International Journal of Advance Research in Engineering, Science & Technology(IJAREST),
ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2,Issue 6, June- 2015, Impact Factor: 2.125

Mechanical Strength Assessment of Reactive Powder Concrete Containing Silica Fume by Non- Destructive Testing

Mujamil K[1].,Vinay D.[1], Sikandar M.[1] Ali, Shridhar B. M.[1] and K. S. Kulkarni

[1]Department of Civil Engineering, KLE's Dr. M.S. Sheshgiri College of Engineering and Technology, Belagavi, Email id- mujamilk77@gmail.com, kishorsk1@gmail.com

Abstract

The aim of present study is to investigate the mechanical strength of RPC containing various percentages of silica fume partially replaced with cement. The Reactive Powder Concrete is made with different proportions of silica fume varying from 0% up to 50% as a partial replacement of cement. The investigation shows partial replacement of silica fume by 25% with cement gives improved mechanical strength properties of concrete. The quality of the RPC is assessed by using rebound hammer and ultrasonic pulse velocity. The relation between compressive and flexural strength is also proposed in the form of statistical equation for the RPC

Keywords- *Reactive powder concrete, Silica fume, Compressive and Flexural strength, Ultrasonic pulse velocity test and Rebound hammer test.*

I. INTRODUCTION

Reactive Powder Concrete (RPC) exhibits very high strength and durability properties of concrete. Reactive powder concrete made up of special combination of Constitute of materials. The composition of RPC includes cement, quartz sand and powder, and silica fume. It extensively uses the pozzolanic properties of highly refined silica fume and optimization of the Portland cement chemistry to produce the highest strength hydrates. This new material demonstrates greatly improved strength and durability characteristics compared with traditional or even High Performance Concrete (HPC).

In the present study following investigations were carried out,

- Determined mechanical strength properties of RPC containing silica fume.
- Proposed relation between compressive and flexural strength of RPC.
- The assessment of RPC by using non destructive techniques such as rebound number Ultrasonic pulse velocity.

II. MATERIALS AND METHODOLOGY

The RPC is prepared with following ingredients: Ordinary Portland cement (OPC-43), Silica fume, Quartz powder (less than 150 micron), Quartz sand (1-3 mm) and sulphonated naphthalene polymers based super plasticizer. The physical properties of cement and silica fume are presented in Table 1 and 2 respectively. The specific gravity of quartz sand and powder were found to be 2.7 and 2.6 respectively. Super plasticizer 'Conplast SP 430' was used. From the several trials the dosage of super plasticizer is finalized as 2% by weight of binder. Specific gravity of super plasticizer is found to be 1.10.

Table 1. Properties of OPC 43 grade

Fineness (in m^2/kg)		*225*
Setting time in minutes	*Initial (min.)*	*30*
	Final (max.)	*600*
Soundness	*Auto Clave (%)*	*0.8*
Specific Gravity		*3.10*

Table 2. Properties of Micro Silica fume

Item	**Results**
SiO_2	92.3%
LOI	2.7%
Moisture	0.2%
Pozzolan Act Index	137%
Surface area	22 m^2/g
Bulk Density	603 kg/m^3
+45 Microns	0.2%
Specific Gravity	2.2

To investigate the effect of partial replacement of cement by silica fume, various mix proportions were studied. The details of test specimen matrix are presented in Table 3. In the present study, total 7 different proportions of RPC concrete with a total of 42 numbers of specimens were cast. The details of mix proportion adopted are presented in Table 4.

Table 3. Test Specimen Matrix

Type of RPC	**Compres -sive Strength**	**Flexural Strength**
RPC with 100% cement (M_0)	3	3
RPC with 90% cement + 10% SF (M_1)	3	3
RPC with 80% cement + 20% SF (M_2)	3	3
RPC with 75% cement + 25% SF ($M_{2.5}$)	3	3
RPC with 70% cement + 30% SF (M_3)	3	3
RPC with 60% cement + 40% SF (M_4)	3	3
RPC with 50% cement + 50% SF (M_5)	3	3

International Journal of Advance Research in Engineering, Science & Technology(IJAREST),
ISSN(O):2393-9877, ISSN(P): 2394-2444,
Volume 2,Issue 6, June- 2015, Impact Factor: 2.125

Table 4. Mix Proportion per m^3 of Concrete

Type of Mix	% of SF	Cement	SF	Quartz Sand	Quartz Powder	Water	SP
		kg					
M_0	0	1000	0	1100	290	250	20
M_1	10	900	70	1100	290	250	20
M_2	20	800	140	1100	290	250	20
$M_{2.5}$	25	750	174	1100	290	250	20
M_3	30	700	209	1100	290	250	20
M_4	40	600	280	1100	290	250	20
M_5	50	500	350	1100	290	250	20

To determine the compressive strength and flexural strength of specimen of cube size 100 x100 x 100 mm and beams of size 160 x 40 x 40 mm were considered. The curing of specimen is done in water for 28 days. After 28 days of curing specimens were taken out and dried in air and taken for testing. Before testing the specimen for its compressive and flexural strength the specimens were taken for Ultrasonic pulse velocity test and rebound hammer test.

