Study Properties of Reactive powder Concrete

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دراسة خواص خرسانة المساحيق الفعالة

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Abstract

Reactive powder concrete is a result of developing process in concrete technology. It is a new type of composite material satisfying the increasing demands for high strength, high durability, offering superior ductility and workability . In this experimental study, four mixtures were casted and testing (slump test, absorption test, density test and compressive strength test). Four different ratio of polymer fibers were used (0% ,0.5% , 1% and 1.5%). The results of the slump test showed that the increasing of the polymer fibers ratio led to decrease the amount of slump. The results of the compression strength tests showed that the increasing of the polymer fibers ratio from 0% to 0.5%, 1% and 1.5% led to decrease the compressive strength by (7.49% , 13.40% and 19.66%) consequently at age 28days. The results of the absorption test showed that showed that the increasing of the polymer fibers ratio from 0% to 0.5%, 1% and 1.5% led to increase the absorption ratio by (3.29% , 5.81% and 7.34 %) consequently at age. The results of the density test showed the increasing of the polymer fibers ratio led to decrease the dry and wet density.

الخلاصة

خرسانة المساحيق الفعالة هو نتيجة لعملية تطوير تكنولوجيا الخرسانة. تعتبر هذه الخرسانة نوع جديد من المواد المركبة التي تلبي المتطلبات المتزايدة للمقاومة العالية والمتانة العالية ، وتوفر ليونة فائقة وقابلية للتشغيل. في هذه الدراسة المختبرية ، تم صب واختبار أربعة خلطات (اختبار الركود ، اختبار الامتصاص ، اختبار الكثافة ، اختبار مقاومة الانضغاط). تم استخدام أربع نسب مختلفة من ألياف البوليمر (0%, 0.5% ، 1% و 1.5%). أظهرت نتائج اختبار الركود أن زيادة نسبة ألياف البوليمر أدت إلى تقليل كمية الركود. أظهرت نتائج اختبارات مقاومة الانضغاط أن زيادة نسبة ألياف البوليمر من 0% إلى 0.5% و 1% و 1.5% أدت إلى إنقاص مقاومة الانضغاط بنسبة (7.49% ، 13.40% ، 19.66%) عند عمر 28 يوم. أظهرت نتائج اختبار الامتصاص أن زيادة نسبة ألياف البوليمر من 0% إلى 0.5% و 1% و 1.5% أدت إلى زيادة نسبة الامتصاص بنسبة (3.29% ، 5.81% ، 7.34%) وبالتالي مع تقدم العمر. أظهرت نتائج اختبار الكثافة أن زيادة نسبة ألياف البوليمر أدت إلى تقليل الكثافة الجافة والرطبة.

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Keywords: Reactive powder concrete, , Silica fume, Polymer Fibers, Superplasticizer.

Introduction

The term "reactive powder concrete" (RPC) refers to a group of cementitious composite materials. It has exceptional physical qualities, notably in terms of strength and ductility. RPC is produced at a cost that is much higher than traditional concrete, but because of its superior ductility and more isotropic composition, it may compete with steel in many structural applications. **[1]**.

RPC has excellent physical characteristics, especially in terms of strength and ductility. RPC provides a substantial cost advantage over steel for many structural applications, while being produced at a higher cost than normal concrete due to its increased ductility and isotropic composition. **[2]**

RPC was developed in France in 1990 and the world's first RPC structure in 1997 was Sherbrook footbridge. RPC is an ultra-high-strength and high ductility composite material with progressive mechanical properties.**[3].**

Reactive powder concrete (RPC) is a cementitious material that exhibits high-performance properties such as limited shrinkage and creep, low permeability, ultra-high strength and increased protection against corrosion. The properties of RPC make it a revolutionary material in the field of concrete technology with the possibilities for use in a wide range of structural and non-structural applications [4].

EXPERIMENTAL PROGRAM

MATERIALS:

Cement: Ordinary Portland cement was used in this investigation, and it was completed according to Iraqi specifications. **(IQS No.5: 1984) [5]**.

Fine Aggregate: In order to get dense form a fine sand is used in reactive powder concrete about (600-150)µm. For the concrete mixtures in this investigation, natural sand from the Al-Najaf region was employed. The sieve analysis test results of this sand is compared with the Iraqi specification **No 45/1984 [6]** .

