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IMPROVEMENT OF CONCRETE PROPERTIES MADE FROM RECYCLEDCONCRETE AGGREGATE USING NON-TRADITIONAL ADMIXTURE

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ABSTRACT

The aim of this work is to improve the fresh and hardened concrete properties made from recycled concrete aggregate, by using a non-traditional admixture.As the previous researches concluded, using different ratios of recycled concrete aggregate has a harmful effect on the properties of fresh and hardened concrete. Otherwise, itpresents a cheap, environmental and sustainable concrete by using the waste materials of demolitions to replace the natural aggregate in concrete mixes. Therefore, organic non-traditional admixture is used in this study to improve fresh and hardened concrete properties.The admixture was prepared using a cheap local material mainly from wastes of vegetable oil industries.Six different types of admixtures were prepared to select the best and most homogenous one.The suggested admixture gives best workability and increase thecompressive strengthof concrete mixescontaining recycled concrete aggregate.

*Keywords:*Soap-stock, non-traditional admixture, natural aggregate, recycled concrete aggregate, compressive, splitting and bond strength.

1. Introduction

The amount of construction and demolition waste has increased considerably over the last few years. Nowadays, almost all demolished concrete has been mostly dumped to landfills. From the viewpoint of environmental preservation and effective utilization of resources, the interest in using recycled materials derived from construction and demolition waste is growing all over the world, [2, 3, 4, and 9]. Previous works concluded,that using different ratios of recycled concrete aggregate has a harmful effect on fresh and hardened concrete properties, [7, 8, 10 and 11].

Modern production of plain and reinforced concrete is closely connected with wide using of different types of chemical traditional admixtures, which in small doses allow obtaining the required physical and mechanical properties of concrete. The effect of chemical admixtures on the forming the microstructure of the hardened concrete is closely connected with the theory of hydration and hardening of mineral astringent substances such as cement, [1], [5].

In the last years, most research tended towards organic materials to fabricate non-traditional admixture, in 2002 "***Abo Elfadl et al***", [1], used the wastes fromvegetables oilindustry of Assiut, in shape of solid parts, to produce three types of admixtures (SM-B, SM-R and SM-F) to use in cement mortar, to get a high impermeable mortar for water tanks. The previous three admixtures wereused by different ratios (0.25%, 0.50%, 0.75%, 1.00% and 1.25 % by weight of cement content).They tested cement mortar cubes (7 x 7 x 7 cm.) used to measure compressive strength, prisms (4 x 4 x 16 cm.) for bending tests. Also water absorption and capillary water absorption were measured. They concluded that,

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his suggested non-traditional admixtures have a good and clear effect on improving mechanical properties and reducing the permeability of cement mortar.

In 2013 "***A. Megahed, M.M. Rashawn and Mostafa A. Razek***",[5], usesthe wastes frompetroleum refining industries (brown liquid solution), wastes of Coke factory (Naphthalene Sulfonate) and Silica fume, to produce admixture to use with the cement mortar affected by environmental conditions. They compared the suggested admixture with other commercial admixtures (SedreteWp and PlastmixWp), and they determined the optimum dose of each admixture according to the compressive strength.They concluded that, the suggested admixture increases compressive strength of specimens hardenedin an oven at 100o C compared to other specimens hardened in the same conditions.Also the suggested admixture decreased water absorption about 23 % compared to the commercials admixtures. Finally suggested admixture showed a better influence compared with the commercial admixtures.

2. Experimental work

Six different types of organic non-traditional admixtures were prepared in laboratory, mainly from wastes of vegetable oil industries (Soap-stock).The best and homogenous one of the six admixturesaccording to workability and compressive strength willbe selectto use in concrete mixes contains different ratios of recycled concrete aggregateto improve its properties. Preparation of admixtures takes into consideration the following parameters:

1 - Method of preparation and producing the suggested admixture in liquidity solutions.
2 - Compatibility of initial components of this admixture.

*2.1. **Materials***

2.1.1. Cement

Ordinary Portland cement with CEM I 42.5 N was used. Mechanical, physical and chemical properties of the used cement agree with the requirements of the Egyptian code (ECP 203-2010), [6].

2.1.2. Aggregate

2.1.2.1.Natural aggregate

The natural aggregate used from Assuit quarries, and its physical, chemical and mechanical properties are shown in table 1, grading of aggregate shown in figure 1.

