Effect of Crumb Tyres Rubber on Some Properties of Foamed Concrete

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ABSTRACT.

During the last years, several researches have been studying the final disposal of tyres wastes, due to the great volume generated worldwide, as well as the difficulty for discarding the disposal sites which become a serious environmental problem. In spite of this, recycling appears as the best solution for disposing tyres residues, due to its economical and ecological advantages.

This research carried out to assess the feasibility of using crumb rubber (the product of shredding used rubber tyres) as a partial sand replacement in foamed concrete, and investigates the effect of it on some properties of foamed concrete such as, density, water absorption, compressive strength, tensile strength, flexural strength and impact resistance. Crumb rubber of tyres ranging from (0.7 to 5mm) in size was used in this research.

Three proportioned mixes were designed in this research, have the same cement content, water-cement ratio, and foam content. The first mix represents a typical reference formulation of foamed concrete without crumb rubber (FC). In the others mixes (FCR-1 and FCR-2), respectively, 20 and 30% of volume of sand were replaced by crumb tyres rubber waste.

Tests carried out to assess the behaviour of final product. The results obtained were demonstrated decreasing in foamed concrete strength (compressive, tensile, flexural, and impact) with the increasing of crumb tyres rubber content in the mixture and rubberized foamed concrete specimens (FCR-1 and FCR-2) show a cohesive behaviour than the specimens of reference mix (FC), especially in tensile strength. Comparing with the reference mix (FC), at an age of (28 days), the decreasing of compressive strength was (20.85%) for (FCR-1) and it for (FCR-2) was (37.76%).

Keywords: Foamed concrete, Tyre rubber, Waste management, Mechanical properties, Impact resistance

1. INTRODUCTION.

The possibility of making concrete tough has been generally pursued by introducing rubber phases among the traditional components (cement, water, and aggregates) and this idea has been largely investigated using, for this purpose, recycled grinded tyre rubber [1,2]. Different kinds of tyres have been employed as partial substitute of natural aggregates in concrete: scrap tyres obtained by simple grinding without further purification thus including steel and textile fibres in their composition [1,3], crumb rubber obtained by cryogenic process[1], milled tyre rubbers treated with sodium hydroxide solution to achieve a patter adhesion with the cement paste [2] , scrap truck tyre rubber [4], tyres tread [5], etc. However, regardless the different nature size and composition of used tyre rubbers.

During the last years, several researches have been studying the final disposal of elastomeric wastes, due to the great volume generated worldwide, as well as the difficulty for establishing disposal sites which become a serious environmental problem (see **Fig. (1)**). In spite of this, recycling appears as the best solution for disposing elastomeric residues, due to its economical and ecological advantages.

On the other hand, the conception of products for concrete is also increasing, due to the high growth of construction in the past years. Even though concrete based on Portland cement is one of the most extraordinary and versatile elements in construction, there is a need modifying its properties, such as tensile, hardness, ductility and recycling rubber simultaneously is to combine both materials [6].

1.1 Lightweight Concrete.

Lightweight concrete can be produced with an over-dry density range of approximately 300 to a maximum of 2000 kg/m^3, with corresponding cube strengths from approximately 1 to over 60 MPa and thermal conductivities of 0.2 to 1.0 W/mK. These values can be compared with those for normal weight concrete of approximately 2100-2500 kg/m^3, 15 to greater than 100 MPa and 1.6-1.9 W/mK. The principal techniques used for producing lightweight concrete can be summarized as follows [7]:

• Omitting the finer fraction of normal weight aggregate to create air-filled voids using a process pioneered by Wimpey in the UK in 1924 (no-fines concrete).

• Including bubbles of gas in a cement paste or mortar matrix to form a cellular structure containing approximately 30-50 per cent voids (aerated or foamed concrete).

• Replacing, either wholly or partially, natural aggregates in a concrete mix with aggregate containing a large proportion of voids (lightweight aggregate concretes).

These are shown diagrammatically in **Fig. (2).**

This research is concerned mainly with foamed concrete and, in particular, this made with a Portland cement, sand, water and foam. In the other two mixes crumb rubber tyres was added to the raw materials.

1.2 Foamed Concrete.

Foamed concrete is classified as having an air content of more than 25 per cent. The air can be introduced into a mortar or concrete mix using two principal methods. First, a pre-formed foam from a foam generator can be mixed with other constituents in a normal mixer or a ready mixed concrete truck. Second, a synthetic- or protein-based foam-producing admixture can be mixed with the other mix constituents in a high-shear mixer. In both methods the foam must be stable during mixing, transporting, and placing. The resulting bubbles in the hardened concrete should be discrete and usual bubble size is between 0.1 and 1 mm[7]. Typical mixes are given in **Table (1)**.