Silica Fume

Silica fume is a very reactive component that can be utilized as a filler as well as an extra binder. The American Concrete Institute defines silica fume as "very fine non-crystalline silica produced in electric arc furnaces as a byproduct of the manufacture of elemental silicon or silicon alloys," according to ACI 234R-96 **[7]**. A gray powder looks like fly ashes or Portland cement. The advantages of utilizing silica fume come from changes in the concrete's microstructure **[8].** The micro silica used in this work conforms to the chemical and physical requirements of ASTM C1240 [**9]**.

Polymer Fibers

Astright polymer fibers were used in this study in order to enhance the reactive powder concrete ductility. In the study, three percentage of polymer fibers 0.5% , 1% and 1.5% were used.

Table (1) polymer fibers properties

Description	Straight
Length (mm)	12
Diameter (mm)	0.18
Density (Kg/m^3)	910
Tensile strength (MPa)	400
Aspect ratio	67

Superplasticizer

GLENIUM 54 a high range water reducing admixture (HRWRA) A high-performance concrete superplasticizer fabricated and supplied by the trade name was used in this study, it is a high range water reducer and complies with ASTM C494 [**10**]. The relative density is equal to 1.07 and it has PH around 5-8.

Water Mixing

All of the specimens were mixed and cured using tap water.

Concrete Mix Design

In this experimental work, eight different types of mixtures were used, as shown in Table (2).

Table (2) Specific types of concrete mixes have different qualities.

Mix symbol	Cement Kg/m^3	Sand Kg/m^3	Silica fume Kg/m^3	Silica fume %*	w/c	Polypropylene fibers % **	Super-plasticizer ***%
M1	920	978	92	10	0.25	0	3
M2	920	978	92	10	0.25	0.5	3
M3	920	978	92	10	0.25	1	3
M4	920	978	92	10	0.25	1.5	3

* % of total cement weight

** % by volume of the concrete.

***The percent (%) is by weight of the binder.

Mixing Procedure

Cement, sand and silica fume were first combined for 3 minutes in a dry state. The dry components were then combined for three minutes with 75 percent of the required water and Super-plasticizer. After that,

Polymer was slowly added and mix for five minutes. Finally, add the residual water to the mixture and continue mixing for another 10 to 15 minutes. It took around 30 minutes to complete the mixing process.

Casting Procedure

Molds were cleaned and lightly lubricated before casting to prevent solidified concrete from adhering to the inside surface of the molds. The concrete was laid out in three stages, with each layer being compressed with a vibration rod.

Curing of Specimens

The concrete specimens were demolded and placed in water bath around (25°C) for 28 days.

Test Procedure

Slump test: Each concrete mix's slump test was measured immediately after mixing using the slump method. **(ASTM C 143-89, 1989) [11].**

Compressive strength test: The compression test was performed on cubes measuring (100*100*100) mm in accordance with **B.S. 1881-part 116-1989** [**12]** using a hydraulic 0.6 MPa/sec loading rate was used to test the device. The compressive strength was calculated using an average of three cubes. The cubes were evaluated when they were 28 days old.

Absorption test: The absorption test was done according to (**BS. 1881, part 122)** [**13**], the test procedure involves drying a specimen to a constant weight at 105˚C, weighing it, immersing it in water for 48 hours, and weighing it again. Its absorption is used to represent how much weight increased relative to the starting weight (in percent). Ages of 28 days were used to determine the average absorption of three test samples.

Density test: The density test was done for all the samples in their dry and wet condition at ages of 28 days.

Results and Discussions

Slump test:

The workability of the mixtures was examined using the slump test. The results of this test are shown in table (3) and figure (1). In general, the results showed that the amount of slump of concrete decrease with

an increase in the ratio of polymer fibers compared to the control mix that does not contain of polymer fibers.

