Behaviour of Reinforced Polymer Modified High Strength Concrete Slabs under Low Velocity Impact

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ABSTRACT.

This research investigates the impact resistace of reinforced high strength concrete slabs with steel meshes (BRC) modified by styrene butadiene rubber (SBR) with different weight ratios of polymer to cement as follows: 3%, 5% and 7%. Reference mix was produced for comparison of results.

For all selected mixes, cubes (100×100×100mm) were made for compressive strength test at (365) days. In conducting low-velocity impact test, method of repeated falling mass was used: 1400gm steel ball falling freely from height of 2400mm on reinforced panels of (50×50×800 mm) reinforced with one layer of (BRC).

The number of blows causing first crack and final perforation (failure) were calculated, according to the former results, the energy of each case was found.

Results showed an improvement in compressive strength of polymer modified high strength concrete (PMHSC) over reference mix; the maximum increase being of it were (3.93%-11.96%) at age of (365) days.

There is significant improvement in low-velocity impact resistance of all polymer modified mixes over reference mix. Results illustrated that polymer modified mix of (3%) give the its higher impact resistance than others, the increase of its impact resistance at failure over reference mix was (154.76%) while, for polymer modified mix (5%) it was (30.95%) and it was (14.28%) for polymer modified mix of (7%).

Keywords: High Strength Concrete, Reinforced Concrete Slabs, Polymer modified concrete, Impact Resistance, Low Velocity Impact.

1. INTRODUCTION.

Impact strength is of importance primarily in connection with pile driving and with foundations for machines exerting impulsive loading, but accidental impact (e.g. during handling of precast members) is also of interest.[1]

As the relatively low tensile strength and fraction energy of concrete results in poor impact resistance, much research has been directed towards developing materials which exhibit better impact resistance than does concrete.

1.1. Concrete Developed by Polymer.

Polymer is defined as a chemical material with different forms (powder, liquid, latex, etc.). The most common particles are CH, CH2 particles connected together with a chemical bond. The Latin word polymer means many particles joined together by a chemical bond. [2]

Polymer is of large molecule consisting of hundreds or thousands of atoms formed by combining one, two or occasionally more kinds of small molecule (monomers) into chain or network structures. The polymer materials are a group of carbon- containing (organic materials), which have macromolecular structures of this sort.

1.2. Impact of Concrete Modified by Styrene Butadiene Rubber.

SBR polymer is most widely used in concrete. The proportion of SBR latex, combined with low water /cement ratio produces concrete that has improved flexural, tensile, bond

strength, lower modulus of elasticity and reduced permeability characteristics compared with conventional concrete of similar mix design. Compressive strength is typically unchanged.[3]
Extensive tests on impact strength of concrete were made by Green[4]. As principal criteria, he considered the ability of a specimen to withstand repeated blows and to absorb energy. In particular, he studied the number of blows which the concrete can withstand before reaching the no-rebound condition, this stage indicating a definite state of damage.
Impact tests, when conducted with a relatively small hammer (25mm diameter face) lead to greater scatter of results than test on static compressive strength of the concrete. This arises from the fact that in the standard compression test some relief of highly stresses weak zone is possible owing to creep, while in the impact test no redistribution of stresses is possible during the very short period of deformation. Hence, local weaknesses have a greater influence on the recorded strength of a specimen.
In general, Green[4] found that the higher the static compressive strength of the concrete the lower the energy absorbed per blow before cracking, but the impact strength of concrete increases with its compressive strength (and therefore age) at a progressively increasing rate.
Al-Numan[5] Studied the high-velocity impact properties of polymer –modified concrete (PMC) including Styrene-Butadiene rubber (SBR), with different weight ratios of polymer to cement: 4%, 8% and 12%. Steel fibers were also included. Sixteen (500mm) diameter, (50mm) thick discs for high-velocity impact tests were used. In addition compressive strength, splitting tensile strength, and flexural strength (modulus of rupture) were companionly recorded. In all the tests, concrete was with and without crimped steel fibers of ratio 1% by volume.
In investigating high-velocity impact strength, the decrease in projectile penetration depth was (5-17%) and the scabbing area reduced (15-35%) over reference concrete.
In studying PMC including 1% by volume steel fibers, an additional increase was observed in all properties.
The increases were quite significant in high-velocity impact strengths. Further reduction was recorded in scabbing area of (64-95%) and penetration depth reduced (28-39%) over control specimens. The fragmentations were reduced also. The range of corresponding compressive strength was (48-64)MPa ,of splitting tensile strength (4.2-7.8) MPa, and of flexural strength (5-8) MPa.
Al-Hadithi[6]**,** studied the improving of impact resistance of concrete using styrene butadiene rubber (SBR) with different weight ratios of polymer to cement 3%, 5% and 10%. Two levels of polymer modified concrete (PMC) were produced level I with moderate compressive strength and level II with higher compressive strength. Results showed an improvement in impact resistance of polymer modified concrete (PMC) over reference concrete in low-velocity and high-velocity impact properties. In conducting low-velocity impact tests, method of repeated falling mass was used: 1300gm steel ball falling freely from three heights 2400mm, 1200mm and 830mm. In high-velocity impact tests, shooting of 7.62mm bullets was applied to slab specimens from distance of 15m. The improvements were significant in low velocity impact resistance. The maximum increases were (33.33%, 75% and 83.33%) at ultimate failure for falling mass heights 2400mm, 1200mm and 830mm respectively.
In high-velocity impact strength tests, maximum reductions recorded in spalling area were (18.5% and 27%) for polymer modified concrete (level I) with moderate compressive strength and polymer modified concrete (level II) with higher compressive strength, respectively. Maximum reductions recorded in scabbing area were (11.42% and 35.6%) for polymer modified concrete (level I) with moderate compressive strength and polymer modified concrete (level II) with higher compressive strength, respectively.
Al-Dulaimi,[7] studied the mechanical properties and investigated the behaviour of Ferrocement slabs modified by (SBR) polymer under impact loading. A total of 48

