JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Review Paper on Reactive Powder Concrete (RPC)

Sugam Gongale, Shreyash Bhovate, Adarsh Vishwakarma, Nandkishor Munde
1-4 Students B.E Civil Engineering
Department of B.V.C.O.E. Lavale, Pune, Maharashtra, India.
Prof. S. C. Mane,
Department of B.V.C.O.E. Lavale, Pune, Maharashtra, India.
Dr. Jyoti A. Dhanke.

Abstract : **Reactive powder concrete (RPC) is also known as coarse aggregate free concrete because the traditional coarse aggregates are replaced by fine sand. It is fibre reinforced, super plasticized, silica fume-cement mixture having very low water-cement ratio. It is having compressive strength about 150MPa.The ingredients used in this investigation are Cement (ordinary Portland cement), crushed Quartz Powder, sand, silica Fumes, steel fibres, superplasticizer, pure water. Mix proportion is based on three stage method and as according to chemical position of ingredients. Compressive strength of reactive powder concrete may goes up to 150 - 200MPa as per studies. RPC enhances the microstructure, porosity and permeability can be significantly decreased in the concrete matrix. Thus RPC benefits the durability characteristics of RPC elements providing long service life and fewer maintenance costs as compared to conventional concrete. Reactive powder concrete is identified as uprising material that gives combination of ultra-high strength and excellent durability. RPC will empower the concrete industry by enhancing material uses, providing economic benefits, and constructing strong and durable structures. RPC has been used for making material containers for radiation waste of high integrity due to its durability and low permeability properties. Also for thin shell structural elements and long span structures, fibre reinforced RPC can be used due to its flexural strength. Structures like piers of bridges, blast protection and military construction can be constructed in RPC due to its better impact resistance.**

I. INTRODUCTION

Reactive powder is the ultra-high strength and also high ductile composite material. It has better and progressive mechanical properties. Reactive powder concrete (RPC) contain elements such as quartz powder, silica fume, steel fibers superplasticizer, cement, sand. It does not contain the coarse aggregate. The coarse aggregate was absent in the RPC and that is why for microstructure and performance of RPC, innovators believed it to be important factor for reducing the diverseness among aggregates and cement matrix.

P.Richard and M. Cheyrezy first introduced the concept of reactive powder concrete. Sherbrook Bridge which is in Canada, which is completely build in July 1997 is first structure constructed of RPC. For removal of coarse aggregates, such concepts are developed in which ingredients should possess additional steel fibers, heat curing treatment, minimum water / binder ratio. Range of compressive strength of RPC is between 200 to 700 MPa and the flexural strength varies between 30Mpa to 50 MPa. RPC has outstanding mechanical properties as well as durability. The RPC structural elements can resist the impact loading, chemical attacks and sudden kinetic loadings due to seismic forces. The most important characteristics of RPC is ultra – high performance. RPC has arranged and more compact hydrates. For producing highest strength hydrates with good pozzolanic properties, RPC contains high quantity of silica fume. After setting down to accelerate the pozzolanic reaction of the silica fume and quartz heat treatment is necessary which alters the microstructure of RPC, and to the more amount of water. Due to its various superior properties like durability, strength, ductility, resistance to abrasion and impact, RPC can be used for constructing various elegant and creative geometrical structures of long span and thinner sections.

II. LITERATURE REVIEW

(Richard et al. 1995) conducted research on RPC. Their main focus was on development of RPC. The compressive strength of RPC ranges from 200MPa to 800MPa. But its tensile is very poor as compared to other. In their research they stated that RPC could be fibred or non-fibred. By using steel fibers the ductility and tensile strength of RPC could be enhanced. A brief analysis for density and homogeneity of RPC has explained in the paper.

(Lee et al. 2007) made a study and considered RPC as new repair technology and compare its obligation with bond strength to the existing concrete. For the analysis of bond durability of the repair material Freeze-thaw cycle acceleration deterioration test was conducted. Various tests such as compressive strength, steel releases strength, bond strength and NDT test before and after aging. The results showed that RPC benefited excellent repair and reversal potentials on compressive and flexural strength and developed high bond strength, dynamic modulus and bond durability as compared to other concretes. As compared to other concretes, the adhesion between RPC and steel was much better.

