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ECO-FRIENDLY CONCRETE CONTAINING PET PLASTIC WASTE AGGREGATE

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ABSTRACT: - The experimental program in this investigation focused on studying the properties of concrete containing different percentages of Plastic Wastes Polyethylene Terephthalate (PET) plastic waste as a volumetric replacement to natural coarse aggregate. Different percentages (10%, 20%, 30%, 40%, and 50%) of PET shredded plastic waste from waste PET bottles as a volumetric replacement to natural coarse aggregate and 10% silica fume as a replacement by weight of cement content were used. The properties of these concrete mixes including, workability, dry density, compressive strength, total flexural energy, impact resistance, thermal conductivity at 28 days age and drying shrinkage at 90 days age were studies. The use of plastic waste aggregate in concrete presents various advantages; one of these advantages is that plastic aggregates result in producing lightweight concrete depending on the percentage of plastic waste used. The dry density of concrete containing higher percentage of PET plastic waste of 40% and 50% as a volumetric replacement to natural coarse aggregate, was 1910 and 1850 kg/m^3 respectively. Also thermal insulating properties of concrete containing plastic waste aggregate were improved.
Keywords: *Polyethylene Terephthalate PET, Volumetric Replacement, Plastic Waste, Coarse Aggregate.*

1- INTRODUCTION

The use of plastic waste materials as aggregate in concrete preparation can consume vast amounts of waste materials. This can solve problems of aggregate lack in construction sites and reduce environmental problems related to aggregate mining and waste disposal [(1)].The use of plastic waste in concrete is increased due to its beneficial properties, which include:

- Reduction of municipal solid wastes being land filled and lower production cost.
- Lighter weight than conventional materials reducing the dead load of concrete members and reduces the dimension of columns, footings and other load bearing elements.
- Resistance to chemicals, water abrasion and impact compared with natural aggregate.
- Excellent thermal and electrical insulation properties.
- Comparatively lower production cost.

The disadvantages of using plastics waste in concrete are the followings:

- The melting point of plastic is low so that it cannot be used at high temperatures.
- Poor workability and deterioration of mechanical behavior [(2)].

Yesilata *et al.* [(3)] indicated that the use of PET plastic waste and rubber tire waste improves insulation property of concrete remarkably. Albano *et al.*[(4)] carried out an experimental study on the influence of PET plastic waste content (10% and 20% replacement by volume of natural aggregate) on workability, compressive strength, splitting tensile strength, modulus of elasticity, water absorption and ultrasonic pulse velocity of concrete. Each content of PET plastic waste divided to three groups according to particle size (2.6mm, 11.4mm and a 50/50 mix of both sizes) of PET plastic waste aggregate in concrete mix. The results show an increase in the slump value with the increase of PET plastic waste aggregate and a decrease in the unit weight and the mechanical properties of concrete produced. Choi *et al.*(5) studied the effect of using PET plastic waste on concrete as 25%, 50% and 75% volumetric replacement to natural fine aggregate. It was found that the compressive strength, splitting tensile strength, and flexural strength of concrete mixtures were decreased with the increase in PET plastic waste aggregates content.

2-RESEARCH SIGNIFICANT

There is a limited detailed study on properties of concrete containing coarse PET plastic waste aggregate as a replacement to natural coarse aggregate. The main objective of this study is to offer an attractive low-cost concrete with consistent properties and improves the sustainability in concrete industry by using PET plastic waste as coarse aggregate in concrete. Also the use of by-product supplementary cementitious materials (silica fume) as a partial replacement by weight of cement content has many benefits such as decreasing the usage of natural resources, wastes consumption, avoiding the environmental pollution by CO_2 and economizing energy.

3-EXPERIMENTAL WORK

3-1 MATERIALS

3-1-1 CEMENT

Ordinary Portland cement Type (I) manufactured in Iraq with trade mark of (Al-Mass) was used. Chemical composition and physical properties of cement used throughout this research indicate that the adopted cement satisfies the requirements of the Iraqi Specifications No.5/1984.

3-1-2 FINE AGGREGATE

Natural sand from (Al-Ukhaider) supplied by Al-Mutasim State Company for Construction Contracts with maximum aggregate size of 4.75mm was used. Its gradation lies within zone (2). The results show that sand grading; physical properties and sulfate content were within the requirements of the Iraqi Specification No.45/1984.

