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AN EXPERIMENTAL INVESTIGATION ON STRENGTH AND WATER PERMEATION PROPERTIES OF RICE HUSK ASH CONCRETE REINFORCED WITH 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 greenhouse effect and the global warming. Rice husk is a agro-waste material and by burring it, rice husk ash is obtained which is highly pozzolanic in nature. RHA and fibres are used in this study to enhance properties of concrete.*

This study was conducted to investigate the strength and water permeation properties of rice husk ash concrete reinforced with polypropylene fibre. The properties included are the workability, compressive strength, splitting tensile strength, flexural strength development and water permeation properties of the concrete. Water permeation properties under consideration were evaluated by Initial Surface Absorption Test (ISAT) and Capillary Suction Test conducted in accordance with BS-1881-208 and ASTM C 1585-04 respectively. For this, an experimental program was planned in which thirteen concrete mixes were prepared. OPC was partially replaced by RHA at 10%, 15% and 20% with addition of fibres at 0.5%, 0.75% and 1% by weight of binder. The water/binder (w/b) ratio was kept constant at 0.38. The results have been presented in the form of figures and tables. It has been observed from the results that workability decreases with increase in RHA and fibres. For 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. For splitting tensile strength, the addition of RHA in concrete mix was found to increase the splitting tensile strength at 10% and 15% replacement whereas slightly decreases at 20% replacement but was more than control mix and inclusion of fibres into concrete mixes increases splitting tensile strength and was maximum at 1% fibres content for all concrete mixes. For flexural strength, 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 fibres into concrete mix increases the flexural strength as compared to plain concrete.

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 green house 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.

3. OBJECTIVES

The objective of the present work is to develop concrete with good strength, less porous, less capillarity so that durability will be achieved. For this purpose it requires the use of pozzolanic materials like rice husk ash along with fibre. So the experimental programme to be undertaken; on strength, sorptivity and surface absorption characteristics of concrete are investigated. The precise objectives of the study are as follows:-

1. To study the compressive strength at different percentage of rice husk ash with different percentages of polypropylene fibres fraction.

2. To study the splitting tensile strength at different percentage of rice husk ash with different percentages of polypropylene fibres fraction.

3. To study the flexural strength at different percentage of rice husk ash with different percentages of polypropylene fibres fraction.

4. To study the initial surface absorption characteristics of concrete at different curing ages, containing different percentage of rice husk ash as partial replacement of OPC with different polypropylene fibres fractions.

5.To study the sorptivity characteristics of concrete at different curing ages, containing different percentage of rice husk ash as partial replacement of OPC with different polypropylene fibers fractions.

3.2.1 CEMENT

conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The physical properties of cement were shown in Table 3.1.

Table 3.1 Physical properties of cement

Characteristic Properties	Observed Value	Codal Requirements
Fineness (m^2/kg)	300	225 Minimum
Standard consistency (%)	32	....
Initial Setting time (minutes)	62	30 Minimum
Final setting time (minutes)	270	600 Maximum
Specific gravity	3.15	....
Soundness by Le-Chat	1.0	10.0 Maximum
Expansion (mm)		
Compressive strength (MPa) 3 days 7-days 28-days	 24.6 34.3 45.2	 23 Minimum 33 Minimum 43 Minimum

3.2.2 FINE AGGREGATE

Crushed stone sand was used as fine aggregate. The fineness modulus by sieve analysis of the fine aggregates is listed in Table 3.2. Clumps of clay and other foreign matter were separated out before using it in concrete.

Table 3.2 Sieve analysis of fine aggregates

IS Sieve designation	Weight retained (Grams)	Percentage weight retained (%)	Cumulative percentage weight retained (%)
4.75 mm	10	1.0	1
2.36 mm	100	10	11
1.18 mm	188	18.8	29.8
600 micron	226	22.6	52.4
300 micron	317	31.7	84.1
150 micron	124	12.4	96.5
Pan	35	3.5	100

Physical properties of fine aggregates determined as given below:

Table 3.3 Physical properties of fine aggregates

Fineness Modulus	2.74
Specific gravity	2.65
Bulk Density	1675 kg/m^3

3.2.3 COARSE AGGREGATE

Locally available crushed stone aggregates of 12.5 mm nominal size were used as coarse aggregate. Sieve analysis of coarse aggregates is listed in Table 3.4. The aggregate was first sieved through 50 micron sieve in order to remove the dirt and other impurities.

Table 3.4 Sieve analysis of coarse aggregate

IS Sieves designation	Weight retained (Grams)	Percentage weight retained (%)	Cumulative percentage weight retained (%)
40 mm	0	0	0
20 mm	0	0	0
10 mm	1131	56.55	56.55
4.75 mm	827	41.35	97.9
pan	42	2.10	100

Physical properties of coarse aggregates determined as given below:

Table 3.5 Physical properties of coarse aggregates

Fineness Modulus	7.54
Specific gravity	2.69
Bulk Density	1690 kg/m^3

3.2.4 WATER

The water used was the potable water as supplied in the Structures laboratory ofour Institute. Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts and sugar, organic materials or other substances that may be deleterious to concrete. As per IS: 456-2000 potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for preparation of all concrete specimens.

