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Study on Mechanical Properties of Nylon Fibred Reactive Powder Concrete

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Abstract-

In recent year, there are many types of concrete were used in construction purpose. The reactive powder concrete is one of them. Reactive Powder Concrete (RPC) is a developing composite material that will allow the concrete industry to optimize material use, generate economic benefits, and build structures that are strong, durable, and sensitive to environment. At such a level of strength, the coarse aggregate becomes the weakest link in concrete. In order to increase the compressive strength of concrete even further, the only way is to remove the coarse aggregate. This philosophy has been employed in Reactive Powder Concrete (RPC). RPC is composed of very fine powders (cement, sand, quartz powder and silica fume), steel fibres (optional) and super-plasticizer. The super-plasticizer, used at its optimal dosage, decreases the water to cement ratio (w/c) while improving the workability of the concrete. A very dense matrix is achieved by optimizing the granular packing of the dry fine powders. This compactness gives RPC ultra-high strength and durability. Textile fibre concrete is a type of concrete in which textile fibre is added by various amount in concrete mix to improve its strength and other characteristics.

Keywords- Cement, Silica fume, Sand, Quartz powder, and Nylon fibre.

1. INTRODUCTION

Reactive Powder Concrete (RPC) is a composite material that will allow the concrete industry to optimize material use, generate economic benefits, and build structures that are sensitive to environment, strong and durable. A comparison of RPC and HPC (High Performance Concrete) by the physical, mechanical, and durability properties shows that RPC have better strength and lower permeability compared to HPC. "This page reviews the available literature on RPC, and also presents the results of laboratory investigations comparing RPC with HPC." Specific advantages and potential uses of RPC have also been described. HPC has given the maximum compressive strength in its existing form of microstructure. Concrete is a composite material of cement, coarse aggregate, and fine aggregate and water majorly and coarse aggregate is the weakest material in concrete at such level. To increase compressive strength and overall strength of concrete, the coarse aggregate are eliminated in reactive powder concrete. This philosophy has been used in Reactive Powder Concrete (RPC).

Reactive Powder Concrete (RPC) has developed in France in the early 1990s and The Sherbrooke Bridge in Canada is the world's first Reactive Powder Concrete structure, was erected in July 1997. Reactive Powder Concrete (RPC) has advanced mechanical and physical properties with ultrahigh-strength and high ductility. It consist a special concrete, where the microstructure is decreased by accurate gradation of all components in the mix to get maximum density. It uses highly refined silica fume and optimization of the Portland cement chemistry to produce the highest strength hydrates.

RPC is combination and mixture of very fine powders like cement, sand, quartz powder and silica fume, steel fibres and super-plasticizer (admixture). The super-plasticizer is used to decreases the water to cement ratio (w/c) while improving the workability of the concrete. The granular packing of the dry fine powders optimization achieves a very dance matrix. Ultra-high strength and durability in RPC is achieved by compactness. Reactive Powder Concrete has compressive strengths ranging from 200 MPa to 800 Mpa.

Table 1: Selection Parameters for RPC components

Components	Selection Parameters	Function	Particle Size	Types
Sand	Good hardness easily available and cheap.	Give strength, fine Aggregate	150 µm to 600 µm	Natural, Crushed
Cement	C_3 S: 60%; C_2S : 22%; C_3A : 3.8%; C_4AF: 7.4%. (optimum)	Binding material, Production of hydrates	1 µm to 100 µm	Ordinary Portland cement
Quartz Powder	Fineness	Max. reactivity during heat-treating	5 µm to 25 µm	Crystalline
Silica fume	Very less quantity of impurities	Filling the voids, Enhance theology, Production of secondary hydrates	0.1 µm to 1 µm	Procured from Ferrosilicon industry (highly refined)
Steel fibres	Good aspect ratio	Increase ductility	L : 13 – 25 mm Ø : 0.15 – 0.2 mm	Straight
Super-plasticizer	Less retarding characteristic	decrease w/c	-	Polyacrylate based

2. Materials and Methods

The present aim of the study is to investigate mechanical properties of reactive powder concrete with different dosage, replacement of cement with silica fume and replacement of fine aggregate with quartz powder and added nylon fibre by volume as per privious mix design refrences of steel fibres. The effect of replacement by compressive strength and split tensile strength of RPC were studied as per is standard.