The Pulse velocity was measured on 100 mm cubes according to IS 13311 (Part 1):1992 by using PUNDIT ultrasonic pulse velocity device as shown in Fig. 1. On the two sides of cubes the pulse velocity is measured (for one cube two readings were taken), average of such 3 cubes reported. The Rebound Hammer test was carried out on 100 mm cubes according to IS 13311 (Part 2):1992 by using Schmidt Hammer (PROCEQ- Original Schmidt) device as shown in Fig. 2.

For evaluating the compressive strength, specimens were tested on 2000 kN capacity Compression Testing Machine (CTM) as per IS 516:1959. To determined flexural strength of concrete universal testing machine of 1000 KN (100 T) capacity was used. The beam specimens were testing for single point loading. Testing is carried out in accordance with IS 516:1959.

Figure 1. 'PUNDIT' Ultrasonic Pulse Velocity Device

Figure 2. Schmidt Hammer (PROCEQ)

III. RESULTS AND DISCUSSIONS

3.1 Ultrasonic Pulse Velocity

Figure 3 shows the variation in UPV with increase in % of silica fume. From the Fig. 3 it is observed that UPV increase as increase in silica fume content up to 25%. The significant decrease in UPV is observed as % of silica fume increases beyond 25%. As per the IS code standard UPV above 4.5 km/sec considered as excellent quality. In the present study RPC concrete made with up to 25% of silica fume belongs to excellent concrete quality. The RPC made with more than 25% of silica fume belongs to good quality concrete. Reactive powder concrete made with 25 % of replacement of silica fume shows higher UPV.

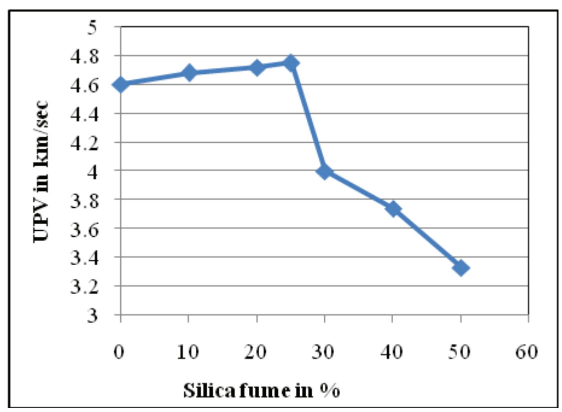

Figure 3. Variation in UPV with silica fume

3.2 Rebound Hammer Index

Figure 4 shows the variation in Rebound hammer index with percentage of silica fume. From the Fig. 4 it is observed that, up 25% of partial replacement of silica fume no significant change in rebound index is observed. As the % of silica fume increases beyond 25%, rebound hammer index decreases

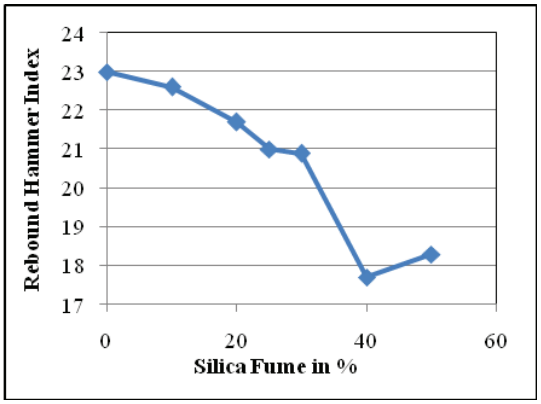

Figure 4. Variation in rebound hammer index with silica fume

3.3 Compressive Strength

The results of compressive strength for various percentage of silica fume is presented in Fig. 5. From Fig. 5 it is observed that, as the silica fume content increase to 25% for both the curing regimes compressive strength decreases and beyond 25% of silica fume compressive strength decreases.

