Effect Of Rubber Treatment On Compressive Strength And Thermal Conductivity Of Modified Rubberized Concrete

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Abstract.

Waste tires have been studied widely for the last twenty years on several applications such as asphalt pavements, water proofing systems and concrete pedestrian block etc. There are several properties of the rubber could be used usefully in this application such as low density and water proofing property etc. On the other hand any undesirable changes in the properties of the material resulted from adding the rubber particles could be improved effectively by a certain way.

The main aim here is to study the compressive strength and thermal conductivity of the rubberized concrete compared with the traditional one and how it affected by using a coupling agent such as SILAN which is used currently in the present study to treat the particles of rubber.

Three patches were prepared. Each one consists of three cubic specimens (15x15x15)cm and two disc specimens (5x1)cm. The first patch was the control concrete, the second was the rubberized concrete, in this one 15% the volume of gravel were replaced by waste tires particles and the third was the modified rubberized concrete in this patch rubber particles were treated with SILAN of 0.1% of water as a coupling agent.

Compressive strength and thermal conductivity tests were conducted for the three patches. The overall results show that the adding of rubber particles to the concrete to obtain a lightweight one cause a reduction in the compressive strength by about 49.8% from traditional concrete, so to improve this property the SILAN used as a coupling agent to treat the surface of rubber particles and it was found to be very effective in improving the compressive strength so that this strength reduced by about 12.9% from traditional concrete. Also, the added rubber particles decreased the thermal conductivity of the rubberized concrete by about 26.7% from traditional concrete while when rubber particles treated with SILAN, thermal conductivity increased by about 17.8% from traditional concrete.

Keywords: rubberized concrete, modified, Silane, coupling agent, thermal conductivity, rubber treatment, rubber particles.

الخلاصة

لقد تم دراسة مخلفات الاطارات المطاطية في السنوات الاخيرة بشكل واسع لاستخدامها في الكثير من التطبيقات مثل الارصفة الاسفلتية, الانظمة المانعة لتسرب المياه والبلوكات الخرسانية المستخدمة للارصفة الخ. هناك الكثير من خواص المطاط ممكن استخدامها بشكل مفيد في هذه التطبيقات مثل الكثافة الواطئة وخاصية الحماية ضد تسرب المياه. من ناحية اخرى اي تغيير غير مرغوب به في خواص المادة نتيجة اضافة جزيئات المطاط ممكن اعادة تحسينها وبشكل فعال بطرق معينة.

الهدف الاساسي هنا هو لدراسة مقاومة الانضغاط والموصلية الحرارية للخرسانة المطاطية مقارنة بالخرسانة الاعتيادية وكيف تتاثر هذه الخواص باستخدام مادة مثل السيلان المستخدم في هذا البحث لمعالجة المطاط.

تم اعداد ثلاث خلطات خرسانية كل خلطة تتكون من ثلاث مكعبات بابعاد (15*15*15) سم وقرصين ذات سمك قليل بابعاد (5*1) سم. الخلطة الاولى خرسانة اعتيادية و الخلطة الثانية خرسانة مطاطية تم فيها استبدال نسبة 15%من الركام الخشن بجزيئات المطاط اما الخلطة الاخيرة فقد تم فيها معالجة سطح المطاط بمادة السيلان بنسبة 0.1% من الماء كمادة تزيد من قوة الترابط بين جزيئات المطاط والخرسانة.

تم اجراء فحص الانضغاط و الموصلية الحرارية للخلطات الثلاثة حيث اظهرت النتائج بان اضافة جزيئات المطاط الى الخرسانة لتكوين خرسانة خفيفة الوزن قد ادى الى تناقص مقاومة الانظغاط بمقدار 49,8% عن الخرسانة العادية ولتحسين هذه الخاصية تم استخدام مادة السيلان لمعالجة سطح المطاط ولقد وجد ان استخدام هذه المادة له تاثير كبير في تحسين مقاومة الانظغاط للخرسانة المطاطية المعدلة بحيث ان هذه المقاومة قد تناقصت بنسبة 12.9% عن الخرسانة الاعتيادية. كذلك ان اضافة جزيئات المطاط يقلل من الموصلية الحرارة بمقدار26.7% عن الخرسانة الاعتيادية بينما عند معالجة جزيئات بمادة السيلان فان الموصلية الحرارية سوف تزداد بمقدار 17.8% عن الخرسانة الاعتيادية.

