Experimental Analysis of Compressive Strength of Reactive Powder Concrete Incorporating with GGBS and Basalt Fibres

Kariya Milap J[1*], Indrajit Patel[2*], Jagruti Shah[3*]

[1]PG Student (Structure Department) Dharmsinh Desai University Gujarat, India
[2]Professor, Structure Department, BVM engineering College Gujarat, India
[3]Professor, Structure Department, BVM engineering College Gujarat, India

Abstract

The aim of this Study is to evaluate the performance of concrete (RPC) containing supplementary cementitious materials such as Microfine and GGBS. The necessity of high performance concrete is increasing because of demands in the construction industry. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. Microfine and GGBS are pozzolanic materials that can be utilized to produce highly durable concrete composites. This study investigates the performance of concrete mixture in terms of Compressive strength 28 days and 91 days. In addition find out the optimum dosage of Microfine and GGBS from given mix proportion. Result show that concrete incorporating Microfine and GGBS have higher compressive strength.

Keywords: *Basalt Fibres, Compressive Strength, GGBS, Microfine*

INTRODUCTION

Reactive powder concrete (RPC) is ultra-high strength and high ductile composite material with advanced mechanical properties. Reactive powder concrete is a concrete without coarse aggregate, but contains cement, Microfine, silica fume, sand, quartz powder, super plasticizer and fiber with very low water binder ratio. The absence of coarse aggregate was considered by inventors to be key aspect for the microstructure and performance of RPC in order to reduce the heterogeneity between cement matrix and aggregate.

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. The world's first Reactive Powder Concrete structure, the Sherbrooke Bridge in Canada, was erected in July 1997. The addition of supplementary material, elimination of coarse aggregates, very low water/binder ratio, additional fine steel fibers, heat curing and application of pressure before and during setting were the basic concepts on which it was developed. Compressive strength of RPC is more than 150 MPa.

RPC will be suitable for pre-stressed application and for structures acquiring light and thin components such as roofs of stadiums, long span bridges, space structures, high pressure pipes, blast resistance structures and the isolation and containment of nuclear wastes. In India the work on RPC has started from last few years. The utility of RPC in actual construction is minimal or nil in India, it is because of non-availability of sufficient experimental data regarding production and performance of RPC.

EXPERIMENTAL INVESTIGATION

Material Specification

The materials used in preparation of RPC are as follows Microfine, GGBS, Quartz sand, cement, Superplasticizer and Basalt fiber. The specifications of materials are described below.

Cement: Ordinary Portland cement of grade 53 make from a single lot is used for the study. The physical properties of cement as obtained from various tests are listed in Table 1.

Table 1: *Specification of Cement*

Properties	Results
Standard Consistency	30 %
Initial Setting Time Final Setting Time	90min 178 min
Specific Gravity	3.15

Microfine: Microfine is an ultrafine GGBS (Ground granulated blast furnace slag) based material. It replaces a substantial proportion of normal cement OPC in RMC. The higher the proportion, the better is durable concrete. Microfine is also used in other forms of concrete including site batched and precast. It consists amorphous silicon dioxide ($SiO2$). Table 2. Shows specification of Microfine.

Table 2: *Specification of Microfine*

Properties	Results
Specific Gravity	2.88
Fine Ness	770.12 m2/kg
SiO2	33.24 %

Quartz Sand: The mean particle size of crushed quartz available in the range between 5µm to 25 µm. Physical properties of Quartz Sand is shown in Table 3.

Table 3: *Specification of Quartz Sand*

Particulars	Specifications
Physical State	Granular Solid
Specific Gravity	2.32
Bulk Density	2200-2500 kg/m3
Colour	White

GGBS: Ground Granulated Blast furnace Slag consist essentially silicates and alumina silicates of calcium. Portland cement is a good catalyst for activation of slag because it contains the three main chemical components that activate slag: lime, calcium update and alkalis. The material has glassy structure and is ground to less than 45 microns. Physical properties of GGBS shown in Table 4.

