Experimental Investigation of Mechanical and Durability Properties of Reactive Powder Concrete (RPC)

Deshmukh Rajkumar[1], Dr. A.A. Bage[2]

[1]*Structural Engineering Department Sardar Patel College of Engineering Andheri (W)*

[2]*Head of Structural Engineering Department Sardar Patel College of Engineering Andheri (W)*

***Abstract*: In this paper investigate the mechanical properties (compressive strength, split tensile strength and flexural strength) and durability properties (Rapid Chloride Penetration Test, RCPT). The comparative study of mechanical and durability properties of RPC at 3,7 and 28 days by varying steel fiber added to concrete (0%,0.5%,1%,1.5%,2%,2.5%). The test results shows the RPC displays excellent compressive and split tensile strength. The adhesion between RPC & the steel fiber is also greater than that for normal concrete.**

***Keywords*: Reactive Powder Concrete, steel fiber, RCPT, compressive strength, flexural test**

I. INTRODUCTION

Reactive powder concrete (RPC) is a new generation concreteand it was developed through microstructure enhancement techniques for cementitious materials.RPC is a developing composite material that will allow the concrete industry to optimize material use generate economic benefits and build the structures that are strong, durable and sensitive to environment. Since RPC first appeared on the world research stage in 1994 it has received considerable attention. The original development of RPC came from the scientific division of bouygesfrance. Since the further development of the material continued throughoutthe world (for example Australia, Canada, Korea and United States of America).

RPC has ultra-high durability characteristics resulting from its extremely low porosity low permeability limited shrinkage and increased corrosion resistance. In comparison to HSC or any other concrete there is no penetration of liquid or gas through RPC. The characteristics enable its use in chemically aggressive environment and where physical wear greatly limits the life of concrete. The objective of project is to investigate the mechanical and durability properties of Reactive Powder Concrete by using low carbon cold drawn wire V type undulated steel fiber having AR-38 and AR-50. Compressive strength, Split tensile strength, Flexural strength these three mechanical properties investigated and the Rapid Chloride Penetration Test (RCPT) is also done for checking durability properties.

II. EXPERIMENTAL INVESTIGATION

2.1 Material Specification

The materials used in preparation of RPC are as follows silica fume, Quartz sand, cement, Superplasticiser and Steel fiber. The specifications of materials are described below.

*Silica Fume***:** It consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The particle size is approximately $1/100^{th}$ the size of an average cement particle. CALIPAR Micro Silica were used in this project following are the list of test mentioned has been sampled and analysed for mandatory parameters of ASTM C-1240.

Particulars	Result	Specification	Unit
SiO_2	95.41	Min 85	%
Bulk Density	617	550-700	Kg/m^3
Moisture	0.20	Max 3	%
CL Content	0.0025	-	%

Table 1: Specification of Silica Fume

*Quartz Sand***:** The mean particle size of crushed quartz used for an RPC is 10 µm. normally available in the range between 5µm to 10 µm.

Particulars	Specification
Physical State	Granular Solid
Odour	Odourless
Colour	White
Specific Gravity	1.8-2.5

Table 2: Specification of Quartz Sand

Superplasticiser: Coreplast SP2 Superplasticising Admixture is used in this project. It is a high range water reducing admixture based on SulphonatedNapthalene Polymers. It is specially made to reduce w/c ratio upto 25% without any loss in workability and to give high strength concrete.

Particulars	Specification
Colour	Dark Brown Liquid
Specific Gravity	Approx. 1.22at 30^0 C
Chloride Content	Nil as IS:456

Table 3: Specification of Superplasticiser

Figure 1: Quartz Sand

Steel Fiber: Low carbon cold drawn wire V type undulated SF us used in this experimental study. Two types of aspect ratio used AR-38/ AR-50.

Figure 2: Steel Fiber

III. EXPERIMENTAL PROGRAMME

In order to study the interaction of steel fibers with low carbon cold drawn wire V type undulated steel fiber with concrete under compression, Split tension, flexure and rapid chloride penetration test; 90 cubes, 90 beams, and 100 cylinders with fibers and 9 cubes, 9 beams and 12 cylinders casted without fiber. Sizes of Specimen used for tests are given below.

