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Experimental Investigation on Reactive Powder Concrete by Partial Replacement of Cement with Different Pozzolanic Materials

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Abstract: Reactive powder concrete (RPC) is one of the ultra-high performance concrete (UHPC). In RPC the coarse aggregate is eliminated and the micro particles like silica fume, quartz powder and sand are utilized in the production process. The high cement content and low water to binder ratio in RPC lead to shrinkage problems. Hence in this study, an attempt is made to produce eco-friendly RPC by replacing cement with 3 different pozzolanic materials from industrial wastes such as Fly ash, GGBS and Granite powder. To assess the viability of partial replacement of cement by pozzolanic materials, nine mixes have been arrived with 10%, 20% and 30% replacements. The fresh concrete property such as slump and the compressive strength are determined for all the mixes. By comparing the strength property the suitable alternate replacement material and replacement percentage for cement in RPC is found out.
Keywords: RPC, Ultra Performance Concrete

I. INTRODUCTION

Reactive powder concrete (RPC) is a form of ultra-high strength concrete created by substituting materials such as quartz powder, silica fume, steel fibres, etc. for the typical concrete's standard aggregate. RPC offers strong ductility in addition to high strength. The range of its compressive strength is 200 MPa to 800 MPa. RPC eliminates coarse aggregates and instead uses micro particles such as silica fume, quartz powder, and sand in the manufacturing process. RPC shrinks because to its high cement content and low water-to-binder ratio. As a result, an attempt is made in this study to make eco-friendly RPC by substituting cement with three distinct pozzolanic materials derived from industrial wastes: fly ash, GGBS, and granite powder. To test the viability of partial replacement of cement by pozzolanic materials in this study, nine mixes with 10%, 20%, and 30% replacements were created..

II. MATERIAL PROPERTIES

A. Cement

The ordinary Portland cement confirming to IS 4031 was used for the preparation of specimens. OPC 53 grade was used. It determines the strength and other properties of both fresh and hardened state of concrete. DALMIA OPC cement was used in this study. Table I shows the properties of cement.

TABLE I. THE PROPERTIES OF CEMENT

S.NO	DESCRIPTION	RESULTS OBTAINED
1	Consistency test	30%
2	Initial setting time	37 minutes
3	Final setting time	365 minutes
4	Specific gravity	3.15

B. Fine Aggregate

M-sand was used as fine aggregate. The results show for the M-sand conforms to Zone II of IS: 383 – 2016 and Fineness Modulus is 2.49. The properties of the M-sand were determined by conducting tests as per IS:2386 (Part- I).

C. Silica Fume

The silica fume, also referred to as micro silica. It's an ultrafine powder made up of spherical particles with an average particle diameter of 150 nanometers that's gathered as a by-product of silicon and ferrosilicon alloy manufacture. Silica fume used is of specific gravity 2.2 and have bulk density of 680 kg/m³.

D. Fly Ash

Fly Ash used is of specific gravity 2.05 and have bulk density of 700 kg/m³.

E. GGBS

GGBS used is of specific gravity 2.8 and have bulk density of 1455 kg/m³.

F. Granite Powder

Granite Powder used is of specific gravity 2.53 and have bulk density of 1600 kg/m³.

G. Super Plasticizer

Super plasticizers are used where well dispersed particle suspension is required to improve the rheology in concrete. Table II shows the properties of super plasticizer.

TABLE II. PROPERTIES OF SUPER PLASTICIZER

S. No	Description	Value
1	Appearance	Yellowish liquid
2	Type	Poly Carboxylate based type
3	Specific gravity	1.08
4	PH	6.9

III. MIX PROPORTION

Mix proportion for conventional RPC, trial mix proportional and mix calculation for reactive powder concrete as partial replacement of cement by different pozzolanic materials are shown in table III, IV, V.

