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Research paper

Experimental Study on Reactive Powder Concrete under Flexural Loading

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Abstract

Reactive powder concrete (RPC) is ultra high strength with advanced mechanical properties. Reactive powder concrete is a concrete without coarse aggregate, contains cement, silica fume, quartz sand, quartz powder, super plasticizer, steel fibre and polypropylene fibre with very low water cement ratio under normal curing condition. RPC has been produce with high compressive strength ranging from upto 800 MPa with high flexural strength up to 50 MPa and in some cases provided with absences of steel reinforcement. Mix proportions of RPC were found by trial and error method, the concrete cubes of size 100mmx100mmx100mm were cast for find compressive strength of NRPC at 7days. Concrete cubes and cylinders of sizes 100mmx100mmx100mm and 100mmx150mm have to be cast for finding compressive strength and split tensile strength at 28 days. Flexural strength of NRPC and MRPC will be find out by casting prism of size 500mmx 100mmx 100 mm. The optimum mix proportion has to be finalized by comparing the results of all concrete specimens. Compressive strength test results shows that addition of silica fume upto 0.22% will increase the compressive strength of reactive powder concrete.

Keywords *- Ordinary Portland cement, Silica fume, Steel fibres, Polypropylene fibres, Compressive strength, Flexural strength.*

1. Introduction

Concrete is one of the necessary elements for structural work in the modern construction. The ultra high strength concrete (UHSC) has been developed in the recent years in concrete technology. RPC is a concrete without coarse aggregate but contains cement, silica fume, quartx sand, quartz powder and fibres with very low water cement ratio. [Richard and Cheyrezy, et.al, 1995].

The silica fume reacts with the calcium hydroxide, thus increasing the strength in the concrete and improves the bond between the cement and aggregate. Because of the pozzolanic property of the silica present in the silica fume reacts with the calcium hydroxide which forms during the hydration process of cement forms the C-S-H gel. [Habel, et.al, 2006].

The production of RPC the optimum percentage of silica fume is found to be of 15% (by weight of cement). The quartz powder increases the compressive strength upto 10% when compared to the normal curing. RPC effectively suitable for prestressed applications. [Khadiranaikar.R.B, et.al, 2012]

The replacement of fly ash with cement increases the compressive strength and flexural strength. The optimum percentage of steel fibre used in the RPC has increases the superior mechanical properties and durability properties than the normal high strength concrete. RPC has an ultra high dense microstructure giving waterproofing and durability characteristics. [Dushmukh.A.R, et.al, 2016].

2. Materials Used

A. Cement

Dalmia, OPC 53 grade of cement is used in this project. The cement properties are determined to meet the requirements of IS 12269- 1987: Specification for 53 grade Ordinary Portland cement.

Fig.1: Cement

Table 1: Properties of Cement

S.No	Property	Result
1.	Fineness	98%
2.	Specific gravity	3
3.	Consistency	26%
4.	Initial setting time	35 minutes
5.	Final setting time	255 minutes

B. *Silica fume*

The silica fume used in this experiment is extremely very fine particles which exists in grey colour powder form. The specific gravity is 2.4 and fineness is 86%.

Fig.2: Silica fume

C. Quartz sand

The quartz sand used in this project was white high purity silica sand crystalline in nature and the particles size ranges from 450 to 600 microns. The specific gravity of quartz sand is 2.43.

Fig.3: Quartz sand

D. Quartz powder

The quartz powder used in the project was white colour powder form and extremely very fine in nature. The specific gravity of quartz powder is 2.5.

Fig.4: Quartz powder

E. Water

Water is a most important ingredient in concrete as it rises above certain limit it affects the water cement ratio and decreases the strength of the concrete. The pH value of the concrete is 6.5.

F. Super plasticizer

The RPC requires the very low water cement ratio can be only possible through the use of super plasticizer to achieve the required workability.
The Glenium 8233 formely B-233 which is reddish brown in colour and it is a poly-carboxylic ether based hyper super plasticizer.

G. Steel fibre

Hook end fibres used in this experiment which have diameter of 0.5mm and length 30mm and aspect ratio of 60 and procured from steel reinforcement redefined proceeded by Jeetmull Jaichandlall, Madras Pvt Ltd.

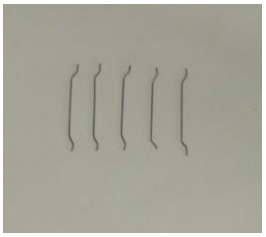

Fig.5 Steel fibre

H. Polypropylene fibre

The polypropylene fibre in this experiment which have the diameter of 0.0445mm and length of 6.2mm and aspect ratio of 139.33. The specific gravity of polypropylene fibre is 1.33. The material was brought from suppliers, Coimbatore.

Fig.6: Polypropylene fibre

3. Mix Proportion

The mix proportion has been taken from the previous literatures guidelines. The mix proportion is based on the trial and error method.