Ferrocement slabs were constructed and tested, 36 slabs tested under low velocity impact and 12 slabs tested under high velocity impact, in addition to 36 cubic specimens for testing compressive strength with dimensions (100×100×100 mm), 36 cylinder specimens for testing splitting tensile strength with dimensions (100×200 mm) and 36 prism specimens for testing flexural strength with dimensions (100×100×500mm).The main parameter considered in that research was the number of wire mesh layers, content of (SBR) polymer and height of falling mass (falling velocity). For low velocity impact, a special testing rig was used to achieve the impact forces using a falling mass (1300 gm steel ball) dropped from (2.5, 1.2, 0.83 m) height. (500 ×500×50 mm) slabs were used for each test. The number of required blows for the first crack and final failure was recorded.
The mode of failure and the crack pattern were also observed. For high velocity impact test, (500×500×50 mm) slabs were tested by 7.62 mm bullets fired from a distance of (15 m) with a striking velocity of (720 m/sec.). The spalling, scabbing and perforation were observed and discussed. The results exhibited that the number of blows which were required to make the first crack and failure, increased with increase of polymer content and number of wire mesh layers. Also for high velocity impact test, it can be noted that the area of scabbing and area of spalling decreased with the increase of polymer content and number of wire mesh layers compared with reference mixes. The compressive strength, splitting tensile strength and flexural strength increased with increase of the polymer content.

2. EXPERIMENTAL PROGRAM.

2.1. Materials.

The materials used in this research are described as follows:

2.1.1. Cement.

Ordinary Portland cement (Type I) according to ASTM C150-86(8) from Kubaisa factory for cement production is used in this research.

2.1.2. Fine Aggregate.

The fine aggregate used is natural sand having a fineness modulus of 2.69 and a water absorption of 1.73% obtained from Kubaisa region . It was clean, free of organic impurities and deleterious substances and relatively free of clay. The grading of sand is conformed to the requirements of the Iraqi specification (IOS) No. 45-84(9), zone (2), as shown in **Table (1)**.

2.1.3. Coarse Aggregate.

The coarse aggregate used in this work is a mixture of crushed and rounded gravel brought from Samarra region with a maximum size of 10 mm. All aggregates were saturated surface dry. The specific gravity and absorption were 2.63 and 1.11% respectively. **Table (2)** shows the grading of this aggregate after sieving on 10 mm sieve to remove particles with size greater than 10 mm. This table gives the limits specified by the Iraqi specification (IOS) No. 45-84[9] .

2.1.5. Water.

Drinking tap water is used for mixing, and for curing the concrete.

2.1.6. Polymer.

Styrene butadiene rubber (SBR) is used as polymer modifier in this study. Styrene butadiene, an elastomeric polymer, is the copolymerized product of two monomers, styrene and butadiene. Latex is typically included in concrete in the form of a colloidal suspension polymer in water. This polymer is usually a milky-white fluid. The emulsion polymerization of latex modifies the concrete structure system through two processes, cement hydration and film formation[10]. The advantages are excellent bond strength to concrete, higher flexural strength, and lower permeability. Wet curing is usually required for 24-48 hours to permit the concrete to gain strength prior to permitting the latex film to form [11]. The typical properties are shown in **Table (3)** [12]. SBR is used as a ratio by weight of cement of (3, 5, and 7)%.

2.1.7. Admixture.

Admixtures are chemical materials, which are added to concrete at the mixing stage to modify some of the properties of the mix. A superplasticizer is one of class of admixtures called water reducers that are used to lower the mix water requirement of concrete. The basic advantages of superplasticizers include, high workability of concrete, resulting in easy placement without reduction in cement content and strength, high strength concrete with normal workability but lower water content, and a concrete mix with less cement but normal strength and workability (13).

The superplasticizer used in the investigation is commercially known as Melment L-10 (sulfonated melamine formaldehyde condensates). Its properties are listed in **Table (4)**[14]. The optimum dosage is found to be 4% of the weight of cement and the reduction in water for this dosage is about 25%(14). Therefore according to ASTM C494/C494M-99[15] this superplasticizer is classified as type F (high range water-reducing agent), because it has the capability of more than 12% water reduction for a given consistency.

2.1.8. Reinforcing Mesh.

Square meshes of reinforcement, fabricated from 6 mm-nominal diameter steel bars (actual diameter being 6.03 mm), were used in the panels. The spacing of bars in both directions was (150 mm) which does not exceed three times the panel thickness, with a clear cover of 10 mm over the bars. The wire mesh provides support to the thinner section (50 mm thick) of the panel. Results of testing 100 mm long bar samples are given in **Table (4)**.

2.2. Molds Fabrication for Casting of Panels.

Steel angles were used to construct the molds. Four profiled steel angles were assembled using bolts passing through the holes in each corner. The assembled test frame was then made to fix on a wooden base. The test frame and the base plate were connected firmly to a frame by bolts through the middle length of the steel angles and the wooden base.

2.3.Mix Proportions.

The proportion of the constituents for the prepared concrete mix is 1: 1.4: 2.25(by weight) of ordinary Portland cement: fine aggregate of maximum size 4.75 mm: coarse aggregate of maximum size of 10 mm with a water/ cement ratio of 0.3. SBR polymer was used as a ratio by weight of cement of 3, 5, and 7 percent. The water/cement ratio used was 0.3. This value was modified for superplasticized concrete with 4% superplasticizer (Melment) by weight of cement to obtain high strength and to improve workability and to reduce particle segregation.

2.4. Preparation of Samples.

2.4.1. Concrete Mixing.

A mechanical mixer of (0.07) m^3 capacity, operated by electrical power was used .First of all, aggregates and cement were added before adding polymer and dry mixing were continued until the dry mix became homogenuous, then the polymer was added until all particles were fully coated with polymer and finally water were added and mixing continues until uniform mix was obtained. This procedure is similar to the method used by Ohama[16].

2.4.2. Panel Specimens.

Eight panels, having the same size and cross section were cast after cutting the reinforcing meshes to the required lengths. The ends of each mesh were hooked at 90 degrees. The steel mesh was placed and secured in the mold, so as to prevent its movements during casting and vibration of concrete. The concrete mix was vibrated externally by using a table vibrator. The panels were covered with plastic sheets to prevent evaporation of mix water and then left in the laboratory. After two days, they were removed from their molds and placed in water for curing.

