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Effect of Adding (SBR) on Concrete Properties and Bond Between Old and New Concrete

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ABSTRACT:

The effect of adding cempatch SBR (Styrene- Butadiene – Rubber) emulsion to the following was studied:

Cement mortar with different dosages of SBR (10 %, 25%, 35%) by volume of water. Compressive strength of this mortar was tested at ages (7, 28, 60) days. Initial and final setting time were also recorded.

SBR also added to concrete mix 1 : 2 : 4 with 0.45 water to cement ratio by weight, and SBR in dosages of (10 %, 2 5%, 35 %)by volume of water . Compressive strength in ages (7, 28, 60) days was tested, also absorption, slump loss with time and flexural strength were also measured.

And SBR was also used as bonding mortar layer between old and new concrete layers, the compressive strength and flexural strength of bonded samples were tested.

The results of adding SBR emulsion to cement mortar affects compressive strength negatively at all age. Initial and final setting time decrease with increasing the dosage of SBR.

The using of SBR emulsion as admixture for concrete mix affects compressive strength negatively at early ages (7 days) and positively at later ages. It also reduces; the absorption of concrete and slump loss with time and increase the flexural strength.

The use of SBR as bonding layer showed increasing in compressive and flexural strength of the bonded samples compared with samples having old and new concrete without bond layer.

Key words: SBR bonding agent, SBR Styrene- Butadiene- Rubber, SBR, Effect of Using SBR.

تأثير إضافة مادة الـ (SBR) على خصائص الخرسانة والربط بين الخرسانة القديمة والحديثة الصب

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الخلاصة:

تم دراسة تأثير إضافة مستحلب (Cempatch SBR) (ستارين ، بيوتا دين ، مطاط) إلى ما يلي:
مونة السمنت بنسب مختلفة من مستحلب (SBR) (١٠%، ٢٥ %، ٣٥ %) من ماء الخلطة ودراسة بعض الخواص مثل زمن التجمد الابتدائي والنهائي ومقاومة الانضغاط بأعمار مختلفة (٧، ٢٨، ٦٠) يوم.

كذلك اضيف SBR الى الخلطة الخرسانيه (١ :٢ : ٤) مع نسبة ماء إلى الإسمنت (٠,٤٥) حيث تم إضافة مستحلب (SBR) بثلاث نسب هي (١٠%، ٢٥%، ٣٥%) من ماء الخلطة، وتم دراسة تأثير هذا المضاف على بعض الخواص الخرسانية مثل ألهطول، الامتصاص ، مقاومة الانضغاط و مقاومة الانثناء.

كما وتم استخدام المستحلب (SBR) كطبقة رابطة بين الخرسانة القديمة والخرسانة الجديدة وتم فحص مقاومة الانضغاط ومقاومة الانثناء للنماذج الخرسانية الملصقة بواسطة المستحلب.

أوضحت النتائج أن استخدام المستحلب مع المونة الإسمنتية يؤثر سلبيا على مقاومة الانضغاط الأعمار المبكرة (٧ يوم) وايجابيا في الأعمار المتأخرة وأيضا يقلل من زمن التجمد الابتدائي والنهائي مقارنة مع الخلطة المرجعية.

أما نتائج استخدام المستحلب كمضاف إلى الخرسانة فوجد أنة يؤثر سلبيا على مقاومة الانضغاط في الأعمار المبكرة (٧ يوم) وايجابيا في الأعمار المتأخرة، كما ويقلل بشكل كبير من الامتصاص للخرسانة كما ويؤدي الى فقدان كبير في الهطول مع الزمن ويزيد من مقاومة الانثناء بزيادة نسب الإضافة مقارنة مع الخلطة المرجعية. وكانت نتائج استخدام المستحلب كطبقة رابطة بين الخرسانة القديمة والخرسانة الجديدة ظهور زيادة في مقاومة الانضغاط لجميع الأعمار (٧، ٢٨، ٦٠) يوم وكذلك زيادة في مقاومة الانثناء مقارنة مع النماذج المتكونة من خرسانة قديمة وخرسانة جديدة بدون إضافة المستحلب كطبقة رابطة.

