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Mechanical Behavior Of Modified Of Reactive Powder Concrete

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ABSTRACT

Original Reactive Powder Concrete (RPC) - in form of a superplasticized cement mixture with silica fume, steel fibers and ground fine quartz (150-600 μ) - was studied in comparison with a modified RPC where a graded natural aggregate (max size 8 mm) was used to replace the fine sand and/or part of the cementitious binder. Original and modified RPC were manufactured at a plastic-fluid consistency, cast by vibration and cured at hot water curing at 90°C for 2 days and normal water curing for remaining 26 days. The addition of the graded aggregate does reduce the compressive strength and flexural strength provided that the quality of the cement matrix in terms of its water-cement ratio is not changed. Cost of the original RPC is less than the cost of modified RPC per m^3 of concrete.

Keywords: Reactive Powder Concrete (RPC); flexural strength; high-strength concrete; silica fume; steels; super plasticizer;

INTRODUCTION

The term Reactive Powder Concrete (RPC) has been used to describe a fiber-reinforced, super plasticized, silica fume-cement mixture with very low water-cement ratio (w/c) characterized by the presence of very fine quartz sand (0.15-0.60 mm) instead of ordinary aggregate. In fact, it is not a concrete because there is no coarse aggregate in the cement mixture. The absence of coarse aggregate was considered by the inventors to be a key-aspect for the microstructure and the performance of the RPC in order to reduce the heterogeneity between the cement matrix and the aggregate. However, due to the use of very fine sand instead of ordinary aggregate, the cement factor of the RPC is as high as 900-1000 kg/m3. This unusual cement factor could increase drying shrinkage and creep strain of the RPC with respect to ordinary concrete with cement factor usually in the range of 300-500 kg/m3.

The main purpose of the present investigation was to modify RPC including some coarse aggregate in the mixture and to study the influence of the coarse aggregate on the properties of cement mixtures in terms of compressive, flexural strength, workability and cost comparison of RPC.

CONCRETE MIXTURE

Three sets of concrete mixtures were manufactured with respect to the Original RPC composition without coarse aggregate:

a) A set where the amount of fine sand (0.15-0.60 mm) of the original RPC composition was partially or totally replaced by the natural coarse aggregate (0-8 mm) without changing the cement factor.

Here we were replaced Fine sand by coarse aggregate with 50% and 100%. (Modified RPC M_1 & M_2 respectively in TABLE 1);

TABLE 1: Composition of RPC mixtures with coarse aggregate (Max. size= 8mm) replacing fine sand (0.15-0.60 mm)

Mixture No.		Original RPC (O_0) (kg/m^3)	Modified RPC (M_1) (kg/m^3)	Modified RPC (M_2) (kg/m^3)
Cement		689.30	689.30	689.30
Silica Fume		220.57	220.57	220.57
Quartz Sand		248.15	248.15	248.15
Fine Sand		1033.95	516.97	-
Coarse Aggregate		-	516.97	1033.95
Steel Fibers		13.786	13.786	13.786
Super plasticizer		24.12	24.12	24.12
Water		151.64	151.64	151.64
Flow in mm		152.00	147.00	150.00
Compressive strength (N/mm^2)	7 Days	138.00	122.53	113.60
	28 Days	151.00	135.60	118.00
Flexural strength (N/mm^2)		24.60	16.33	10.16

b) A set where part of the cementitious binder (cement + silica fume) was replaced by the coarse aggregate (0-8 mm) without changing the amount of fine sand.

Here also we were replaced cementitious binder (cement + silica fume) by coarse aggregate with 10% and 25%. (Modified RPC M_3 or M_4 respectively in TABLE 2);

TABLE 2: Composition of RPC mixtures with coarse aggregate replacing part of the cementitious binder (cement + silica fume)

Mixture No.		Original RPC (O_0) (kg/m^3)	Modified RPC (M_3) (kg/m^3)	Modified RPC (M_4) (kg/m^3)
Cement		689.30	621.00	516.97
Silica Fume		220.57	198.72	165.37
Quartz Sand		248.15	248.15	248.15
Fine Sand		1033.95	1033.95	1033.95
Coarse Aggregate		-	90.98	227.44
Steel Fibers		13.786	13.786	13.786
Super plasticizer		24.12	24.12	24.12
Water		151.64	151.64	151.64
Flow in mm		152.00	149	170
Compressive strength (N/mm^2)	7 Days	138.00	93.87	100.00
	28 Days	151.00	115.73	104.27
Flexural strength (N/mm^2)		24.60	15.31	13.20

c) A set where part of the cementitious binder and the whole of fine sand was replaced by the coarse aggregate.

