Performance of Powdered Polymerized Concrete at High Temperature Degrees

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ABSTRACT

In the domain of concrete modification by using polymers, the present study, focused on the use of Carboxy-Methyl Cellulose (CMC) as a water-soluble polymer and investigate its effects on the behavior of concrete. The study include two issues, the first one is the effect of polymer adding method on mechanical properties of concrete such as compressive strength, tensile strength and modulus of elasticity in additional to impact resistance and the second is the effect of graded temperature on these properties. The polymer/cement ratio used herein is 3%, this ratio never used before in the previous researches on many types of water soluble powder polymers.

Three concrete batches were prepared, the first is the reference one as a normal concrete (NOR), the second is a polymerized concrete (POL1) where the polymer added as a latex, and the last also as a polymerized concrete (POL2) but the polymer added as a powder.Each batch contains twelve cubic specimens (100x100x100)mm for compressive strength test, three cubes for each level of temperature, eight cylindrical specimens (150x300)mm for splitting tensile strength test, two cylinders for each level of temperature, and four paneled specimens (450x450x50)mm for impact resistance test, one panel for each level of temperature.

It can be considered from the results that when the polymer CMC used herein added as a latex will give better strength behavior in polymerized concrete than the one which added as a powder by about 28.86% in compressive strength, 19% in splitting tensile strength, very high percent in modulus of elasticity and 16.66% in impact resistance. On the other hand, it is found that the temperature level of 200°C will affect the behavior of polymerized concrete and that contrast with the behavior of normal concrete while in temperature levels 400°C and 600°C the effects on polymerized concrete will be more slightly and more clearly on normal concrete.

Keywords: Carboxy-Methyl Cellulose (CMC), water-soluble polymer, impact resistance, polymer/cement ratio, polymerized concrete.

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تصرف خرسانة المسحوق البوليمرية عند درجات الحرارة العالية

الخلاصة

في نطاق تطوير الخرسانة باستخدام البوليمرات تم في هذا البحث التركيز على استخدام مادة الكاربوكسي مثيل سيليلوز المعروف برمز CMC وهو من بوليمرات المساحيق القابلة للذوبان بالماء حيث تم التحري عن تاثير هذا البوليمر على تصرف الخرسانة. الدراسة تضمنت محورين اساسيين المحور الاول هو تاثير طريقة اضافة البوليمر على الخواص الميكانيكية للخرسانة مثل مقاومة الانضغاط ومقاومة الشد الانشطاري ومعامل المرونة اضافة الى مقاومة الصدمة اما المحور الثاني هو تاثير الحرارة المتدرجة على هذه الخواص. ان نسبة البوليمر/الاسمنت المستخدمة في هذا البحث هي ٣% وهنا تجدر الاشارة الى ان هذه النسبة لم يتم استخدامها نهائيا في البحوث السابقة على العديد من انواع بوليمرات المساحيق القابلة للذوبان بالماء.

تم اعداد ثلاث خلطات خرسانية الاولى هي خلطة خرسانة اعتيادية NOR اما الثانية فهي خلطة خرسانة بوليمرية POL1 يكون فيها البوليمر المضاف على شكل صمغ اما الخلطة الاخيرة فهي ايضا خرسانة بوليمرية POL2 لكن البوليمر المضاف لها يكون على شكل مسحوق. كل خلطة تتضمن اثنى عشر مكعب (١٠٠x١٠٠x١٠٠) مم من اجل فحص مقاومة الانضغاط, ثلاث مكعبات لكل مستوى حرارة معين, ثمانية اسطوانات (١٥٠x٣٠٠) مم من اجل فحص مقاومة الشد الانشطاري, اسطوانتين لكل مستوى حرارة واربع بلاطات (٤٥٠x٤٥٠x٥٠) مم من اجل فحص مقاومة الصدمة, بلاطة واحدة لكل مستوى حرارة.

لقد بينت نتائج الفحوصات المختبرية ان بوليمر CMC المستخدم في هذا البحث سوف يعطي نتائج افضل للخرسانة البوليمرية بالمقارنة مع الخرسانة المضاف اليها البوليمر على شكل مسحوق بمقدار ٢٨،٨٦ % لمقاومة الانضغاط, ١٩% لمقاومة الشد الانشطاري, نسبة عالية جدا لمعامل المرونة و ١٦،٦٦ % لمقاومة الصدمة. من ناحية اخرى وبعد فحص النماذج المحروقة تبين ان درجة الحرارة ٢٠٠°م لها تاثير واضح جدا على تصرف الخرسانة البوليمرية بعكس الخرسانة الاعتيادية حيث ان هذه الحرارة توثر تاثير طفيف على الخرسانة الاعتيادية, بينما عند درجة حرارة ٤٠٠°م و٦٠٠°م يكون التاثير قليل على الخرسانة البوليمرية وواضح على الخرسانة الاعتيادية.