INTRODUCTION

Admixtures are not essential components of the concrete mix, they are important and increasingly wide spread components in many countries. The mix which contains no admixture is now a day's an exception. The use of admixtures are growing because they are capable of imparting considerable physical and economic benefits with respect to concrete.

Admixture can be defined as a chemical product which, except in special cases is added to the concrete mix, it may be organic or inorganic for the purpose of achieving a specific modification, or modifications, to the normal properties of concrete. **[Neville , 1995]**

Admixtures also can be used as bonding agents :

Bonding layers are generally used to establish unity between new concrete or mortar and the old concrete. Bonding agents may also used for additional insurance. Epoxy, Latexes (SBR) and Polyvinyl acetates are types from bonding agents These materials develop about having greater tensile and shear strength than concrete. They are resistant to most chemicals and some for mulations are highly water - resistant, good crack resistance. **[ACI 201.2R- 92]**

Aim of Research

The aim of this research is to study the effect of using SBR emulsion as admixture in different dosages on properties of cement mortar , concrete mix and using SBR as bonding layer between old and new concrete by conducting the following tests: initial and final setting time, slump, compressive strength, flexural strength, and absorption.

LITERATURE REVIEW

There are many researches which studied the effect of using SBR emulsion in different dosages and different purposes on concrete properties and the efficiency of this admixture to increase durability of hardened concrete.

Ohama (1981) reported that the chemical resistance of latex -modified concrete is dependent on the polymer -cement ratio and the nature of chemicals. Most latex –modified concretes are attacked by inorganic or organic acids and sulfates as they contain hydrated cement that is non – resistant to these chemical agents, but resist alkalis and salts except the sulfates.

Sujjavanich and Lundy (1998) examined the properties of the latex modified concrete (LMC) which contained styrene butadiene polymer. Strength and the properties of this concrete at ages ranging from (5) hours to (28) days were investigated. The mix proportions of the materials used throughout this study the concrete mix ratio were 1 : 2.45 : 2 .1 , the cement content was 391.5 kg /m ^{3}, w/c =0.32 and polymer /cement ratio was (0.15). This study provides information on early age characteristics of latex modified concrete (LMC). Standard cylinders, 152 × 305 mm were tested for compressive strength and splitting tensile strength at ages o.5, 1, 2, 3, 7, and 28 days, flexural strength and dynamic modulus of elasticity tests were conducted on beams at ages 0.5, 1, 3, 7 and 28 days.

Results of tests show that the compressive strength, modulus of elasticity, tensile and flexural strengths increase with the increase of curing time. But ratio of compressive strength to splitting tensile strength (fc / f t) decreases from about 12.5 to 6.8 and increase and again after about 12 hours. Similar rends are reported for conventional concrete.

Folic and Radonjanin (1998) studied the properties of latex -modified concrete containing (SBR) and they tested concretes modified with 2.5, 5 and 7.5 percent of polymer admixture to the cement.

The test results showed that the water absorption decrease with the increase of polymer - cement ratio. Although it was the case of capillary water absorption, such a positive change is important as it influences the increase of concrete durability.

Ohama (1981) reported that the pore structure of latex - modified hydraulic cement system is influenced by the polymer –cement ratio. The total porosity or pore volume tends to decrease with an increase in the polymer - cement ratio. This may be improved in the impermeability and durability of the latex -modified concrete. Generally, the water absorption and permeation of latex- modified concretes are considerably reduced with an increase in polymer - cement ratio. This is because they have a structure in which the larger pores can be filled with polymer or sealed with the continuous polymers films. The freeze –thaw durability of the latex -modified concretes is improved at a polymer - cement ratio of (5) percent or more due to composite effects of water impermeability and air entrainment. Increasing the polymer -cement ratio does not necessarily cause an improvement in the freeze -thaw durability.

EXPERIMENTAL WORK

1- Materials

1- 1 Cement

Ordinary Portland cement type 1 manufactured in Saudia Arabia was used in this research. This cement is conforming to The Iraqi specification IQS No. 5/ 1984.
The chemical composition and physical properties of this cement are given in
Table (1) and table (2).