2.5. Mixing Procedures.

The mixing procedures of the composite material consist of the following steps:

2.5.1. Matrix Preparation.

A horizontal rotating mixer of $0.075m^3$ capacity was used for preparing the concrete mix. First, fine and coarse aggregate were washed and dried to remove any clay particles and then mixed together with the cement for 2 minutes. Then, (SBR) polymer dispersion was added after appropriate dilution with water, and mixing continued for 2 minutes resulting in a uniform matrix. Finally, water with superplasticizer was gradually added, until uniformity is ensured through visual inspection. Within this period, the bottom of the mixing bowl was scraped manually to ensure that no solid material would stick to the bottom.

2.5.2. Casting and Compaction and Curing.

According to ASTM C192/C192M-02(17), the composite material was carefully cast into a mold in two layers. First, about half the material was placed. Then, the mix was vibrated for about 1-2 minutes on a vibrating table to ensure that the material is well compacted. Next, the second half of the mold was filled by the composite in the same manner. After smoothing the surface by using a steel trowel, the specimens were covered with plastic sheets to prevent loss of moisture and then stored at laboratory temperature prior to demolding. After two days the panel specimens were demolded and put into water for curing, special care was taken so that the specimens does not suffer any damage. Control specimens were removed from their molds after one day and then cured by the same manner.

Curing is an important factor in achieving durable concrete structures. This seems reasonable because curing allows the hydration of cement to continue which is expected to reduce capillary porosity, thereby strengthening the concrete and increasing its resistance to penetration by aggressive agents such as chloride and sulfate. As soon as the surface has hardened sufficiently, the concrete should be cured to prevent damage. Both water and dry curing were used in this study. Panel specimens and their control specimens were completely immersed in water for (2) days during which the cement hydration develops followed by a dry curing period for (26) days during which the polymer film formation is promoted.

3. TESTS.

3.1. Compressive Strength Test.

Compressive strength was determined using (100×100×100) mm cubes according to B.S.1881 part 116 (18) . ELE machine with a capacity of (1000) kN was used for that test. The average compressive strength of three cubes was recorded.

3.2. Low Velocity Impact.

Eight Slabs, 365-day age with dimensions of (800 × 800 × 50) mm were tested under low velocity impact load (see **Plate (1)**). The impact was conducted using 1400gm steel ball with 55mm diameter, dropping freely from 2400mm (see **Fig. (1)**). The test rig used for low velocity impact test consists of three main components:(see **Plate (2)**).

-A steel frame; strong and heavy enough to hold rigidly during impact loading. The dimensions of the testing frame were designed to allow observing the specimens (square slab) from the bottom surface to show developing failure, during testing. The specimen was placed accurately on brick walls from 3-sides, and the fourth side which was a steel angle section bond from two sides with two brick walls to ensure the simply supported boundary condition(see **Plate(2)**).

The vertical guide for the falling mass was used to ensure mid-span impact. This was a tube of a round section.

- Steel ball with a mass of 1400 gm and a diameter of 55mm.

-Specimens were placed in their position in the testing frame with the finished face up. The falling mass was then dropped repeatedly and the number of blows required to cause first crack and fully perforation were recorded.

4. RESULTS AND DISCUSSION.

This section deals with discussion of properties of reinforced polymer modified high strength concrete slabs and their behaviour of them under low velocity impact.

4.1. Density.

The results of density of all selected mixes at age of (365) days were averged and presented in **Table (6)**.

For all selected mixes, the relationship between density at (365) days age and (P:C)% ratios is shown in **Fig.(2)**.

In all polymer modified mixes there were increases in density value compared with reference mix(see **Fig.(3)**). These increases in density might be due to the reduction in W/C ratio and the increase in compaction, where the polymer latex addition into fresh concrete causes the effect almost typical to that of admixtures like superplasrisizer which leads to better workability results that are known as ball-bearing influence of surface active substance in polymer latex.(19)

4.2. Compressive Strength.

The results of cpreomssive strength test of all selected mixes at age of (365) days were obtained from the average of three cubes and presented in **Table (7)**, these results showed an improvement in compressive strength of polymer modified high strength concrete (PMHSC) over reference mix, the maximum increases being (3.93%-11.96%). An improvement in the compressive strength at low P/C ratio was found to be due to a reduction in W/C ratio with polymer modification. At high P/C ratio, it appears that the pore size distribution of the paste and the strength of polymer films formed in them markedly affect the compressive strength. A ductile mode of failure, as compared to reference concrete's brittle failure, is observed while testing for compressive strength. The change of mode of failure from a brittle type to a ductile type is an important contribution due to the addition of polymers. The results indicate that the mixes containing polymer are reasonably consistent.

The relationship between compressive strength and (P:C) ratio for all mixes are shown in **Fig.(4)** and **Fig.(5)**, both show that with inceasing in (P:C) ratio the compressive strength is increased. That increase in compressive strength might be due to three facts, the first is that, polymer modified concrete had less W/C ratios, gives higher strengths, the seconed is that, the use of SBR polymer leads to form a continuous three-dimensional network of polymer molecules thoughout concrete causing increases of the binder system due to good bond characteristics of the polymer SBR, and the last is the partial filling of pores with polymer.
Fig.(6) illustrates the compressive strength increases with increasing in density.

4.3. Impact Resistance and Mode of Failure.

The impact resistance of the reiforced polymer modified high strength concrete slabs was determined in terms of the number of blows required to cause complete failure of the slabs. For all slabs, the same mass (1400g) was dropped repeatedly through the same height (2400mm) until complete failure occurs. The energy produced by each blow is given by the product of drop-height and weight. The mean values of the number of blows multiplied by the impact energy per blow (32.96 Nm) have been used to determine the total fracture energy in (Nm) for all slabs.
The results of low velocity impact test of all selected mixes at age of (365) days are presented in **Table (8)**, which shows that there are significant improvement in low-velocity impact resistance of all polymer modified mixes over reference mix.
The effect of (P:C) ratio on impact resistance of all concrete slabs at first crack and failure are shown in **Fig. (7)**, which illustrates that polymer modified mix of (3%) give the higher impact resistance than others, the increase of its impact resistance at failure over reference mix was (154.76%) while, for polymer modified mix (5%) it was (30.95%) and it was (14.28%) for polymer modified mix of (7%).
Fig.(8) illustrates the relation between density of selected mixes and its impact resistance.
Fig.(9) illustrates the relation between compressive strength of the selected mixes and its impact resistance.
Fig.(10) shows the effect of (polymer:cement)% ratios on impact resistance of selected mixes at first crack and failure.
For all mixes which were selected in this rsearch, **Plate (3)** shows the mode of failure of slabs specimens under low velocity impact, in which the crack starts from the contact point with falling mass (center of slab) and then it extends across of specimen in straight direction perpindicular to its edges.
It should be noted that, all specimens didn’t fracture into separate pieces at ultimate failure because of existence of reinforcement that leads to resist the tension stresses and increase the bond strength in concrte slabs. (see **Plate (3)**).
The slabs of reference mix reach the first crack and ultimate failure at number of blows less than that of slabs of polymer modified concrete, therefore, failure of unmodified concrete was more brittle than that of modified concrete slabs. This leads to fact of polymer film in bridging the cracks jnside the concrete micro structure, made the slab suffer from stresses and get more deformations until final failure. That means the reinforced polymer modified high strength concrete (RPMHSCS) are more ductile than the slabs made from reference mix.

