Effect of Fly ash and Used foundry sand on Split Tensile Strength of Reactive Powder Concrete

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Abstract

Newly developed cementitious material, Reactive Powder Concrete (RPC), firstly developed by Richard and Cheyrezy in 1990's at Bouygues Laboratory,and is recognized as a revolutionary material that provides a combination of ultrahigh strength and excellent durability. RPC is a composite mixture of cement, silica fume, natural sand, quartz powder and steel fibres.On the other hand, Generation of Industrial Waste and its disposal is the biggest problem all over the Globe. However, the use of waste in concrete can be a good scope. Locally available industrial waste (Rajkot, Gujarat) used in the study is used foundry sand. Also another waste material used in the study is Fly ash.In this paper, the effect of combination of the two industrial by-product i.e. Fly ash and Used Foundry Sand on the Split Tensile Strength of Reactive Powder Concrete is presented. The results shows that Cement can be replaced by fly ash upto 15% along with the replacement of natural sand by foundry sand up to 20% gives considerable strength along with economy.

Keywords: Reactive Powder Concrete, Fly ash, Foundry sand, Split Tensile strength

Introduction:

'Reactive powder concrete' (RPC) is the generic name for a class of cementitious composite materials developed by the technical division of Bouygues Laboratory, S.A. France in the early **1990s** and the world's first RPC structure, the Sherbrooke Bridge in Canada, was constructed in **July 1997**. It is characterized by extremely good physical properties, particularly strength and ductility. 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.

Since Reactive Powder Concrete (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 Bouygues, France. Since then further development of the material has continued throughout the world (for example Australia, Canada, Japan, Korea and the United States of America) at a frenetic pace. Superior mechanical properties and durability characteristics promise that the material will have a wide and significant impact on the concrete industry.

To date, the greater part of research into RPC has focused on what the material is and its properties, micromechanical analysis, potential applications and preliminary work into the structural behavior. However in India investigations in RPC, using locally sources and materials, developing composition, mechanical properties and durability parameter are still in their infancy. This information is required to assist with the increased use of RPC in practice and to further develop analytical techniques and design standards.

Reactive Powder Concretes (RPCs) are ultra-high strength cementitious materials composed of very fine powders with a maximum particle size of approximately 800μm. In addition to the absence of the traditional coarse aggregates used to produce normal and high strength concrete, RPCs are characterized by very high silica fume content and very low water-cement (w/c) ratios (Cheyrezy et al, 1995). The low w/c ratios are achieved through the use of new generation super plasticizers in large doses, typically in excess of 20L per cubic meter of concrete. The large dose of super plasticizer is required to achieve a workable mix.

A typical RPC has a compressive strength in excess of 150MPa, flexural strength of between 20 and 50MPa and Young's modulus of elasticity in the range of 45 - 65GPa. With the inclusion of steel fibers to overcome the brittleness of the cementitious matrix, RPCs exhibit superior ductility to even high performance concretes. Hence RPCs are often referred to as ultra-high performance concretes (UHPCs). They also have an extremely low porosity resulting in an extremely durable material. Due to the fineness of the constituent materials and the workability of the mix, RPC can take any shape required with a high quality surface finish.

The cement content of the RPC mixes ranged from 800 kg/m3 to 1000 kg/m3.The optimum contents for silica fume and quartz are in the ranges of 15-25% and 30-40% of the cement weight, respectively.It will be more convenient to evaluate the compressive strength of RPC based on its 56 days age rather than the 28 days used for conventional concrete.Curing regime plays a dominant role in determining the strength of RPC.When circular steel fibers are used then the increment in the compressive strength is 10 to 15% of the compressive strength obtained without steel fibers.Strength is decrease as the percentage of Fly Ash increase, but it is negligible as compared to other benefit. Test results indicate that, compressive strength of RPC increased considerably after steam and autoclaving compared to the standard curing

In this paper, the split tensile strength of reactive powder concrete containing various proportions of fly ash and used foundry sand are tested and presented.

Experimental program

Materials Used

The cement used in the present work wasOrdinary Portland cement of 53 grade. The river sand with the particle size ranging from 150 to 600 μm was used as fine aggregates. Silica fume having properties as shown in **Table 1** was used in the study. Corrugated M S Steel fibre crimp type of 12.5 mm in length and 0.5mm diameter were used.Low calcium, Class F fly ash obtained from the Wanakbori Thermal Power Station, Gujarat, India, was used as the filler material.The foundry sand having properties as shown in **Table 2**, was used in the study.The super plasticizer having properties as shown in **Table 3** was used in the study.

