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Study Some Properties of Reactive powder Concrete Containing Rubber Tires wastes

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دراسة بعض خواص خرسانة المساحيق الفعالة المحتوية على مخلفات الاطارات المطاطية

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Abstract

Recycled solid wastes like rubber are one of the issues that impose a significant environmental challenge as a result of the rapid population growth. The reactive powder concrete is experimentally studied with rubber tire waste to replace some of the fine aggregate. In this study, four mixtures were casted and test (slump, absorption, density and compressive strength test). Four different ratio of rubber waste (0% ,5%, 10% and 15%). The results of the slump test showed that the increase was used rubber tires wastes led to increase the slump of the mixture. This increase is due to the fact that the water covers the rubber particles, which in turn leads to reduction in friction between the components of the concrete mix. The results of the compression strength tests showed that. the increase of the rubber tires wastes ratio from 0% to 5% to 10% ,15% led to decrease the compressive strength by 13.02%, 36.56% and 37.87% respectively at age 28days. The results of the absorption test showed that the increase of the rubber tires wastes ratio from 0 to 5% to 10% to15% led to increase the absorption ratio by 7.91%, 11.76% and 13.79% respectively age 28days. The results of the density test showed that increasing of the rubber wastes ratio led to decrease the dry and wet density.

الخلاصة

النفايات الصلبة المعاد تدويرها مثل المطاط هي إحدى القضايا التي تفرض تحديات بيئية كبيرة نتيجة للنمو السكاني السريع. تمت دراسة خرسانة المساحيق الفعالة الحاوية على نفايات الإطارات المطاطية كاستبدال جزئي عن الركام الناعم مختبرياً. في هذه الدراسة ، تم صب أربع خلطات واختبارها (اختبار الركود والامتصاص والكثافة وقوة الانضغاط). أربعة نسب مختلفة من نفايات المطاط (0 ، 5٪ ، 10٪ و 15٪). أظهرت نتائج اختبار الركود أن الزيادة المستخدمة في نفايات الإطارات المطاطية أدت إلى زيادة ركود الخليط. وترجع هذه الزيادة إلى حقيقة أن الماء يغطي جزيئات المطاط ، مما يؤدي بدوره إلى تقليل الاحتكاك بين مكونات الخلطة الخرسانية. وأظهرت نتائج اختبارات مقاومة الانضغاط ذلك. أدت زيادة نسبة نفايات الإطارات المطاطية من 0 إلى 5٪ إلى 10٪ ، و 15٪ إلى انخفاض مقاومة الانضغاط بنسبة 13.02٪ و 36.56٪ و 37.87٪ على التوالي في عمر 28 يومًا. أظهرت نتائج اختبار الامتصاص أن زيادة نسبة نفايات الإطارات المطاطية من 0 إلى 5٪ إلى 10٪ إلى 15٪ أدت إلى زيادة نسبة الامتصاص بنسبة 7.91٪ و 11.76٪ و 13.79٪ على التوالي بعمر 28 يوم. أظهرت نتائج اختبار الكثافة أن زيادة نسبة المخلفات المطاطية أدت إلى تقليل الكثافة الجافة والرطبة.

Keywords: Reactive powder concrete, Rubber tires , Silica fume, Polymer Fibers, Superplasticizer.
الكلمات المفتاحية: خرسانة المساحيق الفعالة, مطاط الاطارات , غبار السيليكا, الياف البوليمر, المضاف الملدن.

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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].

Solid waste recycling is one of the primary issues that has become a global burden as the world's population grows. Rubber tire leftovers (wastes) are a significant component of these solid wastes, posing a significant environmental risk. Rubber tires are burned as a source of energy in some countries, posing extra health dangers. [2]. Furthermore, even after a lengthy period of time, organic rubber remains are difficult to degrade. Tires are long-lasting and chemically stable, yet they contain water-soluble chemicals that can leach into groundwater and poison aquatic species. [3].