2.1.2.2.Recycled aggregate

The recycled coarse aggregates used in this work were produced by crushing the demolitions of a building in Sohag zone. The crushed concrete was from the upper skeleton has been screened using sieve analysis method. The produced RCA having M.N.S. of 40 mm. The physical, mechanical and chemical properties of the RCA are determined according to the Egyptian code (ECP 203-2010), [7]. It was observed that the density and water absorption ratio of RCA are bigger than of NA. The differences observed in these properties are mainly due to the adhered cement mortar as reported by many other researchers [2, 3, 11], and its physical, chemical and mechanical properties are presented in table 1. Grading of aggregate is shown in figure 1.

Table 1.
Properties of used Aggregate.

Property	*Natural Aggregate*		*Recycled Aggregate*	
	Sand	*Gravel*	*Sand*	*Gravel*
Specific Weight	2.58	2.53	2.5	2.44
Bulk Density (t/m^3)	1.68	1.63	1.58	1.46
Water Absorption %	-------	0.93	--------	3.8
Clay and Fine Dust Content %	1.13	-------	0.42	-------
Crushing Value %	-------	10.13	--------	29
Fineness modulus	3.58	6.2	3.55	6.6
chloride content CL- %	0.034	0.025	0.07	0.062
Sulfates content SO3 %	0.093	0.0116	0.226	0.223
Degree of alkalinity (PH)	7.5	8	9.5	9

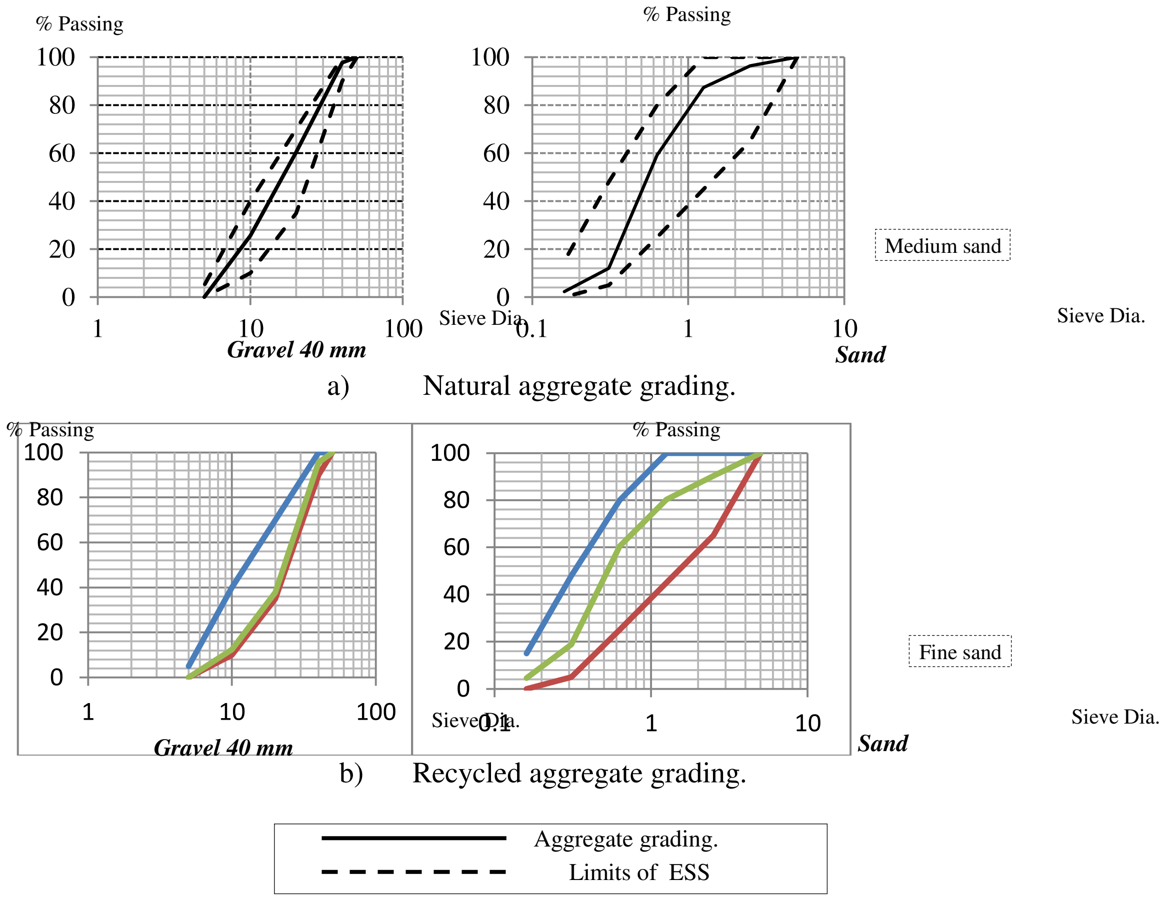

Fig. 1. Grading curve of used Aggregate.