Table (1): Chemical composition of the used cement

Oxide	Test Result	Limits According to IQS No.5 1984
CaO %	62.23	-
SiO_2 %	20.8	-
Al_2O_3 %	5.14	-
Fe_2O_3 %	3.40	-
MgO %	1.52	<=5 %
K_2O %	-	-
Na_2O %	-	-
SO_3 %	2.41	$\leq$ 2.5 % if C_3A <5 % $\leq$ 2.8 % if C_3A >5%
Free Lime %	1.51	-
Loss on Ignition%	4.0	$\leq$ 4 %
Insoluble Residue %	1.27	$\leq$ 1.5 %
L.S .F	0.88	0.66 – 1.02
M.S.	2.43	-
M.A.	1.51	-
TOTAL		
C_3S %	42.8	-
C_2S %	27.34	-
C_3A %	7.87	-
C_4AF %	10.35	-

Table (2) Physical properties of the used cement

Properties	Test Result	Limits According to IQS No.5 1984
Setting Time, (minute) Initial Final	130 240	$\geq$ 45 min $\leq$ 600min
Fineness (Blaine method), in m^2 /kg	345	$\geq$ 230
Compressive Strength, Mpa 3 days 7days	 17 25	 $\geq$ 15 $\geq$ 23

1- 2 Fine Aggregate

Graded sand was used in this research, It was brought from AI –Akhaidhur – Karbalaa, Table (3) shows the sieve analysis and Table (4) shows physical and chemical composition of fine aggregate according to IQS NO. 45 - 1984 specification.

Table (3) : Grading of fine aggregate

Sieve size (mm)	% Passing	Limits of Iraqi specification, No 45/ 1984 (Zone 2)
10	100	100
4.75	95	90-100
2.36	80	75 -100
1.18	67	55- 90
0.6	51	35 -59
0.3	21	8 - 30
0.15	4	0 - 10
0.075	0	≤ 5%
Fineness modulus	2.8	

Table (4) Physical and Chemical Composition of Fine Aggregate

Property	Result	Limit of Iraqi specification No. 45 -1984
Sulfate content as SO_3%	0.135	0.5 (Max)
Materials finer than (75) µm sieve%	1	5 (Max)

1 – 3 Coarse Aggregate

Graded gravel used in this research was brought from AL –Nibaee. Table (5) and table (6) shows the sieve analysis, physical and chemical composition of coarse aggregate according to IQS NO .45- 1984.

Table (5) : Grading of coarse aggregate

Sieve size (mm)	%Passing	Limit of Iraqi specification, No 45/ 1984 (5 -40)mm
63	100	100
37.5	100	95 -100
20	66	35 – 70
10	14	10 – 40
5	0.4	0 - 5

Table (6) Physical and Chemical Composition of Coarse Aggregate

Property	Result	Limits of Iraqi specification No. 45 -1984
Sulfate content as SO_3%	0.03	1 (Max)
Materials finer than 75 µm- Sieve %	1	3 (Max)

1 - 4 Cempatch SBR

Styrene –Butadiene – Rubber, Latex, cempatch SBR is added to improve the physical properties of cement mixes and slurries.

The chemical and physical properties of cempatch SBR used are given in table (7).

Table (7) : Chemical and physical properties of cempatch SBR used [Fosroc company for building chemicals, Ltd]

Colour	White
Shape and appearance	Emulsion
Solid in aqueous solution	45%
Mixing with water	Mix with water at any percent
Specific gravity	1.081 kg/lit
Storage condition	Free from soft, No high temp, and/or high humidity
Shelf life	1year when closed
Butadiene	40 (by weight)
Styrene	60 (by weight)
Sodium alkyl sulfate	0
Sodium phosphate	0
(pH) value	9.5
Packaging	5litre, 25litre,200litre
Fire	Non – flammable

2 - Test Procedures

2 – 1 Compressive Strength Test

The compressive strength of concrete was determined according to BS.1881 – part 116 – 1989. (100mm) cubes were tested using standard testing machine with a capacity of 2000kN, at loading rate of 15N/mm² per minute for the concrete samples. As for cement mortar samples the compressive strength was determined according to BS. 1881 – Part 4. (70.7mm) cubes were tested. The average of three cubes was adopted at each test. The test was conducted at ages of 7, 28, 60 days for both specimens. The cubes were moist cured until the age of testing.