Proportions of 10%, 20%, 30% and 40% rubber tire wastes were used to replace fine aggregate volume. Temperatures varied between 20 and 400℃. The compressive strength of the mixture dropped as the rubber ratio in the mix rose. The charred specimens' compressive strength was also increased at 300 C̊ before falling at 400 C̊. The best rubber substitution ratio among several durability parameters found in the study was 10% [4].

The behavior of reactive powder concrete made using rubber tire wastes (RW) as a partial replacement for fine aggregate (by volume) under higher temperatures. Along with the control, nine RPC mixes split into three groups were also cast. RW decreased the compressive strength of RPC when compared with plain specimens at room temperature (without RW). With the exception of a specimen that was substituted with 50% rubber tire wastes, all specimens were crushed at 400°C at high temperatures but this specimen still had some noticeable residual strength. [5]

As an aggregate replacement, rubber tire wastes have a 12.5% to 50 % by volume had on influence. Rubberized concrete had a significant drop in tangential modulus of elasticity and compressive strength when compared to normal concrete [6].

Adding rubbers to concrete mix lead to make concrete with lower mechanical properties than normal one (compressive strength, flexural strength, tensile strength…etc) But it also has advantages including light weight, high energy absorption, insulation from heat and sound, ductility, and crack resistance. In order to increase the rubber's weak compression resistance, chemical or mineral mixtures might be added to the mixture**. [7].**

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Appending rubber into the stiffer concrete material particles weakens the mix for reasons like: the difference in modulus of elasticity between the materials, loss of bond between cement paste and rubber and due to a micro crack between cement and rubber which develops during loading.[8]

Knowing that, more energy is absorbed when coarse aggregate rubber is replaced with fine aggregate rubber in the same proportion.

According to published studies, adding scrap tire rubber as aggregate or even replacing some of the aggregate results in less concrete's mechanical characteristics but provides good energy absorption. Knowing this, replacing rubber with a coarse aggregate's offers greater energy absorption than replacing rubber with a fine aggregate at the same percentage.[9]

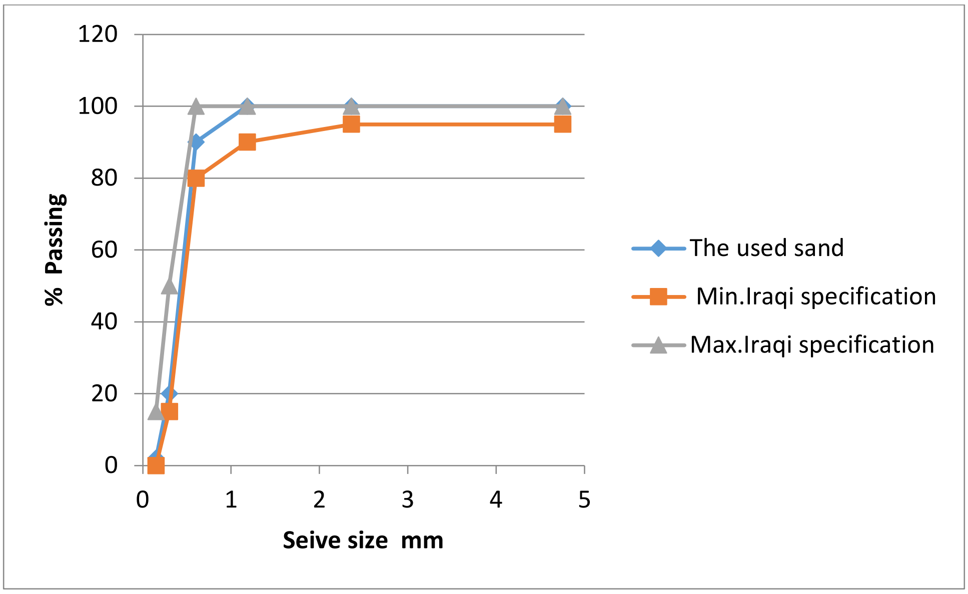
The aim of this research is to study the effect of using rubber tires wastes as replaced the fine aggregate on properties of reactive powder concrete.