2.1.3. Admixture

Organic non-traditional admixture was used to improve fresh and hardened concrete properties.The admixture was prepared in laboratory using wastes of vegetable oil industries.Six different types of admixtures were prepared to select the best and homogenous one that gives the maximumcompressive strength to be usedin concretes fabricated from RCA.

2.1.3.1.The basic components addition

The following materials were used to prepare and produce the suggested admixture:

1- Soap-stock: (the main active material):"***Soap-stock***" means a secondary product wastes from vegetable oil industries, soap-stock used here comes from Sohag factory of Hydrogenated vegetable oil and soap "***Nile Company for oils and detergents***", soap-stock has two main shapes,as shown in figures. (2) and (3):

a. *Liquid shape:*comes from hydrogenation of vegetable oils.
b. *Solid parts:*comes from hydrogenation of margarine.

In this work the used soap-stock was in a liquid shape, come from hydrogenation of sun flower plant and soya beans oils.

Fig. 2.liquid shape of soap-stock

Fig. 3.solid parts of soap-stock

<u>*a.1. Physical properties of liquid Soap- stock:*</u>Brown liquid, homogenous solution at high temperatures, with some sediments and impurities at room temperature, as shown in figure (2), unit volume weight is 1.1 g / cm^3.

<u>*a.2. Chemical properties of liquid Soap-stock:*</u>Soap-stock consists mainly of some organic components melted in water, components ratios of the soap-stock depending on the efficient operation of the factory and these components as follows:

I. Esters of glycerin (Residuals oils from manufacturing process) not exceedthan 2%.
II. Organic components of sodium salts, (R – COO – Na) like as hydrocycarboxylicacid, lingo – Sulfonate and Naphthalene formaldehyde, ranges from 30 to 40 %.
III. Caustic soda "sodium hydroxide" Na OH, ranges from 10 to 20 %.
IV. Water, ranges from 40 to 60 %.

Hydrogen index of the soap-stock (***PH***) = 13.5 to 14, due to the high ratio of sodium hydroxide "NA OH".

2- **Grind lime (Calcium Oxide CaO):**It's necessary to used "Calcium Oxide CaO" as a soluble with water to obtain homogeneous and stabile solution of the proposed admixture against sedimentation. The amount of "Calcium Oxide CaO" not be more than 25% of the soap-stock by weight, [1].
3- **Silka fume (Silka Oxide SiO2):**In some previous works,[5] "Silka Oxide SiO2" melted in water to obtain Silica solution that used to increase liquidity and reduce water surface tension.Also Silica solution was used widely in liquid-soap industry.
4- **Super plasticizer (PVF):**In this work "Super plasticizer (PVF)" was used by small amounts, ranged from 3% to6 %, as "Super plasticizer (PVF)" is an organic plasticizer helps to get a stable solution of the proposed admixture against sedimentation, it gives a validity period, and also improves the properties of proposed admixture to get a homogenous and Soluble in water solution.

2.2. Technique of preparing and producing the admixtures

2.2.1. First step: (Chemically separated components of soap-stock solution)

Soap-stock solution in its initial state may contains some residuals oils from manufacturing process, harmful salts, sodium hydroxide "Na OH" and impurities from the husks and seeds of plants involved in the oil manufacturing process. As all of the previous mention components may be concrete detrimental. So it's important to get rid of impurities and other substances harmful to concrete.

The separate process started by raising the temperature of the soap-stock solution in its raw condition up to 80o C, and adding salt (NaCl) to the heated solution by 5% concentration by weight (55 gram each 1 liter of soap-stock solution), and by rapid flipping. The solution will contain a hardness water does not accept melting any soapy materials as shown in Fig. (4), and it will be easy to separate the soapy material that we need to made the admixture.

$$\text{soap-stock (raw solution)} + NaCl \xrightarrow[80^{o}\,C]{\text{Heating}} \text{Glycerin (residual oil)} + \text{soapy material}$$

The soapy material obtained from the previous chemical reaction viscous like as gel in its density and viscosity due to the water found on it. And like as solid parts shown in Fig. (4) if it drays.