INTRODUCTION

Several attempts have been conducted by using a lot of types of materials either for repairing the concrete or for improving the disadvantages of it, and then investigate its effects on the behavior [1]. One such attempt is polymer-modified concrete, which is made by the modifying ordinary concrete with polymer additives such as latexes, redispersible polymer powders, water-soluble polymers, liquid resins, and monomers. The select of polymer type depend on the function that required from it [2] and then the performances of polymeric concrete depend on the polymer properties, type of filler and aggregates, curing temperature, components dosage, etc. [3][4]. Natural and synthetic polymers can be produced with a wide range of stiffness, strength, heat resistance, density, and even price. With continued research into the science and applications of polymers, they are playing an ever increasing role in society [5] so that polymer concrete presents some advantages compared to the cement Portland concrete such as: rapid hardening, high mechanical strengths, improved resistance to chemical attack, durability, etc. [6] [7].

In the present study the experimental work limited on the use of a one type of a water-soluble polymer. It is very important that both cement hydration and polymer phase formation proceed well to yield a monolithic matrix, so that polymer-modified concretes have a monolithic co-matrix in which the organic polymer matrix and the cement gel matrix are homogenized. Generally, polymer powders are dry blended with cement and aggregate mixtures, followed by wet mixing with water and the fabrication of water soluble polymer modified concrete, the materials, their mix properties and curing conform to the procedures for ordinary concrete. The previous researches that have been conducted to investigate the effects of water soluble powder polymers on behavior of concrete show that the water soluble polymers are added as powder during mixing of a small amount less than 3% of cement. Such a modification mainly improves the workability. In general, this addition will decrease the strength of modified system [8]. When use Methyle Cellulose of polymer/cement 1% in a mortars of cement-sand 1:2 and 1:3 the tensile strength will decrease by about 28.74%, 20.98% respectively. While when Hydroxy Ethyl Cellulose used of polymer/cement 0.39% of cement-sand 1:2 the flexural strength and compressive strength will decrease by about 26.87% and 38.24% respectively [9][10].

OBJECTIVES

It is intended here to use a different type of water soluble powder polymers with a high polymer/cement ratio 3% according to the ratios used in the previous researches. The present experimental work has two main aims: the first is to investigate the effect of adding methods of water soluble powder polymer CMC used herein on the mechanical properties of concrete including compressive strength, tensile strength, modulus of elasticity, and impact resistance. The second aim is to detect graded high temperature effect on these properties.

EXPERIMENTAL PROGRAM

Materials

In the present study, Ordinary Portland cement (type I) (TASLUJA-BAZIAN) was used. The chemical analysis and physical test results of the cement are given in Tables (1) and (2), respectively. They conform to the Iraqi specification No. 5/1984[11].

AL-Ukhaidher natural river sand of grading conforms to the Iraqi Standard Specification No. 45/1984[12] was used, as shown in Table (3). Graded crushed gravel of a maximum size 10mm was used and Table (4) shows the grading of the aggregate which conforms to the limits specified by the Iraqi Specification No. 45/1984[12]. Sieve analysis for fine and coarse aggregate was performed in the Material laboratory at the College of Engineering, Al-Mustansiriya University. Sodium Carboxy-Methyl Cellulose E466 (CMC) was used throughout this experimental work as a water-soluble polymer because it has high viscosity compared with the types of same category which has been used essentially in modification of concrete (see Figure (1)), from previous studies, this type of powder polymers is used essentially in food science as a bulking agent, emulsifier, firming agent, gelling agent, glazing agent, humectant, stabilizer and thickener and it is also a constituent of many non-food products such as water-based paints and various paper products, etc. It is coded as E466 by the European Union. The properties of it according to the producted company are in table (5):

Table (1) Chemical composition of cement*.

No.	Compound Composition	Chemical Composition	%(weight)	Iraqi specification No. 5/1984
1	Lime	CaO	61.19	-
2	Silica	SiO_2	21.44	-
3	Alumina	Al_2O_3	4.51	-
4	Iron Oxide	Fe_2O_3	3.68	-
5	Magnesia	MgO	2.31	5**
6	Sulfate	SO_3	2.7	2.8**
7	Loss on ignition	L.O.I	2.39	4.0**
8	Insoluble residue	I.R	1.18	1.5**
9	Lime saturation factor	L.S.F	0.87	0.66-1.02
10	Tricalcium aluminates	C_3A	6.06	-
11	Tricalcium silicate	C_3S	Not available	-
12	Dicalcium silicate	C_2S	Not available	-
13	Tricalcium alumina	C_4AF	Not available	-

***All tests were made at the National Center for Construction Laboratories and research.**
**Maximum limit

Table (2) Physical composition of cement*.

Physical Properties	Test Results	Iraqi specification No. 5/1984
Fineness using Blain air permeability apparatus(m^2/kg)	405	230***
Soundness using autoclave method	Not available	0.8%**
Setting time using Vicat's instruments Initial(min.) Final(hr)	135 3:25	45*** 10**
Compressive strength for cement Paste Cube(70.7mm) at: 3days(MPa) 7days(MPa) 28days(MPa)	24.4 32.3 47.2	15*** 23***

*All tests were made at the National Center for Construction Laboratories and research.
**Maximum limit.
***Minimum limit.

Table (3) Grading of fine aggregate.

No.	Sieve Size	% Passing	
		% Fine aggregate	Iraqi specification No. 45/1984 for Zone(3)
1	4.75 mm	99	90-100
2	2.36 mm	94	75-100
3	1.18 mm	86	55-90
4	600 µm	70	35-59
5	300 µm	28	8-30
6	150 µm	5	0-10

Table (4) Grading of coarse aggregate.