5. CONCLUSIONS.

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

1- The addition of SBR slightly increases the unit weight of concrete.

2- Comparison with reference mix, an increase in compressive strength at age of 365-days was varying from (3.93%) for (P:C=3%) to (11.96%) for (P:C=7%).
3- There are significant improvement in low-velocity impact resistance of all polymer modified mixes over reference mix. Polymer modified mix of (3%) gives the higher impact resistance than others, the increase of its impact resistance at failure over reference mix was (154.76%) while, for polymer modified mix (5%) it was (30.95%) and it was (14.28%) for polymer modified mix of (7%).

4- The slab specimens of reference mix reach to the first crack and ultimate failure at number of blows less than that of slabs of polymer modified concrete, therefore, failure of unmodified concrete was more brittle than that of modified concrete slabs.
5- Because existence of reinforcement results in resisting the tension stresses and increase the bond strength in concrte slabs, all specimens didn't fracture into separate pieces at ultimate failure.

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Table (1): Grading of Fine Aggregate.

No	Sieve Size (mm)	Percent Passing	
		Fine aggregate	Limits of Iraqi Specifications No. 45:1984 [9] Zone 2
1	4.75	100	90-100
2	2.36	99.49	75-100
3	1.18	80.1	55-90
4	0.6	42.86	35-59
5	0.3	8.68	8-30
6	0.15	0	0-10

Table (2): Grading of Coarse Aggregate.

No	Sieve Size (mm)	Percent Passing	
		Coarse aggregate	Limits of Iraqi Specifications No. 45:1984 [9]
1	14.0	100	100
2	10.0	100	85-100
3	5.0	24.6	0-25
4	2.36	1.5	0-5

Table (3): Typical Properties of the SBR Polymer Used #.

No	Properties	Description
1	Appearance	White emulsion
2	Specific Gravity	1.03 ± 0.02@ 25°c
3	PH Value	9±2
4	Freeze/Thaw Resistance	Excellent
5	Chloride Content	Nil
6	Flammability	Non-flammable
7	Compatibility	Can be used with all types of portland cement

#Properties are obtained from the product catalogue (12)

Table (4): Properties of the superplasticizer #.

No.	Properties	Description
1	Main action	Concrete superplasticizer
2	Subsidiary effect	Hardening accelerator
3	Appearance	Clear to slightly milky
4	Solid in aqueous solution	Approx.20%
5	Density	1.1 g/cm^3
6	Chloride content	Less than 0.005%
7	Sugar content	None
8	Handling	No special precautions
9	PH value	7-9
10	Frost resistance	Melment L-10 withstands any number of frost cycles. It should be thoroughly thawed before use
11	Storage life	At least two years. It should not, however, be exposed to excessive heating.

Properties are obtained from the product catalogue [14]

Table (5): Properties of Reinforcement.

Nominal Diameter (mm)	Measured Diameter (mm)	Area (mm^2)	Modulus of Elasticity (GPa)	f_y (MPa)	f_u (MPa)
6	6.03	28.558	200	376	490

Table (6): Results of Unit Weight of Concrete.

Mix for Panel No.	(Polymer:Cement)%	Unit Weight (Average) (kg/m^3)
S_1	**0**	**2432**
S_2	**3**	**2449**
S_3	**5**	**2458**
S_4	**7**	**2469**

Table (7): Results of Compressive Strength.

Mix for Panel No.	(Polymer:Cement)%	$f_{cu})_{365}$ (Average) MPa
S_1	0	63.5
S_2	3	66.0
S_3	5	68.2
S_4	7	71.1

Table (8): Results of impact test at 365 days age.

Panels	P:C %	No. of blows to first crack		No. of blows to failure		Total energy (Nm)	
		Results	Mean	Results	Mean	First crack	Failure
S1	0	6	7	38	42	230.73	1384.38
		8		44			
S2	3	18	16	110	107	527.38	3526.89
		14		104			
S3	5	9	10	52	55	329.61	1812.88
		11		58			
S4	7	10	8	52	48	263.69	1582.15
		6		44			

Plate (1): Specimens for impact test.

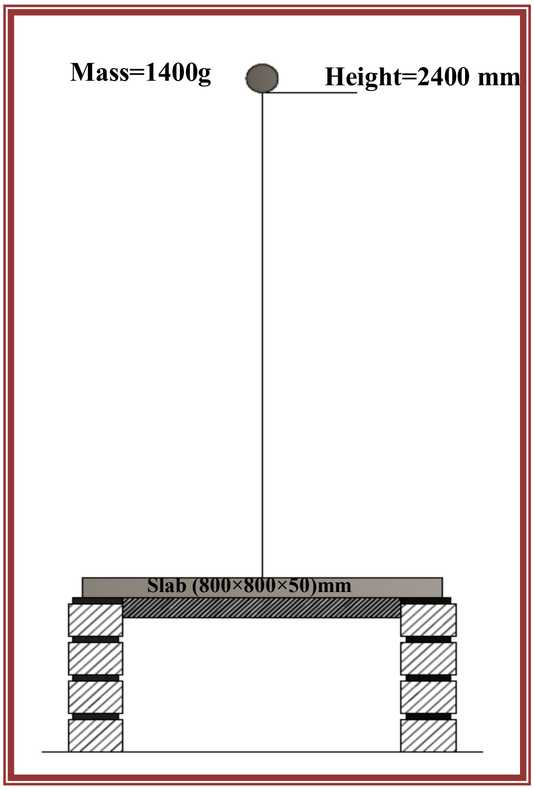


Figure (1): Variables used in the impact test.

