Int. J. Chem. Sci.: 14(S1), 2016, 149-154
ISSN 0972-768X
www.sadgurupublications.com

STUDIES ON STRENGTH CHARACTERISTICS OF REACTIVE POWDER CONCRETE

J. ARAVINDHAN* and G. VIJAYAKUMAR

M. Tech. (Advanced Construction Technology), Pondicherry Engineering College,
PUDUCHERRY (T.N.) INDIA

ABSTRACT

Reactive powder concrete (RPC), which can be classified under Ultra high performance concrete (UHPCs) vows to be a promising material with respect to its mechanical and durability properties. Its performance under adverse environmental conditions is equally important, especially in marine environment, nuclear waste storage units and chemical industries. Its dense and uniform microstructure may lead to high performance characteristics. Assessing the permeability of a concrete with dense microstructure becomes important with focus on its performance. In view of this, RPC with a compressive strength of 120MPa was produced using local available materials. Laboratory investigations like; Compressive test, split tensile test and flexural strength were conducted to evaluate strength characteristics of RPC. The study on rapid chloride penetration reveals that chloride ion penetration is negligible in RPC and hence it can be a promising construction material to use in aggressive environment.

Key words: RPC, Chloride ion, Aggressive environment, Permeability, RCPT.

INTRODUCTION

The construction industry is one of the largest industry which uses concrete as its major ingredient. Concrete is absolutely indispensable in modern society's fascination with new roads, buildings and other constructions. It is estimated that the present consumption of concrete in the world is of the order of 10 billion tones every year. Humans consume no material except water in such tremendous quantities. The ability of concrete to withstand the action of water without serious deterioration makes it an ideal material for building structures to control, store, and transport water.

Reactive powder concrete

Reactive powder concrete (RPC) is an ultra high-strength and high ductility cementitious composite with advanced mechanical and physical properties. It consists of a

*Author for correspondence; E-mail: Aravindjosh007@gmail.com, gvk@pec.edu

special concrete where the microstructure is optimized by precise gradation of all particles in the mix to yield maximum density. It uses extensively the pozzolanic properties of highly refined silica fume and optimization of the Portland cement chemistry to produce the highest strength hydrates. It was developed in the Bouygues laboratory, France in the mid -1990s. It has a typical compressive strength of 150 to 200 MPa, which is four times that of Normal Strength Concrete (NSC). Strengths with up to 810 MPa have also been recorded (Cyr and Shah, 2002). RPC is recognized as a revolutionary material that can provide a combination of ultrahigh strength, high ductility through the inclusion of short steel fiber reinforcement and excellent durability (Wong et al., 2007).

(a) Enhancement of homogeneity of RPC by the elimination of coarse aggregates. It was suggested that the maximum size of ingredients of RPC should be less than 600 µm(Shaheen and Shrive, 2006).

(b) Enhancement of compacted density by optimizing the granular mixture (Richard and Cheyrezy, 1995).

(c) Improved matrix properties by addition of pozzolanic admixtures, i.e. silica fume (Ma and Schneider, 2002).

(d) Improved matrix properties by reducing water-to-binder ratio (Ma and Schneider, 2002).

As this concrete possess very low permeability and excellent strength characteristics, it is suited for study in aggressive environment.

Literature review

Review of literature on materials

As the cement content in RPC is generally as high as 700-1000 Kg/m3 (Collepardi et al., 2003), the choice of cement could be a critical factor affecting the performance of RPC.

The silica fume (SF) has four main functions in the use of concrete technology as follows: (Gonen and Yazicioglu, 2009).

(a) Filling the voids between the large class particles (cement).

(b) Improving the resistance of concrete and the durability of concrete, by reducing the permeability of the cement paste matrix.

(c) Producing secondary hydration with the lime resulting from the primary hydration.

(d) Making the concrete more resistant to abrasive forces, and reducing the expansion generated by alkali-aggregate.

Quartz is the major form of pure silica in nature and is a very hard material with hardness of seven on the Mohr's scale and density of 2.65 g/cm^3. They also suggested that the particle size range of quartz sand is between 150 and 600 µm, in order to prevent interference with largest cement particles (80-100 µm). Ma and Schneider, (2002) stated that Quartz powder with a diameter of about 10-50 µm can be used as micro fillers, which can fill the particle size gap between cement particle (80-100 µm) and silica fume (0.1-1 µm) and make the grading curve of the mixture composed of cement, silica fume and quartz powder continuous. Flexural strengths (f'cf) achieved varied between 25 and 50 MPa. RPC mixtures possessed higher flexure strength when compared to normal concrete. SF provides significant improvement in the compressive strength, flexural strength, in addition to other significant improvement in durability and impermeability (Pigeon and Plante, 1999).

- Tensile strengths (f'ct) achieved varied between 12 and 21 MPa.

Table 1: Mix details

Parameters & materials	Cement	Silica fume	Quartz sand	Quartz powder	SP Dosage	W/B Ratio	Water content
MIX	820 kg/m^3	123 kg/m^3	902 kg/m^3	164 kg/m^3	13.8	0.27	255 kg/m^3

RESULTS AND DISCUSSION

Table 2: Compressive strength

	28 Days	56 Days	90 Days
NC (M35)	43.07	45.08	50.34
15% SF	72.87	73.76	78.65
20% SF	79.08	81.43	84.75
25% SF	93.5	95.67	97.22
30% SF	118.1	119.43	124.43
35% SF	114.2	116.89	120.86

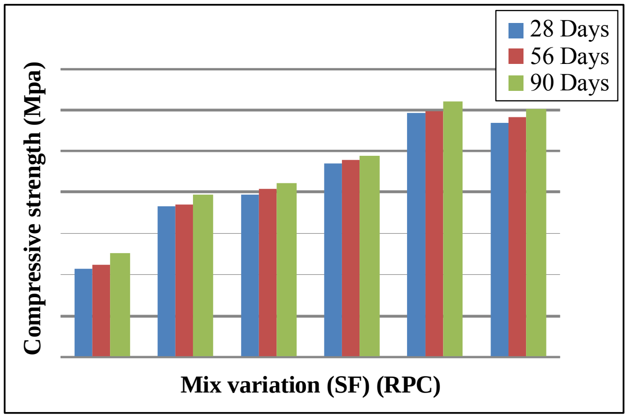

Fig. 1: Compressive strength

The compressive strength of 30 %SF was better than other percentages of RPC.