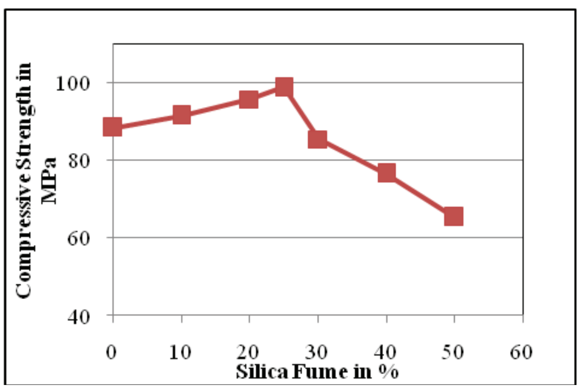

Figure 5. Variation in compressive strength with silica fume content

3.4 Flexural Strength Test Results

The results are presented in Figure 6 shows variation in flexural strength for different silica fume content. From the Fig. 6 it is observed that, up to 25% silica fume replacement no much variation in flexural strength is observed. Thereafter the flexural strength of RPC decreases.

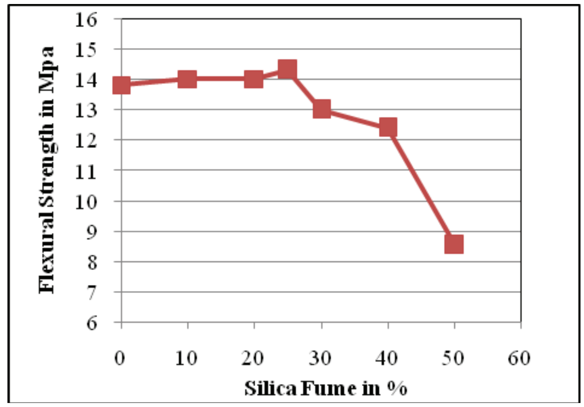

Figure 6. Variation in flexural strength with silica fume content

3.5 Analysis of results

The experimental data have been employed to propose compressive and flexural strength prediction equations for RPC with different percentage of silica fume. Regression analysis is used for the development of equations.

Figure 7 and 8 presents the relation between the variation in % of silica fume with the compressive and flexural strength of RPC respectively. Figure 9 presents the relation between compressive and flexural strength of RPC. From the available experimental data the attempt has also been made to propose relation between rebound hammer index and compressive strength of RPC. Figure 10 presents the relation between compressive strength and rebound hammer index. The relationship between the mechanical strength with silica fume and rebound hammer index is presented in the form statistical equations. The summery of proposed equations is presented in Table 5. For all the proposed equations coefficients of regression is found to be more than 0.75.