Plate (2): Test Rig Used for Low Velocity Impact Test.

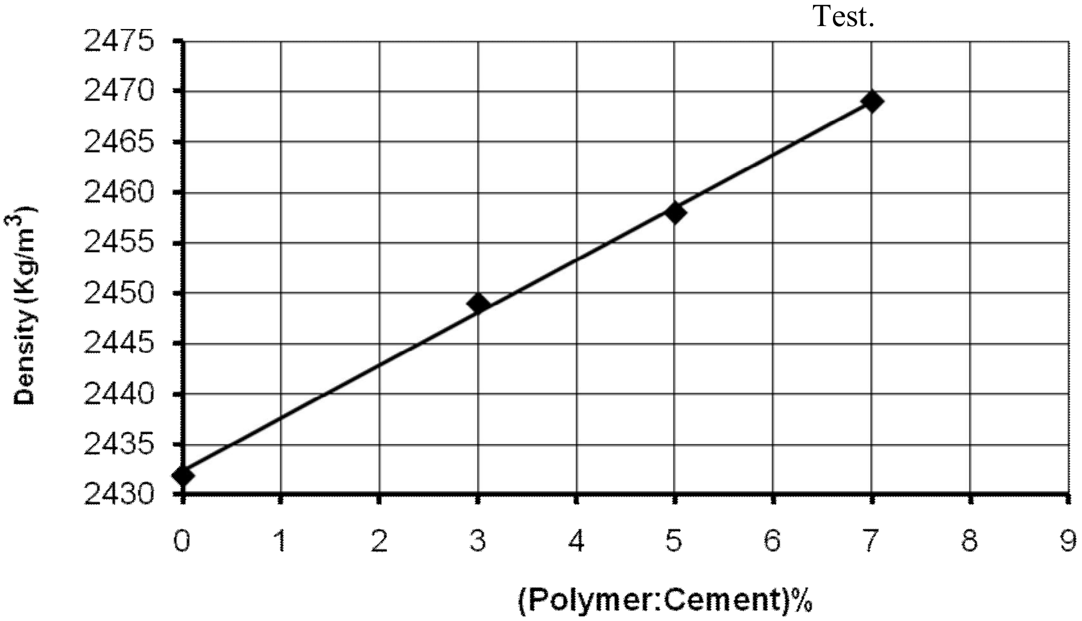


Figure (2): The relationship between density at 365 days age and (P:C) % ratios.

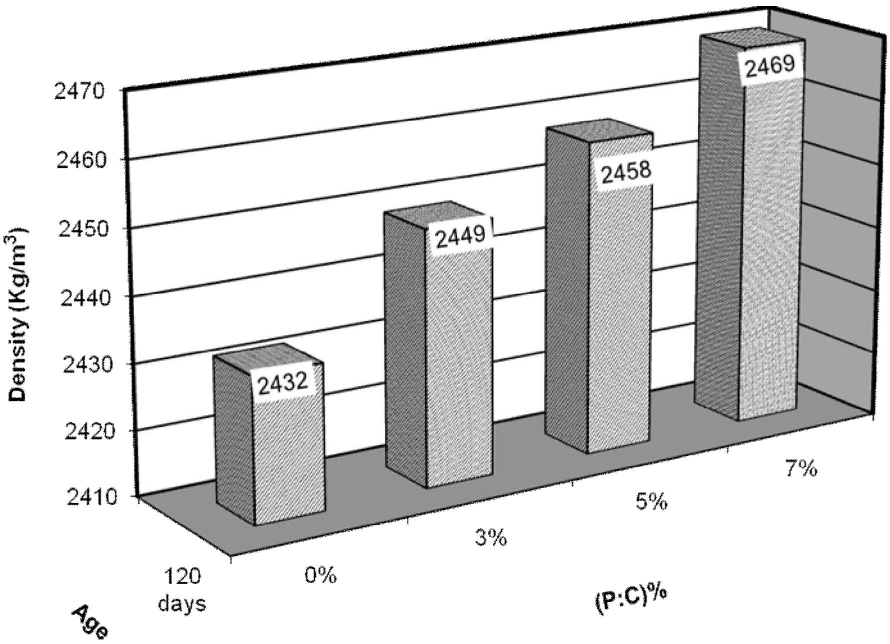


Figure (3): Effect of (P:C) % ratios on density at 365 days age.

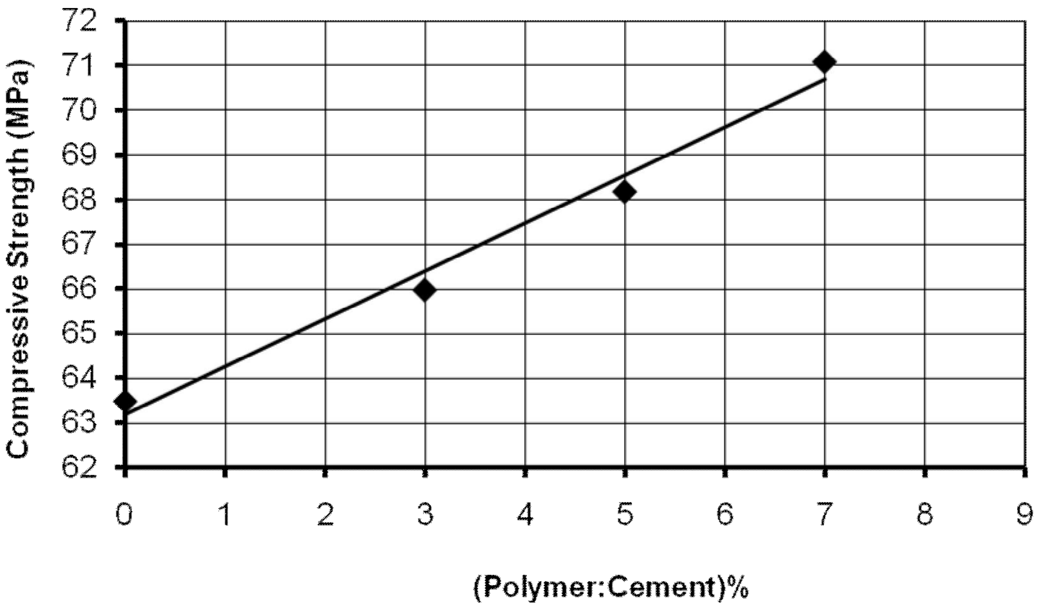


Figure (4): The relationship between compressive strength at 365 days age and (P:C) % ratios