Notation.

I: is the current of the devise in Ampere = 0.4 A

V: is the supplied voltage in Volt = 6 V

r: is the radius of the concrete specimen in Meter = 0.025 m

e: is the taken thermal energy (Wate/m^2.kel)

T_A, T_B, T_C: are the temperature at position A, B and C in Kelvin

d_S: is the thickness of the specimen in Meter = 0.01m

d_A, d_B, d_C: are the thickness of the test disks =12.25x10^{-3}m

k: is the thermal conductivity in (wate/m.kel)

1. Introduction.

Decomposing of the waste tires is one of the most important issues around the world. There are many methods to recycle wasted tires, one method is to grind them into small particles in different sizes and reuse it in a variety of rubber and plastic products, thermal incineration of worn-out tires for the production of steam or electricity, and use of tire rubber in asphalt mixes.

Many problems appeared with the using of these particles in asphalt concrete, included high cost and the fact that the pavements with these particles are themselves recycled[1]. Because of these problems, more attention has been paid to use waste rubber particles in Portland cement concrete as waste aggregate with a portion of aggregate replaced by waste tire particles and called rubberized concrete.

Topcu[2] investigated the effect of particle size and content of tire rubbers on the mechanical properties of concrete. He found that, although the strength was reduced, the plastic capacity was enhanced significantly. Khatib and Bayomy[3] used fine crumb rubber and tire chips to replace a portion of fine or coarse aggregates. They found that the rubber-filled concrete showed a systematic reduction in strength while its toughness was enhanced. Güneyisi et al.[4] worked to develop information about the mechanical properties of rubberized concretes with and without silica fume. They were used crumb rubber and tire chips as fine and coarse aggregate. Test results indicated that there was a large reduction in the strength and modulus values with the increase in rubber content. However, the addition of silica fume into the matrix improved the mechanical properties of the rubberized concretes and diminished the rate of strength loss. Piti and Chalermphol[5] investigated the properties of concrete pedestrian block mixed with crumb rubber. They found that the skid resistance of the block increase with the increasing of rubber content. However, the crumb rubber concrete block performed poorer that plain concrete block in terms of abrasion resistance. Mehmet et. al.[6] examined the interfacial transition zone (ITZ) microstructure of rubber reinforced concrete. They found that the ITZ characteristic of rubberized concrete is poor than the traditional concrete and that the cause of decreasing in strength. Segre and Joekes[7] used saturated NaOH solution to treat waste tire rubber powders. They found that NaOH surface treatment increased rubber-cement paste interfacial bonding strength. Hernandez Olivares et al.[8] used crumbed waste tire fibers and short polypropylene fibers to modify concrete. They concluded that the strength and stiffness of the modified concrete were not reduced significantly.

From previous researches the rubberized concrete results show the following (1)High toughness and ductility and less unit weight compared with the regular concrete, which makes it suitable for many applications (2)The compressive, split, tensile and bending strength are usually lower than the strength of regular concrete.

2. Experimental Procedure.

In the experiments, three concrete batches were prepared. One batch was made without waste tires to be the control (CC) while the second batch prepared using untreated waste tires particles called rubberized concrete (RC) and the last one was with treated waste tires particles called modified rubberized concrete (MRC).

Ordinary Portland cement type I, coarse aggregate with maximum size of 10mm crushed gravel and fine aggregate of river sand were used to prepare the control concrete batch (CC). The mix ratio by weight of control concrete was: cement: sand: gravel: water 1: 1.5: 3: 0.45. The waste tires particles were cut by hand with maximum size of 10mm, Fig.(1) and saturated in NaOH solution to clean it, Fig.(2), (3). This cleaning method increased surface bonding between rubber particles and concrete and resulted in a simple improvement in strength of rubberized concrete[7]. The bulk specific gravity of waste tire was calculated and found to be 557 Kg/m^3.