Name of test	Size of Specimen
Compression test	10cm x 10cm x 10cm
Split tension test	10cm dia x 20cm height
Flexural test	10cm x 10cm x 50cm
RCPT	10cm dia x 20cm height

Table 4: Sizes of Specimen

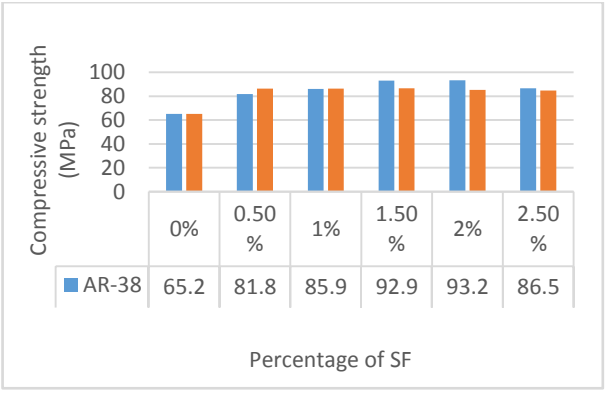
The experimental programme is divided into three groups. First group consists of 9 cubes, 9 beams and 12 cylinders and other two group consist of 45 cubes, 45 beams and 50 cylinders for performing test in serial order.

i. The first group is control (plain) concrete with 0% fiber.
ii. The second group consist of low carbon cold drawn wire V type undulated SF (AR-38) with varying percentage (0.5%, 1%, 1.5%, 2%, 2.5%).
iii. The third group consist of low carbon cold drawn wire V type undulated SF (AR-50) with varying percentage (0.5%, 1%, 1.5%, 2%, 2.5%).

IV. RESULTS AND DISCUSSION

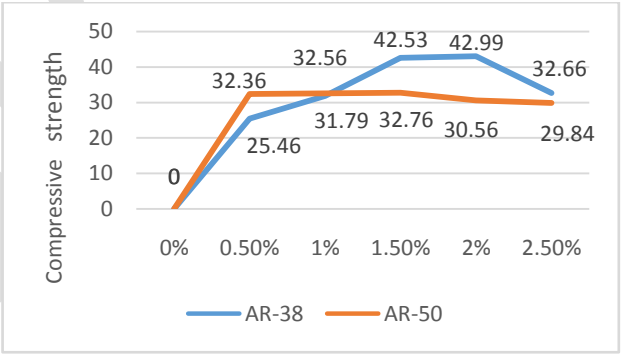
1. Compression Strength test

Following are the result obtained at 28 days. The graph 4.1 shows the comparative result of compressive strength test for SF of AR-38/ AR-50.



Graph 4.1: Comparative result of CS

Percentage increment in the compressive strength of RPC with respect to compressive strength of plain concrete without steel fibers is shown in the graph 4.2 as follows.



Graph 4.2: Percentage increment in CS

In case of AR-38 maximum compressive strength found at 2% of SF where increment in strength is 42.99% thereafter it goes on decreasing gradually, because upto 2% content of steel fiber it helps in maintaining proper bond with matrix which increases strength. After this due to large size and further increasing its percentage, proper compaction reduces and strong bond unable to form hence compressive strength goes on decreasing.

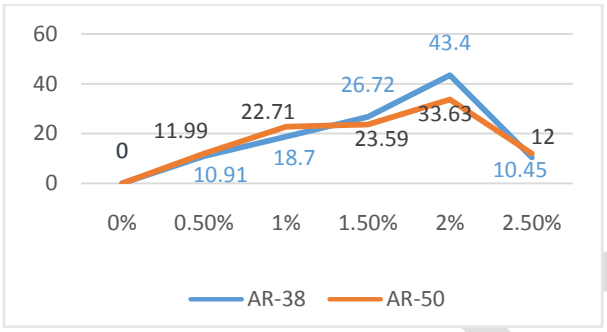
General observation from graph indicates that by addition of steel with varying percentage from 1% to 2.5% to RPC compressive strength increases gradually and becomes maximum at certain percentage and thereafter reduces gradually with increases of further fiber content.