2 - 2 Flexural Strength Test

Flexural strength of concrete was carried out on 100× 100×400 mm simply supported prisms with a clear span of 300mm.The prisms were tested by two – point load. The test was performed according to BS. 1881 – part 118 – 1989. The test was conducted at ages of (28 days) for all specimens. Flexural strength can be calculated from the following equation:

$$fr = \frac{P\,L}{bd^2} \qquad \ldots (1 - 1)$$

Where

fr: flexural strength (N / mm²)

P : maximum applied load (N)

L : effective length (mm)

b : width of prism (mm)

d : depth of prism (mm)

2 – 3 Slump Test

This is a test used extensively in field all over the word. The slump test does not measure accurately the workability of concrete, it is ameasure of consistency, but the test is very useful in detecting variations in the uniformity of a mix of given nominal proportions. **[Neville, 1995]**

The slump test is prescribed by ASTM C 143 -90 a.

2 - 4 Absorption Test

. Cube specimens with 100mm were used for the concrete absorption test. This test was conducted according to BS. 1881 part 122 -1989 after (28 days) of moist curing. These specimens were dried in an oven at (105 ± 5C°)for (72 hours), then the specimens were immersed in water for (24 hours).

The percentage of absorption can be calculated from the following equation:

$$\text{Absorption}(\%) = \frac{(W2 - W1)}{W1} \times 100 \qquad \ldots(1-2)$$

Where:

W1 : the average weight of three dry specimens (g).

W2 : the average weight of three wet specimens (g).

2 - 5 Initial And Final Setting Time

For cement mortar Vicat apparatus was used to record initial and final setting time. This test was carried out according to BS. 12 :1971 specifications.

PREPARING MIXES AND TESTS

SBR was used in the present work in three ways:

1 - SBR was used as admixture to cement mortar (1 : 3) (cement : sand) in dosage of (10% , 25% , 35%) by volume of mixing water . For the specimens the compressive strength in ages (7, 28, 60 days) were tested. Each value in the compressive strength results represents the average of three samples.

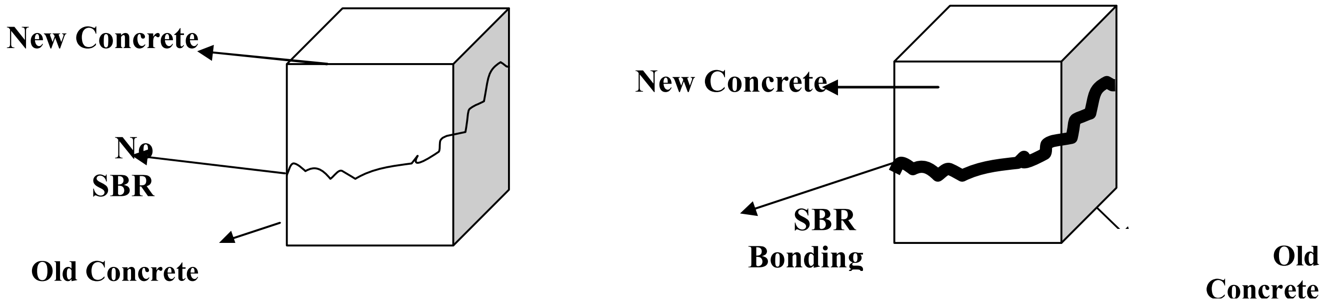
2 - SBR was used as admixture to concrete mix (1 : 2 : 4) (cement : sand : gravel) with (w/ c) ratio (0.45) in dosage of (10%, 25%, 35%) by volume of mixing water. For this concrete mix slump was recorded, the absorption, compressive strength in ages (7, 28, 60 days) and flexural strength were measured.