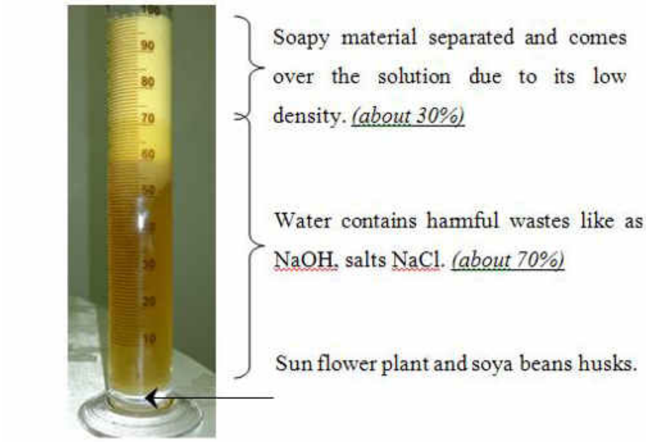

Fig. 4.soap-stock solution after separating process

2.2.2. Second step: (Soluble in water)

Melting the soapy material seprated from the previous step in its double weighing of tap water after heating over 80º C using a mechanical mixer until obtaining a homogenous solution it takes about from 15 to 20 minutes as shown in fig (5), and the speed of the mixer must observed to avoid foaming.

Fig. 5. mixing prosses of water and soap-stoak

2.2.3. Third step

Adding a small amount (about 0.5 to 3 % by weight) of limestone “CaO” or silica-fume “SiO2” in shape of powder to the previous worm solution and mixing until obtaining a homogenous solution it takes about 10 minutes.

2.2.4. Fourth step

Adding a small amount of plasticizer PVF (about 3% to 6 % by weight) to the solution and mixing until obtaining a homogenous solution it takes about 5 minutes.

2.3. Admixture components

The effect of composition and parameters of combination of different elements and materials used in the preparation of proposed six admixtures were studied.Components of Admixture No. 4 (as it was the best one to be used with recycled aggregate) are presented in table (2).

Table 2.
Addition No. 4 trails and components

Constituent materials	Correlation of components (% *by Weight*)					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
Soap-stock	28	28	30	30	28	33
Limestone CaO	2.5	2	1.5	1	1	0.5
Plasticizer PVF	4	6	5	5	6	6
Water	65.5	64	63.5	64	65	60.5
❖ Experiment remarks :						
Time of preparation (min.)	40	40	35	30	35	45
Stability and sedimentation	-	-	*	+	*	-
Hydrogen power (PH)	9.55	9.8	9.73	9.85	9.7	10.25
Acceptance or not	No	No	No	Yes	No	No

The following remarks of table (2) mustbe taken into consideration:

a) **<u>The sign (-)</u>**: in the experimental remarks means that the sedimentation occurs, and non homogenous solution was obtained.

b) **<u>The sign (*)</u>**: in the experimental remarks means momentary stability of the solution against sedimentation don't still more than 24 hours, and it started to appear after thetemperature of the solution dropped, as some components started to sediment.

c) **<u>The sign (+)</u>**: in the experimental remarks means stability of the solution against sedimentation.

d) Temperature during mixing presses not less than 50^o *C*.

e) Control the speed of the mixer during the mixing process to avoid foams.

f) The output solution of the forth trail was selected due its homogeny and stability ageist sedimentation, and named ***<u>Addition No. 4</u>***.

By using the same previous presses to produce the remaining five additions and its compositions are determined and presented in table (3).

Table 3.
Admixtures and its components

Admixture	Components of the Admixture	Percentages of components by weight
ADD 1	1 - soap-stock	30 %
	2- Calcium Oxide "***CaO***"	3 %
	3- water	67 %
ADD 2	1 - soap-stock	32 %
	2- Silka-Fume "***SiO_2***"	1 %
	3- water	67 %
ADD 3	1 - soap-stock	30 %
	2- Calcium Oxide "***CaO***"	2 %

Admixture	Components of the Admixture	Percentages of components by weight
	3- Silka-Fume "SiO_2"	0.5 %
	4- water	67.5 %
ADD 4	1 - soap-stock	30 %
	2- Calcium Oxide "***CaO***"	1 %
	3- Plasticizer " ***PVF*** "	5 %
	4- water	64 %
ADD 5	1 - soap-stock	35 %
	2- Silka-Fume "SiO_2"	0.5 %
	3- Plasticizer " ***PVF*** "	5 %
	4- water	59.5 %
ADD 6	1 - soap-stock	33 %
	2- Calcium Oxide "***CaO***"	1 %
	3- Silka-Fume "SiO_2"	0.5 %
	4- Plasticizer " ***PVF*** "	5 %
	5- water	60.5%

2.4. Concrete mixes

The concrete mixes were designed to achieve target strength 250 kg/cm^2, using 30 % RCA and 70% NA, without using any admixtures, and surface area of combined aggregate equal to the optimum value of 25 cm^2/gm using 40mm M.N.S. of coarse aggregate. Concrete mixes were used to determine the optimum dose of each admixture. The concrete mixes proportions by weight arepresented in table 4.