2. Split tensile strength test

Following are the result obtained at 28 days. The graph 4.3 shows the comparative result of split tensile strength test for SF of AR-38/ AR-50.

Graph 4.3: Comparative result of Split tensile test

Percentage increment in the split tensile strength of RPC with respect to split tensile strength of plain concrete without fibers is shown in the graph 4.4 as follows.

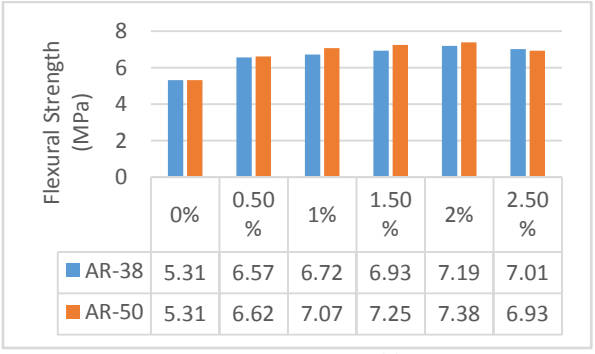


Graph 4.4: percentage increment in STS test

The maximum STS of RPC is found at 2% of SF where increment in strength is 43.4% thereafter it goes on decreasing gradually.

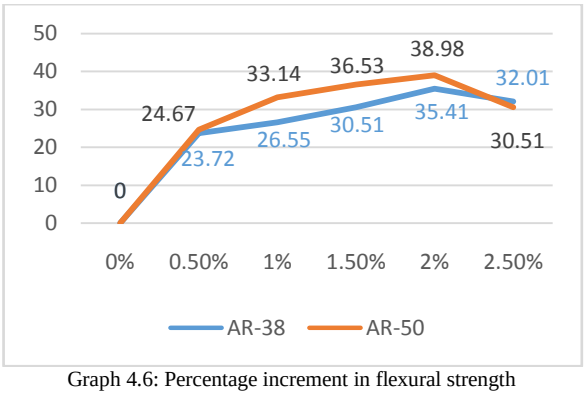
3. Flexural strength test

Following are the result obtained at 28 days. The graph 4.5 shows the comparative result of Flexural strength test for SF of AR-38/ AR-50.



Graph 4.5: Comparative result of flexural test

Percentage increment in the flexural test of RPC with respect to flexural strength of plain concrete without steel fiber is shown in the graph 4.6 as follows.



Graph 4.6: Percentage increment in flexural strength

4. Rapid Chloride Penetration test

For this test 100mm dia and 200mm height of cylinder is casted. This test method consist of monitoring the amount of electrical current passed through 2-in. (51mm) thick slices of 4-in. (102 mm) nominal diameter cores or cylinders during a 6-hour period.

Figure 3: cylinder specimen sample

Test setup as per ASTM C1202 is shown in Figure 4
Samples were placed in the hole and then properly sealed with silicone sealant. One of the chambers was filled up with 3% NaCl solution and the other one with 0.3N NaOH solution. Then 60V DC source was connected to wire meshes at the ends so that the negative end was connected with the side in NaCl solution and the positive end was with the side in NaOH solution.

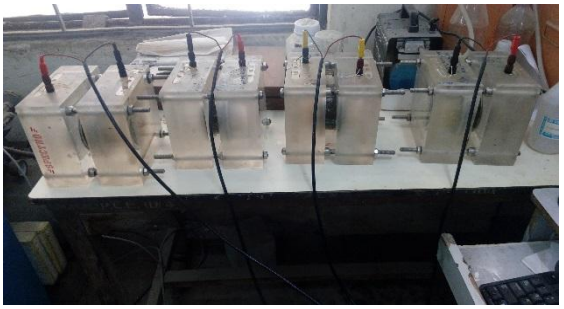


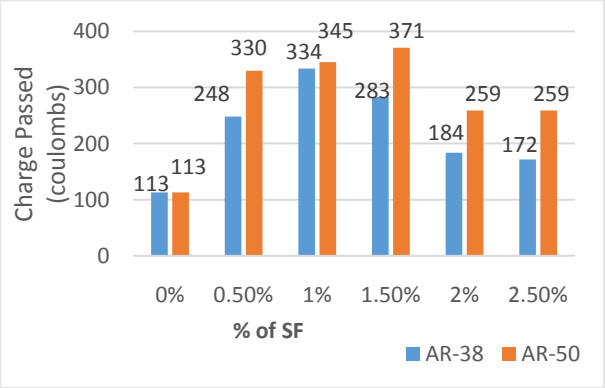
Figure 4: RCPT setup as per ASTM C120

Electricity was allowed to pass for 6 hours during which reading was taken every 30 min. total charge passed was computed from the readings taken.

