INFLUENCE OF MIXING SPEED AND DURATION ON THE FRESH AND HARDENED PROPERTIES OF REACTIVE POWDER CONCRETE

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ABSTRACT

Reactive Powder Concrete is a new generation concrete, is one type of high strength and high durable concrete which is formed with a special combination of constituent materials. The reactive powder concrete is a composition of cement, silica fume, fine sand, quartz powder. This concrete is capable to achieve a very high compressive strength. Production methodology of Reactive Powder Concrete (RPC) is not clearly established yet, as several parameters have a varied influence on the resulting fresh and hardened properties of RPC. Even for the same composition, the fresh and hardened properties differ significantly by changing mixing speed and mixing time/duration. The present investigation is an attempt to study the effect of speed and duration, on the fresh and hardened properties of RPC. Production methodology of Reactive Powder Concrete (RPC) is not clearly established yet, as several parameters have a varied influence on the resulting fresh and hardened properties of RPC. Even for the same composition, the fresh and hardened properties differ significantly by changing mixing method, mixing speed and mixing time/duration. The present investigation is an attempt to study the effect of mixing method, speed and duration, on the fresh and hardened properties of RPC. The study also deals with the microstructure investigation of RPC mixes.

Keyword- RPC, Silica fume, Metakaoline, Fresh And Hardened Properties, Drying Shrinkage

1.1 INTRODUCTION

Reactive Powder Concrete (RPC) is an emerging cementitious construction material which is characterized by its superior properties like high compressive strength, flexural and tensile strength with addition of fibers. The microstructure of RPC is more dense and homogeneous compared to normal concrete. RPC due to its superior performance has provoked many construction practitioners throughout the world in its application to special civil engineering structures, nuclear power plants, petroleum plants, municipal, marine and military uses. The other projects like, roof of stadium, long span bridges, space structures, blast resistance structures, high pressure pipes and isolation and containment of nuclear waste, RPC has been utilized for such specialized applications throughout the world . The ultra-high mechanical performance of RPC, reduces thickness of concrete members leading to large savings in both materials and costs. Owing to its high compressive resistance, precast structural elements can be fabricated in slender form to enhance aesthetics of structure. RPC possesses good durability due to its low porosity nature and dense microstructure. RPC construction requires low maintenance costs in its service life.
2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Cement
Ordinary Portland cement of 53 grades that complies with IS: 12269-1987 was used throughout the experiments.

2.1.2. Silica fume
Undensified silica fume was used in the present study, which complies with ASTM C 1240-95a, and IS: 15388-2003. It exists in grey powder form that contains latently reactive silicon dioxide and no chloride or other potentially corrosive substance.

2.1.3. Silica sand
All RPC mixes were produced using silica sand by replacing coarse aggregate in conventional concrete. The particle sizes used in the experiments is in the range of 150 µm – 600 µm. The sand used confirms to zone IV grading requirements as per IS:383-1970.

2.1.4. Superplasticizer
In the present study superplasticizer (SP) based on second generation polycarboxylic ether polymers, developed using nano-technology was used from BASF India Ltd. The superplasticizer is an extremely high water-reducing agent that meets requirements of IS: 9103-1999.

2.1.5. Metakaoline
Metakaolin (MK) is a pozzolanic material. It is obtained by the calcination of kaolinic clay at a temperature ranging between 500 °C and 800 °C. The raw material input in the manufacture of metakaolin (Al2Si2O7) is kaolin.

2.2 Parameters
Procedure for studying the effect of mixing speed and duration on the performance of RPC are explained as follows;

2.2.1. Mixing speed
RPC was produced, using normal Digital Mortar Mixer, which is facilitated with variable frequency drive, the speed of mixing blades can be varied from 5 to 150 RPM. The selected mixing speeds considered for study were 50, 100 and 150 RPM.