Table 1 Properties of Silica fume

Sr. No.	Properties	Units	Results Obtained	Protocol
1.	Silica as SIO_2	%	92.80	**ASTM C-114**
2.	Alumina as AL_2O_3	%	0.60	**ASTM C-114**
3.	Iron as Fe_2O_3	%	0.30	**ASTM C-114**
4.	Magnesium as MgO	%	0.60	**ASTM C-114**
5.	Total Alkalis as (Na_2O+0.658K_2O)	%	1.17	**ASTM C-114**
6.	Sulphur Trioxide as SO_3	%	Less Than 0.10	**ASTM C-114**
7.	pH of 20% Soln.	--	8.83	**By pH meter**

Table 2 Properties of Foundry Sand

Specific Gravity	2.45	gm/ml
Bulk Relative Density	1760	kg/m³
Moisture	0.46	% by wt.
Clay Lumps	30.19	% by wt.

Table 3 Properties of PCE based Super Plasticizer (Glenium 51)

Sr. No.	Properties	Units	Specification Limit
1.	Specific Gravity	g/cm³	**1.10 ± 0.03**
2.	Chloride	% by mass	**≤ 0.10**
3.	pH	--	**7.0 ± 1**
4.	Alkali	**% by mass**	**≤ 4**

Mix Proportion

The mix proportion of reactive powder concrete was taken based on Literature review and the various pilot study performed. The quantities of various ingredients for 1m^3 volume are given in **Table 4**. Various mixes designated as shown in **Table 5** were prepared by adding different dosage combination of Fly ash and Used foundry sand.

Table 4 Mix proportion of Reactive Powder Concrete for 1 m^3

Cement (kg)	Silica Fume (kg)	Natural Sand (kg)	Steel Fiber (kg)	Super Plasticizer (kg)	Water (kg)
951	220	1051	157	11.75	294

Table 5 Mix Designations of Reactive Powder Concrete

Groups	Mix Designation	Fly ash dosage % of Cement weight	Foundry sand dosage % of Natural sand
Normal RPC	RPC	0	0
Group A	RPC 1	5	0
	RPC 2		10
	RPC 3		20
	RPC 4		30
Group B	RPC 5	10	0
	RPC 6		10
	RPC 7		20
	RPC 8		30
Group C	RPC 9	15	0
	RPC 10		10
	RPC 11		20
	RPC 12		30
Group D	RPC 13	20	0
	RPC 14		10
	RPC 15		20
	RPC 16		30

Tests

According to IS:5816-1999, the split tensile strength was measured by casting cylinders of size 100×200mm and testing them at 28 days for various proportions as shown in **Table 5**.

Results

Split Tensile Strength

The split tensile strengthresults for 28 days of the reactive powder concretefor percentage replacement of cement by fly ash and percentage replacement of natural sand by used foundry sand in various subsequently varying proportion are shown below.