No.	Sieve Size mm	% Passing	
		%Coarse	ASTM C33 Limits
1	12.5	100	100
2	9.5	98	85-100
3	4.75	25	10-30
4	2.36	3	0-10
5	1.18	0.5	0-5

Table (5) The Properties of Sodium Carboxy-Methyl Cellulose E466 (CMC) according to the Producted Company

Molecular weight	Higher than approximately (17000)
Viscosity (2% Solution	in the range of (3000-5000)
Degree of polymerization	approximately (100)
Description	Slightly hygroscopic white or slightly yellowish or greyish
Degree of substitution	Not less than 0.2 and not more than 1.5 (0.65-0.85)
PH of a 1 % colloidal	Not less than 5.0 and not more than 8.5 (6-8)

Figure (1) Sodium carboxy-methyl cellulose E466 (CMC).

Fresh Concrete
Mix Proportioning

For normal concrete (NOR), the mix ratio which is used in this work (cement: sand: gravel: water) was: 1: 1.5: 3: 0.45 by weight, and it is the same for other two polymerized concrete mixes (POL1), (POL2) except the addition of Sodium Carboxy-Methyl Cellulose E466 (CMC) of 3% from weight of cement, so the mix ratio by weight of polymerized concretes (cement: sand: gravel: polymer powder: water) was: 1: 1.5: 3: 0.03: 0.45. The method of CMC addition is as follows:

1. In polymerized concrete mix (POL1) the polymer CMC is added as a latex prepared firstly by solving the powder of 3% by weight of cement (powder (P)/cement (C) ratio) in water of a water soluble ratio 1:5.5 (powder (P)/water (w) ratio) then add this latex to the concrete during the wet mixing (Figure (2)).
2. In polymerized concrete mix (POL2) the polymer CMC is added as a powder of 3% by weight of cement during dry mixing (Figure (3)).

The mix contents for (1 m^3) of concrete are given in Table (6).

Table (6) The Mix Contents per 1m^3.

Mixes	Cement kg/m^3	Sand kg/m^3	Gravel kg/m^3	Water kg/m^3	CMC (E466) latex kg/m^3	CMC (E466) powder kg/m^3
NOR	405	608	1215	182.25	-	-
POL1	405	608	1215	182.25	78.975 (3% P/C, 1:5.5 P/w)	-
POL2	405	608	1215	182.25	-	12.5 (3%

Casting and Curing of the Specimens

After the concrete has been prepared for each batch, three (100x100x100)mm cubes, two (150x300)mm cylinders and one (450x450x50)mm panel were casted for four groups (the groups of temperature levels including lab temperature, heating at 200°C, heating at 400°C and heating at 600°C. Then the specimens of all batches, normal and polymerized concrete were cured in water for 28 days. It is noted here that the specimens of polymerized concrete is of a white color and it take more extent for setting compared with normal.

Figure (2) Sodium carboxy-methyl cellulose (CMC) disolved in water as a latex .

Figure (3) Sodium carboxy-methyl cellulose (CMC) as a powder.

e concrete specimens were heated to different levels using an oven with a maximum temperature of 1200°C and internal dimensions (530x660x750)mm for three different durations for normal and high strength concrete 2hrs, 4hrs, and 6hrs to gain the temperature of 200°C, 400°C, and 600°C respectively and keep each temperature of the specimens constant for one hour, after that the specimens were left to be air cooled.

Testing Program

Compressive strength test

The compressive strength test was carried out according to BS 1881: part 116: 1983[13], for all (100x100x100)mm cubes. The machine used in this work is one of the hydraulic types available in the Material Laboratory in Civil Engineering Dept. College of Engineering, AL-Mustansirya University, composite from two parts, mechanical part for fixing the specimen and test it and digital part to show the force-displacement curve of loading stages for the specimen.

Tensile strength test

The splitting tensile strength test was carried out by using the same machine of compressive strength test by replacing some parts to be consistent with the current test in accordance with ASTM C496-96[14].

Impact Resistance test

The impact loading was simulated by a drop weight of a steel ball as suggested by Green[15], it is stated that the impact strength can be represented by the number of blows that concrete can withstand till there is no “no rebound” of the impacting device. The ball can be dropped at the center of slab from different heights, i.e. (repeated impact from different heights of drop or from same height). The test frame was designed and constructed so that it could be used for the drop-weight impact tests for different thickness of slabs and different impact forces (See Figure (4)). The test frame consists mainly of two parts as described hereafter:- 1)Main supporting frame 2)Vertical guide for the falling mass (steel ball). The main supporting frame is a three dimensional structure consists mainly of steel members which are hollow (30 mm) square cross section for legs and bracing, (80x40x2)mm channel section and (120x55x6)mm C-section which are jointed up together so as to provide a horizontal platform to provide simple support to the slab specimens. The main supporting frame is fixed to the surface by casting the concrete basement at the bottom side of frame to the ground surface. The slab specimens are placed on horizontal platform. The vertical guide is kept in position by means of a three dimensional frame of (2560mm) height and the same width of main supporting frame. All members are steel hollow square sections of (30 mm) size. The mass of striking object used is a (1.041 kg) and (63.2 mm) diameter steel ball, the height of fall is 1345mm. The steel ball is allowed to fall freely, thus, striking the top surface of the tested specimens at center. The process is repeated for each impact test up to failure of slabs.