1.3 Raw Materials and Binders of Tyres.

Tyres look like one simple black mass, but they are actually a complex mixture of various types rubber, carbon black, inorganic materials, organic compounds, and reinforcing wire/fabric in multiple sections of a tyre [9] as shown in the diagram below (**Fig. (3)**).

- **Crumb Rubber and Shredded Products Sizes**

To turn used tyres into useful products, tires are processed into shredded products or crumb rubber, **Table (2)** summarizes representative product sizing of shredded and crumb rubber.

- **Binders**

Tyre chips and crumb rubber can be bound together into a cohesive mass by use of binders under simple cotact mixing or compression molding.

1-4 Recycling Tyres.

Californians generated approximately 33.5 million waste tires in 2002, according to a report by the California Integrated Waste Management Board (CIWMB) entitled California Waste Tire Generation, Markets and Disposal [11]. About three-quarters of California's tires, or 25.1 million tires, were diverted to constructive uses in 2002, but 8.4 million tyres were not. These tires were shredded and disposed of in California's permitted solid waste landfills, stored at permitted sites, or otherwise illegally disposed of around the state. While a majority of tires are reused, a significant amount, one-quarter, are not. New uses must be found the valuable raw materials embodied in whole tires and tire shreds [11].

Civil engineering applications typically use large tire chunks produced by coarsely shredding waste tires at a processing facility or stockpile site. The shreds are used in numerous highway construction applications such as in lightweight fill in highway embankments constructed over unstable solids, in abutment backfill to decrease lateral pressure on containment walls, in a vibration dampening layer under rail tracks, and in thermal insulation under roadways to limit frost penetration. Shreds also serve as leachate drainage layers, gas transmission channels, and daily cover in modern landfills. They have also been used as an alternative septic system drain field aggregate and as a basement foundation backfill providing enhanced drainage and thermal insulation [9]. Tire-derived fuel (TDF), as its name suggest, refers to tires as a supplemental energy resource. Cement Kilns combust whole tires as an alternative to save fossil fuels such as coal, oil, or natural gas. Some power plants use shredded tires as a similar replacement in full compliance with all applicable environmental regulation. Shredded tires used as TDF are typically 1-3 inches in size, with most of the bead wire removed magnetically during processing [9].

2. EXPERIMENTAL WORK.

2.1 Raw Materials Used.

- **Cement**

Cement type I (ordinary Portland cement) it's trade name is Northen Cement was used in this research

- **Fine Sand**

Natural sand from AL- Habaniya region in AL-Anbar Governorate was used with a maximum size (2.38mm) and it conforms to ASTM – Designation : C 144-87 [12].

Table (3) Shows the results of sieve analysis on the sand used.

- **Water**

Ordinary drinking water was used in all mixes.

- **Stable Foam**

It was produced by diluting a foaming agent with water and then mixing this mixture by a blending device (mortar mixer).

TufFlow AEI- foaming agent is the trade name of the liquid material that has been used to produce pre- formed foam for this research .The specific gravity for it is (1.02).

According to ASTM – Designation: C796- 87 [13] the unit weight of foam usually ranges from 32 to 64 kg/m^3 and the foaming solution in the foam will be considered as part of the total mixing water. The quantity of foaming agent required is determined by trial and depends on the type of it, mixing time, mixer efficiency, and the density of concrete desired [14]. From the laboratory work, in order to make one liter foam, (5) ml of chemical foaming agent has been diluted in (50) g of water, Therefore, the unit weight of foam is equal to (55.1) kg/m^3.see **Fig. (4).**

- **Tyres Rubber**

The tyre rubber (TR) aggregates were obtained by hand grinding of tyre rubber waste, therefore they may not contain small amounts of steel but still contain fabric residues. One different grain size distribution [crumb (CT) tyres with size ranges 0.7 to 5 mm] was chosen. This was sorted out to conform to sand grain size distribution, and used without any surface treatment to investigate the effect of untreated tyre particles on final properties of foamed concrete. Shredded rubber tyre (5 to 250 mm) was not used (see **Fig. (5)**). Density of tyres rubber used was (1070 kg/m^3).

2.2 Constituents Proportion.

The mix proportioning begins with the selection of the unit weight of the concrete (wet density) , the cement content, and the water-cement ratio (w/c). Then, the mix is proportioned by the method of absolute volumes.

Foamed Concrete Mixes compositions are reported in **Table (4)**, FC mix is a formulation of foamed concrete with density of (1700 kg/m^3), and water/cement ratio (0.5) [mixing water (165.5 kg/m^3) and water in foam (14.5 kg/m^3)]. The same density and W/C ratio were used in FCR-1 and FCR-2 where respectively 20 and 30 V/V% of sand were replaced by crumb tyre rubber waste, this addition leads to reduce the density of the later two mixes.

