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Development of Reactive Powder Concrete

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Abstract

Reactive Powder Concrete (RPC) is an advanced cement-based composite belonging to the class of ultra-high-performance concretes (UHPC), known for its exceptional strength and durability. This study investigates the mechanical performance of RPC in comparison to a nominal concrete mix. The materials used in the preparation of RPC include Ordinary Portland Cement, quartz powder, sand, silica fume, steel fibers, admixture, and water, designed using a three-stage method based on the chemical composition of ingredients. Experimental results reveal a remarkable improvement in compressive strength RPC achieved 165.36 MPa at 7 days and 172.80 MPa at 28 days, compared to 32.17 MPa and 40 MPa respectively for nominal concrete. The enhanced microstructure of RPC leads to reduced porosity and permeability, thereby improving durability and extending service life with lower maintenance requirements. The findings confirm that RPC can serve as a superior alternative for high-strength, durable, and sustainable structural applications.

Keywords: RPC, Cement, Silica fume, Strength Performance

1. Introduction

Reactive powder is an ultra-high strength, high ductility composite material. It possesses superior and progressive mechanical qualities. Quartz powder, silica fume, steel fibers, superplasticizer, cement, and sand are all components of reactive powder concrete (RPC). It does not contain coarse aggregate. The coarse aggregate was absent in the RPC, which is why the microstructure and performance of RPC Reactive powder concrete is an ultrahigh strength concrete, with a strength greater than 120 MPA. Concrete strength greater than 230 MPA is considered high strength concrete [1-2]. The globe's first RPC footbridge is located in Sherbrooke, Québec, Canada. It has a 60-meter-wide RPC steel tube truss construction. Using RPC not only decreases weight but also improves the structure's resilience to damage from freezing and thawing cycles, as well as frequent corrosion from deicing salt in high-humidity environments. RPC is a type of extremely high-performance concrete characterized by its low porosity, high strength, and high tenacity. The components of reactive powder concrete are displayed, together with their percentages, in Figure 1.

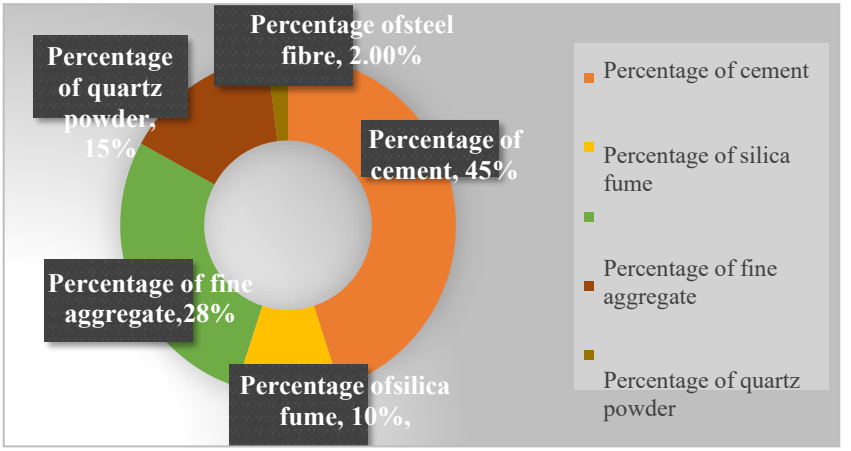


Fig.1 Reactive Powder Concrete Ingredients

The purpose of this study is to conduct a thorough investigation of the consequences of replacing conventional aggregates with Quartz Powder, silica fume, and steel fibers in the context of Reactive Powder Concrete (RPC) and to assess how these changes affect the material's compressive strength in comparison to traditional concrete. The performance of RPC is achieved by steam curing and nominal curing at both high and normal temperatures. It is utilized for high-rise buildings. Thus, it is required to investigate the behavior of the force acting on the structure.

The goals are as follows:

1. Designed RPC and nominal concrete for M40 grade steam curing using IS 10262 - 2019 and compared their behavior.

2. Investigating the compressive, flexural, and elastic strengths of RPC and nominal concrete.

2. Literature Review

Building Engineering, particularly Structural Engineering, is an emerging field that focuses on the use of lateral load resisting systems to resist various loads acting on structures. It is extensive and involves earthquake engineering, tall building design, and structural dynamics. RPC has a flexural strength of 30-50 MPa, a Young's modulus of 50-60 GPa, and a compressive strength of 130-800 MPa [3-5]. RPCs are structurally composed of more organized and compressed hydrates. Each particle in the mixture is precisely graded, optimizing the microstructure for maximum density. It maximizes the Portland cement chemistry and makes great use of the pozzolanic capabilities of highly refined silica fume, producing the strongest hydrates conceivable. The experimental programme compares normal strength concrete (NSC) with RPC to examine how burning temperature and duration impact important mechanical properties[6]. Elastic modulus, splitting tensile strength, rupture modulus, and compressive strength are among the parameters tested. The effects of temperature, time, the presence of steel reinforcement, and slab thickness are also investigated in a series of experiments concerning the punched shear or flexural behavior of simply supported RPC slabs measuring 520x520x50 mm under a concentrated load at the slab's center. To optimize RPC compressive strength, this study seeks to identify the most practical situations and parameters for

investigating the compressive strength of non-steel microfibre reinforced RPC under a variety of curing conditions.