(Zheng et al. 2013) they conducted a research on RPC. Their main focus was on changes in RPC properties due to temperature. They observed the effect of temperature, steel fibre proportion, size shape and dimensions of sample specimen and explosive spalling in temperature ranges from 20°C - 800°C. They observed that at 100°C there was slightly decreased in compressive strength of RPC. But at 200°C to 500°C there was a increased in compressive strength of specimen sample and again decreased in compressive strength at 500°C. As the steel fibre proportion increased the compressive strength of RPC specimen is also increased below temperature 300°C but if the temperature goes above 300°C the compressive strength of specimen decreased. They also observed that tensile strength of RPC is decreased below temperature 200°C and it increased at temperatures ranging from 200°C - 300°C. Their result showed that 2% of steel fibre can reduce dismembering of RPC and upgrade the compressive and tensile strength.

(Liu and Huang 2009) made a study on flowable RPC's performance against fire. By carrying out fire endurance temperature and duration test, results showed that with increase in duration of fire, the residual compressive strength decreased. But during comparison between the ordinary concrete (OC) and high performance concrete (HPC), it was found that after fire, RPC not only possessed higher residual compressive strength but also had higher fire endurance temperature. The results of the study showed that total weight loss of RPC was lower than HPC and OC.

(Kushartomo et al. 2015) observed the mechanical change in RPC by substituting glass powder. By adding quartz powder in RPC, its compressive strength raised upto 180 MPa and also gained better tensile strength. They used 30% of quartz powder to ratio of cement and technique of hot temperature curing upto 250°C.In their research, they utilized recycled and local materials and replaced quartz powder with glass powder from waste of housing industries. The main object of the research was to examine the behavior of glass powder with reactive powder concrete. This included the test like compressive strength, flexural strength and split tensile strength. The RPC with proportion of glass powder 10% 20% 30% of cement mass and steam curing up to temperatures 95°C was used. The result showed that the maximum tensile spilt strength of RPC with 20% glass fibre content was 17.8 MPa. The maximum flexural strength value was 23.2 MPa and maximum compressive strength was 136 MPa. Hence the results showed that quartz powder could be substituted by glass powder.

(Yanzhou et al. 2015) performed experimental study on properties and microstructures of RPC. He also conducted study on properties of RPC specimen. After curing at 95 degree Celsius for given duration, the RPC specimens consisting of silica fume about 50% and phosphorous slag powder was formed. After performing various test, the result showed that RPC achieved good durability and mechanical properties. To understand the durability and mechanical properties based on the microstructure, examinations like scanning electronic microscope investigation, mercury intrusion and thermogravimetric analysis investigation of selected RPC compositions supported. The mercury porosimetry results indicated that RPC contain very low porosity and that the pore width was probably smaller than 10mm.

(Canbaz 2014) conducted research that how high temperature affects the properties of RPC. In this study, they used different plastic fiber content at different temperatures. Ingredients like steel wire, polypropylene fibers, silica fume, quartz sand, water, CEM I 32.5 R (32.5 N/mm2 to 52.5N/mm2) cement and superplasticizer were used in this study. They prepared a sample of size 70mm x 70mm x 70mm. After casting and curing, the specimen subjected to compression in order to achieved high strength. After curing the concrete specimen was exposed to temperature of 20°C, 100°C 400°C 700°C and 900°C for 3 hours. After the heating process a cooling regime was applied to the air. After hot water curing at 90°C for 3 days

and after applying a pre-set pressure of 80MPa to RPC higher compressive strength more than 200MPa were achieved maximum reduction in strength of 140 MPa caused due to addition of polypropylene fiber (PPF). In case of 1% fiber ratio the strength of 165MPa was observed. Decreased in strength occurred due to variation in fiber ratio. The avg. unit wt. of RPC was 2.75kg/dm3 whereas the unit wt. of standard concrete was 2.4 kg/dm3. The RPC with polypropylene fiber turned down the UPV to 10%. The result therefore displayed that the RPC having 1% PPF and temperature curing below 400°C should be preferred.
(Helmi et al. 2016) studied on microstructure formation due to treatment effect (static pressure of 8Mpa and heat curing at 240°C for 48 hour) The results showed that due to movement of grains there was a lower down of the total pore volume and strengthened the capillary pore volume. During hydration additional C-S-H could occurred in space created. Heat treatment speed up the distribution of micro cracks. Due to crystalline hydrate formation capillary pore volume expanded by heat curing treatment.

(Zdeb 2015) In this study, they used three different Portland cement according to strength, mineral and chemical composition. They also presented specific surface area analysis of microstructure and mechanical properties of RPC. They developed advanced materials which subjected to three different curing conditions. The experimental study indicated that the chemical and mineralogical factors mostly influence the concrete mixture consistency and binder composition. The surface area of cement plays major role for mechanical properties. In one of the cement analysis, without adversely affecting buildings of concrete mix, it was possible to reduce W/B average value up to 0.17.