2.3 Mixing Procedure.

After the amount of materials required to make the mixes has been worked out, dry constituents (cement and fine sand) were mixed in ordinary mixer for a few minutes, then mixing water was added and through mixing process tyre rubber was added in stages. Pre-formed foam was added to the wet slurry. Mixing is finishing when foam has been completely mixed with the mortar, see **Fig. (6)**. For foamed concrete without tyres rubber, the same procedure was done except the rubber adding.

2.4 Preparation of Samples.

The procedure of preparation of samples in this study was done conforming with ASTM – Designation: C 192- 88[15].

In molding the specimens, the foamed concrete mix was placed in two approximately equal layers. The sides of the molds were lightly tapped after placing each layer until the surface of the layer has subsided approximately to plane. Foamed concrete mix should not be rodded. see **Fig. (7)**.

After filling the molds, the surfaces of the specimens were planed by using a trowel.
All specimens were removed from molds within 24 hours after molding.

After the test specimens were removed from the molds they have been stored in water for the test day. The temperature of the water in which the specimens were submerged was of 23 ± 2°c.

It should be noted that the distribution of crumb tyres rubber in all specimens for rubberized foamed concrete was uniform as it is evident in **Fig. (8)**. A uniformly distribution of particles of crumb rubber of tyres in all specimens, was achieved during casting.

2.5 Tests.

2.5.1 Density.

For all test specimens, density was found by weighing the specimen before test and dividing the weight by the measured volume of the specimen.

2.5.2 Compressive Strength.

The compressive strength test was carried out on cube specimens [100mm×100mm×100]mm, at an age of (7,21,28) days.
The test was run in conformity with provisions of ASTM – Designation: C513-89 [16]. See **Fig. (9).**

2.5.3 Splitting Tensile Strength.

The splitting tensile strength was carried out on cylindrical specimens [100mm×200mm], at an age of (7,21,28) days. This test was done according to ASTM- Designation: C496-86 [17]. See **Fig. (9).**

Splitting tensile strength (Fsp) of the test specimens has been calculated as follows:

$$F_{sp} = \frac{2P}{\pi L d} \qquad (1)$$

Where:
Fsp: splitting tensile strength (MPa)
P: maximum applied load indicated by the testing machine (N)
L: length of specimen (mm)
d: diameter of specimen (mm)

2.5.4 Flexural Strength.

The flexural strength test was done according to ASTM- Designation : C 78 – 84 [18]. The flexural strength test was carried out on prism [100mm×100mm×500mm], at an age of (7, 21, 28) days. See **Fig. (9).**

Because, the fracture initiates in the tension surface within the middle third of the span length for all specimens, the modulus of rupture is calculated as follows:

$$F_r = \frac{PL}{bd^2} \qquad (2)$$

Where:
Fr: modulus of rupture (MPa)
P: maximum applied load indicated by the testing machine (N)
L: span length (mm)
b: average width of specimen (mm)
d: average depth of specimen (mm).

2.5.5 Water Absorption.

The percentage of water absorption of hardened specimens was determined as prescribed in ASTM – Designation: C 796 – 87a [13].

For all mixes , water absorption test was carried out on cubes specimens [100 mm ×100 mm×100 mm], at an age of (7,21,28)days.

The percentage of water absorption is calculated as follows:

$$Absorption(\%) = \frac{w_w - w_d}{w_d} \times 100 \qquad (3)$$

Where:
Wd: weight of oven-dry specimen (kg).
Ww: weight of wet specimen (kg).

2.5.6 Impact Resistance.

This test was carried out on prisms (100×100×500mm) at an age of 28 days.The beams were demolded after 24 hours and cured in water for the test day.

The procedure of test was used to investigate three variables;
1) Masses of 1.0 and 1.4 kg was used.
2) The potential energy was kept constant by dropping the 1.0 kg mass through 1.4m and the 1.4kg mass through 1m.
3) Supporting span lengths of 400mm was used.

The above variables are illustrated in **Fig. (10).**

In all tests the same mass was dropped repeatedly through the same height until complete failure occurred.

The bottom of each impacting mass (striker) is rounded in order to create a line contact with the test specimen. See **Fig. (11).**

3. RESULTS AND DISCUSSION.

3.1 Density.

Table(5) shows the average air-dry densities for all specimens used to determine the compressive, splitting tensile, and flexural strength at the age of (7,21,28) days.

A partial sand Replacement in foamed concrete by crumb tyres rubber leads to reduce the density of the final product, because of the specific gravity of rubber used was less than it of sand.

3.2 Compressive Strength.

The compressive strength was found by dividing the maximum load (N) by the cross sectional area (mm2). Three Specimens were tested at each selected age, the results are averaged and summarized in **Table (5)**.

For all mixes, the relationships between the compressive strength and the age are shown in **Fig. (12)**, this Figure illustrates that the compressive strength increases with time for all selected mixes and it decreases with increasing in crumb rubber of tyre amount. **Fig. (13)** shows the relation between the compressive strength for the three selected mixes and the age of test.