3 - SBR was used as bonding mortar layer between old and new concrete, with ratio (1: 1: 3),(SBR : Water : OPC (Ordinary Portland cement)) by weight. To investigate this bonding action of SBR mortar. Two types of tests were conducted:

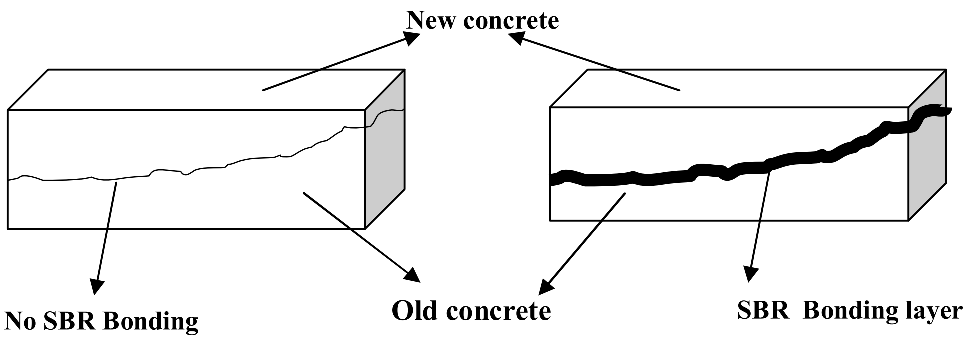
The first type is casting the compressive strength cubes (100 mm) in two layers. The bottom (1: 2 : 4) concrete layer, with (w/ c) ratio (0.45) was cast with the upper surface been highly irregular. After (7) days a layer of SBR mortar (1 : 1 : 3) (SBR : Water : OPC) by weight was applied on the top irregular surface of the stiffened concrete, then after (10) minutes, the cube mould was filled with newly mixed same (1:2 :4) concrete. Figure (1 - A) shows the cubes.

The cubes were moist cured until the age of testing (7 , 28 ,60) days, and the results were compared with the compressive strength of identically cast concrete cubes but without bond layer.

The second type is casing the flexural prisms (100* 100 * 400 mm) in two inclined layers between which a bonding SBR mortar layer was applied in the same procedure mentioned above. These prisms were tested by two point load method for the flexural strength. The results were also compared with the flexural strength of identically cast concrete prisms but without bond layer. Figure (1 - B) shows the prisms. The compressive strength was measured at (7, 28, 60) days, and flexural strength at (28) days.



(A) Concrete cube



(B) Concrete prism

Figure (1) : Samples with and without SBR as a bonding mortar layer

RESULTS AND DISCUSSION

The results of using cempatch SBR as admixture to cement mortar in dosages of 10%, 25%, and 35% affects adversely compressive strength. Figure (2) shows that in all these dosages there was a reduction in compressive strength with increasing of SBR dosage in ages (7, 28, 60 days). These results disagree with the published production references (Cempatch SBR, DCP and Paco system, 1997) .This may be due to partially increasing the total liquid (water +SBR) to cement ratio.

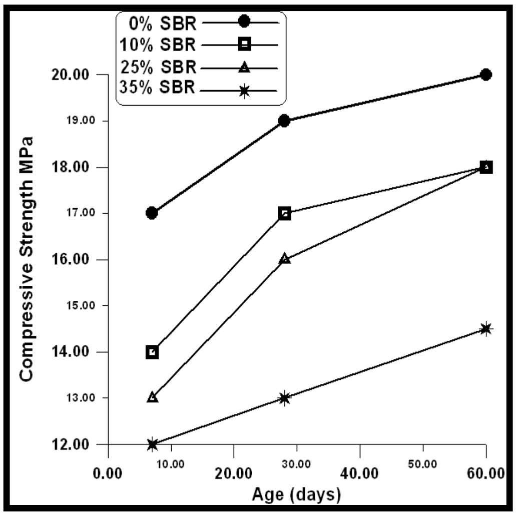
Figure (3) shows the reduction in initial and final setting time with increasing the dosage of SBR and that gives may be accelerating action to the process of setting. This harmful property when preparing and using SBR with cement mortar.

The results of using cempatch SBR as admixture for concrete mixes show a better action. Figure (4)`shows a high reduction in percentage absorption with increasing the dosage of SBR. This agrees with what stated by (Folic and Radonjanin, 1998) . Figure (5) shows the development of flexural strength with increasing the dosage of SBR. This agrees with the instructions for use of SBR with the published production references (Cempetch SBR, DCP and Paco system,1997).

