STUDY ON MECHANICAL PROPERTIES OF REACTIVE POWDER CONCRETE

[1]K SIRISHA,[2]E V RAGHAVA RAO,[3]D SATISH
[1]P G Student, [2]Professor,[3] Assistant Professor
[1]Department of Civil Engineering,
[1]Visakha Technical Campus, Visakhapatnam, India

Abstract :Reactive Powder Concrete (RPC) is a high strength, new generation concrete, formed from a special combination of constituent materials. The composition of reactive powder concrete includes cement (ordinary Portland cement), fine sand, silica fume, quartz powder, and high tensile steel fibres. Reactive powder concrete is grouped under ultra high performance concrete. This concrete has a very high compressive strength of 200 MPa which can be improved further by introducing steel pellets upto 800MPa. This new family of concrete has improved ductile behavior with a flexural strength of 25MPa to 40MPa.The aim of this research program is to find the suitability of Reactive Powder Concrete for prefabricated structures especially angle sections. The first step of this project is to characterize the material property of RPC mix. This research includes the experimental investigation of the mechanical properties of Reactive Powder Concrete using compression, tension flexure and shear test.

Keywords: Compressive Strength, High Tensile Steel Fibres, Portland cement, quartz powder, Reactive Powder Concrete.

I.INTRODUCTION

Reactive Powder Concrete (RPC) is a developing composite material that will allow the concrete industry to optimize material use, generate economic benefits, and build structures that are strong, durable, and sensitive to environment. A comparison of the physical, mechanical, and durability properties of RPC and HPC (High Performance Concrete) shows that RPC possesses better strength (both compressive and flexural) and lower permeability compared to HPC. This page reviews the available literature on RPC, and also presents the results of laboratory investigations comparing RPC with HPC. Specific benefits and potential applications of RPC have also been described. High-Performance Concrete (HPC) is not just a simple mixture of cement, water, and aggregates. It contains mineral components and chemical admixtures having very specific characteristics, which give specific properties to the concrete. The development of HPC results from the materialization of a new science of concrete, a new science of admixtures and the use of advanced scientific equipments to monitor concrete microstructure. Reactive Powder Concrete (RPC) was developed in France in the early 1990s and the world's first Reactive Powder Concrete structure, the Sherbrooke Bridge in Canada, was erected in July 1997. Reactive Powder Concrete (RPC) is an ultra high-strength and high ductility cementitious composite with advanced mechanical and physical properties. It consists of a 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.

II. LITERATURE REVIEW

The concept of reactive powder concrete was first developed by P. Richard and M. Cheyrezy and RPC was first produced in the early 1990s by researchers at Bouygues laboratory in France. A field application of RPC was done on the Pedestrian/Bikeway Bridge in the city of Sherbrooke, Quebec, Canada. RPC was nominated for the 1999 Nova Awards from the Construction Innovation Forum. RPC has been used successfully for isolation and containment of nuclear wastes in Europe due to its excellent impermeability.

Dattatreya. J.K., et al., (**2007)** studied several particle packing models to develop a mix proportion for the reactive powder concrete. The optimization of granular packing of the ingredients was an important factor for getting enhanced mechanical and durability properties. The granular packing of materials like silica fume, quartz powder, standard sand with cement were optimized and the experimental results were compared with the theoretical packing models.

Dili and Manu Santhanam (2005) developed two RPC mixes of 200MPa and 800MPa strength, which could be suitable for nuclear waste containment structures. The workability and durability properties were studied for the designed RPC mix. Also characterization of mechanical properties was carried out. The durability test carried out for the RPC mixes showed that the flow table test as per ASTMC 10916 was in the range of 120%-140% and the water and chloride ion Permeability is extremely low. These test results indicates the suitability of the designed RPC mix for nuclear waste containment structures. However, the suitability of RPC mix for use in nuclear waste containment structures with respect to resistance then penetration of heavy metals and other toxic wastes emanating from nuclear plants has to be studied.

III.MIX PROPORTION

In the present work, to facilitate comparative study different types of specimens of plain RPC, steel fiber reinforced RPC (SFRPC) and recron 3s fiber reinforced RPC (RSFRPC) are prepared and are tested to find compressive strength at 7 days and 28 days and static flexural strength at 28 days with all samples casted using previously engineered composition of RPC in different curing condition.

