulated blast-furnace slag, silica fume, metakaolin and rice husk ash as part of binders for concrete has been increasing throughout the world, particularly in the production of high strength and high performance concrete. This is due to the potential ability of these materials to enhance the properties and performance of concrete through their filler effect as well as pozzolanic reaction.

Sustainable development of the cement and concrete industry requires the utilization of industrial and agricultural waste components. At present, for a variety of reasons, the concrete construction industry is not sustainable. Firstly, it consumes huge quantities of virgin materials which can remain for next generations. Secondly, the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Thirdly, many concrete structures suffer from lack of durability which may waste the natural resources. So, finding a solution to substitute a practical recycled product for part of the cement seems to be desirable for sustainable development.

2. MATERILAS

2.1.1 Cement

In this experimental study, Ordinary Portland Cement 53 grade, conforming to IS: 8112-1989 was used. The different laboratory tests were conducted on cement to determine the physical and mechanical properties of the cement used are shown in

Table 1.

Physical properties	Results
Fineness	8%
Normal consistency	31.5%
Vicat initial setting time(minutes)	43mins
Vicat final setting time (minutes)	256min
Specific gravity	3.15
7-days compressive strength	39.65
28-days compressive strength	54.86

2.1.2 Aggregates

Locally available natural sand with 4.75 mm maximum size confirming to class II- IS 383 was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 3 and crushed stone with 16mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 3 was used as coarse aggregate. Table 2 gives the physical properties of the coarse and fine aggregates.

Table 2: Physical Properties of coarse aggregate and fine aggregate

property	Fine aggregate	Coarse aggregate
Specific gravity	2.66	2.95
Fineness modulus	3.1	7.96
Surface texture	Smooth	--
Practical shape	rounded	angular

Table 2.3 Physical properties of Coarse Aggregate

Properties	**Values**
water absorption	**0.2 to 0.4 %**
Fineness modulus	**3.43**
Specific gravity	**4.05**
bulk density (gm/cc)	**2.20**

2.1.3 Water

Ordinary potable water available in the laboratory has been used.

RHA are of two types depending upon burning temperature of the rice husk.

AMORPHOUS SILICA

Amorphous silica rice husk is burnt in controlled temperatures which are below 700°C.

The ash generated is amorphous in nature. The highest amount of amorphous silica occurs in samples burnt in the range of 500°C - 700°C. A highly reactive ash can is produced by maintaining the combustion temperature below 500°C.

CRYSTALLINE FORM

When rice husk is burn above 800°C longer than one hour, because of prolonged heating above this temperature cause the material to convert into crystalline silica; first to cristobalite and then tridymite. At 800°C, the ash will convert to cristobalite and after burning at 1150°C both cristobalite and tidymite will be formed. This crystalline form is less reactive.

1.3 Fibers

Fibres can be characterized as a little bit of strengthening material having certain dimensional attributes. The most vital parameter depicting a fiber is its Aspect proportion. "Perspective proportion" is the length of fiber separated by an identical breadth of the fiber. The properties of fiber fortified cement are particularly influenced by the kind of fiber.

(A) LOW MODULUS HIGH ELONGATION FIBRES

This group includes high elongation fibres having large energy absorption characteristics and is capable of imparting toughness and resistance to impact and explosive loadings. Fibres that are generally included in this group are nylon, polypropylene, polyethylene, rayon, acrylic and polyester fibres.

(B) HIGH MODULUS FIBRES

This group includes fibres which are capable of producing strong composites: they primarily impart strength and stiffness to the composite to varying degrees and resistance under dynamic loading. Fibres that are included in this group are steel, carbon, asbestos, organic fibres etc.

3.3 Testing Procedures

This paper entailed subjecting the designed concrete mixes to a series of tests to evaluate the strength, and other properties. For this experiment, it was important to monitor the strength development with time to adequately evaluate the strength of each concrete mix. For each test, 3 samples from each mix were tested at each curing age, ad the average values were used for analysis. The following sections present the procedures used for the various tests.