EXPERIMENTAL PROCEDURE

MATERIALS:

Cement: Ordinary Portland cement was used in this investigation. The test results indicated that the adopted cement conforms to the Iraqi specifications. (IQS No.5: 1984) [10].

Fine Aggregate: In order to get dense form a fine sand were used in a 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 shown in figure (1) which compared with the Iraqi specification No 45/1984 [11] .



Figure(1) Sieve analysis of fine sand

Silica Fume

In this study, densified micro silica from the United Arab Emirates was employed. 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 [12]. Silica fume is a gray powder looks like fly ashes or Portland cement. The advantages of utilizing silica fume is to changes in the concrete's microstructure [13]. The micro silica used in this work conforms to the chemical and physical requirements of ASTM C1240 [14].

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 [15]. The relative density is equal to 1.07 and has PH around 5-8.

Rubber

Rubber tire wastes from the AL-Najaf tires factory, (old tires)were washed and sliced into various sizes to replace some of the natural sand. The average density of the rubber wastes, which is 450 kg/m3, which sieved to be between 0.15mm and 1.18 mm.

Water Mixing

All the specimens were mixed and cured using tap water.

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Concrete Mix Design
Four different types of mixtures were used, as shown in Table (1).

Table (1) 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 %*	Water cement ratio	Rubber tire wastes %	Super-plasticizer ***%
M1	920	978	92	10	0.25	0	3
M2	920	874	92	10	0.25	5	3
M3	920	828	92	10	0.25	10	3
M4	920	782	92	10	0.25	15	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 mixed for 3 minutes in a dry state. The dry components were then combined for 3 minutes with 75% of the required water and super-plasticizer. After that, Polymer fibers was added Finally, add the residual water to the mixture and continue mixing for another 10 to 15 minutes. This method required approximately 25 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 at(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) [16].
Compressive strength test: The compression test was performed on cubes measuring (100*100*100) mm in accordance with B.S. 1881-part 116-1989 [17] 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 reading. The cubes were evaluated when they were 28 days old.

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Figure (2) sample after compressive strength test

Absorption test: The absorption test was done according to (BS. 1881, part 122) [18], the test procedure involves drying a specimen to a constant weight at 105˚C, weighing and 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 carried out for all the samples in their dry and wet condition at age 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 (2) and figure (3). In general, the results showed an increase in the amount of slump by increasing the ratio of the rubber in the concrete mix compared to the control mix without rubber.