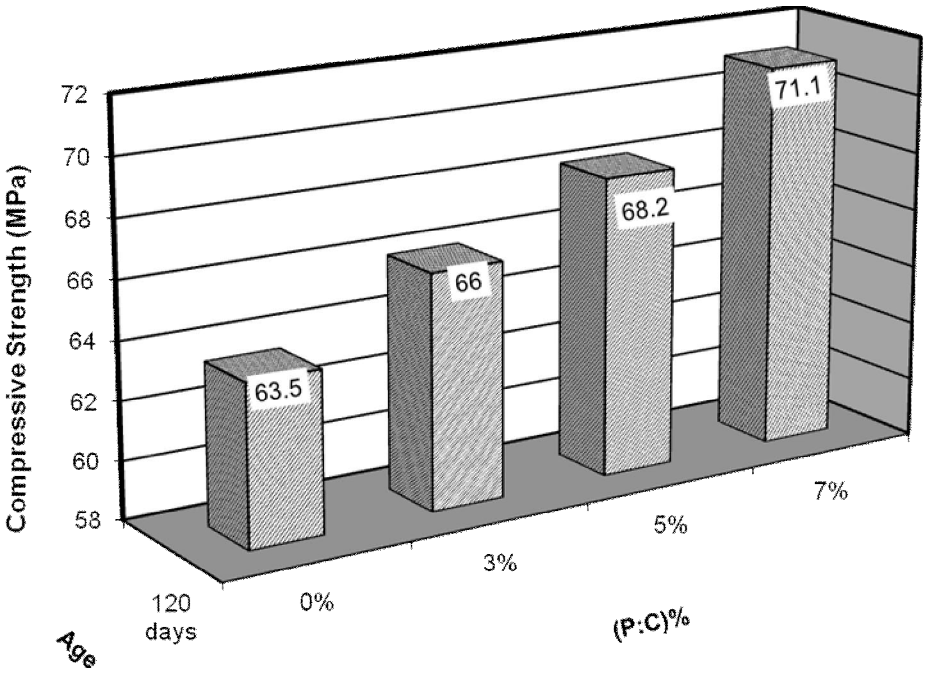


Figure (5): Effect of (P:C) % ratios on compressive strength at 365 days age.

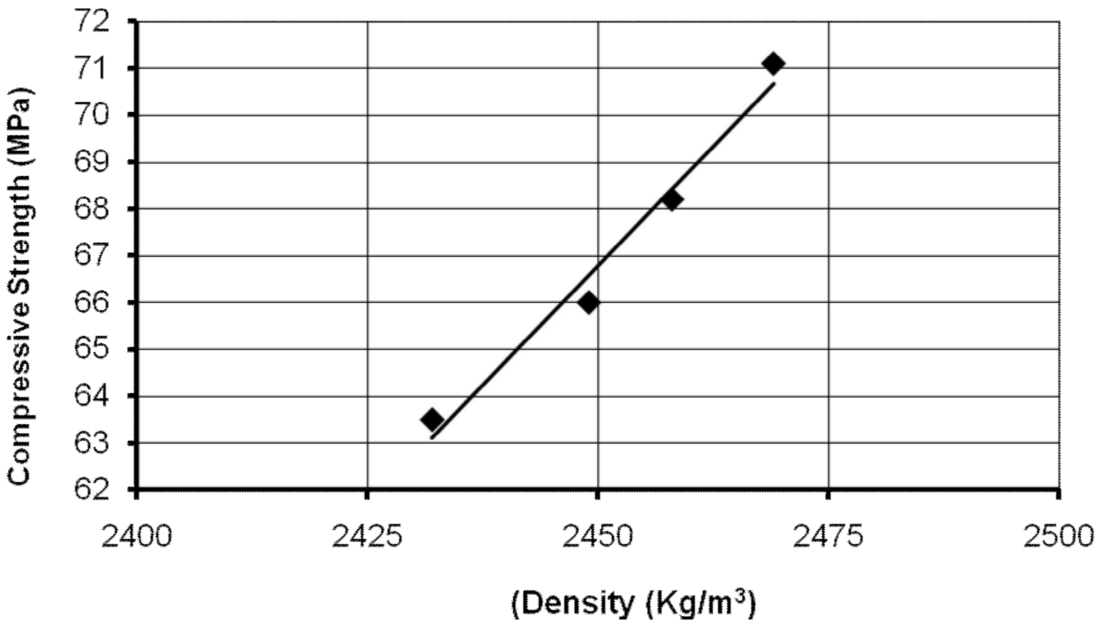


Figure (6): The relationship between compressive strength and density of selected mixes.

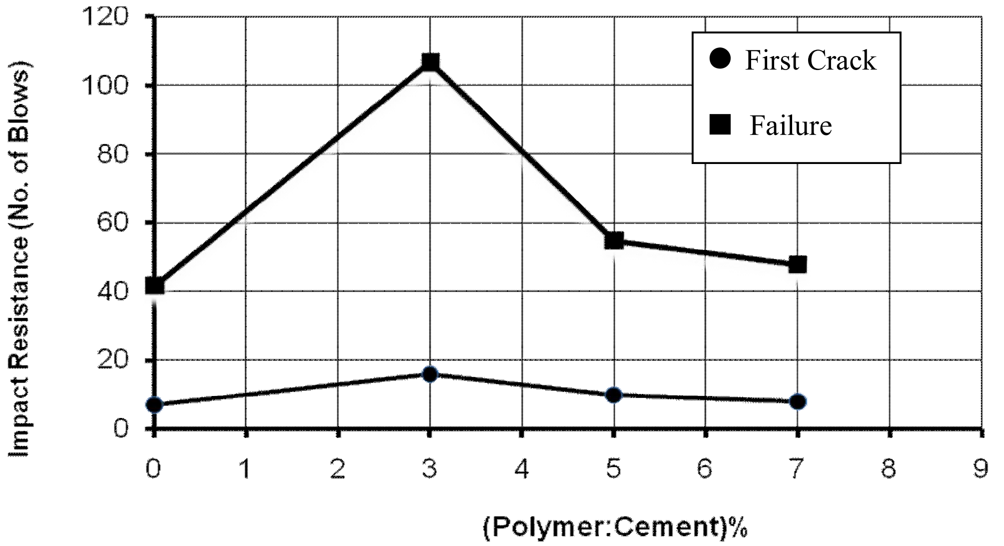


Figure (7): The relationship between impact resistance at 365 days age and (P:C) % ratios.