3-1-3 COARSE AGGREGATE

Natural crushed aggregate with maximum size of 10mm has been used in this investigation. The properties of natural coarse aggregate used, its grading and sulphate content satisfy to the requirements of Iraqi Specification No. 45/1980.

3-1-4 PET PLASTIC WASTE AGGREGATE

Coarse PET plastic waste aggregate was prepared by grinding waste PET plastic bottles. The preparation process of PET plastic waste aggregate includes the following steps:

- Collecting the PET bottles wastes.
- Removing the cover and trade label.
- Washing and drying the bottles.
- Shredding and grinding the PET bottles to the specified particle size as that of natural coarse aggregate used in concrete by plastic granulator machine (blade mill). The grinding process was carried out in the Bob Al-Shaam area in Baghdad.
- Grinded PET plastic waste was then screened on standard sieves and prepared with grading which conforms to the grading of natural coarse aggregate used in this investigation.

Table (1) shows the grading of PET plastic waste aggregate. Table (2) illustrates the physical properties of PET plastic waste aggregate, while Figure (1) shows samples of natural aggregate and PET plastic waste aggregate used in this investigation.

3-1-5 WATER

The water used for mixing and curing of concrete was potable water from the water-supply network system (tap water).

3-1-6 ADMIXTURES

Two types of concrete admixtures were used in this work:

a) HIGH-RANGE WATER REDUCING ADMIXTURE

A high range water reducing admixture (superplasticizer) with a trade name GLENIUM 54[6] was used. The dosage was in the range of 0.5-2.5 liters/100 kg of the cementitious material which is recommended by the manufacturer. This type of admixture is free from chlorides and complies with ASTM C494-04 type F. Table (3) shows the main properties of this superplasticizer.

b) SILICA FUME

Silica fume is a highly active pozzolanic material. It is a by-product from the manufacture of silicon or ferro-silicon metal. Silica fume used throughout this investigation is commercially known as **MEYCO MS 610** from the chemical company BASF as partial replacement of cement weight. Table (4) and Table (5) illustrate the physical and chemical properties of silica fume used in this investigation. The results show that silica fume used satisfies the requirements of ASTM C1240-06[7].

3-2 CONCRETE MIXES

Six concrete mixes were prepared in this study including, concrete mix with natural aggregate (reference mix) and five concrete mixes containing different volumetric replacement of coarse natural aggregate (10%, 20%, 30%, 40% and 50%) by coarse PET plastic waste aggregate.

3-3 MIXING OF CONCRETE

The mixing process was performed in an electrical rotary mixes of 0.1m^3 capacity. The coarse and fine aggregate were wetted to be in a saturated surface dry condition and mixed for one minutes. Cement and silica fume were mixed by hand for two minutes, then two-thirds of mixing water was added to the dry mixture and mixed for one minute. The superplascizer was mixed with the remaining third of mixing water, then added to the mix and mixed for two minutes.

3-4PREPARATION OF SPECIMENS

The steel molds were well cleaned and their internal surfaces were oiled to prevent adhesion with concrete after hardening. The molds were filled with concrete in layers according to standard specifications for each test, each layer was compacted by a vibrating table for about 20 seconds which is a sufficient period to remove any entrapped air. After compaction, the specimens were leveled by hand troweling, covered with polyethylene sheet and left in the laboratory. After 24 hours the specimens were demolded, marked and then cured.

3-5CURING

After demolding, all the specimens were completely immersed in water until the time of testing at 28 days.

3-6EXPERIMENTAL TESTS

A number of experimental tests were carried out to study some properties of the concrete containing PET plastic waste aggregate. These tests are as following:

- Slump test according to ASTM C-143.
- Oven dry density test according to ASTM C642-03.
- Compressive strength test according to B.S. 1881 (using cubes of 100 mm).
- Total flexural energy test according to ASTM C78 (using prisms of 100×100×400mm).
- Thermal conductivity using the Hot Disk TPS 500 Thermal Constants Analyzer, according to ISO/DIS 22007-2.2 standard.
- Impact test according to the procedure suggested by ACI committee 544-1R. The impact energy delivered to the specimen is calculated by using the following equation [8].

$$EI = N*m*g*h \qquad \ldots\ldots (1)$$

Where:

EI : impact energy, (N.m).