2.2.2. Mixing duration
The present study is an attempt to find an optimum total mixing duration for production of RPC. The total mixing duration is defined as the time elapsed between the loading of all ingredients in first phase to the final discharge of the concrete at last phase. The total duration of mixing studied were 10, 15, 20 min.

3. RESULTS AND DISCUSSION

3.2. Effect of mixing speed

3.2.1. Fresh properties
Fresh properties of RPC with different mixing speeds are evaluated. It is observed that mixing speed of 100 RPM has shown higher flow value compared to other mixing speeds (50 and 150 RPM). The lowest flow value is obtained for 50 RPM. This may be due to improper distribution of water throughout the mix. With this speed, it is very difficult to break down lumps, which gets formed in during mixing process. These unbroken lumps hold water and superplasticizer, as a result all particles do not get sufficient moisture and superplasticizer. The reduced flow rate at 150 RPM may be due to high mixing speeds allowing moisture to evaporate from the mix at a fast rate. In production of RPC, during mixing process, the point where semi-harsh plastic mix gets converts to flowable mix is called change point.
3.2.2. Hardened properties

Compressive strength results of RPC with different mixing speeds are presented in fig. It is noticed that results obtained for 7 and 28 days with 100 RPM, have shown higher strength value compared to other mixing speeds. The reduced early strength in case of RPC specimen prepared with mixing speeds of 50 RPM is due to improper mixing speed and non-uniform distribution of moisture hinders the hydration process. And also, there may be presence of agglomerated particles, due to insufficient mixing speed which slow down the process of hydration. The reduced 28 days strength values at speeds 50 RPM may be due to agglomerated particles hindering the hydration process that may lead to development of unhealthy C-S-H gel and less quantity C-S-H product at the end of curing. Reduction in compressive strength can be observed for RPC specimen produced with speeds 150 RPM. This reduced strength may be due to the escape of bonded water from the mix leading to formation of pores.

3.4.3. Effect of mixing duration

This finding is in accordance with compressive-strength results in which RPC specimen produced with mixing duration of 20 min has shown lowest strength value compared to RPC specimen produced with mixing duration of 15 min. The results have shown that mixing duration of 15 min is a beneficial one for RPC production, where in RPC constituents are optimally packed.

5.1.2. Effect of superplasticizer dosage on shrinkage behaviour for RPC

Superplasticizers are chemical admixtures that are incorporated into the concrete to increase the workability in its fresh state. Many investigations showed that significant SP dosage is needed to decrease the amount of water required without loss of workability. The high drying shrinkage strain and shrinkage rate are found for RPC with higher SP dosages. The high SP dosage would cause changes in the pore structure which influence the state of the evaporable water (or physical bound water) and consequently the shrinkage behaviour.

![Fig 1: Flow result of different mixing](image1)

![Fig 2: Flow result of different mixing](image2)
Fig 3: Compressive strength of different mixing

Fig 4: Compressive strength of different mixing

Fig 5: Drying Shrinkage of different mixing
4. CONCLUSIONS

The following conclusions are drawn from this study.

1) As mixing speed increases, the flow and strength characteristics also increase up to 100 RPM. Higher mixing speeds of 150 RPM decreases strength of concrete. Concluding from results of compressive strength presented in chapter 5 it could be summarised that compressive strength of silica fume is on an average 4.5% higher than metakaolin which is very low.

2) Results of flow table test suggest that workability of RPC is more by metakaoline over silica fume. RPC prepared with mixing duration of 15 min has shown better flow and strength characteristics compared to other RPC mixes prepared with different mixing durations (10, 15 and 20 min).
3) It is recommended to use metakaoline over silicafume because though strength is slightly decreased but it is more enough for safe construction practice.

4) Higher SP dosages give higher drying shrinkage strains and shrinkage rate development. This is because high SP dosage would cause changes in the pore structure which influences the state of the evaporable water and consequently the shrinkage behaviour.

5) The optimum superplasticizer dosages were typically found as 1-1.5%.

5. REFERENCES