For mix (FCR-1) the decreasing of 28-day strength (%) of 28-day value of mix (FC) was (20.85%), while for mix (FCR-2), it was (37.76%).

3.3 Splitting Tensile Strength.

For the three mixes, two specimens were tested at each selected age, the results are averaged and summarized in **Table (6)**.

Fig. (14) shows the relationships between Fsp and age of the test for all selected mixes.

It should be noted that for foamed concrete (FC), after testing, specimens were split into two halves, while for rubberized foamed concrete (FCR-1 and FCR-2), specimens appear cohesive behavior and still without splitting after testing.

3.4 Flexural Strength (Modulus of Rupture).

Two test specimens were used for flexural strength test using the simple beam with third-point loading.

Table (7) shows the results of flexural strength test of the three selected mixes at each age of test. **Fig. (15)** shows the development of Fr with time for all selected mixes. It can be seen that the higher amount of crumb rubber of tyres would decrease the flexural strength.

3.5 water Absorption.

Two rest specimens have been used to determine the water absorption (%) for each selected age. Results are averaged and summarized in **Table (8). Fig.(16)** shows the relationships between water absorption (%) of the selected mixes and the age of test, it can be seen that water absorption decreases with age for selected mixes.

3.6 Impact Test.

Two test specimens were used for impact test at an age of 28 days. **Table (10)** shows the results of impact test for the three selected mixes.

The impact resistance of the beams was determined in terms of the number of blows required to cause complete failure of the specimens.

The energy produced by each blow is given by the product of drop-height and weight and hence the results can be converted readily into energy values (Nm). In **Table (10)**, the mean values of the numbers of blows multiplied by the impact energy per blow (13.734 Nm) have been used to determine the total fracture energy (Nm) for the two mass/ drop-height combinations.

These results show that there is a mass effect in the values obtained in this test. The largest consumption of energy during fracture is obtained for the smallest mass (1 kg) and the least consumption of energy during fracture is obtained for the largest mass (1.4 kg). it can be calculated that the largest mass raveling at the least velocity at impact, has the greatest effect in transmitting the impacting energy into the test specimen.

Table (10) also shows the effect of the addition of crumb rubber of tyres on the impact resistance of the three selected mixes specimens, it illustrated that there is no large difference in number of blows that cause specimen failure of the three selected mixes, and the total energy was decreasing with increase crumb rubber of tyers content.

4. CONCLUSIONS.

According to the experimental work and from the analysis of results obtained, the following conclusions can be drawn

1- A partial sand Replacement in foamed concrete by crumb tyres rubber leads to reduce the density of the final product, because of the specific gravity of rubber used was less than it of sand.
2- Water absorption (%) increases with increasing of crumb rubber of tyres content.
3- Decreasing in rubberized foamed concrete strength (compressive, tensile, flexural, and impact) with the increasing of crumb rubber of tyres content in the mixture was always detected.

4- Rubberized foamed concrete (FCR-1 and FCR-2) show a cohesive behavior at failure than foamed concrete (FC), and this is obviously appear in splitting tensile test.
5- Addition of rubber cause deceasing in foamed concrete strength, in spite of this, in many applications high strength concrete is not essential, therefore, recycling the waste of tyres rubber by using it in foamed concrete that used for non-structural purposes will achieve economical and ecological advantages.

5. REFERENCES.

[1] N. N. Eldin, A. B. Senouci, " Rubber-tire particles as concrete aggregate", J. Mater, Civ. Eng. 5 (4), pp. 478-496, 1993.
[2] N. Segre, I. Joekes, " Use of tire rubber particles as addition to cement paste", Cem. Cnocr. Res. 30 (9), pp. 1421-1425, 2000.
[3] Z. K. Khatib. F. M. Bayomy, " Rubberized Portland cement concrete", J. Mater. Civ. Eng. 11 (3), pp. 206-213, 1999.
[4] N. I. Fattuhi, L. A. Clark, "Cement based materials containing shredded scrap truck tyre rubber", Constr. Build. Mater, 10 (4), pp. 229-236, 1996.
[5] I. B. Topcu, "The properties of rubberised concretes", Cem. Concr. Res. 25(2), pp. 304-310, 1995.
[6] C. Albano, N. Camach, and others, "Influence of scrap rubber addition to Portland I concrete composites: Destructive and non-destructive testing", Composite Structures 71, pp. 439-446, 2005.
[7] J. Newman, B. S. Choo, "Advances concrete technology, Processes", Part2. 2/3-2/8.
[8] Cox. L., Van Dijk S., "Foam concrete: a different kind of mix, Concrete", 36, No. Feb. pp. 54-55, 2002.
[9] C. Hammer, T. A. Gray, "Designing building products made with recycled tires", California Integrated Waste Management Board. Jun, 2004.
[10] Dr. Krishna C. Baranwal, "Akron Rubber Development Laboratory", ASTM Standards and Testing of Recycle Rubber, paper presented at Rubber Division Meeting of the American Chemical Society, San Francisco, Calif., April 29, 2003.
[11] California Waste Tire generation, "Markets and Desposal", 2002 Staff Report, California Integrated Waste Management Board, Sacramento, Calif., p.7, 2003.
[12] ASTM Committee, C-144, "Standard Specification for Aggregate for Masonry Mortar", 1987.
[13] ASTM Committee, C-796, "Standard Test Method for Foaming Agents for use in Producing Cellular Concrete Using Preformed Foam", 1987.
[14] ACI Committee 523, 1986, "Guide for Cellular Concretes above 50 pcf, with compressive strengths less than 2500 psi", ACI 523-86, Revised 1982 Reapproved 1987.
[15] ASTM Committee, C-192, "Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory", 1988.
[16] ASTM Committee, C-513, "Standard Test Method for Obtaining and Testing Specimens of Hardened Lightweight Insulating Concrete for Compressive Strength", 1989.
[17] ASTM Committee, C-496, "Standard Test Method for Splitting Tensile Strength of Cylindrical Specimens", 1986.
[18] ASTM Committee, C-78, "Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third- Point Loading)", 1975.