Table 3: Flexural strength

	28 Days	56 Days	90 Days
NC (M35)	3.287	3.34	3.45
15% SF	5.136	5.28	5.67
20% SF	6.939	7.05	7.23
25% SF	8.91	9.05	9.24
30% SF	8.76	8.89	9.12
35% SF	7.49	7.54	7.61

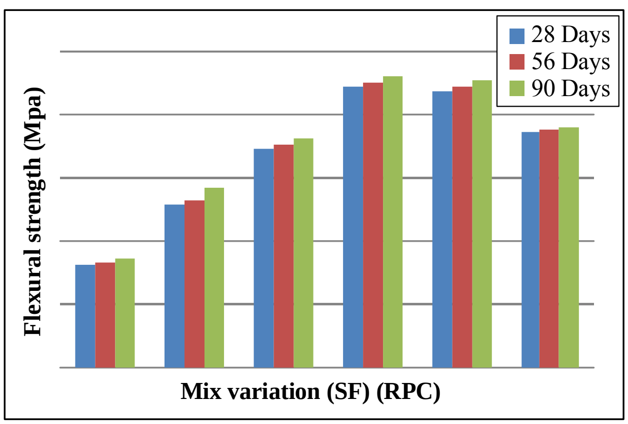

Fig. 2: Flexural strength

The flexural strength was observed higher for 25% SF addition and it can be increased further by adding steel fibres.

Table 4: Split tensile strength

	28 Days	56 Days	90 Days
NC (M35)	3.95	3.96	4.04
15% SF	5	5.03	5.1
20% SF	6.5	6.64	6.89
25% SF	6.64	6.83	6.94
30% SF	7.21	7.46	7.66
35% SF	7.1	7.21	7.35

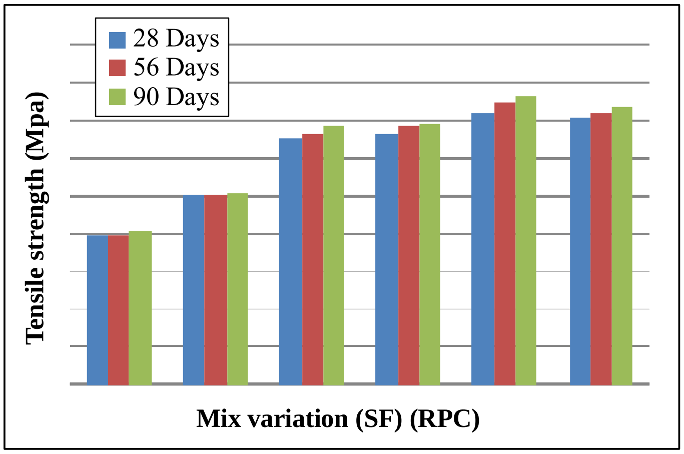

Fig. 3: Split tensile strength

CONCLUSION

The compressive and split tensile strength of 30% SF was better than other percentages of RPC. The flexural strength was observed higher for 25% SF addition and it can be increased further by adding steel fibres. RPC 25% SF was found to have lower penetration values than RPC 25% SF. It represents that, RPC is more durable when corrosion resistance is considered with other class of high strength concrete. RPC exhibits excellent corrosion resistance characteristics compared to other concretes and may be effectively utilized in marine construction.

REFERENCES

1. P. Richard and M. Cheyrezy, Composition of Reactive Powder Concretes, Cement and Concrete Research, **25(7)**, 1501-1511 (1995).
2. N. Roux, C. Andrade and M. A. Sanjuan, Experimental Study of Durability of Reactive Powder Concretes, J. Mater. Civil Engg., **8(1)**, 1-6 (1996).
3. M. Pigeon and M. Plante, Air-Void Stability Part I: Influence of Silica Fume and other Parameters, ACI J., **86(5)**, 482-490 (1989).
4. V. Matte and M. Moranville, Durability of Reactive Powder Concrete Composites: Influence of Silica Fume on the Leaching Properties of Very Low Water/Binder Pastes, Cement and Concrete Composites, **21(1)**, 1-9 (1999).
5. J. X. Ma and H. Schneider, Properties of Ultra-High-Performance Concrete, LACER, **7**, 25-32 (2002).
6. N. P. Lee and D. H. Chisholm, Study Report Reactive Powder Concrete, BRANZ, **146**, 1-29 (2005).
7. H. A. Toutanji and T. El-Korchi, The Influence of Silica Fume on the Compressive Strength of Cement Paste and Mortar, Cement and Concrete Res., **25(7)**, 1591-1602 (1995).
8. E. Shaheen and N. G. Shrive, Optimization of Mechanical Properties and Durability of Reactive Powder Concrete, ACI Mater. J., **103(6)**, 444-451 (2006).
9. A. Sadrekarimi, Development of a Light Weight Reactive Powder Concrete, J. Adv. Concrete Technol., **21(3)**, 409-417 (2004).
10. B. Ahmadi and M. Shekarchi, Use of Natural Zeolite as a Supplementary Cementitious Material, Cement Concrete Composites, **32(1)**, 134-141.

Accepted : 04.05.2016