TABLE III. MIX PROPORTION FOR CONVENTIONAL RPC

Materials	Cement	Fine aggregates	Silica fume	Super Plactizier	Water
RPC	1	1.1	0.25	0.016	0.15
Density Kg/m³	761.5	865.08	72.08	7.5 Lit/m³	64 Lit

TABLE IV. TRIAL MIX PROPORTION

S.NO	MIX ID	CEMENT	FA	GB	GP	FA	S.F	QUARTZ	SP	WATER
1	FA 10	0.90	0.10	0	0	1.1	0.25	0	0.016	0.15
2	FA 20	0.80	0.20	0	0	1.1	0.25	0	0.016	0.15
3	FA 30	0.70	0.30	0	0	1.1	0.25	0	0.016	0.15
4	GB 10	0.90	0	0.10	0	1.1	0.25	0	0.016	0.15
5	GB 20	0.80	0	0.20	0	1.1	0.25	0	0.016	0.15
6	GB 30	0.70	0	0.30	0	1.1	0.25	0	0.016	0.15
7	GP 10	0.10	0	0	0.10	1.1	0.23	0.39	0.019	0.17
8	GP 20	0.20	0	0	0.20	1.1	0.23	0.39	0.019	0.17
9	GP 30	0.30	0	0	0.30	1.1	0.23	0.39	0.019	0.17

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TABLE V. MIX CALCULATION

S.NO	MIX ID	CEMENT	FA	GB	GP	FA	S.F	QUARTZ	SP	WATER
1	FA 10	685.4	51.6	0	0	865.8	72.08	9.02	64	685.4
2	FA 20	609.3	102	0	0	865.8	72.08	9.02	64	609.3
3	FA 30	533.1	153.6	0	0	865.8	72.08	9.02	64	533.1
4	GB 10	685.4	0	62.5	0	865.8	72.08	9.02	64	685.4
5	GB 20	609.3	0	123.6	0	865.8	72.08	9.02	64	609.3
6	GB 30	533.1	0	186	0	865.8	72.08	9.02	64	533.1
7	GP 10	691.3	0	0	68.8	873.2	66.64	7.5	73	691.3
8	GP 20	614.5	0	0	136	873.2	66.64	7.5	73	614.5
9	GP 30	537.7	0	0	205	873.2	66.64	7.5	73	537.7

IV. CASTING AND CURING

Specimens such as cube (50mmX50mmX50mm) were cast and cured with reactive powder concrete with varying pozzolanic materials such as fly ash, GGBS and granite powder of 10%, 20% and 30% as partial replacement of cement.

A concrete mixer machine was used to mix the ingredients of concrete. First, aggregates and cement were mixed for one minute and water being added within two minutes. The fig. 1 shows the specimen after demoulding.

Fig. 1. Specimen after demoulded

V. EXPERIMENTAL INVESTIGATION

A. Workability

The workability of concrete is important in fresh concrete. Workability is defined as the ease with which a sample given set of materials can be mixed into concrete and subsequently handled, transported, placed and compacted with minimum loss of homogeneity. The fresh concrete properties are evaluated by conducting a slump cone test. The apparatus for conduction the slump test consists of a metallic mould in the form of a frustum of a cone having 200 mm bottom diameter, 100 mm top diameter and 300 mm height. The mould is filled with concrete in three layers. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross-section. The mould is removed from the concrete by raising it slowly and carefully in a vertical direction. The difference in level between the height of the mould and the height of subsided concrete is noted and it is taken as slump value.

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B. Compression Test

According to IS: 516- part 4: 2018, the cube made of certain size is to be tested in the compressive testing machine as shown in fig 2.

Fig. 2. Compression Test

VI. RESULTS AND DISCUSSION

A. Workability

The variation of workability of fresh concrete determined by slump test for various concrete mixes is shown in Table VI and Fig 4.

TABLE VI. SLUMP VALUES FOR FRESH CONCRETE MIXES

Sl. No.	Mix	Slump Value(mm)
1	RPC	700
2	FA 10	600
3	FA 20	620
4	FA 30	650
5	GB 10	610
6	GB 20	630
7	GB 30	670
8	GP 10	630
9	GP 20	640
10	GP 30	660