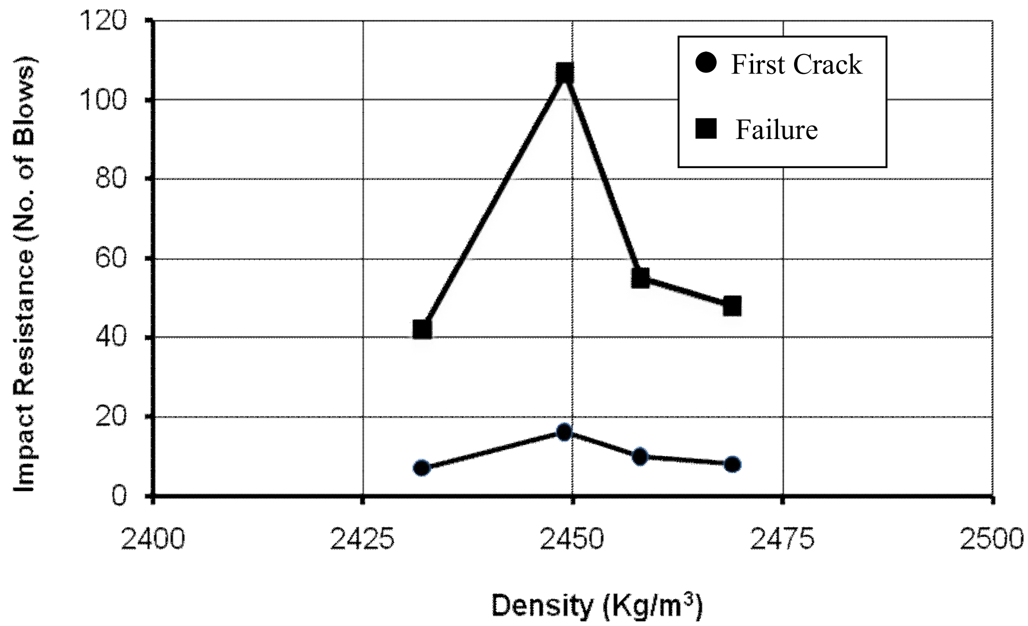


Figure (8): The relationship between impact resistance at 365 days age and density.

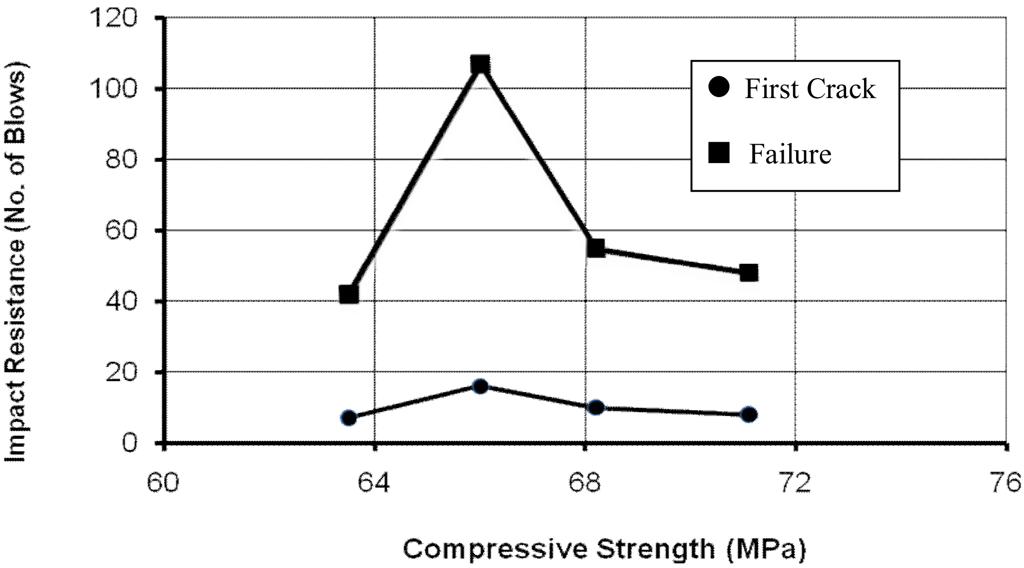


Figure (9): The relationship between impact resistance at 365 days age and compressive strength.