Table (2) Results of the slump test

Mix symbol	Slump (mm)
M1	40
M2	60
M3	72
M4	80

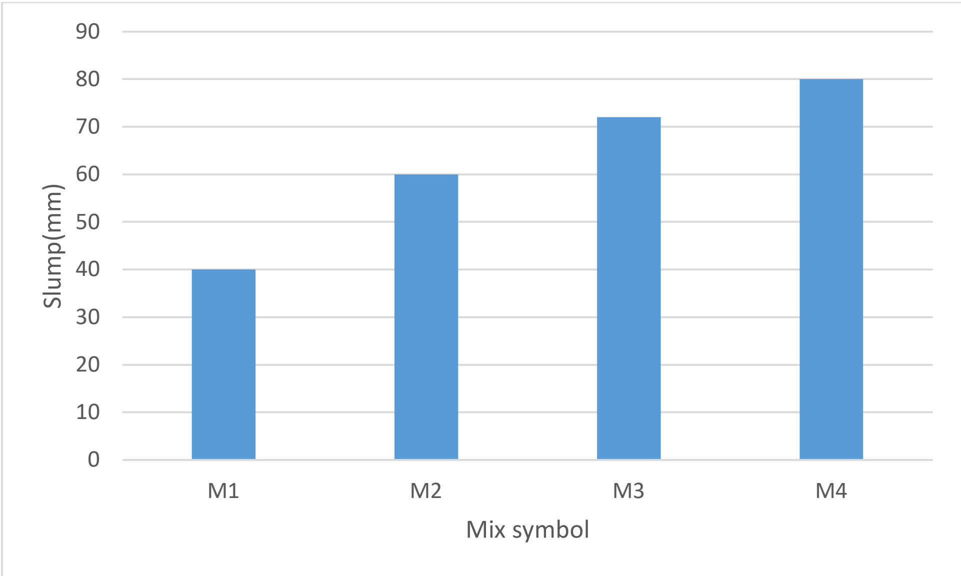

Figure (3) Results of the slump test

Compressive Strength test

the compressive strength test results were found and shown in Table (3) and figure (5). the results also showed that the compressive strength was decrease by increasing the content of rubber.

Figure (4) Compressive strength test

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Table (3). The Compressive strength test results

Mix symbol	7-days compressive strength (MPa.)	28-days compressive strength (MPa.)
M1	29.17	41.24
M2	24.76	35.87
M3	20.54	26.16
M4	17.86	25.62

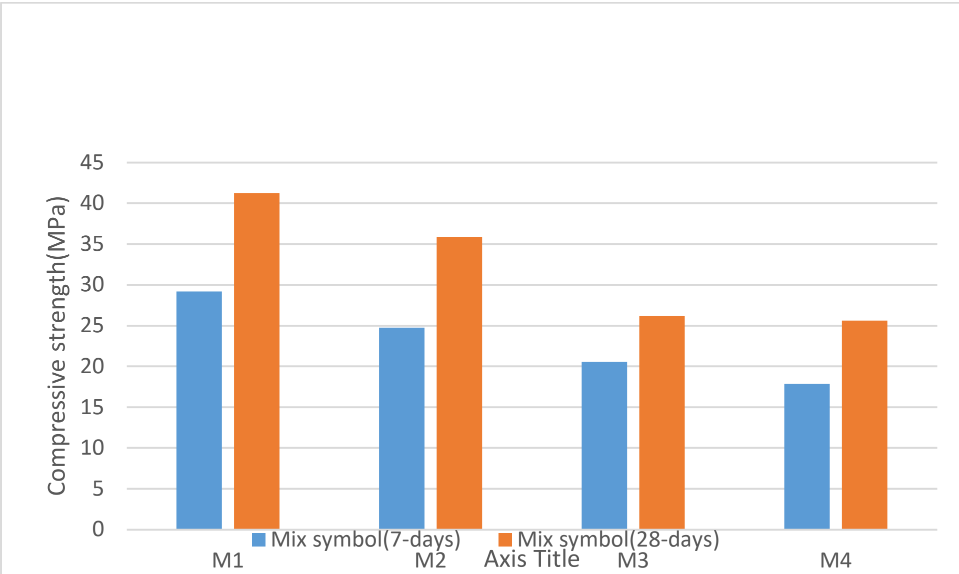

Figure (5) The Compressive strength test results

Absorption test:
The absorption test results (at age 28 days) were obtained and shown in table (4) and figure (6). The test results showed the Absorption was increase by increasing the content of rubber as compared to the control mix and rubber.