N : the number of blows .

m : mass of the drop hammer, (kg).
g : gravity acceleration, (N/kg).
h : height of drop hammer, (m).
- drying shrinkage test according to ASTM C341M.

4-RESULTS AND DISCUSSIONS

4-1SELECTION OF MIX PROPORTIONS FOR CONCRETE

Reference concrete mix was designed in accordance with ACI 211.1-91[9] in order to obtain concrete with minimum compressive strength of 40 MPa at 28 days without any admixtures. The mix proportion is 1:1.19:1.8 (cement: sand: gravel) by weight with cement content of 525 kg/m^3, w/c ratio of 0.41 and slump value of 90±5 mm. Several trail mixes were carried out to select the optimum dosage of high range water reducing admixture (HRWRA) and silica fume. The w/c ratio was adjusted to have the same workability of the reference mix (slump of 90±5 mm). The main function of using HRWRA is to reduce the quantity of mixing water while maintaining the same workability of the reference mix. The details of the designed reference concrete mix containing different dosages of superplasticizer (HRWRA) are given in Table (6). According to manufacturer the normal dosage of HRWRA is between 0.5 and 2.5 liters per 100kg of cement or cementitious material. The experimental results in this investigation indicate that the optimum dosage of HRWRA is 1.5 liters per 100 kg of cement, which leads to a water reduction of about 44% and maximum compressive strength of 84MPa at age 28 days. A significant attention has been given to the use of silica fume in concrete mixtures. Silica fume was used as an addition or as a partial replacement to cement, or both. It is suggested that silica fume can be added in addition to existing cement in very highly aggressive environments, in order to substantially increase the chemical resistance and durability of the concrete[10,11]. In this investigation, silica fume was used as a replacement by weight of cement with 5%, 10% and 15% dosages. The results listed in Table (7) show that the compressive strength increases with the increase in silica fume dosage. This is due to the physical and chemical effect of silica fume. The results indicate that the maximum compressive strength obtained is 110.4 MPa at 28 days age for concrete mixture with 15% silica fume as a replacement by weight of cement.

4-2- WORKABILITY

The relationship between the workability and the volumetric replacement of PET plastic waste aggregate is illustrated in Table (8). It can be observed that as the content of PET plastic waste aggregate increases to 30%, 40% and 50% as volume replacement to natural coarse aggregate, the slump value increases by about 4.4%, 6.66% and 7.77% respectively. This is due to the smooth surface texture and low water absorption of PET plastic waste particles.

4-3- OVEN DRY DENSITY

The results in Table (8) show that the dry density of concrete containing coarse PET plastic waste aggregate decreases as the content of PET plastic waste aggregate increase. This is due to the angular shape which contributes to formation of large cavities in concrete and also due to the low specific gravity of PET plastic waste compared with natural coarse aggregate. Concrete containing 40% and 50% PET plastic waste as volume replacement to natural coarse aggregate have dry density of 1910 and 1850 kg/m^3 respectively. These concretes are classified as lightweight concrete according to **ACI 213R** [12].

4-4 COMPRESSIVE STRENGTH

The effect of PET plastic waste aggregate content as volume replacement to natural coarse aggregate on the compressive strength of concrete is illustrated in Table (8). The results indicate that the compressive strength decreases with the increase in PET plastic waste aggregate content. The percentage reduction in compressive strength for concrete containing 10%, 20%, 30% 40%, and 50% PET plastic waste as volumetric replacement to natural coarse aggregate is about 33%, 41.39%, 68.47%, 69.61% and 84.4% respectively compared with the reference specimens. The compressive strength for concrete specimens containing

PET plastic waste aggregate is in the range of (17.15-73.9) MPa. The results of dry density and compressive strength for concrete specimens with 40% PET plastic waste aggregate indicate that this concrete can be classified as structural lightweight concrete, while concrete with 50% PET plastic waste aggregate is non-structural lightweight concrete according to **ACI 213R**[12]. The reduction in compressive strength is attributed to the reduction in adhesive strength between the surface of PET plastics and the cement paste. Also it is due to the mismatch of particles size between natural and plastic waste aggregate [13].