Table 4.
mixes proportions

Cement (Kg)	Gravel (Kg)		Sand (Kg)		Water (liter)	Add(% cement)	W/C
	NA	RCA	NA	RCA			
350	756.8	324.3	420.5	180.2	213.5	0.00	0.61
350	774.2	331.8	430.15	184.35	203	0.25	0.58
350	786.2	337	436.8	187.2	192.5	0.50	0.55
350	801	343.4	445.2	190.8	182	0.75	0.52
350	815	349.2	452.75	194	168	1.00	0.48
350	828.7	355.1	460.4	197.3	154	1.25	0.44
350	835.6	358.1	464.24	198.9	143.5	1.50	0.41

3. Tests

Properties of fresh and hardened concrete were determined in this study according to the Egyptian code,[7]. Slump and compacting factor were used to measure the properties of fresh concrete. Hardened concrete properties were determined by measuring compressive, splitting tensile, bond and flexural strength.

The compressive strength test was carried out according to the ESS 1658/2010 [6]. Cube specimens of (150 × 150 × 150 mm) were tested to evaluate concrete compressive strength at ages of 7 and 28 days.

The splitting tensile strength test was carried out according to the ESS 1658/2010 [6]. Standard cylinders of 150 mm diameter and 300 mm height were tested to determine the splitting tensile strength after 28 days, as shown in figure (6).

Fig. 6. Splitting tensile test.

The pull out bond strength test was carried out according to the ESS 1658/2010 [6]. The bond strength is measuringby using three ribbed steel barsof 16 mm diameter embedded in three standard cylinders of 150 mm diameter and 300 mm height, as shown in figure (7).

Fig. 7. Pull out bond strength test.

The flexural strength was measured by testing of three standard prisms with dimension 15 x 15 x 75, according to the ESS 1658/2010 [6], specimens tested under one-half point load. As shown in figure (8).

Fig. 8.flexural strength test.

4. Results and discussion

4.1. Determination of optimum doses of each admixture

Concrete mix contains ***30% RCA***waschosen to determine the optimum dose of each admixtureaccording to compressive strength results and slumpranging between ***7 to 8*** cm.Admixturedoses, slump and compressive strength after 7 and 28 days are presented in table 5 and Fig.9.

Table 5.
Effect of doses of Admixture 4 on compressive strengths.

w/c	Admixture Dose (% Of Cement)	Slump	Fc 7 (Kg/cm^2)	Fc 28 (Kg/cm^2)
0.61	0.00	8	167	218
0.58	0.25	7.5	174	238
0.55	0.50	7.5	190	263
0.52	0.75	8	195	275
0.48	1.00	8	200	284
0.44	1.25	8	195	270
0.41	1.50	7.5	191	268

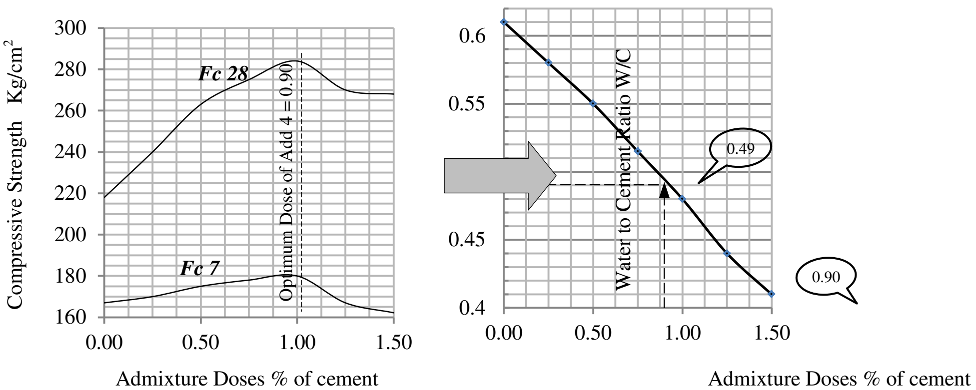

Fig. 9. Determination of optimum Dose of Add 4.