Table 4: *Specification of GGBS*

Properties	Results
Specific gravity	2.88

Fine Ness	402.1 m2/kg
SiO2	33.24 %

Superplasticizer: BASF Master Glenium SKY 8777 Admixture is used in this project. It is a high range water reducing admixture based on second generation polycarboxylic ether polymers. It is specially made to reduce w/c ratio without any loss in workability and to give high strength concrete. Properties of Superplasticizers shown in Table 5.

***Table 5:** Specification of Superplasticizer*

Properties	Results
Specific gravity	1.1
Color	Light Brown
Chloride ion Content	< 0.2%
Physical State	Liquid

Basalt Fibre: Basalt fiber is a material made from extremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. The fibers used in the study are of 13 μm in diameter and 18mm in length.

EXPERIMENTAL SET-UP

In order to study the effect of Basalt Fibre and GGBS on Compressive Strength of Reactive Powder Concrete 36 cubes casted with and without fibres. Sizes of Specimen used for tests are 100 mm x 100 mm x 100 mm.

Mix Proportion

The mix proportion adopted for the RPC mix is given in Table 6.

***Table 6:** Standard Mix Design*

Sr. No.	Material	Quantity
1.	Cement	890 kg/m^3
2.	Fine Aggregates	1100 kg/m^3
3.	Microfine	89 kg/m^3
4.	Quartz Sand	180 kg/m^3
5.	Superplasticizer	11 kg/m^3
6.	w/b Ratio	0.18

In RPC slumps has been observed is moderate comparing to conventional concrete. Slump Values are in ranged of 100 to 120 mm for water cement ratio 0.2 with different mixes of this proportion, which has been confirmed as per BIS-456:2000. In this test, observed slump value is not collapse of concrete while taking up cone but, it has settled down due to self-weight of concrete.

The RPC mixtures incorporated with different GGBS and Basalt Fibre contents were designated as summarized in Table 6.

Table 7: *Percentage of GGBS Replace and Basalt Fibre Adding.*

Sr. No.	Mix	GGBS	Basalt Fibre
1.	Mix 1 (M1A1)	0 %	0 %
2.	Mix 2 (M1A2)	0 %	1 %
3.	Mix 3 (M1A3)	0 %	2 %
4.	Mix 4 (M2A1)	10 %	0 %
5.	Mix 5 (M2A2)	10 %	1 %
6.	Mix 6 (M2A3)	10 %	2 %
7.	Mix 7 (M3A1)	15 %	0 %
8.	Mix 8 (M3A2)	15 %	1 %
9.	Mix 9 (M3A3)	15 %	2 %
10.	Mix 10 (M4A1)	20 %	0 %
11.	Mix 11 (M4A2)	20 %	1 %
12.	Mix 12 (M4A3)	20 %	2 %

Specimen Preparation and Curing

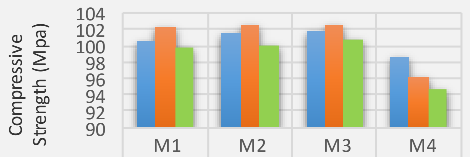
Materials are weigh batched, mixed in a mixer, cast into steel moulds and specimens were stored in room temperature for 24 hours, then removed from the moulds, and cured in normal water until tested.

Testing

Cubes of size 100 mm × 100 mm × 100 mm were tested to compute compressive strength 7, 28, and 91 days.

RESULTS AND DISCUSSIONS

The result of Compressive Strength are as in Fig. 1, Fig. 2 and Fig. 3 at 7, 28 and 91 days respectively.



	M1	M2	M3	M4
0% B.F A1	100.6	101.4	101.7	98.6
1% B.F A2	102.1	102.4	102.5	96
2% B.F A3	99.8	99.9	100.7	94.6

Fig. 1: *Comparative result of CS at 7 Days*

At 7 days, the highest Strength is achieved for the mix with 15% GGBS for all varying percentage of Basalt Fibres. There is negligible strength increment for the specimen with 10% and 15%, while the strength is reduced by 6 – 7% for the 20% of GGBS. For the 2% Basalt Fibres, the results obtained were lower than the result of 1%. (Fig. 1)