Table (1): Typical foamed concrete mixes[8].

Constituents	Proportions				
Wet density (kg/m^3)	500	525	600	1200	1200
Cement content (kg/m^3)	160	340	340	340	340
Foam volume (%)	72	73	69	44	39
Filler type	PFA	-	Sand	Sand	PFA
Filler content (kg/m^3)	160	0	66	635	486
Cube strength at 28 days (MPa)	1.0	2.0	2.0	6.0	7.5
Cube strength at 91 days (MPa)	1.4	2.2	2.2	7.0	10.0

Table (2): Product sizing of shredded and crumb rubber[9].

	Product	Size	Applications
Shredded Products	Coarse	5–10"	Civil Engineering (CE)
	Nominal 2"	2–3"	Tire Derived Fuel (TDF), CE
	Nominal 1"	<2"	TDF, CE
Crumb Rubber	**Product**	**Size**	**Applications**
	Particles	3/8–1/4"	Mulch, playground
	Coarse	1/5–1/10"	Sports Surfaces
	Medium	1/10–1/30"	Rubber Modified Asphalt, Molding
	Fine	1/40"	Rubber Modified Asphalt, Molding

Table (3): Recommended natural sand gradation and the results of sieve analysis of sand.

Sieve Size	Recommended Sand Gradation %Passing	Sand Used % Passing
4.75 mm	100	100
2.36 mm	95 to 100	97.1
1.18 mm	70 to 100	84.3
600 micron	40 to 75	62
300 micron	10 to 35	29
150 micron	2 to 15	11.5

Table (4): Constituents proportion of the mixes.

Constituents \ Mixes	FC	FCR-1	FCR-2
Tyre rubber (V/V% of sand)	0	20	30
W/C ratio	0.45	0.45	0.45
Cement (kg/m^3)	400	400	400
Sand (kg/m^3)	1120	896	784
Water (gross) (kg/m^3)	180	180	180
Foam (L/m^3)	289	289	289
Crumb Tyre rubber (TR) (kg/m^3)	-	89.4	134.2

Table (5): Results of compressive strength test for the selected mixes**.**

Mix	FC			FCR1			FCR2		
Age (days)	7	21	28	7	21	28	7	21	28
Average Density(Kg/m^3)	1702	1710	1715	1585	1595	1605	1515	1524	1529
Compressive Strength (MPa)	10.08	15.56	17.21	7.75	10.83	13.62	5.38	8.67	10.71

Table (6): Results of splitting tensile strength test for the selected mixes.

Mix	FC			FCR1			FCR2		
Age (days)	7	21	28	7	21	28	7	21	28
Average Density(Kg/m^3)	1705	1715	1727	1578	1588	1591	1512	1519	1526
Splitting Tensile Strength (MPa)	1.12	1.38	1.55	0.89	1.11	1.21	0.62	0.78	0.83

Table (7): Results of flexural strength test for the selected mixes.

Mix	FC			FCR1			FCR2		
Age (days)	7	21	28	7	21	28	7	21	28
Average Density(Kg/m^3)	1710	1716	1720	1584	1589	1592	1512	1517	1519
Flexural Strength (MPa)	2.24	3.21	3.42	1.80	2.03	2.23	1.27	1.59	1.78

Table (8): Results of water absorption test for the selected mixes.

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Mix	FC			FCR1			FCR2		
Age (days)	7	21	28	7	21	28	7	21	28
Water Absorption (%)	18.28	13.89	12.01	20.60	14.62	13.25	21.25	16.06	14.67

Table (9): Results of impact test for the selected mixes.