Figure (4) Frame for Impact Resistance Test.

THE RESULTS

It is known that the strength of concrete will decrease with increase the ratio of polymer, it is obvious that in the present study, the water soluble powder polymer used here is of food type not of the typical one which was previously used in the researches as a concrete modification. The limited upper ratio of polymer/cement of 3% is chosen here while in the previous researches of non-food polymers, this ratio could not be reaching to 3%. All the experimental results are listed in the following sub-articles:

Compressive Strength

The Effects of Polymer Mixing Method

Figure (5) represents a comparison between the compressive strengths of normal concrete (NOR), and polymerized concretes (POL1), and (POL2) at lab temperature, it is clear from this figure that the CMC adding as a powder in POL2 will decrease the compressive strength of concrete by about 32.4% from traditional value of NOR, When the CMC adding as a latex in POL1 the compressive strength of concrete decreased by about 12.9% from normal concrete NOR.

The Effects of High Temperature

The results of compressive strength for all mixes in different levels of temperature are presented in Figure (6) as a percentage of residual compressive strength. For reference concrete of NOR the residual compressive strengths are about (96.6%, 78.5%, 62.88%) at temperature of (200, 400, 600)°C respectively and the residual compressive strengths of polymerized concrete POL1 are about (53.5%, 50.42%, 47.46%) at temperature of (200, 400, 600)°C respectively, while the the residual compressive strengths of the polymerized concrete POL2 are about (62.5%, 47.64%, 41.74%) at temperature of (200, 400, 600)°C respectively.

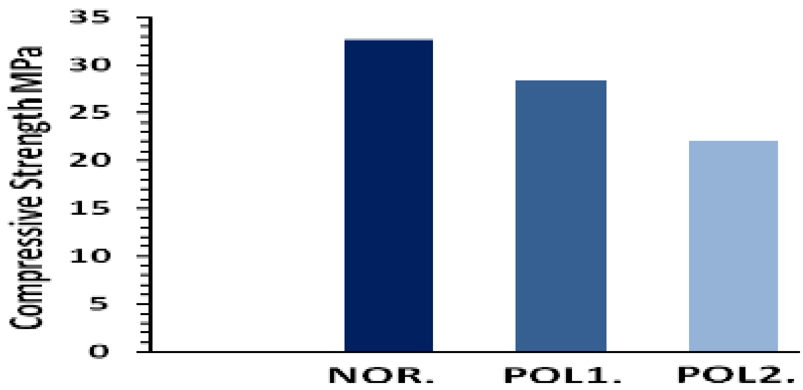


Figure (5) Compressive Strength of Concrete mixes in Lab Temperature

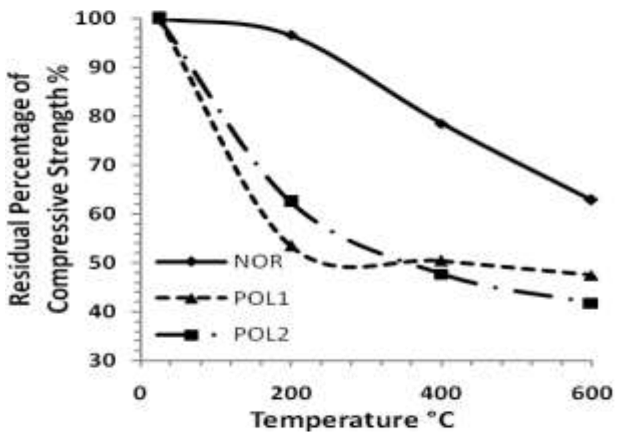


Figure (6) Residual Percentage of Compressive Strength for mixes at each level of temperature.

Splitting Tensile Strength

The Effects of Polymer Mixing Method

The splitting tensile strength of normal concrete (NOR), and polymerized concretes (POL1), and (POL2) are shown in Figure (7). It is considered from this figure that the splitting tensile strength of POL2 will decrease by about 17.81% from traditional value of NOR, while in POL1 the decreasing percentage was 2.19% only from NOR.

The Effects of High Temperature

The results of splitting tensile strength for all mixes in different levels of temperature are presented in Figure (8) as a percentage of residual splitting tensile strength. It can be noticed by considering this figure that the effects of temperature levels on splitting tensile strength are approximately of the same effects on compressive strength but with different reduction percentage. For reference concrete of NOR the residual splitting tensile strengths are about (97%, 78.13%, 63.44%) at temperature of (200, 400, 600)°C respectively and the residual splitting tensile strengths of polymerized concrete POL1 are about (61.02%, 59.1%, 57.83%) at temperature of (200, 400, 600)°C respectively, while the residual splitting tensile strengths of polymerized concrete POL2 are about (53.2%, 42.6%, 37.9%) at temperature of (200, 400, 600)°C respectively.