3.2.5 RICE HUSK ASH

Rice husk ash is an agro based material. Rice husk ash used was of grey colour and light in weight. Specific gravity of RHA was 1.96.

Table 3.6 Sieve analysis of Rice Husk Ash

IS Sieves designation	Weight retained (Grams)	Percentage weight retained (%)	Cumulative Percentage Weight retained (%)
4.75mm		0	0
2.36mm		0	0
1.18mm		0	0
600micron		11.5	11.5
300 micron		51.5	63
150 micron		26	89
90 micron		7	96
75 micron		1	97
pan		3	100

3.2.6 FIBRES

Polypropylene fibres of ENDURO® HPP45 were used in the concrete mix. It complies with ASTM C 1116 Type 111 4.1.3. These are non corrosive in nature.

Table 3.7 physical and chemical properties of fibres

Fibre length	45 mm
Shape	Monofilament shape
Acid and salt	High resistance
Absorption	Nil
Melting point	164^{o}c
Ignition point	550^{o}c
Specific gravity	0.91
Thermal and electrical conductivity	Low
Alkali resistance	Alkali proof

3.2.7 SUPER-PLASTICIZER

The super-plasticizer used in the study was Glenium SKY777. Glenium SKY777 is based on second generation polycarboxylic ether polymers and supplied as a light brown liquid instantly dispersible in water. Glenium SKY777 complies with IS: 9103:1999 and EN 934-2 T11.1/11.2. Glenium SKY777 conforms to ASTM-C-494 Type 'F' and Type 'G' depending on the dosages used. The dosage of SP was different for different concrete mixes to obtain constant slump value of 100 ± 10 mm.

Table 3.8 Properties of Glenium SKY 777 super-plasticizer

Aspect	Light brown liquid
Relative Density	1.10 ± 0.01 at 25°C
pH	>6
Chloride ion content	< 0.2%

4.RESULTS

4.1 COMPRESSIVE STRENGTH TEST RESULTS

The compressive strength test was conducted at curing ages of 7, 14, 28, 56 and 90 days.

Mix no	Description	Compressive strength (MPa)				
		7 days	14 days	28 days	56 days	90 days
1	100%PC	41.37	42.93	47.92	53.11	57.11
2	90%PC+10%RHA	42.78	42.9	46.94	56.90	60.10
3	85%PC+ 15%RHA	33.90	37.75	38.50	40.93	59.00
4	80%PC+20%RHA	31.43	33.51	35.41	40.69	57.56

5	90%PC+10%RHA +.5%PP	43.85	45.45	47.20	52.89	67.7
6	90%PC+10%RHA +.75%PP	40.9	44.15	47.86	51.30	55.76
7	90%PC+10%RHA +1%PP	34.56	39.5	42.67	44.03	54.14
8	85%PC+ 15%RHA+.5%PP	40.40	42.32	45.36	47.75	66.91
9	85%PC+15%RHA +.75%PP	32.69	39.20	41.71	47.06	54.45
10	85%PC+ 15%RHA+1%PP	31.86	37.00	40.84	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

4.2 CAPILLARY SUCTION (SORPTIVITY) TEST

RESULTS Table-4.6 Variation of initial rate of absorption values of various mixes at different curing ages

Mix no.		Average IRA mm/Sec1/2)	
1	100%PC	0.0200	0.0130
2	90%PC+10%RHA	0.0160	0.0120
3	85%PC+ 15%RHA	0.0146	0.0103
4	80%PC+20%RHA	0.0130	0.0100
5	90%PC+10%RHA+.5%PP	0.0170	0.0150
6	90%PC+10%RHA+.75%PP	0.0120	0.0110
7	90%PC+10%RHA+1%PP	0.0156	0.0153
8	85%PC+ 15%RHA+.5%PP	0.0153	0.0146
9	85%PC+15%RHA+.75%PP	0.0146	0.0100
10	85%PC+ 15%RHA+1%PP	0.0156	0.0110
11	80%PC+20%RHA+.5%PP	0.0166	0.0143
12	80%PC+20%RHA+.75%PP	0.0156	0.0126

The results of the capillary suction tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. Typical plots of cumulative water absorption against the square root of time for all concrete mixes at curing time of 28 and 56 days. Each set of plots refer to the three specimens tested for each concrete mix. The tests conducted on the three specimens at a particular curing time give identical slopes, particularly during the early part of the test, i.e. the relationship between cumulative water absorption and the square root of time of exposure begins to deviate from linearity after about 6 hours. The results clearly show that sorptivity decreases with increase in curing time.

6.CONCLUSION

1.As the replacement of cement by RHA in concrete mix increases, the workability of concrete mix was found to decrease as compared to control mix and the addition of polypropylene fibres into concrete mix also decreases the workability.

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 inclusion of RHA into concrete mix led to 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 incorporation of RHA in concrete mix was found to increase the splitting tensile strength at 10% and 15% replacement whereas slightly decreases at 20% replacement but was more than control mix and addition of polypropylene fibres into concrete mixes increases the splitting tensile strength and was maximum at 1% fibres content for all concrete mixes.

5.The inclusion of RHA and fibres into concrete mix led to increase the long term splitting tensile strength for all the mixes.

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