# PERFORMANCE OF REACTIVE POWDER CONCRETE

By

**Mostafa Mohammad Ahmad Said El Shrief**

A thesis submitted to the Faculty of Engineering at Cairo University in a partial fulfillment of the requirements for the degree of

Master of Science

In

**Structural Engineering**

**FACULTY OF ENGINEERING, CAIRO UNIVERSITY**

**GIZA, EGYPT**

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Under the supervision of

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**Title of Thesis:** **Performance of Reactive Powder Concrete**


**Key Words:** Reactive powder concrete, compressive strength, flexural and splitting tensile strength, Young's modulus, drying shrinkage



**Summary:** Reactive powder concrete "RPC" is an ultra high strength concrete without coarse aggregate that looks like a mortar paste with a superior mechanical and durability characteristics. This research was carried out to investigate the applicability of producing RPC using local available materials in the Egyptian market and investigating the influence of different ingredients and curing regimes on workability and mechanical properties of RPC. Selected mixes that attained the highest compressive strength with satisfactory workability were tested to determine the flowability, long-term compressive strength, flexural strength, splitting tensile strength, Young's modulus and drying shrinkage. The experimental program led to produce RPC of 165 MPa compressive strength.

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Cairo, 2015

Mostafa El Shrief

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# ABBREVIATIONS

| | |
|---|---|
| ACI: | American Concrete Institute |
| AFGC: | Association Française de Génie Civil |
| ASTM: | American Society for Testing and Materials |
| BPR: | Béton Poudres Réactives (reactive powder concrete) |
| CH: | Calcium Hydroxide |
| CSH: | Calcium Silicate Hydrates |
| ECP: | Egyptian Code of Practice |
| ESS: | Egyptian Standard Specifications |
| GGBFS: | Ground Granulated Blast Furnace Slag |
| HPC: | High Performance Concrete |
| HSC: | High Strength Concrete |
| PC: | Polycarboxylic Superplasticizer |
| RPC: | Reactive Powder Concrete |
| SP: | Superplasticizer |
| UHPC: | Ultra High Performance Concrete |
| UHPFRC: | Ultra High Performance Fiber Reinforced Concrete |
| W/B: | Water Binder ratio |
| W/C: | Water Cement ratio |

# ABSTRACT

Reactive powder concrete “RPC” is one of the ultra high strength concrete “UHPC” types that was developed in France at the early of 1990s. It is a concrete without coarse aggregate that looks like a mortar paste more than a concrete. RPC has shown superior high performance in strength, durability, and impact resistance that breaks the current known limitations. It has been used in the construction of bridges of unusual shapes or very limited depths, precast slabs, rehabilitation and isolation of nuclear wastes. Its applications also extended to the architectural applications like decorative features, facade and cladding. Due to the newness of RPC and the lack of information about the materials and manufacturing process of RPC in the Egyptian market, this research was carried out to investigate the applicability of producing RPC using local available materials in Egypt, optimizing of materials’ proportions and curing regimes and investigating of their influence on RPC performance. The research was carried out in three phases. The first phase was carried out to determine the optimum water/cement ratio “W/C” and the dosage of superplasticizer that produce a workable mix. In this phase, flowability and compressive strength of RPC mixes were investigated. In the second phase, the effect of each ingredient and curing regimes on the compressive strength and flowability of RPC was investigated to select the optimum mix proportions and curing regime. The third phase investigated the effect of using different combinations of the optimum ingredients on RPC performance such as flowability, compressive strength, flexural strength, splitting tensile strength, Young’s modulus and drying shrinkage. The experimental program led to produce RPC of 165 MPa compressive strength.

# CHAPTER 1. INTRODUCTION

## 1.1. GENERAL

As the most known and widely used construction material, concrete and its composing materials were subjected to many researches aiming to the enhancement of concrete mechanical properties and to produce a durable concrete able to resist different environmental conditions. By the mid of the last century, high strength concrete has been produced to be used in offshore oil and gas structures. Strength was not the only requirement, but also higher durability characteristics, which created more general classification that was called high performance concrete “HPC”. By the beginning of 80s of the last century, high performance concrete has been developed through extensive researches to produce a superior material in its mechanical and durability characteristics. This new class of concrete was called ultra high performance concrete “UHPC”. The aim of UHPC development is to achieve high tensile strength through the participation of the fibres that provide tensile strength after the cement matrix has cracked to dispense with conventional reinforcement in addition to the high durability characteristics. One of UHPC types that considered having the highest performance and durability produced until now is the reactive powder concrete “RPC”. Reactive powder concrete was developed at the early of 1990s in France by the researchers Richard and Cheyrezy at Bouygues’ technical laboratories.

In addition to the high compressive strength, RPC has also very low permeability. It has been successfully used in bridges, prestressed concrete structures, shell roofs of irregular shapes, marine works, nuclear wastes containment, retrofitting and rehabilitation works. Applications also extended to non-structural applications such as facade panels, cladding, furniture and