Compression Strength Test

One of the most important properties of concrete is the measurement of its ability to withstand compressive loads. This is referred to as a compressive strength and is expressed as load per unit area. One method for determining the compressive strength of concrete is to apply a load at a constant rate on a cube (150×150×150 mm), until the sample fails. The compression tests performed in this project were completed in accordance with IS standard 516 "Methods of Tests for Strength of Concrete". The apparatus used to determine the compressive strength of concretes in this experimental work was a universal testing machine (UTM). For this study samples were tested for compression testing at 7, 28, 56 days of curing. The compressive strength of the concrete in terms of pressure was then calculated using the Equation

$$fc=P/A$$

Where,
fc = Compressive Strength of Concrete, (Kpa or psi)
P = Maximum load applied (KN or lb), and
A = The cross-sectional area of sample (mm2 or in2)

4. RESULTS

Compressive Strength

Mix no.	Description	Compressive strength (MPa)				
		7 days	14 days	28 days	56 days	90 days
1	100%PC	42.37	42.93	48.20	53.51	58.11
2	90%PC+10%RHA	43.78	44.12	46.94	56.76	60.22
3	85%PC+ 15%RHA	34.12	37.92	38.50	40.83	59.10
4	80%PC+20%RHA	32.43	33.51	35.41	41.69	58.16
5	90%PC+10%RHA+.5%PP	43.11	46.45	47.20	52.89	67.7
6	90%PC+10%RHA+.75%PP	41.02	45.15	46.86	51.30	55.76
7	90%PC+10%RHA+1%PP	35.56	38.9	43.67	44.03	54.12
8	85%PC+ 15%RHA+.5%PP	40.20	42.32	46.36	47.35	68.91
9	85%PC+15%RHA+.75%PP	31.69	38.90	42.11	48.06	55.25
10	85%PC+ 15%RHA+1%PP	32.16	36.90	40.44	46.19	52.72

11	80%PC+20%RHA+.5%PP	32.43	39.80	43.27	47.30	62.15
12	80%PC+20%RHA+.75%PP	28.06	31.75	39.80	49.32	50.47
13	80%PC+20%RHA+1%PP	28.06	36.91	41.79	43.06	50.12

Flexural strength results

Mix no.	Description	Flexural strength (MPa)		
		28 days	56 days	90 days
1	100%OPC	3.96	5.69	6.04
2	90%OPC+10%RHA	4.26	5.80	6.51
3	85%OPC+ 15%RHA	3.75	4.84	5.29
4	80%OPC+20%RHA	3.56	4.43	4.99
5	90%OPC+10%RHA+.5%PP	4.18	5.08	5.6
6	90%OPC+10%RHA+.75%PP	4.05	5.18	6.28
7	90%OPC+10%RHA+1%PP	2.59	3.73	5.12
8	85%OPC+ 15%RHA+.5%PP	2.64	4.66	5.85
9	85%OPC+15%RHA+.75%PP	4.10	5.39	5.80
10	85%OPC+ 15%RHA+1%PP	3.69	4.40	5.51
11	80%OPC+20%RHA+.5%PP	3.14	5.28	5.99
12	80%OPC+20%RHA+.75%PP	4.12	4.88	5.83
13	80%OPC+20%RHA+1%PP	4.74	5.22	6.26

5. CONCLUSIONS

1. As the replacement of cement by RHA in concrete mix increases, the workability of concrete mix was found to decrease..
2. The addition of RHA in concrete mix was found to increase the compressive strength at 10% replacement as compared to control mix whereas further addition of RHA at 15% and 20% decreases the compressive strength and inclusion of polypropylene fibres into concrete mixes increases the compressive strength at 0.5% fibres content as compared to the control mix whereas further addition of fibres at 0.75% and 1% with RHA decreases the compressive strength for all mixes as compared to the control mix.
3. The addition of RHA into concrete mix is increase the long term compressive strength for all the mixes without

fibres and with fibres at 0.5% volume fraction of fibres and the effect of polypropylene fibres was more than RHA in decreasing compressive strength.

4. The addition of RHA in concrete mix was found to increase the flexural strength at 10% replacement as compared to control mix whereas further addition of RHA at 15% and 20% decreases the flexural strength and inclusion of polypropylene fibres into concrete mixes increases the flexural strength at 0.75% fibre content with 10% RHA replacement as compared to control mix whereas at 0.5% and 1% fibre content decreases flexural strength.

5. The resistance to deflection was more offered by concrete mix at 10% RHA replacement with all fibres contents for 90 days of curing.

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