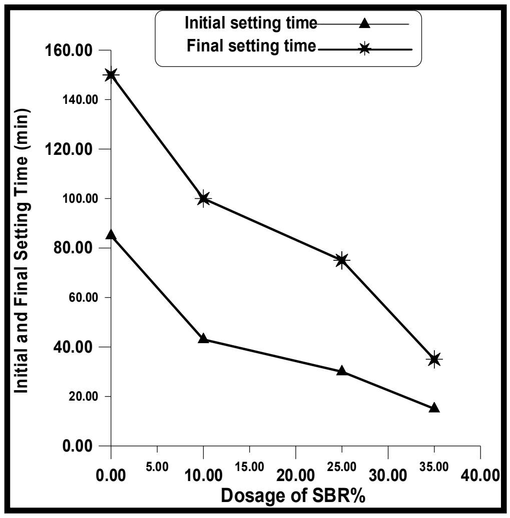
In Figure (6) the results show also decreasing in slump values with increasing the dosage of SBR, which means that it affects negatively the concrete workability.

In Figure (7) the results of concrete compressive strength show increasing with the dosage of SBR (25 %, 35%) at ages of (7, 28, 60) days. But the concrete mix with a dosage of (10 %) SBR by volume of water shows a decreasing in compressive strength. This may be due to the low concentration of SBR. That agrees with what was found by (Abdul Amir, 2008)

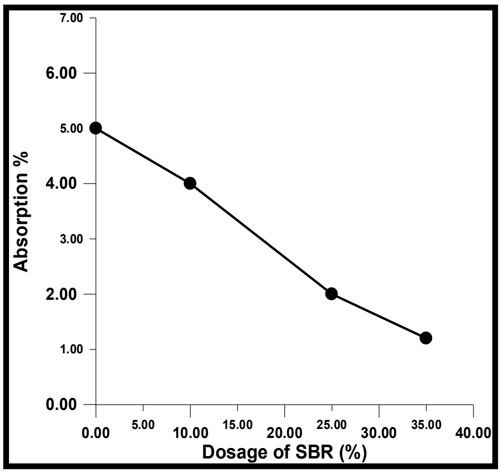
From figures (8)and (9) it was found that using SBR as a bonding mortar layer with ratio (1: 1: 3) (SBR : water : OPC) gives increasing in flexural strength and compressive strength as compared with samples of old and new concrete but without bond layer.



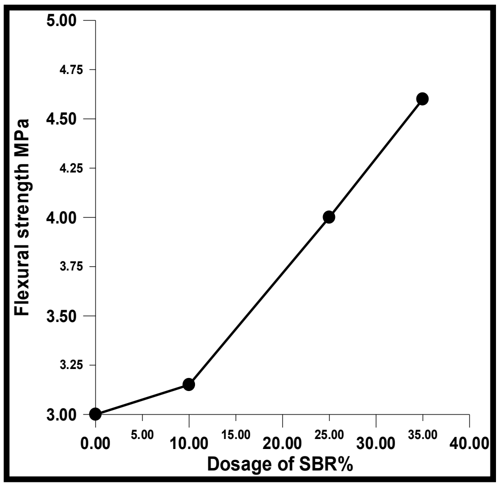
Figure(2) Development of compressive strength with age for different dosages of SBR in cement mortar



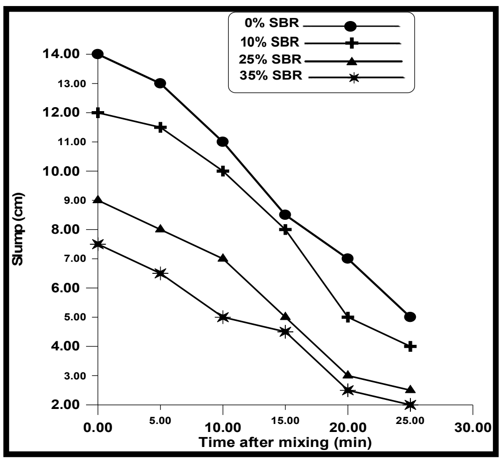
Figure(3) Decreasing of initial and final setting time with dosage of SBR in of cement mortar