From table (5) and Fig.(9), the optimum dose of Admixture 4 equals to 0.90 by weight of cement and the corresponding water to cement ratio equals to 0.49. By using the same previous process to determine the remaining optimum doses of the five admixtures are determined and presented in table (6).

Table 6.
Optimum dose of the resulting Admixtures and concrete properties.

Admixture type	Optimum dose (% of cement)	w/c	Slump (cm.)	Compressive strength (Kg/cm^2)			
				Fc 7	Fc 28	Fc 90	Fc 180
Control	0.00	0.61	8	167	218	236	242
ADD 1	1.41	0.51	7.5	197	271	288	306
ADD 2	1.44	0.51	7.5	192	262	275	290
ADD 3	1.43	0.51	7.5	200	275	290	300
ADD 4	0.9	0.49	8	205	289	315	340
ADD 5	0.94	0.47	8	202	280	308	325
ADD 6	0.92	0.47	8	205	283	308	330

4.2. Using "admixture 4" to improve fresh and hardened concrete properties

From table (6) it is clear that "*Admixture No.4*" is the preferred admixture to improve the fresh and hardened concrete properties contains*30% RCA*. Therefore, admixture 4 used to improve concrete properties contains different ratios of RCAranging from 10% to 50%. Optimum doses of admixture were determined for each ratio of RCA using the same previous method presented in table (5) and Fig. (6). Optimum doses of the suggested admixture for each ratio of RCA and the corresponding fresh and hardened concrete properties are presented in table (7).

Table 7.
Effect of optimum dose of "Admixture 4"on concrete properties

Aggregate		*W/C*	Optimum dose (% of cement)	Fresh concrete properties		Hardened concrete properties (Kg/cm^2)				
NA %	RCA %			Slump (mm)	C.F.%	Fc 7	Fc 28	Fct	Fb	Fcr
90	10	0.47	0.88	82	97	220	305	22.5	34.8	48.4
80	20	0.47	0.90	82	97	212	295	22	34.3	47.6
70	30	0.49	0.90	80	96	205	289	21.3	34.00	47.2
60	40	0.50	0.92	78	96	202	275	20.8	33.8	45.8
50	50	0.50	0.93	75	95	192	266	19.5	32.9	44.5

4.3. Influence of using Admixture 4on fresh and hardened concrete properties

Comparing the fresh and hardened concrete properties of mixes contains "*admixture 4*"presented in table 7 with the control mixes without admixtures presented in Ref. [3].The effect of using non-traditional addition on improving fresh and hardened concrete properties is clear.

The investigation of the fresh concrete properties indicates that using "*admixture 4*" by its optimum dose has a clear effect on improving both of workability and compacting factor. Slump increase by105 %, 120 %, 116 %, 122 % and 114 % for ratios of *RCA* equal to 10%, 20%, 30%, 40%, and 50% respectively.Compacting factorincrease by 6.6 %, 7.8 %, 6.6%, 9% and 8% for ratios of *RCA* equal to 10%, 20%, 30%, 40%, and 50% respectively.

The examination of the tested cubes after 7 and 28 days indicates that, using admixture 4 by its optimum dose has a clear effect on improving compressive strength. ***Fc7***increase by 11.7 %, 13.3 %, 14.5 %, 17.4 % and 17 % for ratios of *RCA* equal to 10%, 20%, 30%, 40%, and 50% respectively. ***Fc28*** increaseby 15.1 %, 22.4 %, 22.9 %, 23.3% and 22.5 % for ratios of *RCA* equal to 10%, 20%, 30%, 40%, and 50% respectively, as shown in fig 10.

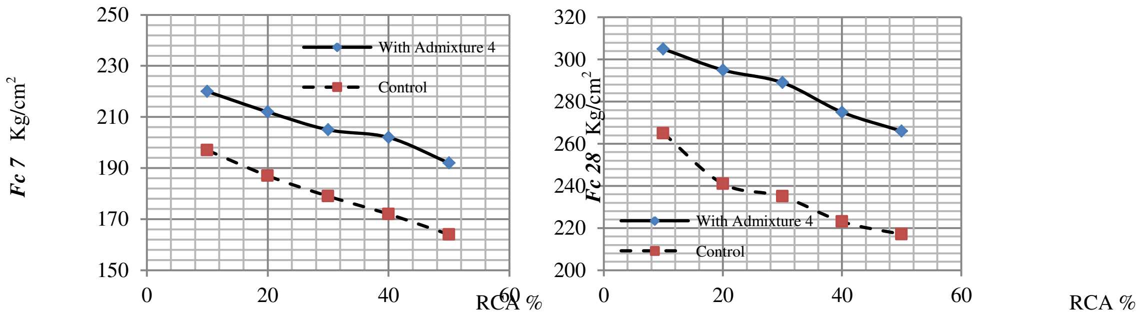

Fig. 10. Effect of Admixture 4 on compressive strength.