4-5 TOTAL FLEXURAL ENERGY

The total flexural energy results of reference and different mixtures of concrete containing various percentages of PET plastic waste aggregate as a volumetric replacement to natural coarse aggregate are shown in Table (8), while the flexural load-deflection relationship is illustrated in Figure (2). The results clearly show a considerable improvement in flexural energy values for all concrete specimens containing PET plastic waste aggregate. The deflection value increases as the content of PET plastic waste coarse aggregate increase for the same value of load. This can be explained by the ability of PET plastic waste aggregate to prolong crack propagation interval due to their non-brittle characteristics [14, 15]. The percentage increase in flexural energy of concrete specimens with 10%, 20%, and 30%, 40% and 50% PET plastic waste aggregate is 251.7%, 272.4%, 337.9%, 362.1% and 413.7% respectively in comparison with reference specimens. The failure in reference concrete specimens without plastic waste aggregate occurs in, matrix, through coarse aggregate and around the aggregates in interfacial transition zone (ITZ), while in concrete containing PET plastic waste aggregate the failure occurs mainly around the PET particles. Therefore, concrete containing PET plastic waste aggregate can withhold a larger deformation while still keeping its integrity compared with the reference concrete.

4-6 THERMAL CONDUCTIVITY

The test results of thermal conductivity at 28 days of concrete containing PET plastic waste aggregate as a volumetric replacement to natural coarse aggregate are shown in Table (9). It can be observed a considerable reduction in thermal conductivity with the increase in PET plastic waste content. This is due to the formation of huge amount of cavities in the structure of concrete containing PET plastic waste aggregate.

Porosity is one of the factors affecting the thermal conductivity of concrete and enclosed pores reduce the conductivity due to the low thermal conductivity of air [16]. Also the lower thermal conductivity of the PET plastic waste aggregate (0.15 to 0.24 W/m.K) in comparison with natural aggregate (2W/m.K)[17] causes this reduction in thermal conductivity.

Marzouk et al. [18] mentioned that concrete containing 50% volume replacement of natural fine aggregates by PET plastic waste aggregate leads to a reduction in thermal conductivity of concrete by about 46%. In this research the use of 50% volume replacement of natural coarse aggregate by coarse PET plastic waste aggregate leads to reduction in thermal conductivity of 88.5% in comparison with reference concrete (without PET plastic waste aggregate). It can be concluded that recycled PET plastic aggregate can be used for thermal insulation of buildings. Concrete with high content of PET plastic waste aggregate (containing 40% and 50% volumetric replacement of PET plastic waste aggregate to natural coarse aggregate) can be used in structural insolated lightweight concrete members and as filler for the cavities of concrete masonry units.

4-7IMPACT ENERGY

Impact energy results represented by the number of blows required to cause the first crack and failure crack for concrete with PET plastic waste aggregate are given in Table (9) and Figure (3). Based on the test results, it can be concluded that using low content of coarse PET plastic waste aggregate (10%, 20% and 30% by volume of natural coarse aggregate) slightly enhances the impact energy of concrete. As the content of coarse PET plastic waste aggregate increases (40% and 50% by volume of natural coarse aggregate) the impact energy of concrete significantly decreases. This is attributed to the formation of large pores and the weak bond between the cement paste and PET plastic waste aggregate. The failure modes for concrete specimens under impact load are shown in Figure (4).

4-8DRYING SHRINKAGE

In this test an assessment of the potential volumetric contraction of reference mix and concrete with different volumetric replacement of natural coarse aggregate by PET bottle plastic waste aggregate is investigated. The results are shown in Table (10) and Figure (5). The drying shrinkage values of concrete containing coarse PET plastic waste aggregate increase as volumetric replacement to natural coarse aggregate gradually increases especially at early ages(7 and 14 days), while at 28 and 56 days age the drying shrinkage slightly decreases. This is due to the capillary tensile stresses which result from loss of water from the concrete containing higher content of PET plastic waste aggregate due to the formation of high amount of large cavities, also this is due to the lower elastic modulus of plastic waste aggregate than that of natural aggregate.[19, 20, 21]. Generally, the increase in PET plastic waste aggregate has a slight effect on drying shrinkage of concrete.