Table (4). The absorption percent test results

Mix symbol	Absorption percent(%) 28 days
M1	30.08
M2	32.46
M3	33.62
M4	34.23

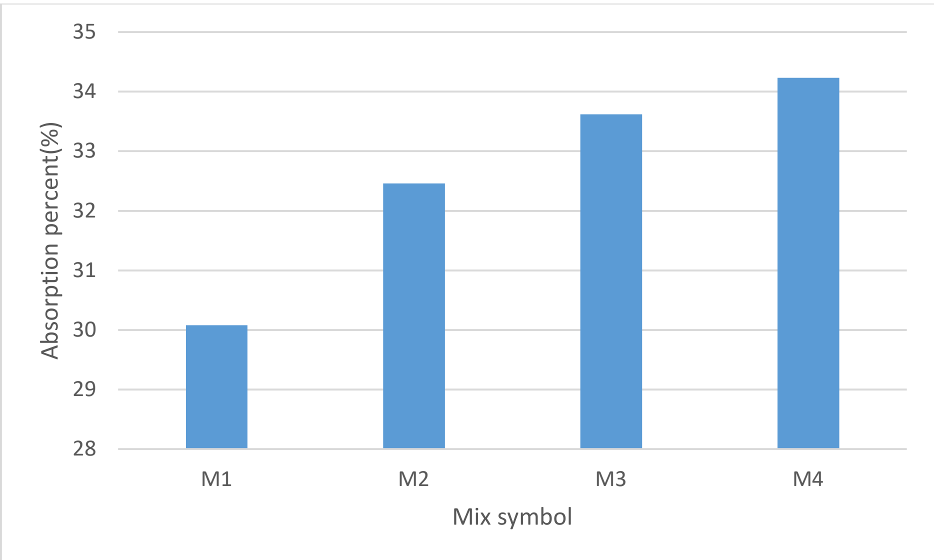

Figure (6) The absorption percent test results

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Density test

the density test results (at age 28 days) were obtained and shown in table (5) and figure (8). The results showed that the dry density and wet density were decrease by increasing the content of rubber as compared to the control mix without rubber.

Figure (7) dry density test

Table (5). Wet and dry density test results

Mix symbol	Wet density kg/ m^3	Dry density kg/ m^3
M1	2775.62	2717.70
M2	2762.88	2742.25
M3	2717.33	2633.48
M4	2655.70	2590.37

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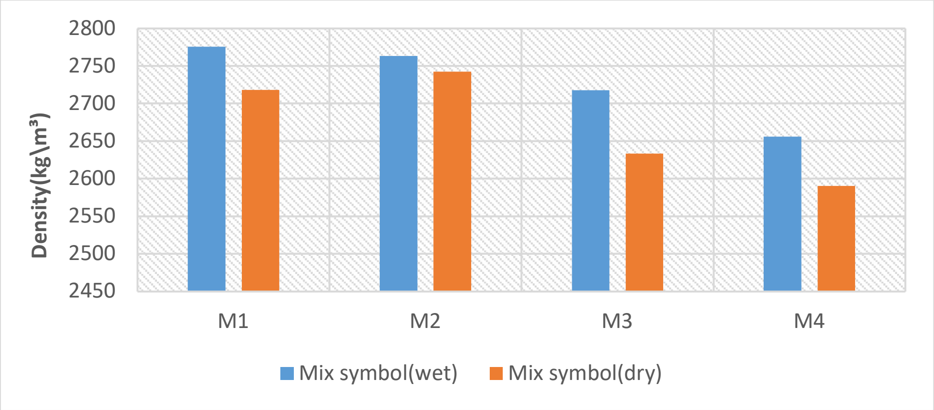

Figure (8) Wet and dry density test results

Conclusions

1- The results of the slump test showed that the increase of the rubber tires wastes ratio from 0 to 5% to 10% ,15% led to increase the slump of the mixture. This increase is due to the fact that the water covers the rubber particles, which in turn leads to reduction in friction between the components of the concrete mix.

2-The results of the compression strength tests showed that the increase of the rubber tires wastes ratio from 0 to 5% to 10% ,15% led to decrease the compressive strength by (13.02%, 36.56% and 37.87%) respectively at age 28days. This decrease in the compressive strength is due to the fact that the rubber particles are weak and compressed, so they will be affected by the strength of other concrete components and the voids increase in the mixtures containing rubber and this affects the compressive resistance of concrete negatively.

3- The results of the absorption test showed that the increase of the rubber tires wastes ratio from 0 to 5% to 10% ,15% led to increase the absorption ratio by (7.91%, 11.76% and 13.79%) respectively at age 28days, this increase in the amount of absorption is due to the fact that the workability of the concrete mix with addition of rubber wastes is low.