Table 2: Mix Proportion for Normal RPC

S. N	MP	C	SF	QS	QP	Water	SP
1	MP1	1	0.22	1.2	0.5	0.4	3
2	MP2	1	0.24	1.2	0.5	0.4	3
3	MP3	1	0.26	1.2	0.5	0.4	3

Thus the optimum mix ratio of concrete is **1:0.24:1.2:0.5**

Table 3: For Modified RPC

S. N	MP	C	SF	QS	QP	W	SP	SFB	PPF
1	MP4	1	0.24	1.2	0.5	0.4	3	1	0.25
2	MP5	1	0.24	1.2	0.5	0.4	3	1	0.5
3	MP6	1	0.24	1.2	0.5	0.4	3	1	0.75
4	MP7	1	0.24	1.2	0.5	0.4	3	1.5	0.25
5	MP8	1	0.24	1.2	0.5	0.4	3	1.5	0.5
6	MP9	1	0.24	1.2	0.5	0.4	3	1.5	0.75
7	MP10	1	0.24	1.2	0.5	0.4	3	2	0.25
8	MP11	1	0.24	1.2	0.5	0.4	3	2	0.5
9	MP12	1	0.24	1.2	0.5	0.4	3	2	0.75

Thus optimum mix ratio of concrete is 1:0.24:1.2:0.5:1.5:0.5

4. Experimental Program

A. Compressive strength test

The compressive strength test was carried out as per IS: 516 – 1959. The compressive strength was determined by the cubes specimen of size (100mm x 100mm x 100mm). The cubes specimen of size (75mm x 75mm x 75mm) was also used. The required quantity of materials were weighed and then mixed the materials manually. The concrete was filled in the mould by four different layers and each layer was compacted well with help of tamping rod. The specimen was demoulded after 24 hours and adopted three different types of curing (a) cured in clean water for 7 days and 28 days, (b) Hot water curing for 7 days, (c) Hot water and Normal water curing for 7 days and 7 days. The specimens were taken out and wiped dry and then tested in compressive testing machine as per Indian Standard. The specimen was placed in such a way that the load acts opposite to the compacted surface of the specimen. The load was applied until the failure of the cubes. The ultimate load was noted. The compressive strength of the specimens were calculated and mentioned in the table. IV & V.

Fig.7: Compression testing machine

B. Flexural strength test

The prism of standard size 100 x100 x 500 mm was used to determine the flexural strength of concrete. Three specimens were tested for 7 and 28 days. The required amount of material was weighed and the materials were mixed manually. The concrete was filled in the mould by four different layers and each layer was compacted well with help of tamping rod. The specimen was demoulded after 24 hours, cured in clean water for 7 days and 28 days of curing. The specimens were taken out and wiped dry and then tested in universal testing machine as per Indian Standard. Flexural strength is found using centre point loading system. The specimen is placed in the machine in such a manner that the load is applied to the uppermost surface as compacted in the mould. The axis of specimen is carefully placed with the axis of the loading device. Load is applied until the failure of the specimen. The ultimate load and breaking load is noted. The flexural strength of the specimens were calculated and listed in the table VII.

Fig.8: Universal testing machine

5. Results And Discussions

Test Results

Normal Curing

Table 4: For Normal RPC

MP	Average compressive strength (N/mm^2)		Average tensile strength (N/mm^2)
	7 days	28 days	28 days
MP1	30	31	3.18
MP2	**32**	**40**	**3.82**
MP3	27.5	35	2.55

Table 5: For Modified RPC

MP	Average compressive strength (N/mm^2)		Average tensile strength (N/mm^2)
	7 days	28 days	28 days
MP4	32.5	37.5	4.78
MP5	34	45	5.57
MP6	36	38	6.36
MP7	34	39	6.46
MP8	**40**	**48**	**6.59**
MP9	38	41	4.78
MP10	36	39	4.42
MP11	38	42	3.8
MP12	34.5	38	3.6

Hot Water Curing And Hot Water+Normal Curing

Table 6: For Modified RPC

MP	Average compressive strength (N/mm^2)	
	Hot water curing (7 days)	Hot water + Normal curing (7 days + 7 days)
MP4	40.5	36
MP5	42.5	39
MP6	40	42.5
MP7	42.6	45
MP8	**45**	**52**
MP9	35.5	45
MP10	34	43
MP11	39	40
MP12	37	36

Table 7: For Optiimum Mix in NRPC and MRPC

MP	Average flexural strength (N/mm^2)
	7 days
MP2	6.25
MP8	8.25

6. Results And Discussion

1) The maximum compressive strength and tensile strength results at 7 days and 28 days for NRPC was MP – 2 (because of the 24% replacement of silica fume by the weight of cement).
2) The maximum compressive strength and tensile strength results at 7 days and 28 days for MRPC was MP – 8(because of the 1.5% of steel fibre and 0.5% of polypropylene fibre).
3) The addition of silica fume upto 24% the compressive and tensile strength gets gradually increased.
4) The compressive strength and tensile strength for 1% and 2% of steel fibre gives lesser value compared to the 1.5% steel fibre.
5) The combined curing (hot water and normal water curing) gives the maximum value compared to the normal curing and hot water curing.

7. Conclusion

The conclusion from this project were

1) Reactive powder concrete is a concrete without coarse aggregate, possess high compressive, tensile and flexural strength.
2) RPC is used to make a precast concrete element as highway barriers, compound walls of nuclear power plants, etc.
3) Addition of steel fiber and polypropylene fiber in RPC possess additional strength during tension and flexure behavior.
4) For the combined curing (normal curing + hot water curing) results of MRPC, we attain high strength over the other types of curing.
5) Finally, we concluded that RPC with the addition of steel fiber and polypropylene fiber provides high strength when adopt with combined curing.

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