5-CONCLUSIONS

The main conclusions that can be drawn from this study are:

1. Concrete containing 40% and 50% PET plastic waste aggregate as volumetric replacement to natural coarse aggregate has dry density of 1910 and 1850 kg/m^3 respectively.
2. The compressive strength of concrete decreases as the content of PET plastic waste aggregate in concrete increase. The compressive strength for concrete specimens containing 40% and 50% coarse PET plastic waste aggregate by volume is 23 and 17.15 MPa respectively according to the density and compressive strength of these mixes they can be classified as structural and non-structural lightweight concrete respectively according to ACI 213-03.
3. The use of coarse PET plastic waste aggregate in concrete improves the flexural energy absorption of concrete, which is very interesting to several civil engineering applications such as concrete structures subjected to dynamic loading.
4. There is a considerable reduction in thermal conductivity with the increase in PET plastic waste aggregate content. Concrete with high content of PET plastic waste aggregate (40% and 50% volumetric replacement to natural coarse aggregate) can be used in structural insulation lightweight concrete members and as filler for the cavities in concrete masonry units.
5. The use of low content of coarse PET plastic waste aggregate (10%, 20% and 30% by volume of natural coarse aggregate) slightly enhances the impact resistance of concrete.
6. The inclusion of PET plastic waste aggregate has a slight effect on drying shrinkage of concrete.

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Table (1) Sieve analysis of PET plastic waste aggregate

Sieve size (mm)	% Passing	Limits of Iraqi Specification No. 45/1984 with single size (10mm)
14	100	100
9.5	94	85-100
4.75	23	0-25
2.36	0	0-5

Table (2) Physical and mechanical properties of PET plastic waste aggregate*.

Physical properties	Results
Specific gravity	1.34
Water Absorption (24 hr)	0.00%
Thickness	(1 – 0.15) mm
Shape of particles	Flaky and shredded particles and some pellets pieces with maximum size 10 mm
Color	crystalline white to blue sky

* Tests were carried out in the laboratory of the Department of Building and Construction Engineering, University of Technology.

(a)Natural coarse aggregate (b) Coarse PET plastic waste aggregate

Figure (1) Types of aggregate used in this investigation.

Table (3) Technical description of high range water reducing admixture*

Typical properties	Technical description
Appearance	Whitish to straw colored liquid
Specific gravity	1.07
Chloride content	Nil

*According to manufacturer (The Chemical Company BASF).

Table (4) Physical properties of silica fume (SF)*.

Physical properties	SF Results	ASTM C1240-06 requirements
Color	Gray	-
Percent retained on 45µm (No.325), maximum.	8.5	≤ 10
Bulk density	550 - 700 kg/m^3	-
Specific surface area, minimum, (m^2/g)	21	> 15
Activity Index with Portland cement at 7 days, minimum % of control	126	> 105

*According to manufacturer (The Chemical Company BASF).

Table (5) Chemical composition of silica fume*

Oxides	Percentage content	ASTM C1240-05 limitation
SiO_2	92.25	≥ 85
Al_2O_3	0.60	—
Fe_2O_3	2.32	—
Na_2O	0.15	—
CaO	0.58	—
MgO	0.3	—
TiO_2	0.01	—
K_2O	1.26	—
P_2O_5	0.10	—
SO_3	0.35	≤ 4
L.O.I	3.82	≤ 6

*Test was carried out by the State Company of Geological Survey and Mining.

Table (6) Details of trial mixes for various dosages of HRWRA.

Mix proportions by weight	Dosage of HRWRA (liter/100kg of cement)	w/c ratio	Slump (mm)	Water reduction (%)	Compressive strength (MPa)	
					14days	28days
1:1.19:1.8 Cement: Sand: Gravel Cement content 525kg/m^3	0	0.41	95	-	26.4	35.06
	0.5	0.30	90	26.8	50.6	60.5
	1	0.25	93	39	57.8	76.6
	1.5	0.23	95	43.9	69.8	84.2
	1.7	0.22	95	46.3	58.4	76.5

Table (7) Details of trial mixes for various dosages of silica fume as a replacement by weight of cement.