Fig.(1)Waste Tires Particles

Fig.(2)Washing The Tire Particles

Fig.(3) Tire Particles Saturated in NaOH

In rubberized concrete batch (RC), 15% of the volume of gravel was replaced by waste tires particles, this value was chosen according to the experiments that have been conducted by Gregory[9] it was found that if the rubber ratio greater than 20% was used, the strength and toughness of the concrete would be so low that the material would not be usable. On the other hand, if less than 10% was used it would not be economically viable, so that the mix ratio by weight of rubberized concrete was: cement: sand: gravel: rubber: water 1: 1.5: 2.526: 0.15: 0.45.

The same ratio of rubber particles (15% of the volume of coarse aggregate) was used to prepare modified rubberized concrete (MRC) except these rubber particles were pretreated by SILAN as a coupling agent of 0.1% of the water used in this batch.

Sand content, cement content, water/cement ratio and aggregate volume were kept constant in all mixtures. Five specimens were used for each batch, three were (15x15x15)cm to test the compressive strength, and two were discs (5x1)cm to test thermal conductivity of concrete. The materials used for each batch per 1m^3 are in Table(1) as follows:

Table (1) Main Compound of CC, RC, MRC batch (kg/1m^3)

	CC	RC	MRC
Gravel	**1188**	**1010**	**1010**
Sand	**594**	**594**	**594**
Cement	**396**	**396**	**396**
Water	**178.24L**	**178.24L**	**178.24L**
Rubber	_	**58.4**	**58.4**
Silane	_	_	**0.1782**

2.1 Compressive Strength.10

Test results of each batch for compressive strength of 28 days are listed in Table (2).

Table (2) Compressive Strength of the Samples

	Compressive	Average
Control concrete CC1	**35.5**	**34.1**
Control concrete CC2	**33.36**	
Control concrete CC3	**33.36**	
Rubberized Concrete	**16.55**	**17.125**
Rubberized Concrete	**17.7**	
Modified Rubberized	**28.1**	**29.7**
Modified Rubberized	**32.17**	
Modified Rubberized	**28.87**	

2.2 Thermal Conductivity.

Thermal properties have been very important in many concrete applications as an in the concrete of certain buildings, so that according to the well known of this properties a conditioner systems can be done correctly. When a temperature gradient exists, experience has shown that there is an energy transfer from the high temperature region to the low temperature region. It can be said that the energy is transferred by conduction and that the heat-transfer rate per unit area is proportional to the normal temperature gradient. In the present study thermal conductivity symboled by (k) has been determined because of the impotency of this property to know the amount of the heat released from massive concrete and to know the characteristics of concrete walls about transferring the heat energy and heat

keeping. Thermal conductivity (k) can be defined as the heat energy transferred through unit length of the material when there is a temperature gradient of one unit.
The test of thermal conductivity was carried out in AL.TECHNOLOGY UNIVERSITY using the devise shown in Fig.(4) which is called Lee's Disc devise. To determine the thermal conductivity (k) for each specimen, some parameters are measured and used in certain equations. This devise consists of three metallic discs A,B and C one beside another and there is a heater between disc B and C connected with electrical source to cause a heat gradients and the disc concrete specimen positioned between disc A and B so that the temperatures measured in three positions at these discs position A, B and C. The test continued until reach the thermal equilibrium. These three temperatures with the devise constants represented by the current (I) equals to (0.4) Ampere and the supplied voltage (V) equals to (6) Volt used here to determine the thermal conductivity (k).