Here we were taken combination of two above sets. Where replacing all fine sand and replacing cementitious binder by coarse aggregate with 10% & 25%. (Modified RPC M_5 or M_6 respectively on TABLE 3).

TABLE3: Composition of RPC mixtures with coarse aggregate replacing all fine sand and part of the cementitious binder.

Mixture No.		Original RPC (O_0) (kg/m^3)	Modified RPC (M_5) (kg/m^3)	Modified RPC (M_6) (kg/m^3)
Cement		689.30	621.00	516.97
Silica Fume		220.57	198.72	165.37
Quartz Sand		248.15	248.15	248.15
Fine Sand		1033.95	-	-
Coarse Aggregate		-	1124.93	1264.39
Steel Fibers		13.786	13.786	13.786
Super plasticizer		24.12	24.12	24.12
Water		151.64	151.64	151.64
Flow in mm		152.00	167	170
Compressive strength (N/mm^2)	7 Days	138.00	75.60	90.93
	28 Days	151.00	101.20	99.84
Flexural strength (N/mm^2)		24.60	10.70	11.88

For each concrete mixture, a proper amount of mixing water - including that of the super plasticizer aqueous solution - was used to attain to the same workability level corresponding to a plastic-fluid consistency: 150-155 mm according to a flow table test.

All concrete specimens were consolidated by vibration and cured at two stages. In first stage, after demoulding put sample in hot water curing tank (90°c temperature) for 2 days and in second stage, remaining 26 days for normal water curing.

TESTING OF SAMPLE

COMPRESSIVE STRENGTH:-

- It is the most useful and important property of concrete.
- While improving one of the weaker properties it should not happen that we are reducing its stronger property.
- Cubes (5X5X5 cm) are casted and tested to check the compressive strength of the material.
- The compressive strength of both original RPC and modified RPC were tested by using universal testing machine of capacity 50 tones.

- For the mixture of original RPC and for modified RPC specimens size were 4 X 4 X 16 cm.
- Three specimens each were tested for all mixtures after 28 days by third point loading method.
- The testing set-up for three points loading is shown in Fig.1 for original RPC and for modified RPC.
- The flexural strength of both original RPC and modified RPC were tested by using universal testing machine of capacity 50 tones
- Test results and comparison of flexural strength of Original RPC with Modified RPC are shown in TABLE 3 & Fig.4 respectively.

Fig.1 SET-UP FOR TESTING

FLEXURAL STRENGTH:-

TABLE4: TEST RESULTS OF COMP. STRENGTH & FLEXURALSTRENGTH

		O_0	M_1	M_2	M_3	M_4	M_5	M_6
Comp. strength (N/mm^2)	7 Days	138.00	122.53	113.60	93.87	100.00	75.60	90.93
	28 Days	151.00	135.60	118.00	115.73	104.27	101.20	99.84
% Strength reduce		-	10.19	21.85	23.35	30.94	32.93	38.80
Flexural strength (N/mm^2)		24.60	16.33	10.16	15.31	13.20	10.70	11.88
% Strength reduce		-	39.3	62.24	43.24	50.91	60.21	55.84
Flow in mm		152	147	150	149	165	167	170