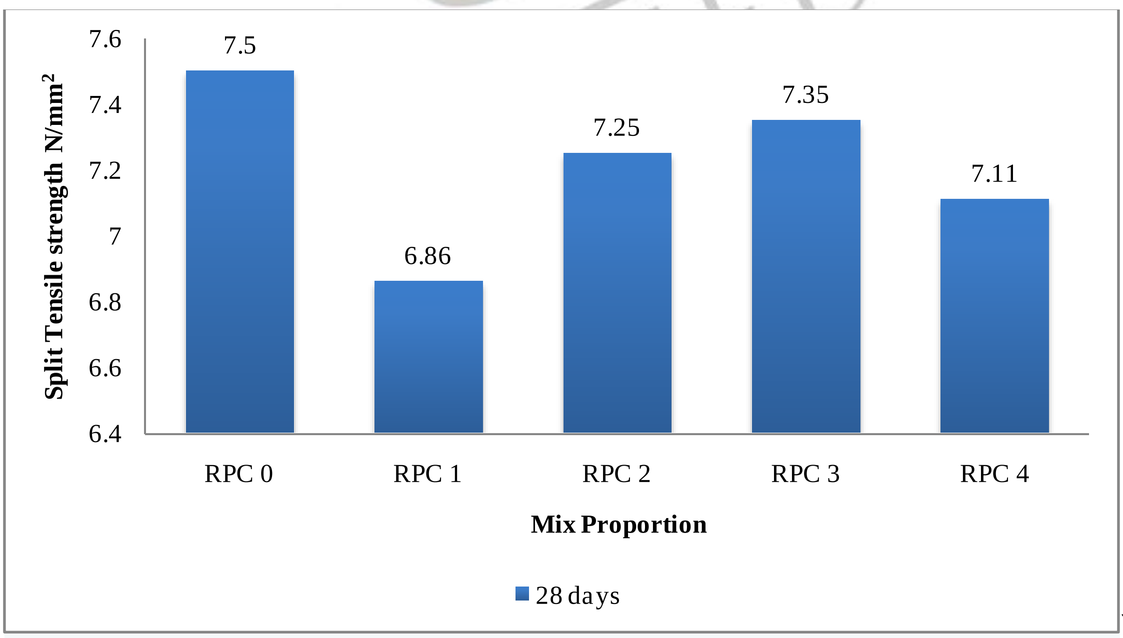

Figure 1Split Tensile Strength Result of Normal RPC andGroup A

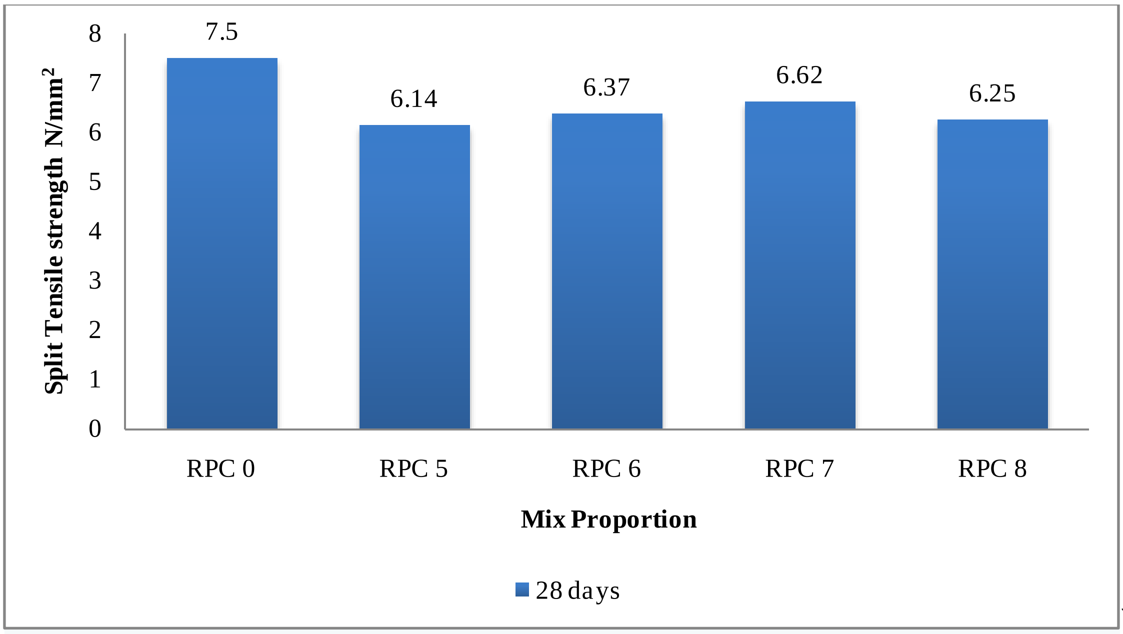

Figure 2 Split Tensile Strength Result of Normal RPC and Group B

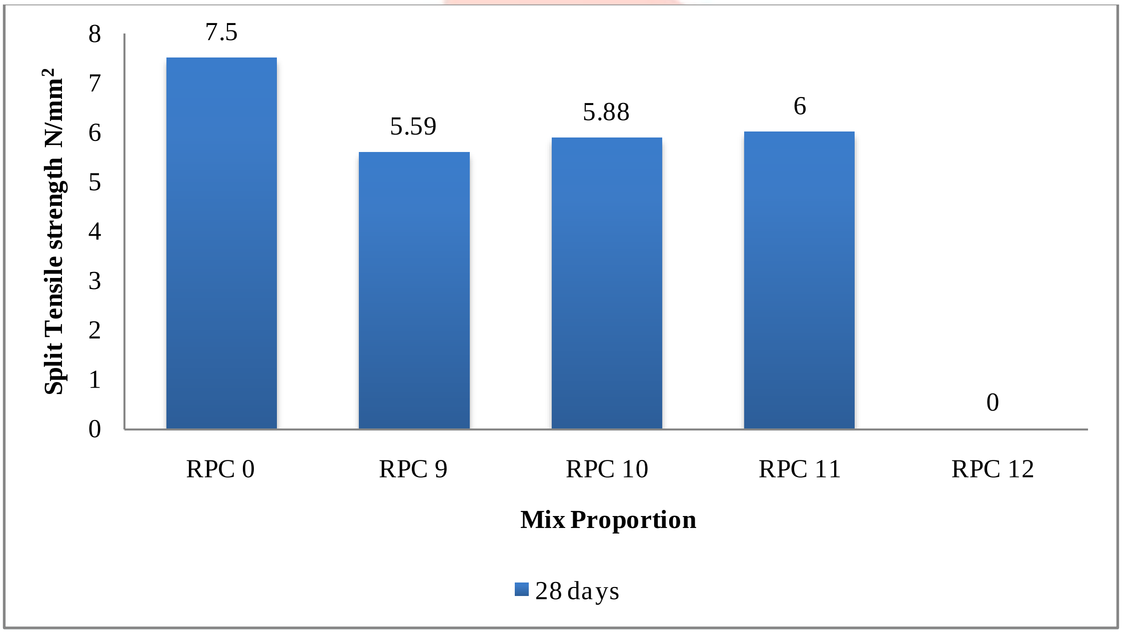

Figure 3 Split Tensile Strength Result of Normal RPC and Group C

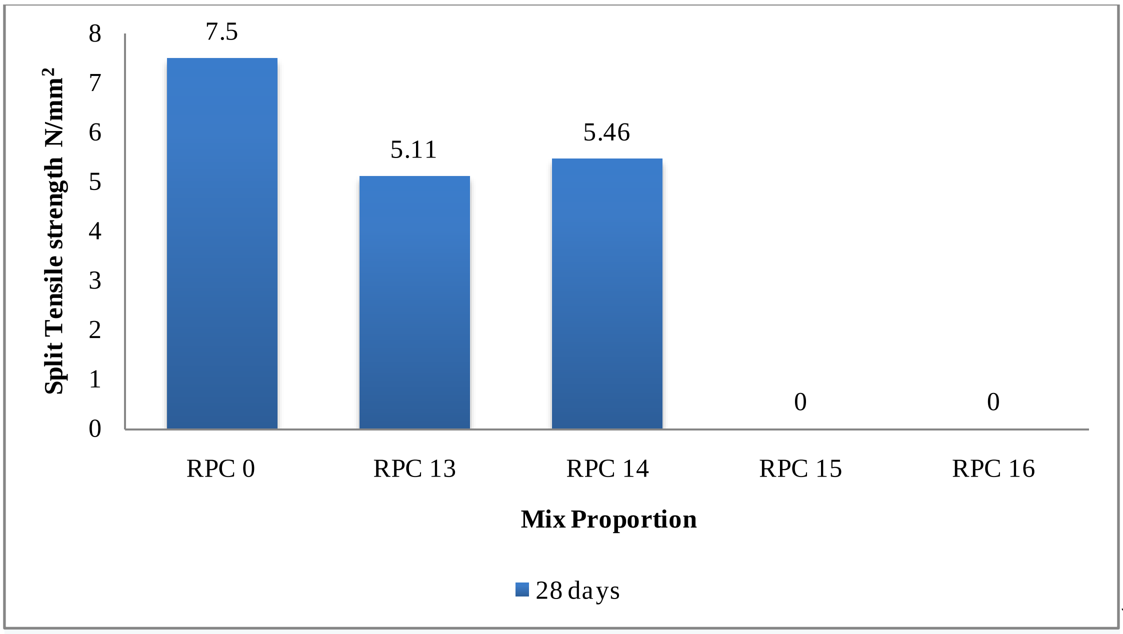

Figure 4Split Tensile Strength Result of Normal RPC andGroup D

Conclusions

The effect of replacement of cement and natural sand by fly ash and used foundry sand in various proportions is presented on the split tensilestrengthof reactive powder concrete is presented. The following are the broad conclusions made from the above test results:

1. For Group A, the 5% replacement of Cement by Fly ash showed that the Split Tensile Strength decreases by 8.5%. However the strength increases by 5.7% and 7.4% on replacement of natural sand by used foundry sand by 10% and 20% respectively.
2. For Group B, the 10% replacement of cement by Fly ash showed that the Split Tensile Strength decreases by 18.1%, however the decrease in strength is negligible as compared to economy.Similar results was concluded for other mixes.
3. The replacement of natural sand by used foundry sand showed the increase in strengthfor 10% and 20% replacement in each group, however the strength decrease for 30% replacement. This is due to decrease in pore space of the concrete.
4. For Group C and Group D, it was noted that as the quantities of fly ash and foundry sand was increasing, the water requirement was also increasing. As a result the mix was not formed for RPC 12, RPC 15 and RPC 16.

From the above results, it could be concluded that on increasing the fly ash content, strength decreases but in parallel if we increase the content of foundry sand, then upto some extent (i.e. 20% replacement of natural sand), the split tensilestrength increases and at the same time water demand also increases. Also beyond 20% replacement, thestrength decreases. So, for RPC, fly ash can be used as a replacement of cement by 15% and foundry sand can be used as a percentage replacement of natural sand by 20% for same w/b ratio

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