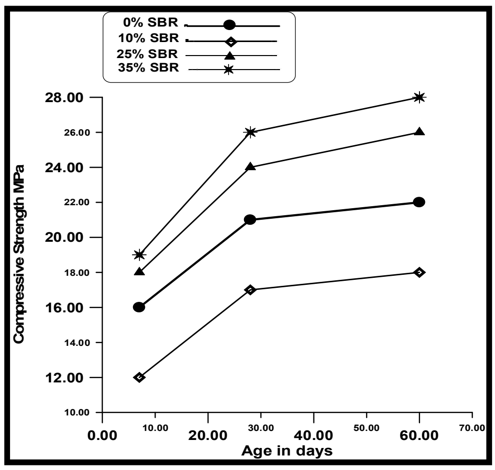
Figure(4) Effect of SBR on absorption of concrete samples



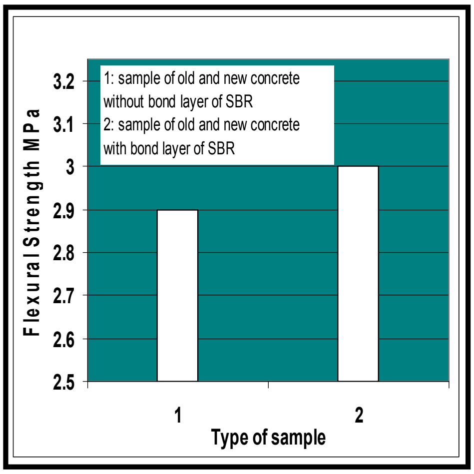
Figure(5) Development of flexural strength with dosage of SBR in concrete samples



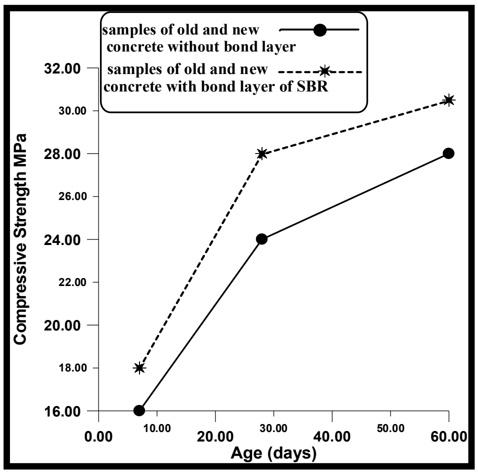
Figure(6)Slump loss with time for with concrete samples



Figure(7) Development of compressive strength with age for defferent dosages of SBR for concrete samples



Figure(8) Development of flexural strength for concrete samples with and without bond layer of SBR



Figure(9) Development in compressive strength with age for concrete samples with and without bond layer of SBR

CONCLUSIONS

1. Adding SBR to cement mortar in dosages of (10%, 25%, 35%) by volume of mixing water caused a reduction in compressive strength about (22%, 33%, 67%) respectively in the age of (28) days. It acted as acceleration admixture. Also these dosages caused a reduction in initial and final setting time by 49% and 50% for dosage 10% SBR by volume of water, 65 % and 50% for dosage 25% SBR by volume of water, and a reduction of 82 % and 76 % for dosage 35 % SBR by volume of water.
2. Using SBR as admixture with concrete caused a reduction in; slump after 5 minutes from mixing reaches to 50% for dosage 35% SBR by volume of water, Absorption with 20 %, 60 %and76 % for dosage 10%, 25% and 35% respectively It caused a considerable reduction in compressive strength at early age (7 days),Also it caused an increase in compressive strength with increase the dosage of adding. Also adding of SBR to concrete mix caused an increase in flexural strength at 28 days with increase of SBR dosage by (7%, 33%, 53%)for dosage (10%, 25% and 35%) respectively.
3. Using SBR as bond layer between old and concrete brings good results by increasing compressive strength about 12.5 %, 17 % and 9% at ages 7, 28 and 60 days as compared with samples having old and new concrete layers but without bond layer and increase the flexural strength about 3 % comparing with samples having old and new concrete layers but without bond layer.

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