Also investigation of the results of the Brazilian tensile test indicates that, using "admixture 4" by its optimum dose has a clear effect on improving splitting tensile strength, Ft increaseby 7.1 %, 20.2 %, 23.8%, 26 % and 23.4 % for ratios of RCA equal to 10%, 20%, 30%, 40%, and 50% respectively, as shown in fig 11.

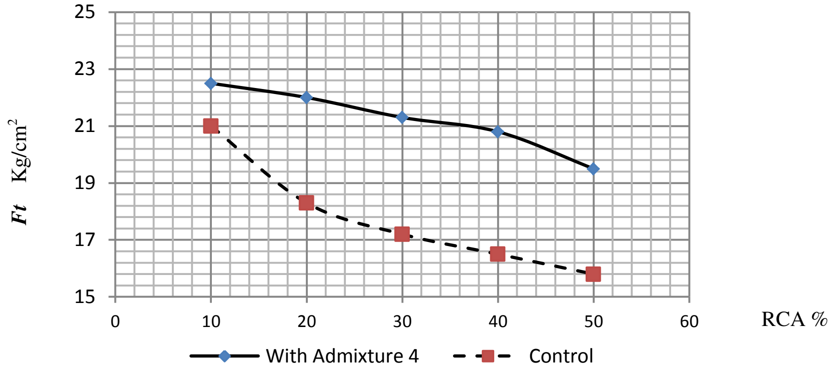

Fig.11. Effect of Admixture 4 on splitting tensile strength.

The examination of the tested cylinders that having embedded steel bars of 16 mm diameter, under pull-out bond test indicates that, using admixture 4by its optimum dose has a significant effect on improving bond strength. The bond strengthincrease by 28.8 %, 41.7 %, 44.6 %, 52.6 % and 55.9 % corresponding to ratios of RCA equal to 10%, 20%, 30%, 40%, and 50% respectively, as shown in fig 12.

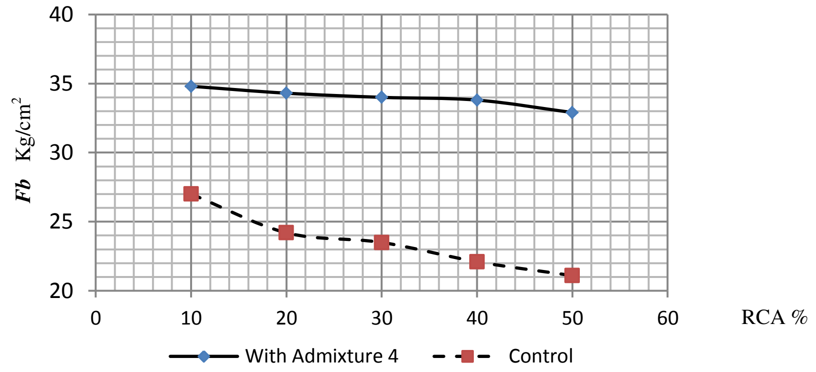

Fig.12. Effect of Admixture 4 on bond strength.

Also examination of the tested prisms under one-half point load test indicates that, using admixture 4 by its optimum dose has a clear effect on improving flexural strength. Flexural strengthincrease by 14.4 %, 24.6 %, 27.5 %, 31.8 % and 34 % for ratios of RCA equal to 10%, 20%, 30%, 40%, and 50% respectively, as shown in fig 13.

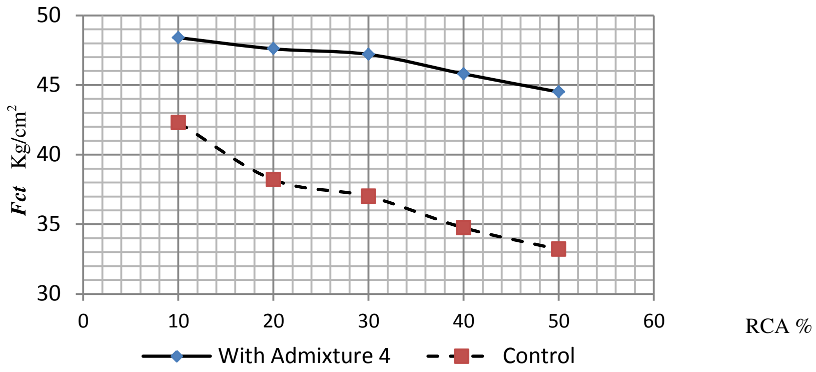

Fig.13. Effect of Admixture 4 on flexural strength.