Mass (M) and drop-height (H) details	Mix	No. of blows to failure (Mean)	Total energy (Nm)
M=1.4 kg H=1 m	FC	5.5	75.537
	FCR1	5.0	68.67
	FCR2	4.0	54.936
M=1 Kg H=1.4 m	FC	6.0	82.404
	FCR1	5.5	75.537
	FCR2	4.5	61.803

Figure (1): Sites of scrap tyers near houses.

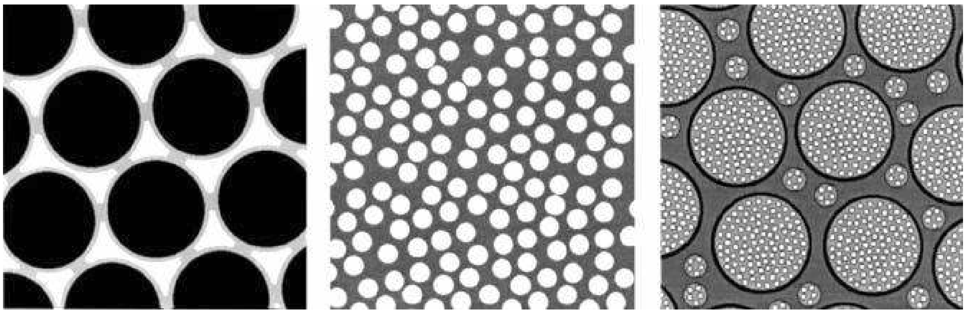

Figure (2): Basic forms of lightweight concrete.

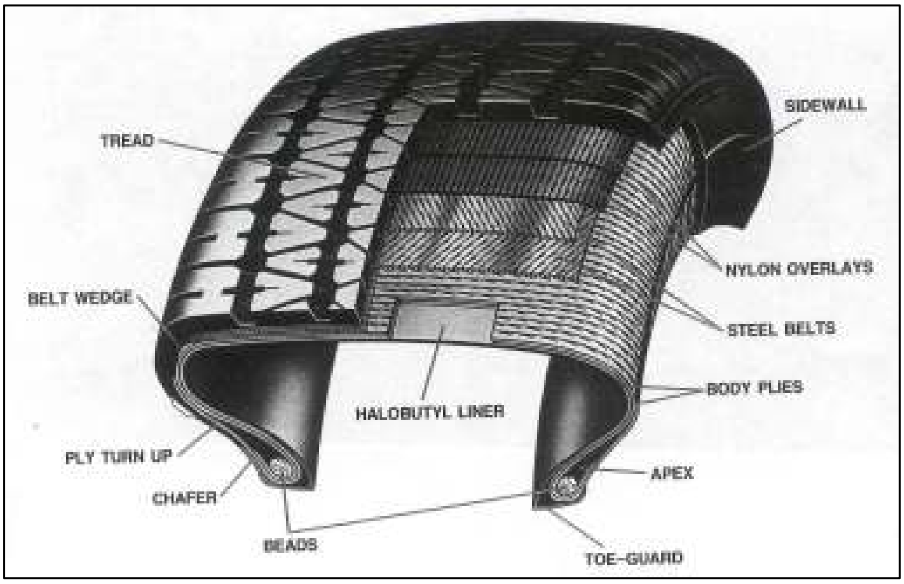

Figure (3): Sections of a tyre[10].

Figure (4): Foam that produced in laboratory for this research.

Figure (5): Crumb Rubber Tyre Used.

Figure (6): Mix appearance through mixing process.

Figure (7): Some of specimens after casting.

Figure (8): Crumb rubber distribution through specimens.

Figure (9): Specimens inside the testing machine during test.

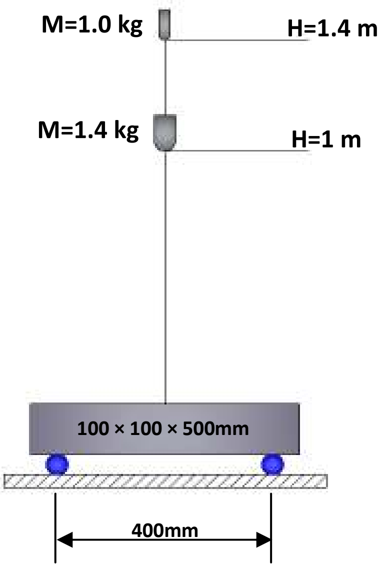

Figure (10): Variables used in the impact test.

Figure (11): Impact apparatus and specimen during test.