2.1 Raw materials

The raw meterial were used in study are ordinary portland cement of 53 grade of binani cement compony and locally available sand of grade III were used as per IS code criteria. The corse aggregate are eliminated in Reactive powder concrete. Quart powder particle size of 5 µm to 25 µm have been used. Silica fume of 0.1 to 1µm were used. Nylon fibre were used instad of steel fibre.

2.3 Mix proportions

There were total 12 num of mix design made.

Table 2: Replacement of fine aggregate by quartz powder in %

Specimen no.	Quartz powder replacement%	Fine aggregate %
A1	25	75
A2	50	50
A3	75	25
A4	100	0

Table 3: Replacement of cement by silica fume

Mix no.	Silica fume replacement%	Cement%
B1	10	90
B2	20	80
B3	30	70

Table 4: Number of specimen

Name of test		Compressive strength specimen	Split Tensile Test
Specimen no	**A1B1**	3	3
	A2B1	3	3
	A3B1	3	3
	A4B1	3	3
	A1B1	3	3
	A2B2	3	3
	A3B3	3	3
	A4B4	3	3
	A1B1	3	3
	A2B2	3	3
	A3B3	3	3
	A4B4	3	3

Mixture A indicates replacement of fine aggregate by quartz powder in % and Mixture B indicates replacement of cement by silica fume in percentage. The specimen have been made by me simultaneously of mixture A and mixture B. i.e. Mixture A2B3 means 50% replacement of fine aggregate by quartz powder as per A2 and 30% replacement of cement by silica fume.

Table 5: mix proportion as per P. Richard and M. Cheyrezy

Material	Proportion	Mass (kg/m^3)
Portland Cement	1	846
Silica fume	0.23	195
Sand	1.1	930
Quartz Powder	0.39	330
Superplasticizer	0.0019	1.61
Nylon fibre	0.025	21
Water	0.19	161

2.3 Method

2.3.1 Compressive strength

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Cube compressive strength at age 7 days and 28 days. Cube specimens sizes of 150mm were casting for compressive strength as per Indian standard specification IS: 516-1959.

After casting, all test specimens were finished with steel trowel. Immediately after finishing the specimens were covered with sheets to minimize the moisture loss from them. Specimens were demoulded after 24 hours and then cured in water at approximately room temperature till testing. Compressive strength tests for cubes were carried out at 7 and 28 days. All the specimens were tested in automated CTM shown in figure.

The compression strength was calculated according to the formula:
Compressive strength = P/A
Where, Compressive strength in (N/mm2)
P = Maximum load (N)
A = Cross Sectional area of cube (mm2)

2.3.2 Split tensile strength

The splitting tensile strength is well known indirect test used for determining the tensile strength of concrete. Tensile strength is one of the most important fundamental properties of concrete. An accurate prediction of tensile strength of concrete will help in mitigating cracking problems, improve shear strength prediction. The splitting tensile strength was determined at the age of 7days and 28 days on cylinder 150 mm x 300 mm as per Indian standard specification IS: 5816-1999.

The test consists of applying compressive line loads along the opposite generators of concrete cylinder placed with its horizontal between the plates. Due to applied line loading a fairly uniform tensile stress is introduced over nearly two third of the loaded diameter as obtained from an elastic analysis.

Horizontal Tensile Stress = $2P/\pi LD$

Where, P = compressive load on the cylinder

L = length of cylinder

D = diameter of cylinder

3. RESULTS

3.1 Results on compressive strength of RPC

Table 6: Compressive strength of RPC

Description of specimen	Compressive strength(N/mm^2)	Average
Mix A1B1	123.85	121.45
	120.2	
	120.32	
Mix A1B2	144.96	146.06
	152.75	
	140.47	
Mix A1B3	98.35	100.24
	105.64	
	96.73	
Mix A2B1	112.48	108.24
	102.43	
	109.82	
Mix A2B2	128.46	126.17
	126.92	
	123.13	
Mix A2B3	102.43	102.31
	99.83	
	104.68	
Mix A3B1	109	109.21
	106.36	
	112.29	
Mix A3B2	119.42	112.71
	107.44	
	111.28	
Mix A3B3	93.75	97.77
	104.25	
	95.32	
Mix A4B1	78.85	83.17
	86.20	
	84.48	
Mix A4B2	87.28	89.49
	92.81	
	88.38	
Mix A4B3	77.88	75.14
	73.89	
	73.89	