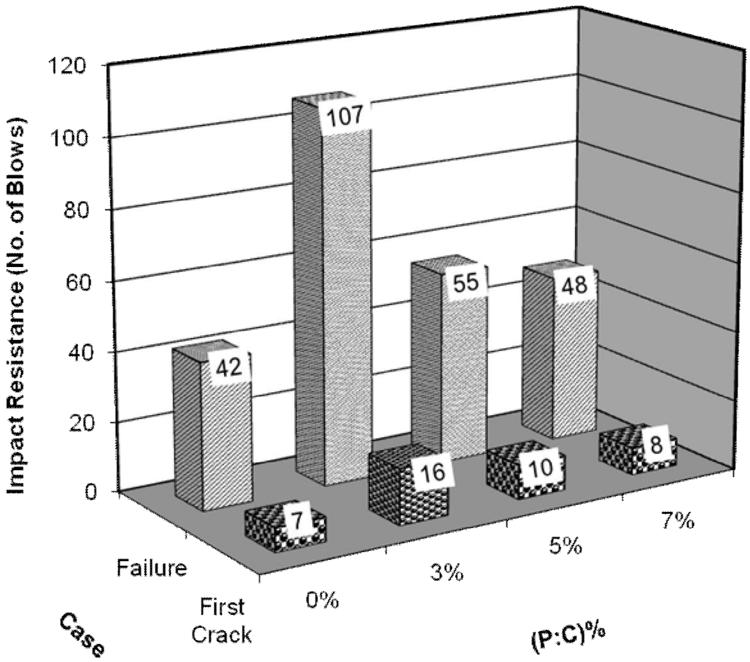
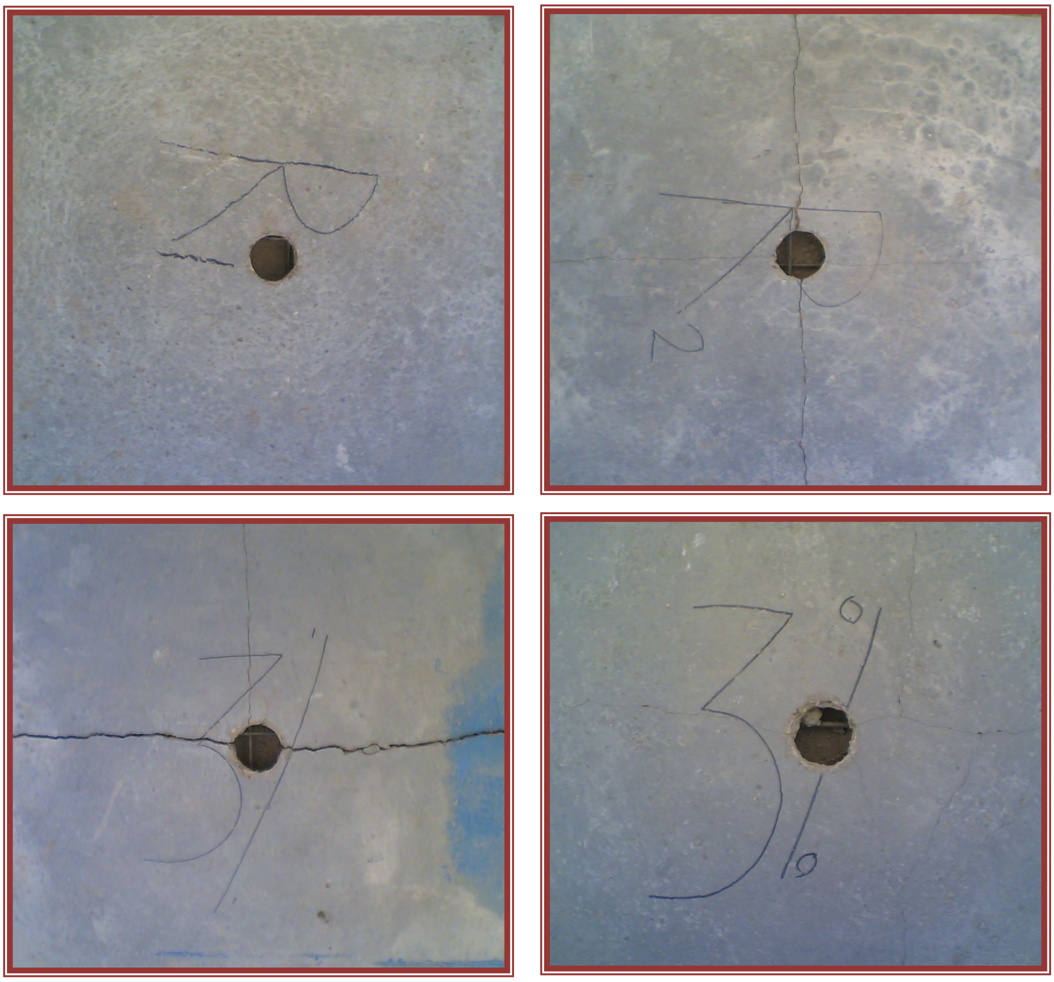


Figure (10): The effect of (P:C)% ratios on impact resistance at first crack and failure.



Bottom of Slab

Plate (3): Mode of ultimate failure.

تصرف الألواح الخرسانية ذات المقاومة العالية والمطورة البوليمر تحت الصدم واطئ السرعة

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الخلاصة.

يتضمن هذا البحث دراسة مقاومة الصدم لألواح خرسانية عالية المقاومة مسلحة بشبكات حديدية (BRC) ومحورة ببوليمر الـ (SBR) Styrene Butadiene Rubber . لقد تمت إضافة مادة البوليمر كنسبة مئوية من وزن السمنت حيث تم استخدام ثلاث نسب من (البوليمر:سمنت) وهي 3% ، 5% و 7% ، كما وتم انتاج خلطة مرجعية لغرض المقارنة.

تم عمل مكعبات خرسانية بأبعاد (100×100×100ملم) لغرض فحص مقاومة الانضغاط لجميع الخلطات المختارة بعمر(365) يوم وأستخدم اسلوب الإسقاط الحر المتكرر لكرة فولاذية تزن 1400 غم من ارتفاع 2400ملم على الألواح الخرسانية بابعاد (50×50×800 ملم) والمسلحة بطبقة واحدة من الشبكات الحديدية (BRC) لغرض فحص مقاومة الصدم بالسرعة المنخفضة. لقد تم حساب عدد الضربات المسببة للتشقق الابتدائي والاختراق النهائي للكرة الفولاذية (الفشل) واعتماداً على هذه النتائج تم حساب طاقة الصدم الكلية لكل حالة.

اظهرت النماذج المصنعة من الخرسانة العالية المقاومة والمحورة بالبوليمر تحسناً في مقاومة الانضغاط ولقد كان مقدار الزيادة في مقاومة الانضغاط عن الخرسانة المرجعية يتراوح ما بين (3.93% – 11.96%) بعمر (365) يوم.

لوحظ تحسناً في فحص مقاومة الصدم بالسرعة الواطئة لجميع الخلطات المحورة بالبوليمر عن الخلطة المرجعية، حيث أعطت نماذج الخلطات الثلاث المحورة بالبوليمر نتائج لمقاومة الصدم أعلى من الخلطة المرجعية وأظهرت النتائج المستحصلة من العمل المختبري بان الخلطة المحورة بالبوليمر بنسبة (3%) قد أعطت أعلى مقاومة للصدم حيث كان مقدار الزيادة في هذه المقاومة عند الفشل عنها للخلطة المرجعية هو (154.76%) بينما كان هذا المقدار للخلطة بنسبة بوليمر (5%) هو (30.95%) وكان (14.28%) للخلطة بنسبة بوليمر (7%).

الكلمات الرئيسية: الخرسانة عالية المقاومة، البلاطات الخرسانية المسلحة، الخرسانة المحورة بالبوليمر، مقاومة الصدم، الصدم بطئ السرعة.