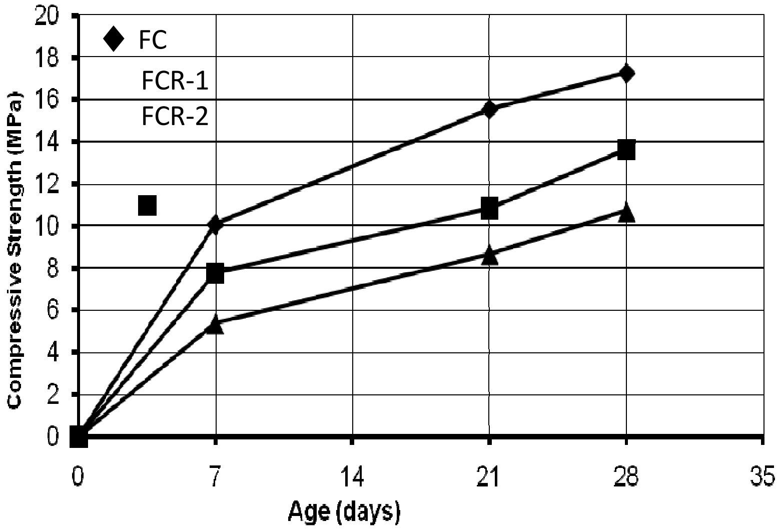

Figure (12): The relationships between the compressive strength and age.

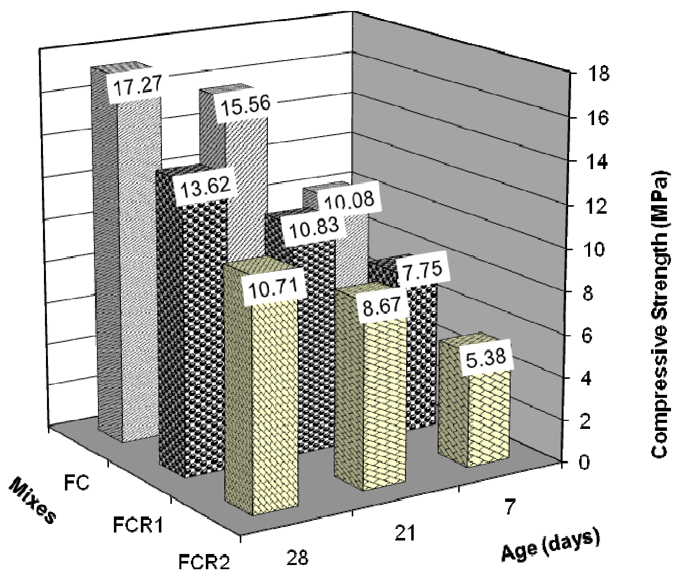

Figure (13): The relation between the compressive strength for the three selected mixes and age.

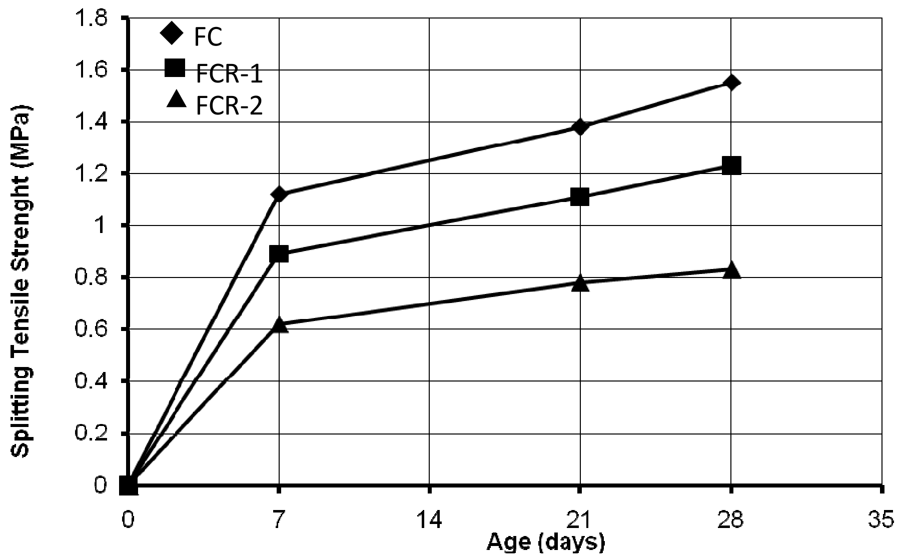

Figure (14): The relationships between Fsp and age of the test for all selected mixes.