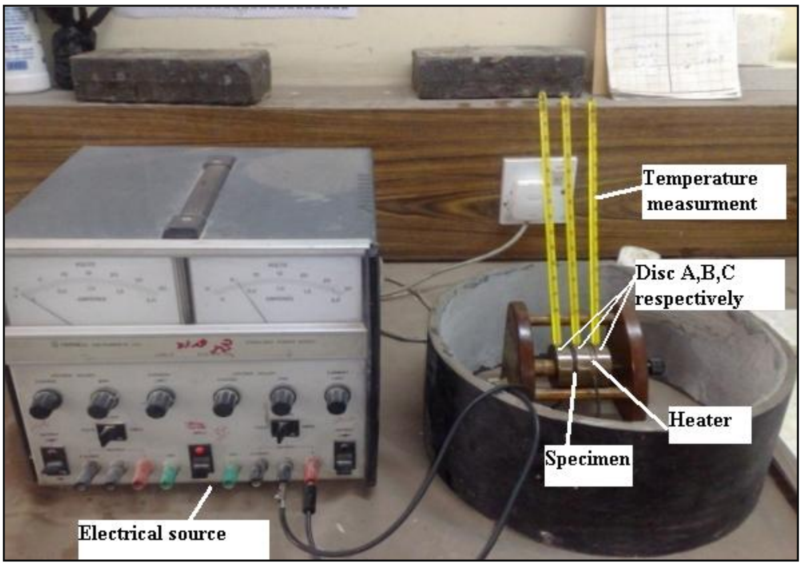

Fig. (4) Lee's Disk Devise

The test results of Lee's Disk are listed in Table (3).

Table (3) The Average Temperature of the Two Specimens in Position A, B and C

	T_A C°	T_B C°	T_C C°
CC	28	35	35
RC	28.5	38	38
MRC	29.8	36.3	36.6

to find the parameter (k) in (wate/m.kel) is as follows:

$$IV = \pi r^2 e (T_A + T_B) + 2\pi r e[d_A T_A + \frac{d_S}{2}(T_A + T_B) + d_B T_B + d_C T_C] \ldots\ldots\ldots\ldots(1)$$

Where
I: is the current of the devise in Ampere = 0.4 A..…………………..(constant)
V: is the supplied voltage in Volt = 6 V…………………………(constant)
r: is the radius of the concrete specimen in Meter = 0.025 m………(constant)
e: is the taken thermal energy (Wate/m^2.kel)………………………(determined)
T_A, T_B, T_C: are the temperature at position A, B and C in Kelvin…..(measured)
d_S: is the thickness of the specimen in Meter = 0.01m..………….....(constant)
d_A, d_B, d_C: are the thickness of the test disks =12.25x10^{-3}m………(constant)
From eq.(1) the value of taken thermal energy (e) can be determined as in table (4).

$$k\left(\frac{T_B - T_A}{d_S}\right) = e(T_A + \frac{2}{r}(d_A + 0.25\, d_S)T_A + \frac{1}{2r} d_S T_B) \ldots\ldots\ldots\ldots(2)$$

where
k: is the thermal conductivity in (wate/m.kel)………………………(determined)
from eq.(2) the value of thermal conductivity (k) can be determined as in table (4).

Table (4) Thermal Conductivity and Taken Thermal Energy Calculations

	CC	RC	MRC
e (wate/m^2.kel)	**0.698**	**0.693**	**0.6944**
k (wate/m.kel)	**1.129**	**0.8031**	**1.232**

3. Conclusions.

There are some conclusions conducted from the present study as follows:
1. Mechanical properties of concrete such as compressive strength is found to decrease with adding of rubber content resulted from weak bond between rubber particles and concrete compared with bond between concrete and concrete and this confirm the results from previous researches. In the present study the average decrease in the compressive strength when added 15% rubber particles is about 49.8% from traditional concrete.
2. The results show that the bond between rubber particles and concrete can be enhanced by increasing electrostatic interactions and / or facilitating chemical bonding. In the present study, rubber particles were pretreated by a coupling agent (SILAN) and this method was

found to be very effective in improving the compressive strength of the RMC and there is no adverse effect on the workability, it is found that the average decrease in the compressive strength when added 15% rubber particles and treat it with SILAN is about 12.9% from traditional concrete, so that the SILAN was very effective in improving the compressive strength by about 42.34% from untreated rubberized concrete.

3. Thermal conductivity of the concrete is decreased with adding rubber particles by about 26.7% from traditional concrete, the rubberized concrete can be used effectively in many applications which need isolation property. On the other hand when the rubber particles of waste tire was treated with SILAN to improve its compressive strength the thermal conductivity of the modified rubberized concrete increased by about 17.8% from traditional concrete. Thus, it is very important to know the purpose from the structure to specify what type of concrete may be used to satisfy needed requirement which is either rubberized concrete or modified rubberized concrete.

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