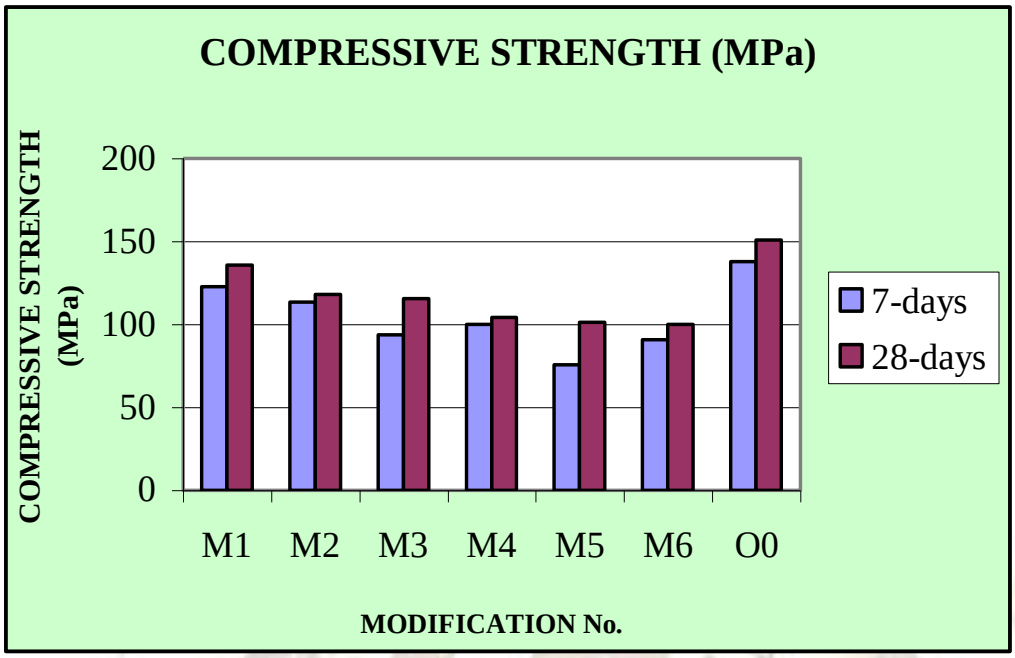

Fig.2: COMPARISON OF COMPRESSIVE STRENGTH OF ORIGINAL RPC AND MODIFIED RPC

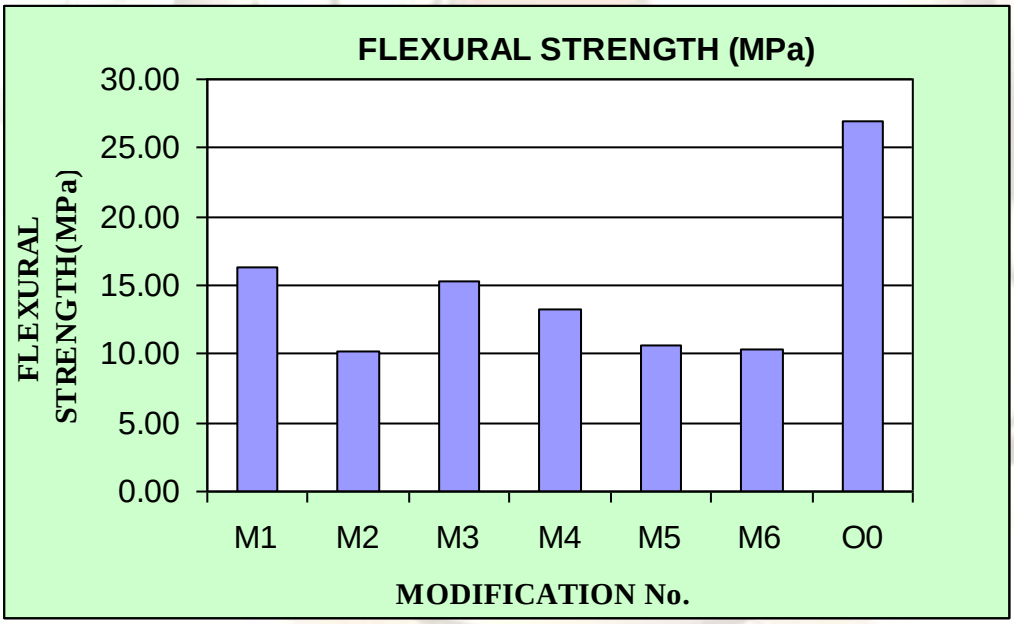

Fig.3: COMPARISON OF FLEXURAL STRENGTH OF ORIGINAL RPC AND MODIFIED RPC

COST COMPARISON

Here the Cost comparison of Original RPC and Modified RPC are done. The rates used for this estimation are the prevailing rates in Indian context. TABLE 5, 6 & 6.1 represent the cost calculation of original RPC and modified RPC.