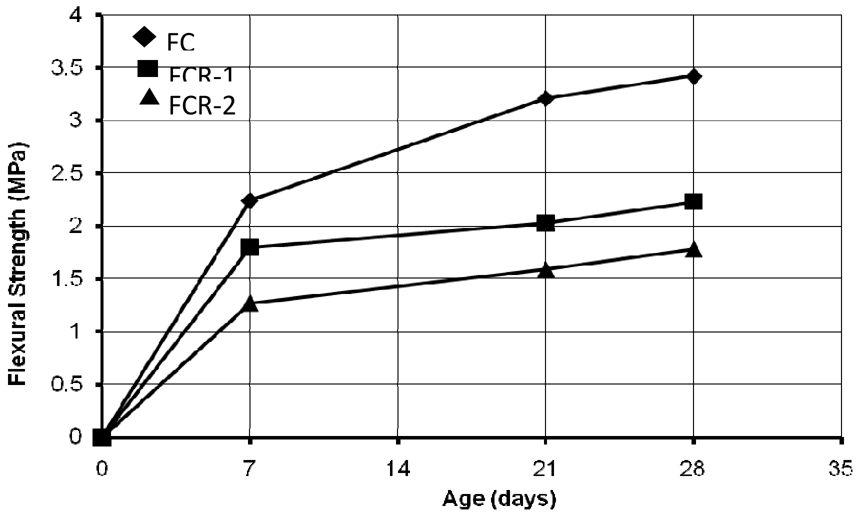

Figure (15): The relationships between flexural strength and age of the test for all selected mixes.

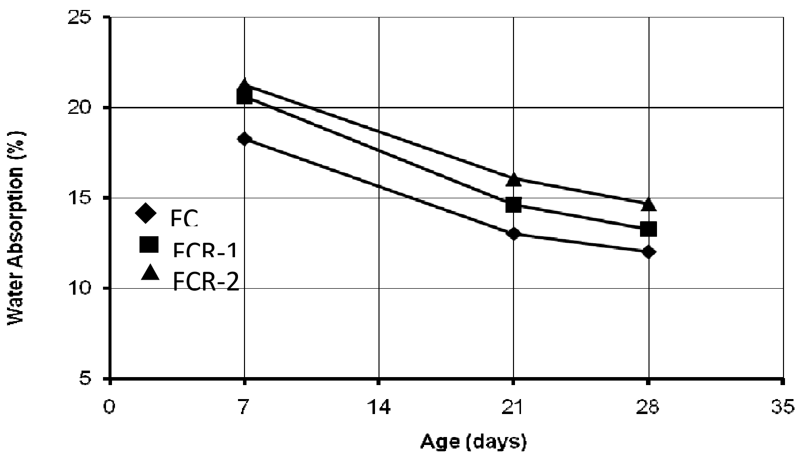

Figure (16): The relationships between water absorption (%) of the selected mixes and the age of test.

تأثير فتات مطاط الإطارات على بعض خصائص الخرسانة الرغوية

أمير عبد الرحمن هلال
مدرس في قسم الهندسة المدنية
كلية الهندسة/ جامعة الانبار

الخلاصـة.

الميكانيكية، مقاومة الصدم خلال السنوات السابقة، درست العديد من البحوث فضلات الإطارات القابلة للطرح، وبسبب الكميات الكبيرة لتلك الفضلات وصعوبة التخلص من مواقعها، أصبحت هنالك مشكلة بيئية جدية. على الرغم من ذلك ظهرت عملية إعادة أستخدام تلك الفضلات كحل امثل للتخلص منها بالإضافة إلى تحقيق فوائد اقتصادية وبيئية

اجري البحث لغرضت تقييم عملية استخدام فتات المطاط (ناتج تقطيع الإطارات المطاطية) كبديل عن جزء من الرمل في الخرسانة الرغوية والتحري عن تأثير إضافته على بعض خواص الخرسانة الرغوية مثل الكثافة، امتصاص الماء، مقاومة الانضغاط، مقاومة الشد، مقاومة الانثناء ومقاومة الصدم.

تضمن الجزء العملي استخدام فتات مطاط الإطارات بحجم من (0.7 ملم) إلى _5 ملم).

في هذا البحث تم تصميم ثلاث خلطات تمتلك نفس محتوى الاسمنت، نسبة الماء إلى الاسمنت و محتوى الرغاوي. الخلطة الأولى(FC) تمثل الخلطة المرجعية وكانت مكوناتها لا تحتوي على فتات الإطارات بينما تم في الخلطات (FCR-1 وFCR-2) استبدال 20 و 30 % من حجم الرمل بفتات فضلات الإطارات المطاطية.

أجريت عدد من الفحوصات على الناتج النهائي وقد أظهرت النتائج المستحصلة من العمل المختبري بان مقاومة الخرسانة الرغوية سواء كانت مقاومة (انضغاط، شد، انثناء، صدم) تقل مع زيادة محتوى فتات مطاط الإطارات وان عينات الخلطات الحاوية على الفتات قد أظهرت تماسكا عند الفشل بخلاف عينات الخلطة المرجعية خصوصا في فحص الشد. كان مقدار النقصان في مقاومة الانضغاط بعمر (28 يوم) للخلطة (FCR-1) عن الخلطة المرجعية (FC) (20.85%) بينما كان مقدار النقصان بمقاومة الانضغاط لنفس العمر للخلطة (FCR-2) عن الخلطة المرجعية (37.76%).

كلمات رئيسية: الخرسانة الرغوية، مطاط الإطارات، إدارة الفضلات، الخواص.