Table 1. Conventional Mix Proportion for Plain RPC

MATERIAL	***PLAIN RPC***
CEMENT	***1***
SILICA FUME	***0.32***
QUARTZ SAND	***-***
SAND	***1.50***
SUPER PLASTICIZER	***0.032***
STEEL FIBERS	***-***
W/C RATIO	***.20***

Table 2. Conventional Mix Proportion for SFRPC

MATERIAL	***PLAIN RPC***
CEMENT	***1***
SILICA FUME	***0.32***
QUARTZ SAND	***0.36***
SAND	***1.50***
SUPER PLASTICIZER	***0.035***
STEEL FIBERS	***.20***
W/C RATIO	***.22***

Table 3. Conventional Mix Proportion for Plain RSFRPC

MATERIAL	***PLAIN RPC***
CEMENT	***1***

SILICA FUME	***0.30***
QUARTZ SAND	***0.36***
SAND	***1.50***
SUPER PLASTICIZER	***0.03***
STEEL FIBERS	***.25***
W/C RATIO	***.079***

IV. EXPERIMENTAL PROGRAM

A. MATERIAL PROPERTIES

1). CEMENT

The Cement used was Jaypee Ordinary Portland Cement (OPC) of grade 43 conforming to IS: 8112-1989. The various laboratory tests confirming to IS: 4031-1996 (PART 1 to 15) specification was carried out and the physical properties were found as such:
Fineness - 0.225 m^2/g
Consistency - 30%
Initial setting time - 30 min
Final setting time - 600 min
Specific gravity - 3.15

2). SILICA FUME

Silica fume, also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

3).QUARTZ SAND

Quartz is the most important sand-forming mineral and occurs in very many sand types but usually not exclusively. In this sand type (which is aptly named quartz sand), quartzes almost the sole component of sand. Similar sandstones are called quartz arenites or orthoquartzites.

Specific Gravity**:** 2.6 to 2.7

4).SAND

River sand from nagavali river bed having the following characteristics has been used
Specific gravity - 2.66
Fineness modulus - 2.60
Water absorption - 1.35

5).SUPER PASTICIZERS

Super plasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics (rheology) of suspensions such as in concrete applications.

6). STEEL FIBRES

The steel Fibres were straight ones with Modulus of Elasticity of 200 GPa. The Fibres were intended to be randomly placed in the beams at 1.0 and 1.5% by volume. Steel Fibres with aspect ratio of 66.67 were used. The diameter of the Fibre was 0.6 mm and the length was 40 mm.