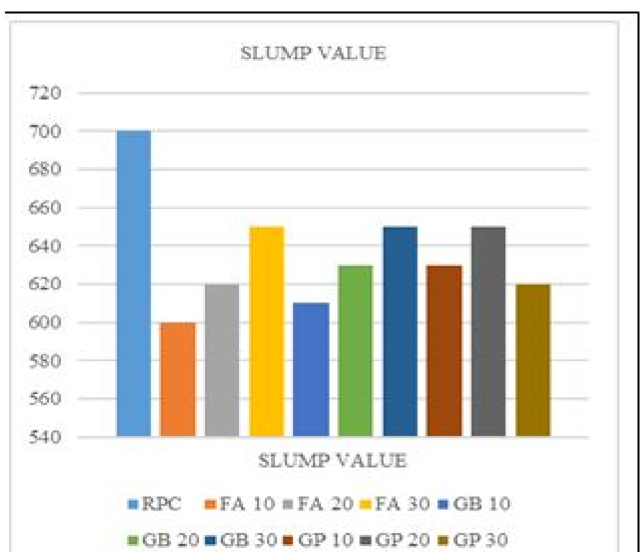

Fig. 3. Slump Test Results

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From the table, it is observed that replacement of Cement by pozzolanic materials tend to decrease the slump value which means the decrease of workability. This is due to the presence of the considerable amount of cement mortar which absorbs the water.

B. Compression Strength Test

The compression test results obtained for 7 days are tabulated below in the table VII and Fig 4 and for 28 days are tabulated below in the table VIII and Fig 5.

TABLE VII. COMPRESSION STRENGTH OF CUBES AT 7 DAYS

S No	MIX ID	COMPRESSIVE STRENGTH AT 7 DAYS(N/mm²)
1	RPC	118
2	FA 10	120
3	FA 20	127.5
4	FA 30	129.5
5	GB 10	121
6	GB 20	126.5
7	GB 30	130
8	GP 10	119
9	GP 20	123
10	GP 30	126

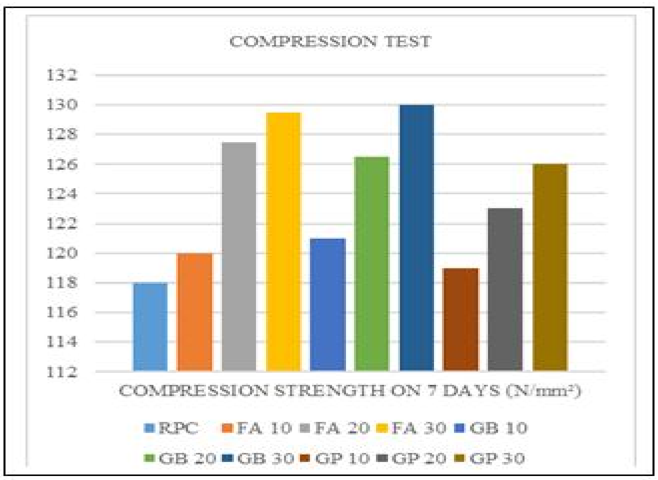

Fig. 4. Compression strength of cubes at 7 days

TABLE VIII. COMPRESSION STRENGTH OF CUBES AT 28 DAYS

S No	MIX ID	COMPRESSIVE STRENGTH AT 28 DAYS(N/mm²)
1	RPC	210
2	FA 10	225
3	FA 20	228
4	FA 30	230
5	GB 10	224
6	GB 20	227
7	GB 30	231
8	GP 10	223
9	GP 20	226
10	GP 30	228

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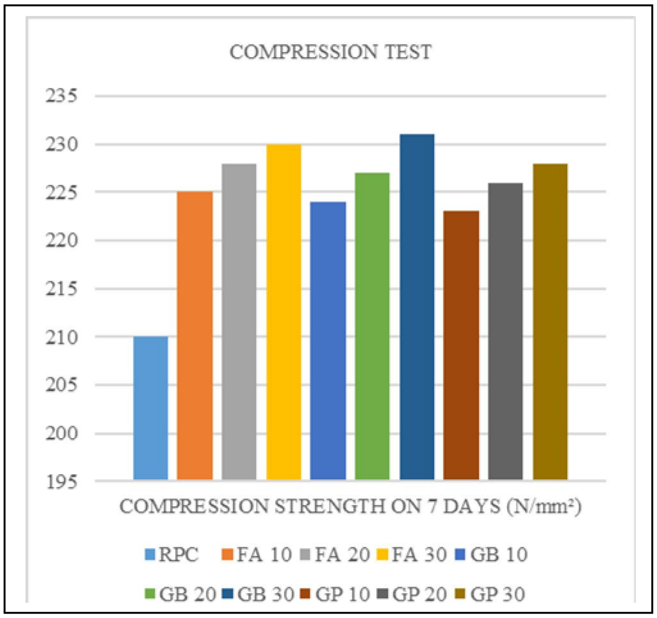