According to the study's findings, the eight-step method improved compressive strength by 174%, from 85 MPa (28 days) to 233 MPa (13 days). After experimenting with various cure treatment schedules, it was discovered that a combination treatment—three days of autoclave cure at 125°C and seven days of heat cure at 220°C performed better and produced better mechanical properties in a shorter period of time [6]. The literature review conducted for this study revealed that Reactive Powder Concrete (RPC) has a wide range of applications in structural element design and analysis. RPC has a wide range of applications, including structural analysis and concrete mix composition [7-9]. Key areas of RPC application include strength analysis, RPC structure design, fracture and damage detection, structural dynamics, form optimization of prestressed concrete beams, and crack width prediction in RPC beams [10-11].

3. Materials and Method

The RPC technique guarantees that the concrete mix is properly made, tested, and assessed to establish its compatibility for various building circumstances. Certainly, here is the process in a more thorough version. The process of assessing Reactive Powder Concrete (RPC) begins with the careful selection of materials. High-quality components such as cement, silica fume, silica sand, quartz powder, steel fibers, and superplasticizers are selected depending on the qualities and quantities necessary to generate the ideal RPC mixture. This complete technique meticulously prepares, exhaustively tests, and rigorously evaluates RPC to establish its applicability and possible advantages in various building settings. Quantity of materials for RPC are placed in Table 1. Procedure of reactive powder concrete is summarized into Fig.2

Table 1. Quantity of materials for RPC

Total cementitious	510	Cement	250	Kg
		Quartz Powder	100	Kg
		Steel fibre	10	Kg
		Micro silica	50	Kg
Total fine aggregate	1114	Total Aggregates	1893	Kg
Total coarse aggregate	780			

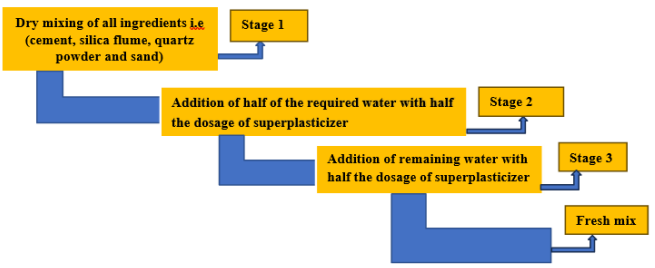


Fig.2 Procedure of reactive powder concrete

4. Result

The cube compressive strength results at 28days in Fig.3, Flexural results are noted in Table2.

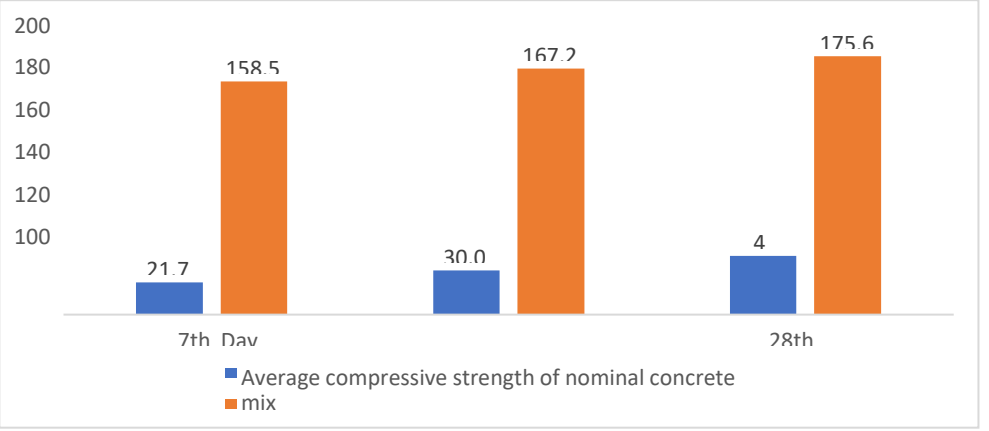


Fig.3 compressive strength results

Age of concrete	Average flexural strength beams of nominal concretemix	Average flexural strength beams of RPC mix
7th Day	3.23	28.76
28th Day	5.63	55.53

5. Conclusion

A comparison of the physical and mechanical qualities of RPC with normal M40 grade concrete illustrates RPC's exceptional strength. While the initial cost of standard concrete cubes is cheaper, it is clear that RPC's advantages, particularly in terms of strength, make it a better choice. After 7 days, RPC had an average compressive strength of 165.36 MPa, more than five times that of the nominal mix (32.17 MPa). Similarly, at 28 days, RPC measured 172.80 MPa vs 40 MPa for the nominal concrete. This shows that RPC has outstanding early and long-term strength development. As a result, Reactive Powder Concrete is a superior material for structural applications that require great strength and performance..

Declaration of Conflicting Interests

The authors declare no potential conflicts of interest with respect to the research, authorship and publication of this article.

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