Mix proportions by weight	Dosage of HRWRA (liter/100kg of cement)	Silica fume as a replacement by weight of cement	w/c ratio	Slump (mm)	Compressive strength (MPa)	
					14 days	28 days
1:1.19:1.8 Cement: Sand: Gravel Cements content 525kg/m^3	1.5	0	0.23	95	69.8	84.2
	1.5	5	0.20	92	73.8	90.0
	1.5	10	0.22	93	85.2	92.5
	1.5	15	0.23	90	84.0	110.4

Table (8) Some properties of PET plastic waste aggregate concrete.

	Mix symbol	PET plastic waste (%) by volume of natural coarse aggregate	Slump (mm)	Dry density (kg/m^3)	Compressive strength at 28 days (MPa)	Percentage reduction in compressive strength	Total flexural energy at 28 days (N.m)	Percentage increase in total flexural energy
Reference	R	0	90	2418	110.4	-	2.9	-
Concrete containing PET plastic waste aggregate	PET10	10	90	2335	73.9	33.06	10.2	251.7
	PET20	20	91	2290	64.7	41.39	10.8	272.4
	PET30	30	94	2120	34.8	68.47	12.7	337.9
	PET40	40	96	1910	23.0	79.61	13.4	362.1
	PET50	50	97	1850	17.15	84.4	14.9	413.7

Table (9) Effect of PET plastic waste aggregate content on some mechanical properties of concrete.

Mix symbol		PET plastic waste (%) by volume of natural coarse aggregate	Dry density (kg/m3)	Thermal conductivity (W/m.K)	Percentage reduction in thermal conductivity	No of blows		Impact energy at failure(N.m)	Percentage of change in impact energy (%)
						First crack	Failure crack		
Reference	R	0	2418	2.02	-	280	286	5821.1	-
Concrete containing PET plastic waste aggregate	C- PET10	10	2335	1.84	9.8	284	292	5943.2	+ 2.1
	C- PET20	20	2290	1.49	35.5	295	304	6187.5	+ 6.3
	C- PET30	30	2120	1.13	78.8	310	328	6675.9	+ 14.7
	C- PET40	40	1910	1.0	98.0	174	180	3663.6	- 37.1
	C- PET50	50	1850	0.7	188.5	128	136	2768.1	- 52.4

Table (10) Drying shrinkage of concrete containing PET plastic waste aggregate.

Mix symbol		PET plastic waste (%) by volume of natural coarse aggregate	Drying shrinkage ($* 10^{-6}$)				
			7 days	14 days	28 days	56 days	90 days
Reference	R	0	98	160	273	315	328
Concrete containing PET plastic waste	PET10	10	102	182	212	275	336
	PET20	20	105	180	220	290	341
	PET30	30	115	187	234	298	346
	PET40	40	123	186	240	283	332
	PET50	50	131	190	245	277	318