Table (3) Results of the slump test

Mix symbol	Slump (mm)
M1	43
M2	33
M3	15
M4	10

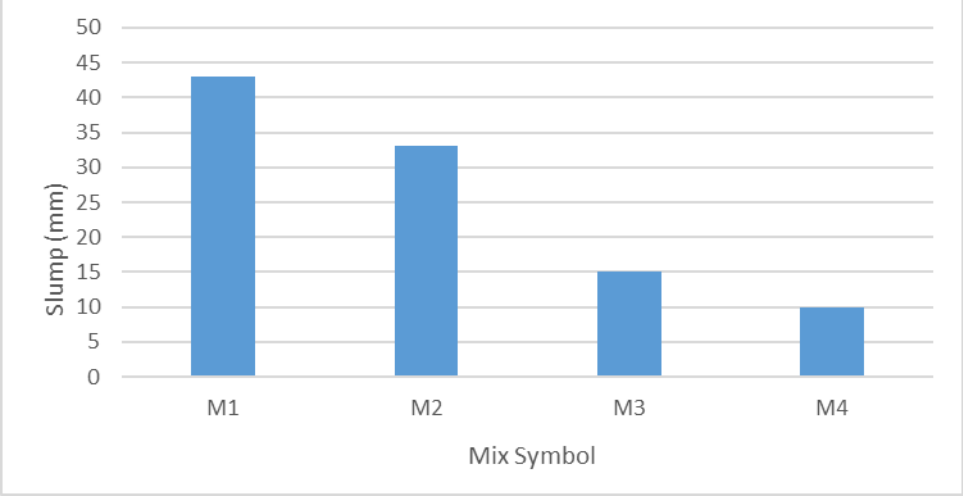

Figure (1) Results of the slump test

Compressive Strength test

The compressive strength test results are abstracted in Table (4) and figure (3). The test results showed that the compressive strength was decrease by increasing the content of polymer fibers.

Figure (2) Compressive strength test

Table (4). The Compressive strength test results

Mix symbol	7-days compressive strength (MPa.)	28-days compressive strength (MPa.)
M1	30.21	40.19
M2	26.95	38.15
M3	25.37	35.71
M4	23.25	33.13

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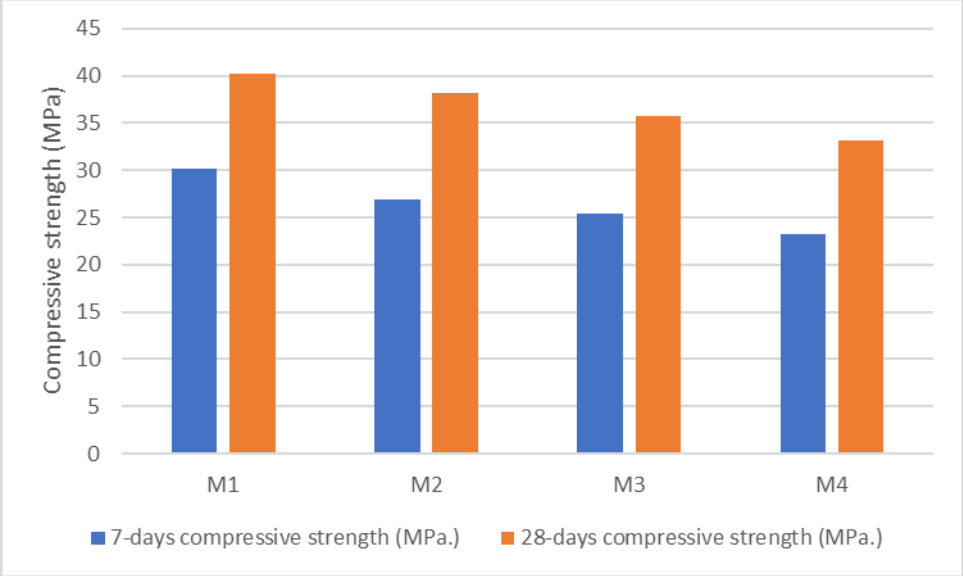

Figure (3) The Compressive strength test results

Absorption test:

The absorption test results (at age of 28 days) are shown in table (5) and figure (4). The test results showed the Absorption was increase by increasing the content of polymer fibers and rubber as compared to the control mix without polymer fibers and rubber.