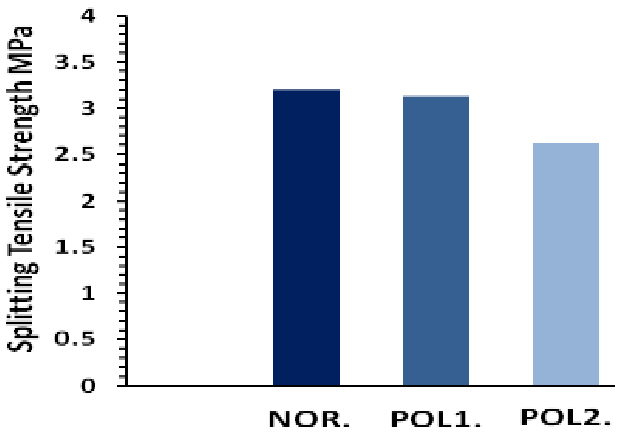


Figure (7) Splitting Tensile Strength of Concrete Mixes in Lab Temperature.

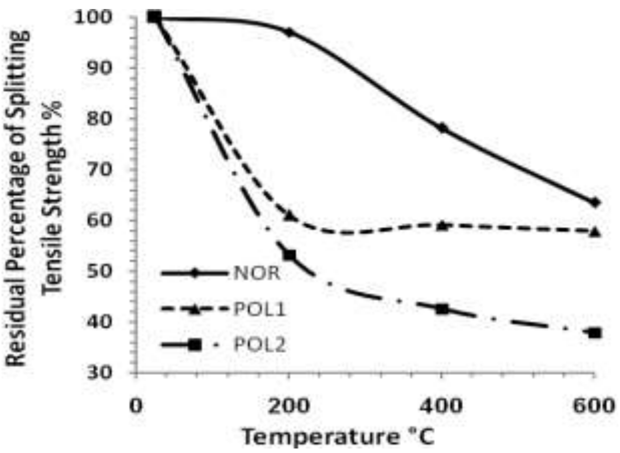


Figure (8) Residual Percentage of Splitting Tensile Strength for mixes at each level of temperature.

Modulus of Elasticity

The Effects of Polymer Mixing Method

The secant modulus of elasticity of the different mixes was calculated according to ACI code from the stress-strain relations recorded in the digital part of compressive strength test machine. Figure (9) show the stress-strain relations and its variation with each type of mixes in lab temperature. It is obvious from the figure that there is a high decreasing in the secant modulus of elasticity from traditional concrete NOR. The secant modulus of elasticity decrease by about 93.4% and 97.3% from concrete NOR for concrete POL1 and concrete POL2 respectively.

The Effects of High Temperature

Figures (10), (11), and (12) show the variation of the stress-strain relations for all mixes in different temperature levels, it is obvious from the figure that there is a decreasing in the secant modulus of elasticity from traditional concrete with increasing the temperature. Figure (13) represents the residual secant modulus of elasticity, as shown, in temperature level 200°C the secant modulus of elasticity decreased by a clear ratio of 24%, 25%, and 31.84% for NOR, POL1, and POL2 respectively from the reference of each one. On the other hand, at temperature levels 400°C and 600°C the reduction of secant modulus of elasticity will continue at a considerable rate in normal concrete NOR, while in polymerized concretes POL1 and POL2 the rate of reduction decreased and become more lower.

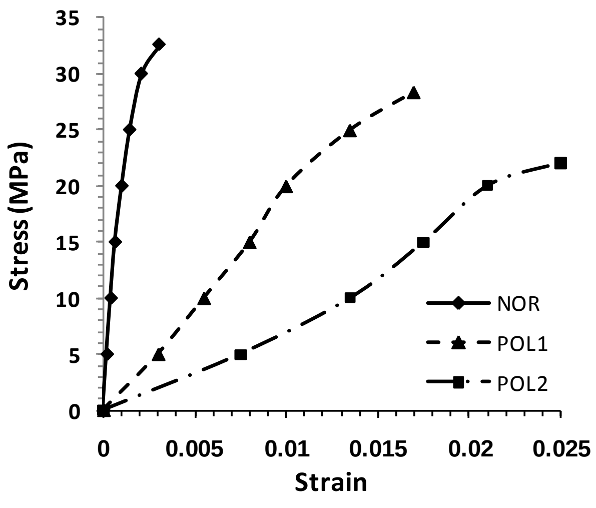


Figure (9) Stress-Strain Relation of Concrete Mixes in Lab Temperature.

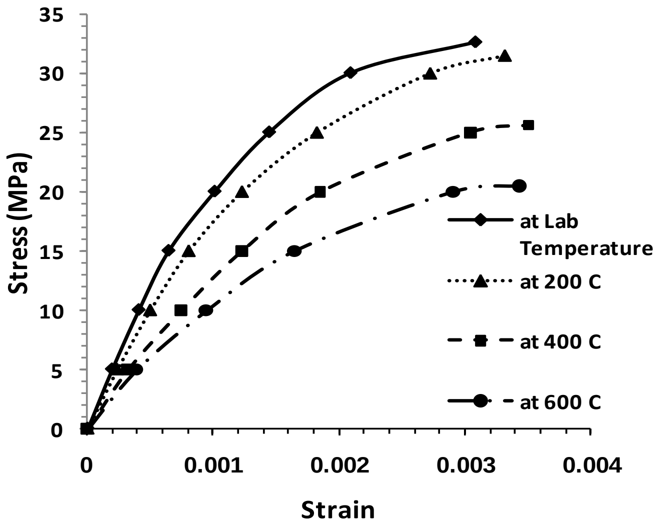


Figure (10) Stress-Strain Relation neither for Normal Concrete NOR at each level of temperature.