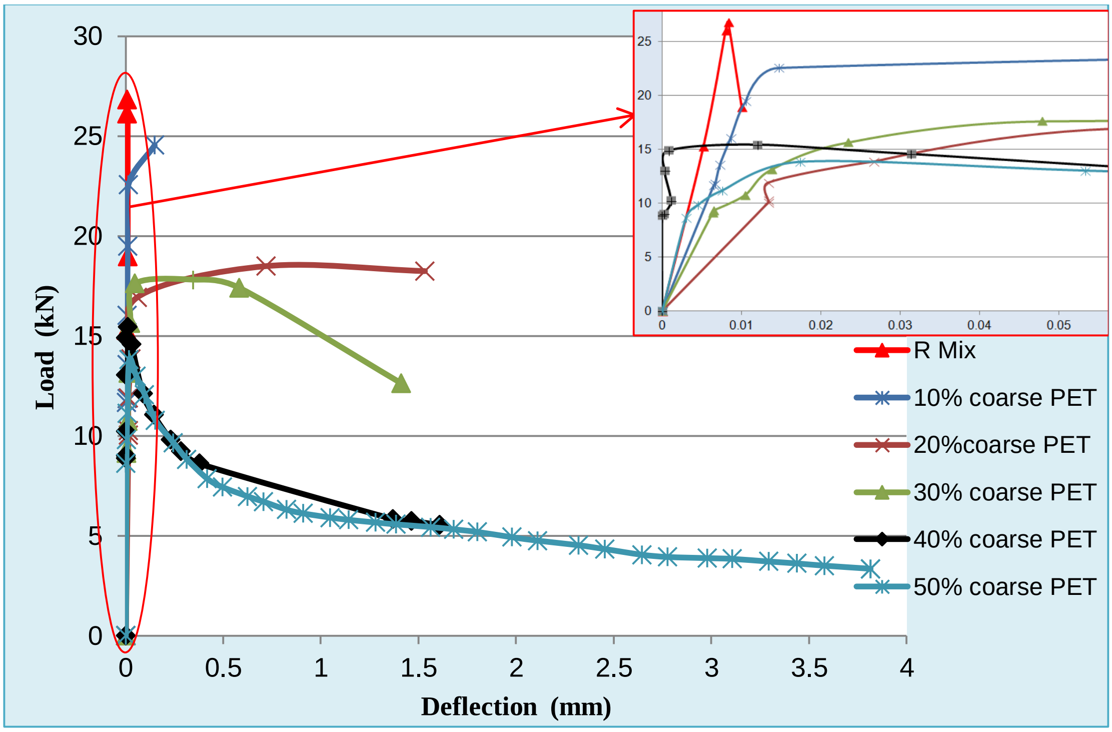

Figure (2) Load-deflection relationship for concrete with PET plastic waste aggregate.

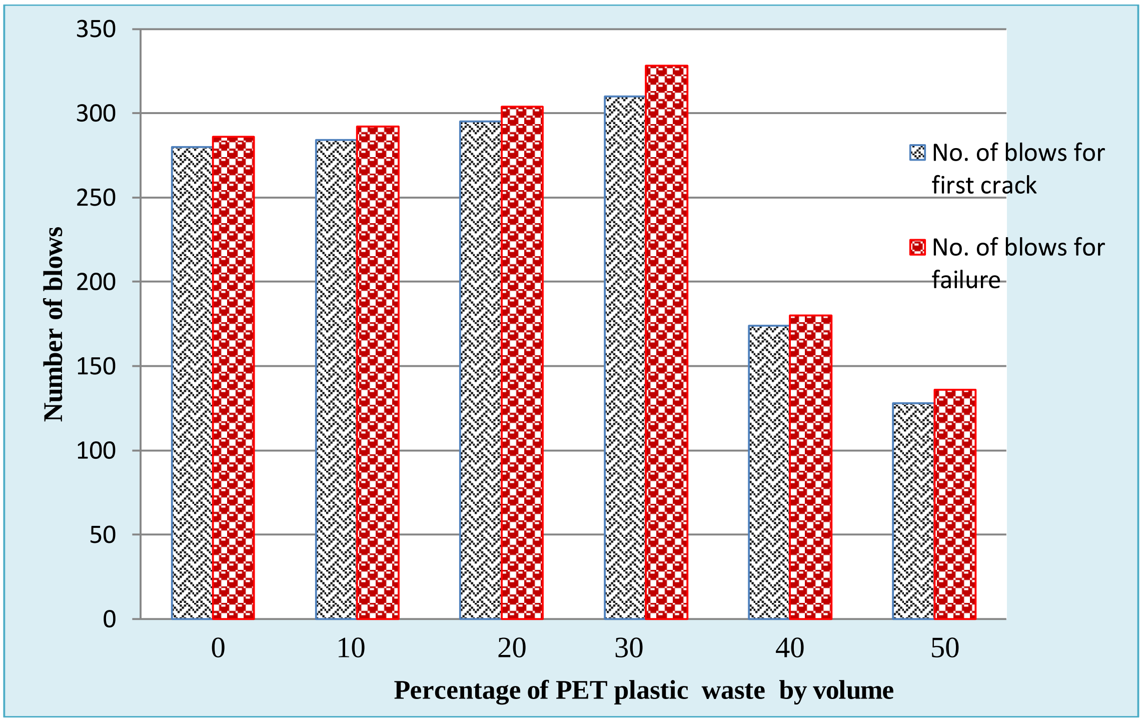

Figure (3) The number of blows for concrete with PET plastic waste aggregate.

(a) Reference mixture (b) PET10 (c) PET20

(d) PET30 (e) PET40 (f) PET50

Figure (4) Typical failure modes of specimens containing varies percentage of PET plastic waste aggregate under impact load.