5. Conclusions

Based on theexperimental results carried out on concrete mixes, usingnon-traditional "***admixture 4***" and recycled concrete aggregate, andwithin the scope of the present study and range of investigated parameters the following conclusions can be drawn:

1. New non-traditional admixture in a liquidity solutionis successfully achieved in laboratory. Optimum and stable composition of the suggested admixture can be drawn as following (% by weight):
    a. Soap-stock. ……………………………….............. 30 %
    b. Calcium Oxide "***CaO***"………………………… 1 %
    c. Plasticizer "***PVF***"…………………………………..... 5 %
    d. Water……………………………………………....... 64
2. Optimum dose of the suggested admixture equals to 0.9 % by weight of cement, for concrete mixes contains 30% RCA, at which ***w/c*** reduced about 20 %, and compressive strength increases about 23 %, compared to mixes without admixtures.
3. The new admixture has a good and clear effect on improvement fresh concrete properties, the slump andcompacting factor increases about 100%and8 % respectively, water to cement ratio reduces about 11%. Compared to the control mixes.
4. The new admixture has a good and clear effect on improvement of hardened concrete properties; the compressive, splitting, bond and flexural strength increases about 21.2%, 20.1%, 44.7% and 26.5% respectively.

Notations

RCA	: Recycled Concrete Aggregate.
NA	: Natural Aggregate.
Fc7 & Fc28	: Cube compressive strength after 7 and 28 days respectively.
Ft	: Splitting tensile strength (Brazilian tensile test).
Fb	: Pull-out bond strength.
Fcr	: Flexural strength.

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تحسين خواص الخرسانة المصنوعة من ركام خرسانة معاد تدويرهباستخدام إضافات غير تقليدية

الملخص العربى

نتيجة للزيادة المطردة في كمية المخلفات الناتجة من هدم المباني والتي تشكل الخرسانات المكونة للهيكل النسبة العظمى فيها من هذه المخلفات، وخاصة في بيئتنا المحيطة التي يتم التخلص من هذه المخلفات بطرق عشوائية مما يتسبب عنه ضررا بيئيا بالغا و إهدار للموارد الطبيعية المتمثلة في الركام الطبيعي. ونظرا لان نتائج الأبحاث السابقة أوضحت التأثير السيئ لاستخدام الركام المعاد تدويره على كلا من خواص الخرسانة الطازجة والمتصلدة، كما أوصت بعض الأبحاث الاخري بعدم استخدام الخرسانات المحتوية على ركام معاد تدويره في الخرسانات الإنشائية.

لذا فان الغرض الرئيسي من هذه الدراسة هو إمكانية تحسين خواص الخرسانة الطازجة والمتصلدة باستخدام إضافات رخيصة محلية الصنع وكذلك تكون فعالة مع الخرسانات المحتوية على ركام معاد تدويره. لذلك تم الاتجاه لاستخدام مخلفات مصانع هدرجة الزيوت بسوهاج، لإنتاج وتصنيع إضافة محلية يتم تحضيرها بالمعمل، ودراسة تأثير الجرعة المثلى على تحسين خواص الخرسانة المحتوية على ركام معاد تدويره،للاستفادة من الناحية البيئية والاقتصادية.

وبالفعل تم تحضير إضافة من مخلفات مصانع هدرجة الزيوت يمكنها العمل بكفاءة مع الخرسانات المحتوية على ركام معاد تدويره لتحسين خواص الخرسانة الطازجة حيث تضاعف مقدار الهبوط و تم إنتاج خرسانة لها معامل دمك كبير. وكذلك ساهم استخدام الإضافة في تحسين ملحوظ في خواص الخرسانة المتصلدة متمثله في زيادة مقاومة الضغط بعد 28 يوم بنسبة 25 % وكذلك زيادة ملموسة في كلا من مقاومة الشد بالانفلاق ومقاومة الشد بالانحناء ومقاومة التماسك بين الحديد والخرسانة ، مقارنة بتلك الخرسانات المنتجة بدون استخدام الإضافة.