TABLE 5: COST CALCULATION OF 1m^3 OF ORIGINAL RPC

Materials	Quantity (Kg/m^3)	Rate (Rs/Kg)	Amount (Rs)
Cement	690	5	3450
Silica Fume	220	40	8960
Quartz Sand	248	10	2650
Fine Sand	1033	0.35	368
Super Plasticizer	24	180	3780
Steel Fiber	138	250	34450
Total Amount			53690

TABLE 6: COST CALCULATION OF 1m^3 OF MODIFIED RPC

Materials	Rate (Rs/Kg)	Quantity For M_1 (Kg/m^3)	Amount (Rs)	Quantity For M_2 (Kg/m^3)	Amount (Rs)
Cement	5	689.30	3446.5	689.30	3450
Silica Fume	40	220.57	8822.8	220.57	8960
Quartz Sand	10	248.14	2481.4	248.14	2650
Fine Sand	0.35	516.97	180.93	-	-
Aggregate	0.7	516.97	361.87	1033	723.76
Super Plasticizer	180	24.12	4342.5	24.12	3780
Steel Fiber	250	137.8	34465	137.8	34465
Total Amount			54101		54282

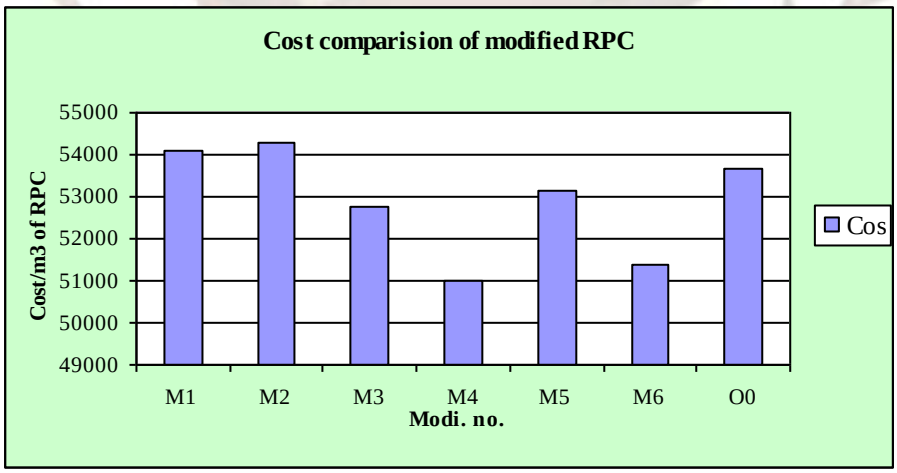

Fig.4: COST COMPARISON OF ORIGINAL RPC AND MODIFIED RPC

CONCLUSION

The compressive strength results of the modified RPC (M_1 & M_2) do not confirm the beneficial role played by the fine sand with respect to a coarse aggregate. Due to reduction in the cementatitious material the compressive strength of modified RPC (M_3 & M_4) is lower with respect to original RPC (O). Modified RPC (M_5 & M_6) without all fine sand and with reduced amount of cement + silica fume with respect to original RPC, the compressive strength decreased by increasing the aggregate to cement ratio.

The flexural strength results shows that when fine sand replaced by coarse aggregate (M_1 & M_2) there was a reduction in strength and the effect was more significant when part of cementitious binder & all fine sand were replaced by the coarse aggregate (M_5 & M_6).

The cost comparison shown in Fig.4 indicates that the cost of modified RPC is increase or decrease with respect to cost of original RPC. But when we are comparing strengths with cost of different modified RPC and original RPC, original RPC is looking economical than modified RPC.

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