(Zhu et al. 2016) made a study on using recycled powder from cement waste and waste of clay bricks in reactive powder concrete. Recycled powder obtained from waste of construction and demolition contains unhydrated cement particles. Use of recycled powder as a cementing material helps in reduction of environmental pollution. Study was made in RPC for replacing cement or silica fume by recycled powder for developing the environmental friendly cost saving mixture of RPC of high performance. The RPC mix with the recycled powder was designed by maximum packing theory. The effects of fine aggregate, natural sand and quartz sand, on the reactive powder concrete were investigated.

(N. Roux 1996) an experimental study is conducted on durability of reactive powder concretes. The toughness of reactive powder concretes (RPC) is determined by measuring air permeability, water absorption, porosity, and accelerated carbonation, chloride ions migration, solid corrosion resistance, resistance to mechanical abrasion. The differentiation of results were done with M30 grade features MPa concrete with a less cement content and grade M80 MPa very high performance concrete. The RPC resulted that it has excellent granular compactness, and RPC low water content help to reduce porosity. That resulted in the better resistance to the intrusion of various aggressive agents in relation to reference concretes, and structures constructed with the help of RPC were expected to be significantly superior to those made of conventional concrete. The exceptionally good resistance of RPC200 concrete to the invasion of aggressive agent is accompanied by excellent longevity characteristics, thus producing a strong increase in the life span of building constructed of reactive powder concretes.

(Agharde and Bhalchandra 2015) investigation of the mechanical properties of RPC made with the use of fly ash. The main objective of the study was to evaluate the effect of changing silica fume with fly ash by changing the percentage of steel fiber in reactive powder concrete so that they can gaining the economy without any significant changes in RPC properties. The silica fume was replaced by fly ash with weight of of 0% to 50% and 10 % interval. It was found that applying upto 40% fly ash with silica fume would save a maximum of 90 MPa under normal curing treatment. Content of steel fiber percentages varies from 0% to 1% with 0.25% interval. It was found that addition of 0.75 %of fibers content provided better flexibility and strength.

(Faizan Akbar, Fawad Bilal 2015) conducted research for design mix proportion of reactive powder concrete and compressive strength is computed. The samples were examined for the compressive strength of RPC design in effective way that would deliver RPC performance in terms of compressive strength / power. A total of 54 cubes 150x150x150 mm were prepared. The samples were treated with plain water and hot water. The w-b ratio and content of ingredients were also kept altering, for better understanding. As a result of the all test performed combining concentrations with high silica content and low concentration of water cement yields good results.

(M K Maroliya 2012) carried an investigation on RPC which contain of steel fibers and fly- ash. They considered the results of various factors such as the amount of water in cement, the curing properties of track having the effect of mixing minerals and chemicals in order to obtain high compressive strength. Various tests such as flexural and compressive strength test were performed. The results showed that silica fume had better compression strength and better flow in lower water/cement scales. Alteration of part of silica fume with fly ash and metakaolin did not occur increase power significantly but from cost factor can be justified.

III. METHODOLOGY :

RPC is mainly composed of high volume of cement, silica fume, quartz powder, fine silica sand and due to very low w/b ratio, second generation polycarboxylic ether superplasticizer was used to maintain required workability. Generally, in production of RPC cement content varies between 700 and 1000 kg/m3, silica fume varies between 15 and 35% by weight of cement and quartz powder from 10 to 40% by weight of cement. Normally the water-binder ratio ranges between 0.14 and 0.24. In this study, the volume of cement has been used between 850 and 950 kg/m3. The silica fume content used is 15 and 20%, and amount of quartz powder used is 10 and 20% by weight of cement. Water-binder ratios of 0.18 and 0.20 have been used. To attain good workability, superplasticizer content has been varied from 1% to 4% by weight of cement.

Generally RPC is produced with three stages of mixing in which mixing sequence is as follows, addition of all ingredients in the first stage to complete dry mixing, in next stage addition of half dosage of superplasticizer with half volume of water and in stage third, remaining water with superplasticizer is added. In the present study this procedure of mixing is considered as three stage mixing method. The present study carried out four stage mixing approach. After several preliminary experiments total of four different mixing sequences, A, B, C and D were considered in this method.

Three stage mixing method.