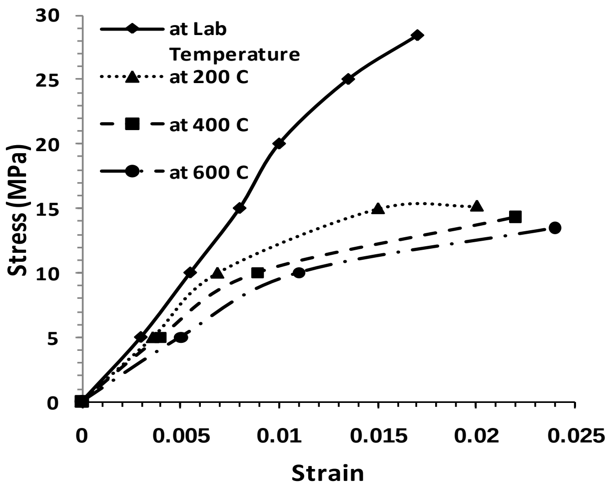


Figure (11) Stress-Strain Relation for Polymerized Concrete POL1 at each level of temperature.

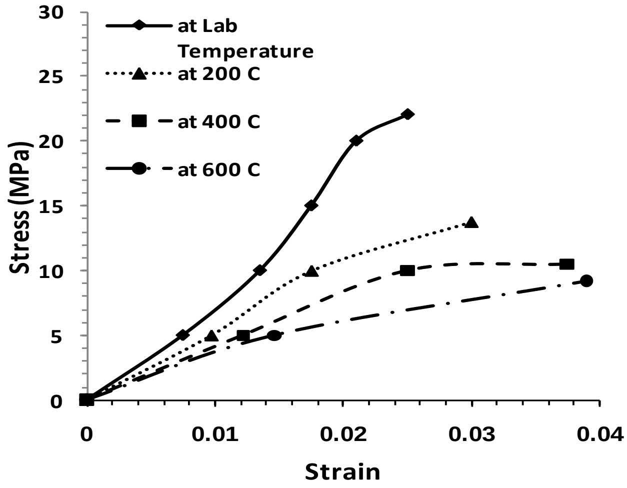


Figure (12) Stress-Strain Relation for Polymerized Concrete POL2 at each level of temperature.

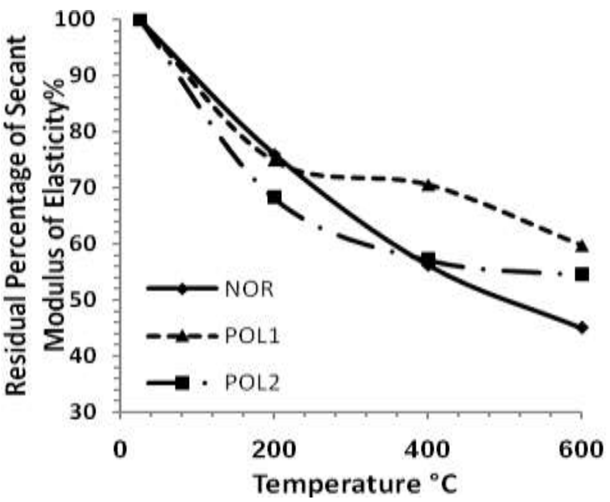


Figure (13) Residual Percentage of Secant Modulus of Elasticity for mixes at each level of temperature.

Impact Resistance

The Effects of Polymer Mixing Method

The impact resistance is indicated in the present study as a number of impact blow up that will cause failure. It is shown from Figure (14) that the impact resistance of polymerized concrete POL1 increased by 40% from normal concrete NOR, while the impact resistance of polymerized concrete POL2 increased by about 20% from normal concrete NOR. There are some observations can be considered from the results of impact test as follows:

1. Repeated impact causes spalling of the top surface of polymerized concrete panel of POL1 and POL2 while spalling is associated with penetration of striker into the surface of normal concrete panel NOR, so that the spalling or damaged areas at the top surfaces of tested panels seems to be larger in normal concrete than in polymerized concrete (see Figure (15)).
2. Noticeable crack can be considered in the panel of normal concrete NOR more than in polymerized concrete POL1 and POL2.
3. The failure of polymerized concrete panel occurs gradually with hairical crack propagation along the whole panel while the failure of normal concrete panel occurs suddenly with wide crack little propagation in whole panel but in only one direction (see Figure (16)).

The Effects of High Temperature

The results of impact resistance are shown in Figure (17). It is considered from these results of each mixes at different levels of temperature that for normal concrete NOR, the impact resistance represented by the number of blows up is the same at 25°C (lab Circumstances) and 200°C temperature levels, then it decreased from reference concrete by about 20% and 40% at 400°C and 600°C respectively. For polymerized concrete POL1, the impact resistance decreased from reference by 28.6% at 200°C and it is the same at 200°C and 400°C, then it decreased from reference one by about 42.9% at 600°C. For polymerized concrete POL2, the impact resistance decreased from reference by 16.7% at 200°C and it is the same at 200°C and 400°C, then it decreased from reference one by about 33.33% at 600°C.