V. RESULTS & DISCUSSIONS

A. *Compressive Strength*

Table 4. Compressive Strength Test Results of Plain RPC

PLAIN RPC	COMPRESSIVE STRENGTH	
	7 DAYS	28 DAYS
RPC 1	90	100
RPC 2	96	106
RPC 3	95	114

Table 5. Compressive Strength Test Results of SFRPC

SFRPC	COMPRESSIVE STRENGTH	
	7 DAYS	28 DAYS
SFRPC 1	102	114
SFRPC 2	125	137
SFRPC 3	127	139

Table 6. Compressive Strength Test Results of RSFRPC

RSFRPC	COMPRESSIVE STRENGTH	
	7 DAYS	28 DAYS
RSFRPC 1	81	90
RSFRPC 2	108	120
RSFRPC 3	110	122

Table 7.Comparision of Compressive Strength Test Results

Mpa	COMPRESSIVE STRENGTH					
	SFRPC 1	RSFRPC 1	SFRPC 2	RSFRPC 2	SFRPC 3	RSFRPC 3

7 DAYS	102	81	125	108	127	110
28 DAYS	114	90	137	120	139	122

B. Tensile Strength

Table 8. Tensile Strength Test Results of Plain RPC

PLAIN RPC	TENSILE STRENGTH
	28 DAYS
RPC 1	10
RPC 2	12
RPC 3	13

Table 9. Tensile Strength Test Results of SFRPC

SFRPC	TENSILE STRENGTH
	28 DAYS
SFRPC 1	16
SFRPC 2	19
SFRPC 3	21

Table 10. Tensile Strength Test Results of RSFRPC

RSFRPC	TENSILE STRENGTH
	28 DAYS
RSFRPC 1	14
RSFRPC 2	16
RSFRPC 3	18

C. Modulus of Rupture

Table 11. Modulus of Rupture Results of Plain RPC

PLAIN RPC	MODULUS OF RUPTURE
	28 DAYS
RPC 1	14
RPC 2	16
RPC 3	18

Table 12. Modulus of Rupture Results of Plain SFRPC

SFRPC	MODULUS OF RUPTURE

	28 DAYS
SFRPC 1	22
SFRPC 2	27.5
SFRPC 3	30

Table 13. Modulus of Rupture Results of Plain RSFRPC

RSFRPC	MODULUS OF RUPTURE
	28 DAYS
RSFRPC 1	19.5
RSFRPC 2	22
RSFRPC 3	25

VI CONCLUSIONS

Depending upon above results and methodology adopted following conclusion were made regarding properties of concrete.

1. Addition of steel fiber at 2% volume fraction is found not to affect the workability of RPC. RPC is easily mixed with steel fibers, however addition of 0.039 Recron 3s fibers is found to affect the workability of concrete. Even after taking utmost care balling effect of fibers was observed while casting some of the samples, workability of RSFRPC mix can be improved by using lower percentage of fibers.
2. Addition of steel fibers does not affect the finishibility of RPC outer surface of concrete after casting was as smooth as plain RPC. While in case of Recron 3s fiber finishibility was not as good as plain and steel fiber reinforced RPC.
3. Marginal increase in bulk density and marginal decrease of flow of concrete was observed due to addition of steel and Recron 3s fibers.
4. Ultimate compressive strength of SFRPC is 30% higher may be because of more confined and densed concrete while in case of RSFRPC the strength is reducing by 19% as we could not get a good. Flow as a measure of workability which can be improved by readjusting the doses of plasticizers more workable concrete can be obtained and strength can be improved. This is very obvious as compressive strength of RPC is primarily affected by the property of matrix and not due to the influence of the fibers.
5. Split tensile strength of SFRPC and RSFRPC in comparison to plain RPC is found 50% and 30% more respectively addition of fibers is significantly affecting the splitting tensile strength.

REFERENCES

[1].Richard, P. & Cheyrezy, " Reactive powder concretes with high ductility and 200–800 MPa compressive strength", ACI Spring Convention, San Francisco, April, 1994.
[2]. Richard, P. & Cheyrezy, "Composition of reactive powder concretes", Cement and Concrete Research, 25(7): 1501–1511, 1995.
[3].H. Wang and A. Belarbi, "Flexural Behavior of Fiber-Reinforced-Concrete Beams Reinforced with FRP Rebars", transportation.mst.edu, SP-230—51, 895-914.
[4]. XiaoXin Z., Gonzalo R., Rena C., Manuel T., Miguel C.," CRACK VELOCITIES IN HIGH-STRENGTH CONCRETE AT A WIDE RANGE OF LOADING RATES", Anales de Mecánica de la Fractura 26, Vol. 2 (2009).
[5]. Shiyun X., Wenbo C. and Haohao P.," Experiment of Reinforce Concrete Beams at Different Loading Rates", 15 WCEE, Dalian University of Technology, Dalian 116024, China.
[6]. Georgia E. T., Konstantin's K. and George M.," Influence of The Loading Rate on The Axial Compressive Behavior of Concrete Specimens Confined with SRG Jackets", 4th ECCOMAS Thematic Conference on Computational Methods in Structural Dynamics and Earthquake Engineering, Kos Island, Greece, 12–14 June 2013.
[7]. ASTM C39- 80 "Compressive Strength of Cylindrical Concrete Specimens", Annual Book of American Society for Testing Concrete and Materials, Philadelphia, Pennsylvania, Vol.04: 02, pp. 19-23.

[8]. British Standard Institute, “Method for Determination of Compressive Strength of Concrete Cubes”, BS 1881: part116: 1983.
[9]. ACI Committee 318, " Building Code Requirements for Structural Concrete (ACI 318-2011, ACI 318R-2011)", American Concrete Institute, 2011.