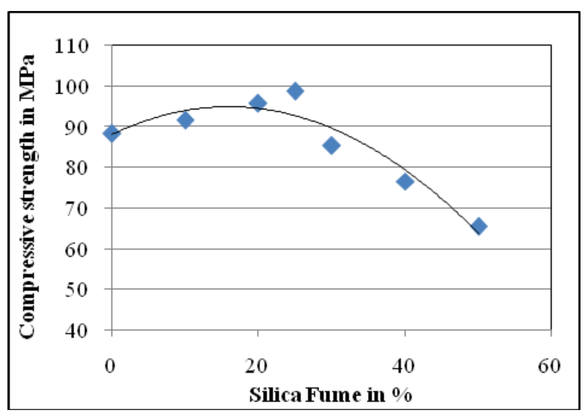

Figure 7. Compressive strength with silica fume

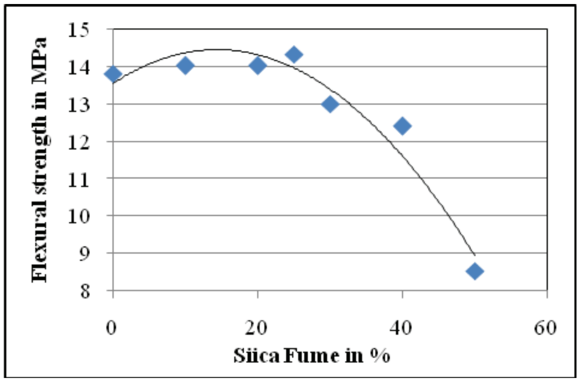

Figure 8. Flexural strength with silica fume

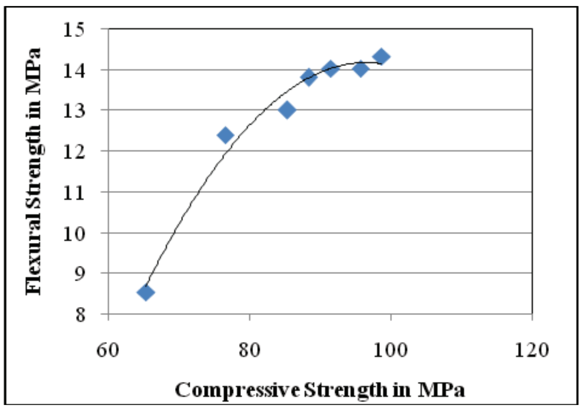

Figure 9. Relation between flexural and compressive strength

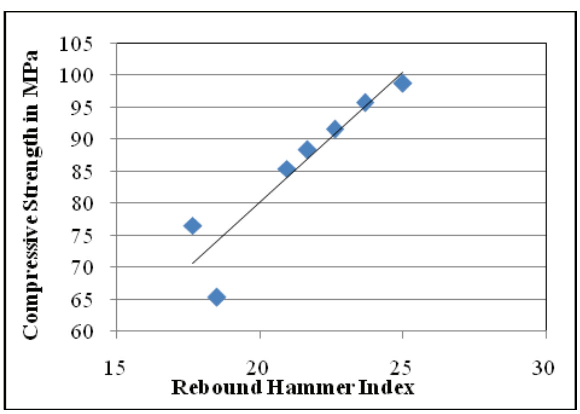

Figure 10. Relation between rebound hammer index with compressive strength

Table 5. Predicted equations

Figure No.	Predicted equations
6	$C_C = -0.026(SF)^2 + 0.854(SF) + 88.013$
7	$F_C = -0.004(SF)^2 + 0.1253\ (SF) + 13.546$
8	$F_C = -0.0056(C_C)^2 + 1.0864(C_C) - 38.276$
9	$C_C = 4.043(RH) – 0.772$

Where,
C_C- 28 day's compressive Strength in MPa
F_C- 28 day's flexural strength in MPa
SF- Silica Fume in %
RH - Rebound hammer index

III. CONCLUSIONS

On the comprehensive experimental investigation, the following conclusions are drawn,

It has been demonstrated from the test results carried out in this project that, the mechanical strength of a RPC made with silica fume related to the strength of an OPC control mixture. The optimum use of silica fume in RPC is found to be 25%. The proposed can be used to determine the mechanical strength of RPC for different percentage of silica fume. The relation between compressive strength and flexural strength is different from the conventional concrete. In the present study the relation between compressive and flexural strength is presented.

The direct relationship between flexural strength and compressive strength of RPC is presented. The relation between rebound hammer index and compressive strength for reactive powder concrete is proposed which can be useful for the assessment.

ACKNOWLEDGEMENTS

We are thank full to our sponsors, Mr.Siddappa Hasbi, MD, Corniche for Micro Silica fume, Mr. GanpatiMumbare, Ultratech Cements, and Mr. Raghuchandra, Nikshepa Industrial Minerals Bangaluru for providing materials to complete the project.

REFERENCES

[1] A. Sadrekarimi, "Development of a Light Weight Reactive Powder Concrete Reactive Powder Concrete (RPC)", Journal of Advanced Concrete Technology, Vol. 2, No. 3, PP.409-417, 20014.

[2] A. Abdelalim, M. Ramadan, T. Bahaa and W. Halawa, "Performance of reactive powder concrete produced using local materials", HBRC Journal, Vol. 4, No. 3, PP. 66-78, 2008.

[3] H. Yazıcı, M. Yardımcı, S. Aydın, and A. Karabulut, "Mechanical properties of reactive powder concrete containing mineral admixtures under different curing regimes",Construction and Building Materials, Vol. 23, No. 3, PP.1223-123, 2008.

[4] H. Zanni, M. Cheyrezy, V. Maret, S. Philippot and P. Nieto, "Investigation of hydration and pozzolanic reaction in reactive powder concrete (RPC) using 29Si NMR", Cement and Concrete Research, Vol. 26, No. 1, PP. 93-100, 1996.

[5] IS 15388:2003, Specification for silica fume, BIS, New Delhi

[6] IS 4031:1988, Method of physical test for hydraulic cement, BIS, New Delhi.

[7] IS 516:1959, Methods of tests for strength of concrete, BIS, New Delhi.

[8] IS 650: 1966, Standard specification for testing cement specification, BIS, New Delhi.

[9] IS13311:1999, Non- destructive testing of concrete methods of tests, BIS, New Delhi.

R. B. Khadiranaikar and Muranal S. M., "Factors affecting the strength of reactive powder concrete (RPC)", International Journal of Civil Engineering and Technology, Vol. 3, No. 2, PP.455-464, 2012.