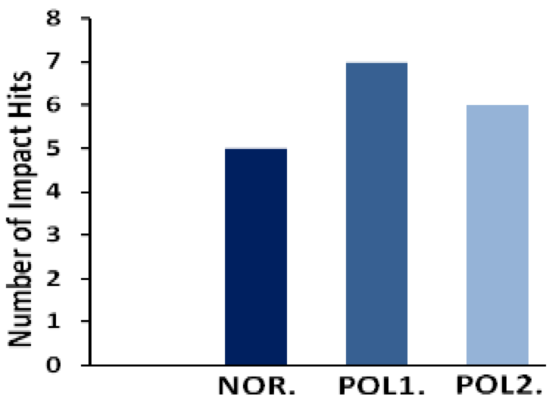
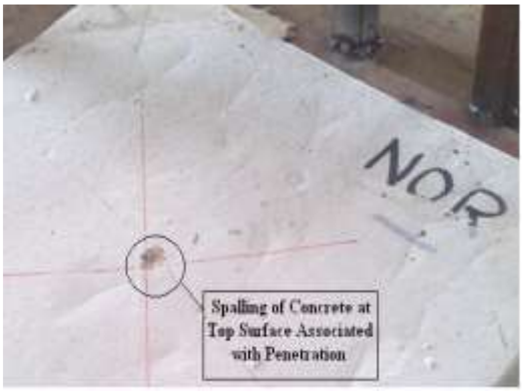


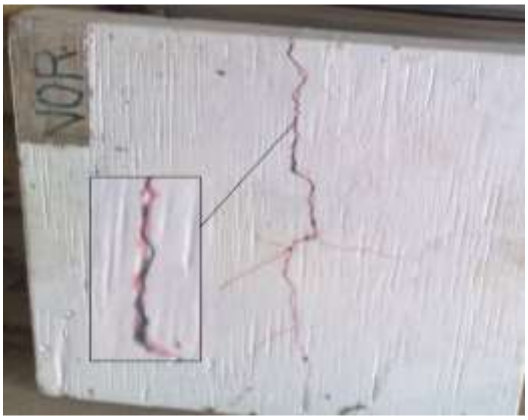
Figure (14) Number of Impact Blow up for Mixes of Concrete at Lab Temperature.



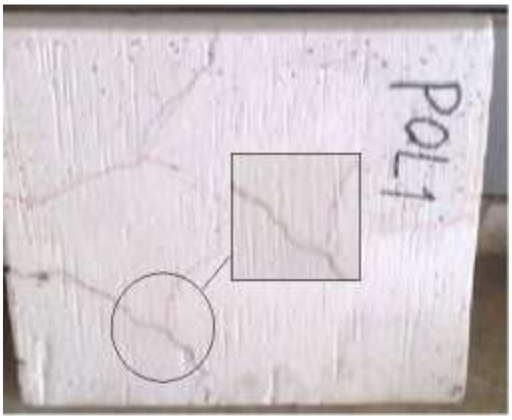
(a) Normal Concrete

(b) Polymerized Concrete

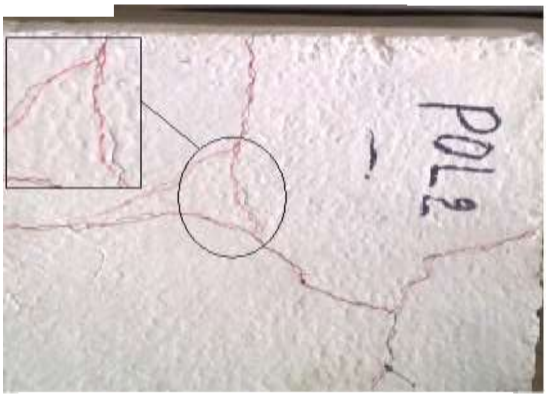
Figure (15) Failure at Top Surface of Concrete Slabs.



(a) Normal Concrete NOR



(b) Polymerized Concrete POL1



(c) Polymerized Concrete POL2

Figure (16) Failure at Bottom Surface of Concrete Panels.

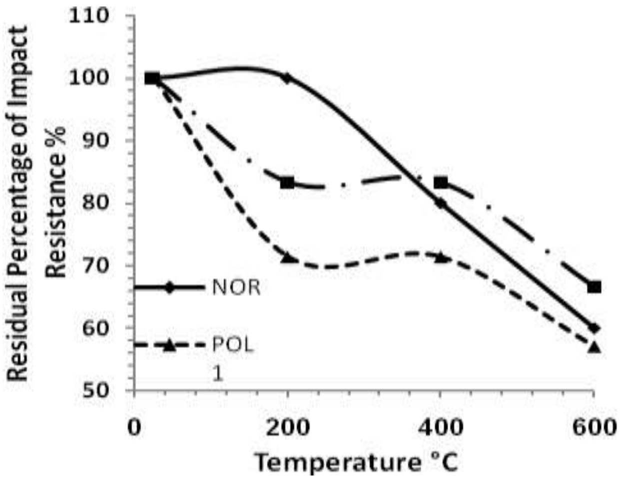


Figure (17) Residual Percentage of Impact Resistance for mixes at each level of temperature.