4- The results of the density test showed that the increase of the rubber tires wastes ratio from 0 to 5% to 10% ,15% led to decrease the wet density by (0.45%, 2.1% and 4.32%) respectively and dry density by (0.90%, 3.09% and 4.68%) at age 28days. This decrease in the amount of the wet and dry density relative to the control mix is due to the fact that the rubber wastes make concrete lightweight in order to replace the rubber wastes whose specific weight is 0.95 which is less than the specific weight of fine sand and this leads to a reduction in the weight of dead loads and this affects the type of the foundation.

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References
[1] Lee, N.P. & D.H. Chisholm 2005, "reactive powder concrete", study report No. 146.
[2] RedaTaha M.M., El-Dieb A.S., Abd El-Wahab M.A. and Abdel-Hameed M.E. 2008. Mechanical, fracture, and microstructural investigations of rubber concrete. Journal of Materials in Civil Engineering. 20(10): 640-649.
[3] Al-Mutairi N., Al-Rukaibi F., and Bufarsan A. 2010.Effect of microsilica addition on compressive strength of rubberized concrete at elevated temperatures. Journal of Material Cycles and Waste Management. 12(1): 41-49.
[4] Topçu İ.B. and Demir A. 2007. Durability of rubberized mortar and concrete. Journal of Materials in Civil Engineering. 19(2): 173-178.
[5] Tholfekar H. Hussain, Mohammed S. Nasr and Hassein J. Salman,2019 "EFFECT OF ELEVATED TEMPERATURE ON DEGRADATION BEHAVIOUR OF REACTIVE POWDER CONCRETE MADE WITH RUBBER TIRE WASTES AS AN AGGREGATE REPLACEMENT" , ARPN Journal of Engineering and Applied Sciences . VOL. 14, NO. 3,
[6] Khaloo A.R., Dehestani M. and Rahmatabadi P. 2008. Mechanical properties of concrete containing a high volume of tire–rubber particles. Waste Management. 28(12): 2472-2482.
[7] Al- Mutairee, H. M and Makki, O.M., 2021 J. Phys.: Conf. Ser. 1895 012011 Rubberized concrete mix – discussions for literature review., 2nd International Conference for Civil Engineering Science (ICCES 2021).
[8] Makki, O,M,. Al-Mutairee, H. M., Al-ibraheemi ,M.M and 4 Al- Khafajy, Z,H . Sustainable Rubberized Concrete mixe., International Journal of Engineering, Vol. 34, No. 05, (May 2021) 184-191.
[9] O. M. Makki*, H. M. K. Al-Mutairee, Response of Rubcrete Continuous Deep Beams under Sinusoidal Loads, International Journal of Engineering, Vol. 35, No. 07, (July 2022) 1307-1316.
[10] IQS No.5/1984,.Portland Cement., Central Agency for Standardization and Quality Control, Planning Council, Baghdad, Iraq, translated from Arabic edition.
[11] IQS No. 45/1984, .Aggregate from Natural Sources for Concrete., Central Agency for Standardization and Quality Control, Planning Council, Baghdad, Iraq, translated from Arabic edition.
[12] ACI Committee 234 (1996) .Guide for the use of silica fume in concrete . pp.1-51
[13] U.S. Department of Transportation. Silica Fume User's Manual, Federal Highway Administration, April, 2005, 183 pp.

[14] ASTM C1240 (2015). Standard Specification for Silica Fume used in Cementitious mixtures. USA: ASTM International , pp.1-7.
[15] ASTM C494/C494M (2015) . Standard Specification for Chemical Admixtures for Concrete. USA: ASTM International , PP.1-10.
[16] ASTM C 143-89, 1989. "Standard test method for slump of hydraulic cement concrete". Annual Book of ASTM Standards, Vol.04.02,
[17]B.S.1881.Part116, (1989). Method for determination of compressive strength of concrete cubes. British Standards Institution, 3 pp.
[18]BS. 1881, part 122, "Method for determination of water Absorption ", British standards institute , 2PP ، 1989.