Fig. 5. Compression strength of cubes at 28 days

From the result, it is observed that replacement of cement by pozzolanic materials tend to increase the compression strength at 7 days and 28th days. From the graph, it is observed that compression strength for all the mixes at 7 days has been gradually increased. For 10% and 20% replacement, the mix GB 10 and FA 20 gives the maximum strength at 7 days. For 30% replacement, the mix GB 30 gives the maximum strength of 130N/mm² at 7 days and 231N/mm².

VII. CONCLUSIONS

Understanding the mechanical properties of Reactive Powder Concrete (RPC) with partial replacement of cement by different pozzolanic material like silica fume, GGBS and granite powder.

1) From experimental study, it is observed that the slump valve is decreased with the replacement of pozzolanic materials whereas the compressive strength is gradually increased with replacement percentage.
2) For 10% ,20% and 30% replacements of cement by fly ash, GGBS and granite powder the compression strength is gradually increased than conventional RPC.
3) The various mix of pozzolanic material with 30% of replacement of cement gives better results.

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REFERENCES

[1] Richard, P. and Cheyrezy, M.H. "Reactive Powder Concretes with High Ductility and 200-800 MPa Compressive Strength", Concrete Technology:Past, Present, and Future, Proceedings of the V. Mohan Malhotra Symposium, ACI SP-144, S. Francisco 1994, pp. 507-518. Editor: P.K. Mehta.
[2] Coppola, L., Troli, R., Collepardi, S., Borsoi, A., Cerulli, T. and Collepardi, M. "Innovative Cementitious Materials. From HPC to RPC. Part II. The Effect of Cement and Silica Fume Type on the Compressive Strength of Reactive Powder Concrete" L'Industria Italiana del Cemento, 707, 1996, pp.112-125.
[3] Coppola, L., Cerulli, T., Troli, R. and Collepardi, M. "The Influence of Raw Materials on Performance of Reactive Powder Concrete", International Conference on High-Performance Concrete, and Performance and Quality of Concrete Structures, Florianopolis, 1996, pp.502-513.
[4] B. El-Jazairi, J.M. Illston, "A semi-isothermal method of thermogravimetry and derivative thermogravimetry and its application to cement pastes", Cem. Concr. Res. Vo17, pp 247-258,1977.
[5] G.L. Kalouzek, T; Mitsuda, H.F.W. Taylor, "Xonotlite: Cell-parameters, thermogravimetry and analytical electron microscopy", Cem. Concr. Res. Vol 7, pp 305-3 12", 1977.

[6] Collepardi, M. "Superplasticizers and Air Entraining Agents: State-of-the-Art and Future Needs", Concrete Technology: Past, Present, and Future, Proceedings of the V. Mohan Malhotra Symposium, ACI SP-144, San Francisco 1994. Editor: P.K. Mehta, pp. 399-416.
[7] Neville, A.M. "Properties of Concrete", Fourth Edition, 1995, Editor: Longman Group Limited, Essex, England, p. 844.
[8] IS 269 : 2015 Ordinary Portland Cement specifications.
[9] IS 4031(PART 4): 1988 Methods of physical tests for hydraulic cement: Part 4 for Determination of consistency of standard cement paste.
[10] IS 4031(PART 5): 1988 Methods of physical tests for hydraulic cement: Part 5 for Determination of initial and final setting times.
[11] IS 4031(PART 6): 1988 Methods of physical tests for hydraulic cement: Part 6 for Determination of Compressive Strength of hydraulic cement.
[12] IS 4031(Part 11): 1998 Methods of physical tests for hydraulic cement for Determination of specific Gravity by Le-Chatelier method.
[13] IS 383: 2016 Coarse aggregate and fine aggregate of concrete specifications.