Table (5). The absorption percent test results

Mix symbol	Absorption percent (%) 28 days
M1	28.1
M2	31.07
M3	31.83
M4	32.29

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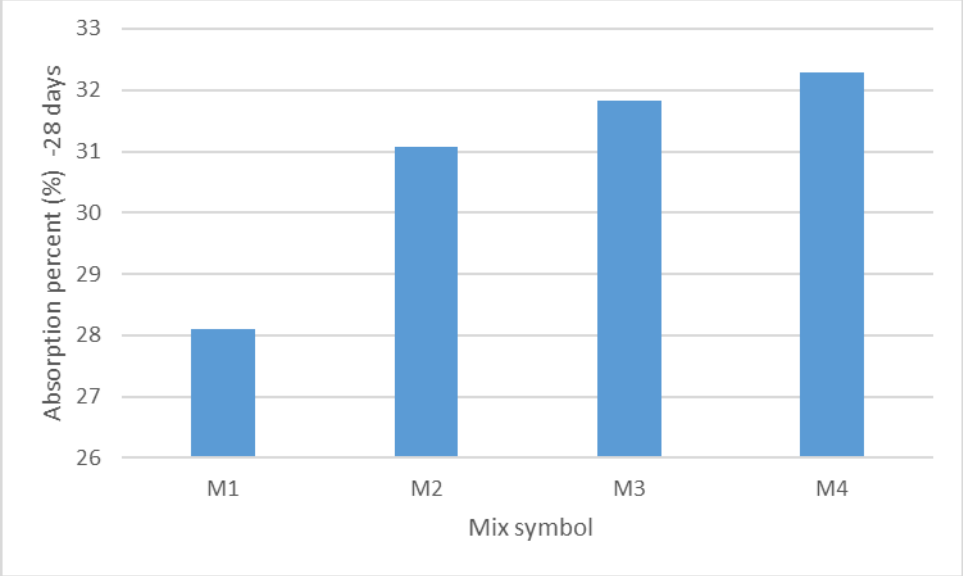

Figure (4) The absorption percent test results

Density test

The density test results (at age of 28 days) are shown in table (6) and figure (5). The results showed that the dry density and wet density was decrease by increasing the content of the polymer fibers and rubber as compared to the control mix without polymer fibers.

Table (6). Wet and dry density test results

Mix symbol	Wet density kg/ m^3	Dry density kg/ m^3
M1	2765.52	2727.30
M2	2759.70	2711.60
M3	2753.18	2708.29
M4	2743.03	2702.25

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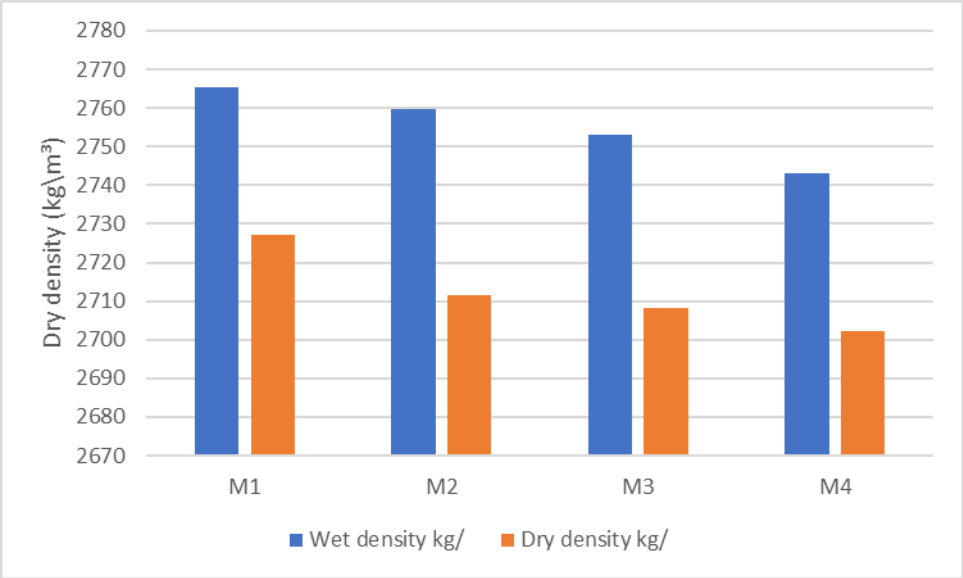

Figure (5) Wet and dry density test results

Conclusions

The experimental testing conducted in this study led to the following conclusions:

1- The results of the slump test showed that the increasing of the polymer fibers ratio from 0 to 0.5%, 1% and 1.5% led to decrease the amount of slump.

2-The results of the compression strength tests showed that the increasing of the polymer fibers ratio from 0 to 0.5%, 1% and 1.5% led to decrease the compressive strength by (7.49% , 13.40% and 19.66%) consequently at age 28days.

3- The results of the absorption test showed that the increasing of the polymer fibers ratio from 0 to 0.5%, 1% and 1.5% led to increase the absorption ratio by (3.29% , 5.81% and 7.34 %) consequently at age 28days.

4- The results of the density test showed the increasing of the polymer fibers ratio from 0 to 0.5%, 1% and 1.5% led to decrease the wet density by (0.57%, 0.80% and 1.17%) consequently and dry density by (0.22%, 0.34% and 0.56%).

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