Charge passed (Coulombs)	Chloride Permeability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

Table 5: Interpretation of result from RCPT

Following are the result obtained the graph 4.7 shows the result of RCPT containing SF of AR-38



Graph 4.7: Result of RCPT

V. CONCLUSION

The RPC displays excellent potential on compressive and flexural strength as elimination of course aggregates combined to optimization of the granular mixture allows the homogeneous and dense cementitious matrix that exhibits high mechanical performance.

Following are the experimental result obtained.

1. Addition of steel fiber in the concrete reduces workability. Concrete becomes stiffer at 2.5% of steel fiber and unable to compact concrete properly.
2. Maximum increment in compressive strength obtain by low carbon cold drown wire v type undulated SF with AR-38 at 2% of fiber is 42.99%.
3. Maximum increment in split tensile strength obtain by low carbon cold drown wire v type undulated SF with AR-38 at 2% of fiber is 43.40%.
4. Maximum increment in flexural strength obtain by low carbon cold drown wire v type undulated SF with AR-50 at 2% of fiber is 38.98%.
5. It is observed that the amount of charge passes is in the range of 100-1000 coulomb it indicates the chloride permeability is very low. Thus the test indicates that the concrete is very low penetrated by accelerated chloride ions.

RPC displays significantly enhanced material properties when compared to NC and HPC.

The extremely low levels of water and chloride ion permeability indicate the potential of RPC as a good material for storage of nuclear waste.

The SF used in this project has shown considerable improvement in all the properties of concrete like compressive strength, flexural strength and split tensile strength.

Addition of SF in the concrete reduces workability. Concrete becomes stiffer at 2.5% and unable to compact properly.

REFERENCES

[1]. MetinIpek, KemalettinYilmaz, Mansur Sumer, Mehmet Saribiyik, Effect of pre-setting pressure applied to mechanical behaviours of reactive powder concrete during setting phase, Construction and Building Materials Journal, 2010.
[2]. HalitYazıcı, MertYucelYardımcı, Serdar Aydın, Anil S. Karabulut , Mechanical properties of reactive powder concrete containing mineral admixtures under different curing regimes, Construction and Building Materials, 2008.
[3]. Yen Lei Voo, Stephen J. Foster and R. Ian Gilbert, Shear strength of fiber reinforced Reactive Powder Concrete Prestressed girders without stirrups, Journal of ACT,4(1)123-132.
[4]. Ming-Gin Lee , Yung-Chih Wang, Chui-Te Chiu; A preliminary study of reactive powder concrete as a new repair material; Construction and Building Materials 21 (2007) 182–189
[5]. AbouzarSadrekarimi, Development of Reactive powder concrete, Journal of ACT vol.2, No.3, 409-417.
[6]. Collepardi, L. Coppola, R. Troli, M. Collepardi, Mechanical Properties of modified RPC, 2001
[7]. Pierre Richard, Marcel CheyrezyComposition of reactive powder concrete; Cement and Concrete Research, Vol. 25. No. 7, pp. 1501-1511.1995
[8]. Chin-Tsung Liu, Jong-Shin Huang, Fire performance of highly flowable reactive powder concrete, Construction and Building Materials Journal, 2008.
[9]. M K Maroliya, C D Modhera, Influence of type of super plasticizer on workability andcompressive strength of reactive powder concrete, International Journal of Advanced Engineering Technology.
[10]. Mahesh K Maroliya1, Chetan D Modhera, Comparative study of RPC containing steel fibers&recron 3s fibers, Journal of Engineering Research and Studies.