3.2 results on split strength of RPC

Table 7: Split tensile strength of RPC

Description of specimen	Split tensile strength(N/mm^2)	Average
Mix A1B1	11.28	11.25
	11.42	

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	11.07	
Mix A1B2	12.03	12.77
	12.65	
	13.65	
Mix A1B2	11.65	11.80
	12.71	
	11.06	
Mix A2B1	10.65	10.75
	11.23	
	10.36	
Mix A2B2	11.69	11.81
	11.06	
	12.16	
Mix A2B3	11.02	10.41
	10.16	
	10.07	
Mix A3B1	9.62	9.95
	10.36	
	9.87	
Mix A3B2	11.13	10.55
	10.17	
	10.35	
Mix A3B3	9.5	9.80
	9.86	
	10.06	
Mix A4B1	8.31	8.71
	8.68	
	9.13	
Mix A4B2	8.84	9.10
	9.03	
	9.43	
Mix A4B1	7.63	7.71
	7.58	
	7.92	

The results of compressive strength of different specimens are shown and that results shown in graphs below.

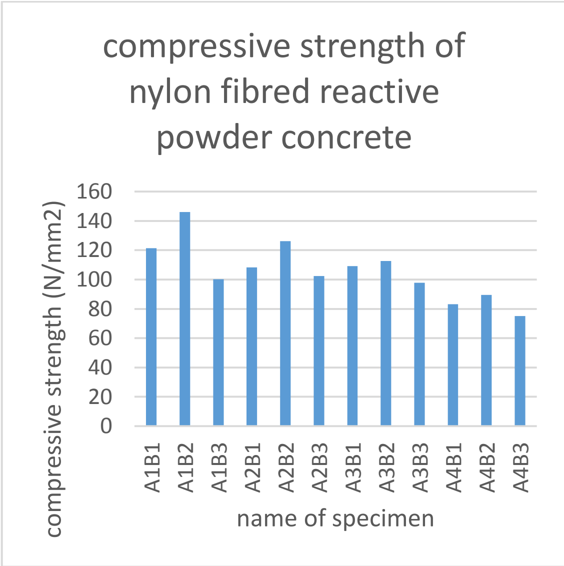

Fig. 1. Compressive strength of RPC

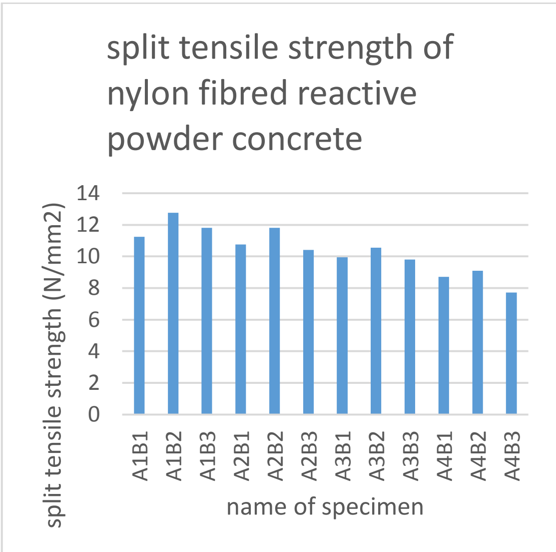

Fig. 2. Split tensile strength of RPC

4. CONCLUSION

- A1B2 mix possesses maximum compressive strength in all above. It have 20% replacement of cement with silica fume and 25% replacement of sand with quartz powder which is mention above.
- A1B2 mix has also maximum split tensile strength in all above mixtures. It has 12.77 N/mm^2 of split tensile strength which is highest in all above mixture.

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- It means, we conclude that, mix A1B2 appropriate mix.

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