- First stage - Dry mixing of silica fume, quartz powder, cement and sand.
- Second stage - Half of the required water is added with half the dosage of superplasticizer.
- Third stage - Remaining water with half the dosage of superplasticizer is added.
- Fresh mix

Preparation of concrete

1. Batching:- The process in which the quantity or proportion of materials like cement, silica fume, quartz powder, water etc. are determined.
2. Mixing:- The concrete mixing ratio depends on what strength you are trying to achieve. In the mix we take on the basis of proportion of RPC 130 and in plain concrete we took M40 Grade. (1:1.3:2.6).

1. For the preparation of RPC in the first stage all the dry materials such as cement, Silica fume, Silica sand, Quartz powder are mixed together. 2. In the second stage after mixing of all half amount of water and half dosage of superplasticizer are added. This mortar is mixed until it becomes moderate slurry. 3. In the third stage remaining dosage of superplasticizer and half amount of water is added. 4. After completing the all 3 stage the workable concrete is form.

3. Placing of concrete: - It is an operation which determines the structures success and its durability.
4. Curing of Concrete RPC Cubes: - Curing of concrete is a process where adequate moisture, temperature and time is provided to allow the concrete to attain its desired properties.

IV. CONCLUSION:

• RPC is an emerging innovation that leads another feature in the term - high performance concrete. It has gigantic expected in development because of predominant mechanical and sturdiness properties rather than high standard use concrete and may replace steel in some applications.

• RPC upgrades depend on the use of other basic standard to achieve improved uniformity, generally better performance, higher cohesion, improved microstructures and higher ease of use.

• RPC has a very thick microstructure, which provides important features for water protection and durability.

• It could, be a modern decision once and for all atomic dissolution.

REFERENCES

1. Agharde, A. D., and Bhalchandra, S. A. (2015). "Mechanical properties of reactive powder concrete by using fly ash." (3), 603-608.

2. Canbaz, M. (2014). "The effect of high temperature on reactive powder concrete." Construction and Building Materials, Elsevier Ltd, 70, 508-513.

3. Faizan Akbar, Fawad Bilal, Z. S. (2015). "Optimizing mix proportions for Reactive Powder Concrete (RPC) and investigating the compressive strength." 4(2).

4. Helmi, M., Hall, M. R., Stevens, L. A., and Rigby, S. P. (2016). "Effects of high-pressure / temperature curing on reactive powder concrete microstructure formation. Construction and Building Materials, Elsevier Ltd, 105, 554-562.

5. Kushartomo, W., Bali, I., and Sulaiman, B. (2015). "Mechanical behavior of reactive powder concrete with glass powder substitute." Procedia Engineering, Elsevier B.V., 617-622.

6. Lee, M., Wang, Y., and Chiu, C. (2007). "A preliminary study of reactive powder concrete as a new repair material." Construction and Building Materials, 21, 182- 189.

7. Liu, C., and Huang, J. (2009). "Fire performance of highly flowable reactive powder concrete." Construction and Building Materials, Elsevier Ltd, 23(5), 2072-2079.

8. M K Maroliya. (2012). "An Investigation on Reactive Powder Concrete containing Steel Fibers and Fly- Ash." International journal of emerging technology andadvanced engineering, 2(9).

9. N. Roux, C. A. and M. A. S. (1996). "Experimental study of durability of reactive powder

concrete." 8(February), 1-6.

10. Richard, P., Cheyrezy, M., Bouygues, S. D., and Quentin, S. (1995). "Composition of Reactive powder concretes." Cement and concrete research, 25(7), 1501- 1511.

11. Yanzhou, P., Jun, Z., Jiuyan, L., Jin, K., and Fazhou, W.(2015). "Properties and microstructure of reactive powder concrete having a high content of phosphorous slag powder and silica fume." CONSTRUCTION & BUILDING MATERIALS, Elsevier Ltd, 101, 482-487.

12. Zdeb, T. (2015). "Influence of the physicochemical properties of Portland cement on the strength of reactive powder concrete." Procedia Engineering, Elsevier B.V., 108, 419-427.

13. Zheng, W., Luo, B., and Wang, Y. (2013). "Compressive and tensile properties of reactive powder concrete with steel fibres at elevated temperatures." Construction and Building Materials, 41, 844-851.

14. Zhu, P., Mao, X., Qu, W., Li, Z., and John, Z. (2016). "Investigation of using recycled powder from waste of clay bricks and cement solids in reactive powder concrete." Construction and Building Materials, Elsevier Ltd, 113, 246-254.