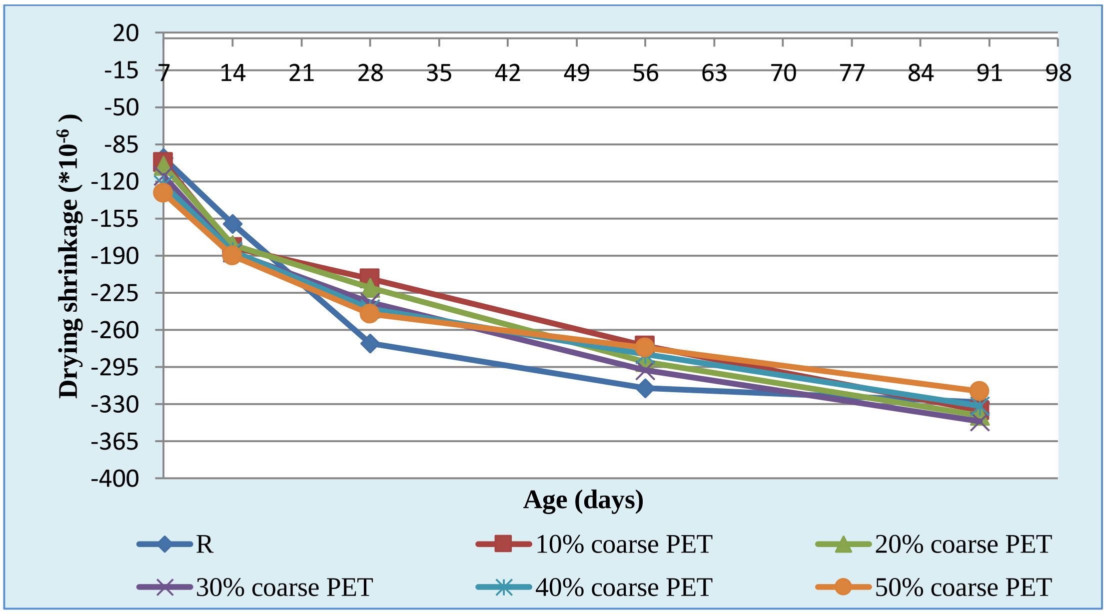

Figure (5) Effect of PET plastic waste aggregate content on drying shrinkage of concrete.

الخرسانة الصديقة للبيئة المحتوية على ركام مخلفات بلاستك ال PET

الخلاصة

الفحوصات المختبرية في هذه الدراسة تركز على دراسة خواص الخرسانة المتضمنة على مخلفات بلاستك البولي اثيلين تيريفثاليت (PET) كبديل حجمي للركام الخشن الطبيعي. تم استخدام نسب مختلفة (10٪، 20٪، 30٪، 40٪، و 50٪) من الركام البلاستيكي الذي تم الحصول عليه من مثروم مخلفات القناني البلاستيكية نوع بولي اثيلين تيريفثاليت كبديل حجمي عن الركام الخشن الطبيعي كذلك تم استخدام أبخرة السليكا المكثفة (Silica Fume) بنسبة استبدال 10% من وزن الاسمنت. تم دراسة خواص الخلطات الخرسانية والمتضمنة على قابلية التشغيل, الكثافة الجافة, مقاومة الأنضغاط, طاقة الانثناءالكلية,معامل الموصلية الحرارية, مقاومة الصدم في عمر 28 يوم وانكماش الجاف في عمر 90 يوم. أظهر استخدام ركام مخلفات البلاستك في الخرسانة مزايا عديدة, واحدة من هذه المزايا هو ان استخدام ركام مخلفات البلاستك يساهم في انتاج الخرسانة خفيفة الوزن اعتماداً على نسبة المخلفات البلاستيكية المستخدمة. كانت الكثافة الجافة للخرسانة المتضمنة على نسبة عالية من مخلفات بلاستك ال PET بمقدار 40% و 50% كتعويض حجمي عن الركام الطبيعي الخشن 1910 و 1850 كغم/ م^3 على التوالي. كذلك فان خواص العزل الحراري للخرسانة المتضمنة على ركام المخلفات البلاستيكية قد تحسنت.