DISCUSSION

The Compressive and Splitting Tensile Strengths of Concrete

It is considered from the results that there is a reduction in compressive strength, and splitting tensile strength. About concrete mixes in lab temperature, the reduction in compressive strength, and splitting tensile strength of (POL2) can be referred to that the water soluble powder polymer CMC is considered as a water retention material so when it added to the concrete, a percent of mixing water would be absorbed by powder CMC, that will cause partially incompetent of cement hydration and then reduction in concrete strength, While in (POL1) the latex of CMC will retent a lower percent of water than in (POL2), this refers to that the most of particles of CMC would be resolved in water before mixing so that there is no need to water again for the resulting solution. But the reduction in splitting tensile strength is lower than the one in compressive strength, this can be referred to that the latex in concrete, framed as a bridges bonding between the concrete particles, these bridges act more in tension resistance.

While when considering the compressive and splitting tensile strengths of concrete mixes in different levels of temperature, there are some observations can be noted from the previous results as listed below:

1) In normal concrete, the temperature level of 200°C has no noticeable effect on the compressive and splitting tensile strengths and the reductions were about (3% in tension-3.4% in compression) only from the reference, while the reductions become more noticeable of (21.5% in compression-21.88% in tension) and (36.56% in tension-37.12% in compression) from the reference at (400, 600) °C levels.

2) In polymerized concrete POL1 the temperature level of 200°C was of a great effect on the strengths so that it reduce by about (38.98% in tension-46.5% in

compression) from the reference POL1, this reduction was because that the polymer gel in concrete is a sensitive material to temperature at once, so it exposed to chemical changes at this temperature. In temperature levels of 400°C and 600°C, the rate of reduction will gradually become more slowly by about (3.14-5.79)%, and (5.24-11.66)% from the concrete POL1 of level 200°C at 400°C, and 600°C respectively, this behavior can be explained as that the polymer gel exposed to chemical changes till a cross linked structures formed which of a little affects by temperature, this thermoset structure formed gradually at a temperature greater than 200°C.

3) Also in polymerized concrete POL2 the temperature level of 200°C was of a great effect on the strengths so that it reduce by about (37.5-46.8)% from the reference for the same previous reason, but in temperature levels of 400°C and 600°C, the rate of reduction become more than in POL1 by about (13.78-19.9)%, and (24.28-28.74)% from the concrete POL2 of level 200°C at 400°C, and 600°C respectively.

Modulus of Elasticity

It is clear from the results that the presence of polymer gel in concrete either of POL1 or POL2 decreased the secant modulus of elasticity by a very high percentage, so that the polymerized concrete can be considered as a ductile material. However, the effects of temperature levels are as follows:

1) In normal concrete, the secant modulus of elasticity will decrease gradually at each temperature level by a considerable rate of 24%, 26%, and 20% for 200°C, 400°C, and 600°C respectively.

2) In polymerized concretes POL1 and POL2 the secant modulus of elasticity will decrease at 200°C by a considerable percentage then the rate of reduction become lower in 400°C and 600°C.

Impact Resistance

The results of impact resistance indicated to some points as follows:

1) Generally the presence of polymer CMC increased the impact resistance of the concrete from traditional one and that was clear from the failure shape of the panels so that the spalling of top surface was without penetration and that contrast with normal concrete also the cracks at bottom surface were hairical and propagate in whole panel, all that related to the larger energy absorption encountered due to bonding bridges of polymer gel.

2) Generally increase in temperature level will decrease the impact resistance. The equality of impact resistance at any two stages of temperature referred to that the reduction in the impact resistance at this stage is small not non, on the other hand the applied impact load of 1.041kg weight and 1345mm falling height is considered here as a high load so the small reduction will not appear clearly.

3) Accordingly to the previous it can be say that the impact resistance of normal concrete reduced by a small percent at 200°C from reference then it reduced by a noticeable percent at 400°C and 600°C. While in polymerized concrete the impact resistance reduced by a noticeable percent at 200°C then the rate of reduction decreased greatly at 400°C and 600°C respectively.

CONCLUSIONS

1) The method of adding water-soluble powder polymer to concrete has a powerful effect on the resulted properties, so that the addition of CMC as latex prepared firstly is better than the one as a powder.
2) Although the polymer/cement ratio used here (3%) is considered as an upper limit with respect to the previous researches that never used before, it gave the concrete a better strength than in previous studies and that referred to the adding method and the type of polymer used here which of food type with high viscosity comparing by other types which is used essentially in concrete, while in the previous studies the polymer/cement ratio was 1% or less.
3) The presence of polymer CMC of 3% (adding as latex) decreased the compressive strength by a moderate ratio, the splitting tensile strength by a small ratio, and the elastic modulus of elasticity by a large ratio also increased the impact resistance.
3) Accordingly to the present results it can be say that a lower than 3% of polymer/cement ratio can be added to concrete as latex and that will give a more better strength behavior even increase the strength and offer a ductile material with large energy absorption.

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