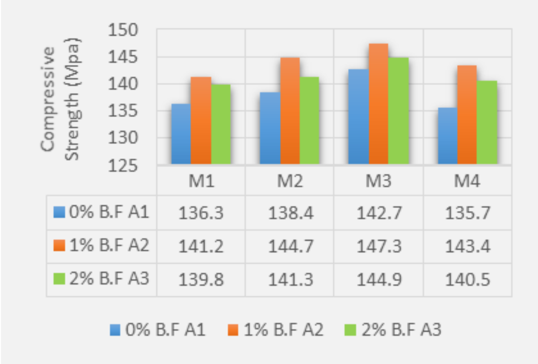


Fig. 2: *Comparative result of CS at 28 Days*

There is minor strength increment for the specimen with 15% GGBS than 10% GGBS, while the strength is reduced for the 0% and 20% of GGBS. For the 15% GGBS the results were obtained higher for all the specimen at 28 days. Compressive strength getting from 10% GGBS and 20% GGBS have very slight variance. (Fig. 2)

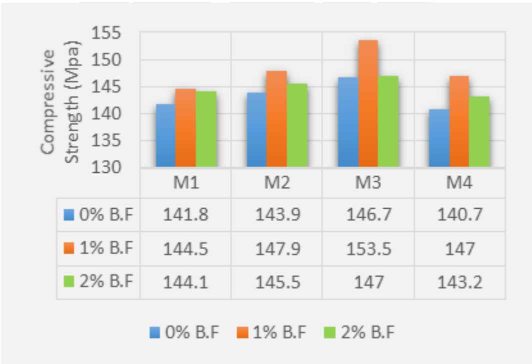


Fig. 3: *Comparative result of CS at 91 Days*

Comparing result of 91 day with 28 days result, there is no vast difference in compressive strength, strength gain mechanism in Reactive Powder Concrete is achieved maximum strength at 28 day curing period. Further increase in strength hardly 5 – 10% of 28 days results. (Fig. 3)

In RPC by using Basalt Fibres above 1% of weight of cement, Basalt Fibres Produced strong negative influence on the workability and this requires additional Super plasticizer dosage up to 0.2 – 0.3%. By experiments, incorporating of GGBS up to 20% does not affect initial setting and partial replacement of cement by GGBS adds to be workable due to fineness of GGBS. There is increases in compressive strength up to 15% partial replacement of cement with GGBS but it decreases at 20%. Compression failure for RPC observed a Brittle failure.

CONCLUSION

The RPC displays excellent potential on compressive 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.

There existed an optimal GGBS and Basalt Fibres content for the Compressive Strength of RPC. The optimum GGBS content was 15%, while 1% for Basalt Fibres. When excessed these values, a drop in compressive strength was observed. This work further extended for the durability properties also.

AKNOWLEDGMENTS

We wish to thank Suyog Elements India Pvt. Ltd., GIDC, BASF Chemicals and Swaraj Mineral, Balasinor for providing the material.

REFERENCES

Journal Articles

1. Ali Alsalman, Canh N. Dang, W. Micah Hale, "Development of ultra-high performance concrete with locally available materials". Construction and Building Materials 133 (2017) 135-145
2. Assem Abdelalim, Mohamed Ramadan, Tarek Bahaa and Wael Halawa. "Performance of Reactive Powder Concrete Produced using Local Materials". HBRC Journal VOL. 4 No. 3 December 2008.
3. Davood Mostofinejad, Mojtaba Rostami Nikoo, Seyed Arman Hosseini, "Determination of optimized mix design and curing conditions of reactive powder concrete (RPC)" Construction and Building Materials 123 (2016) 754-767
4. Gohil Gaurav, Dr. Indrajit Patel, Amit Raval, "Experimental study used of SCMs on engineering properties of reactive powder concrete." Journal of Civil Engineering and Environmental Technology, Volume 3, Issue 1; January-March, 2016.
5. Sumith Kumar K, Gururaj Acharya, Siddesh R Kamat Mhamai. "Reactive Powder Concrete with Mineral Admixtures" JETIR, May 2015, Volume 2, Issue 6.