Effect of Adding SBR on Properties of Cement Mortar

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Abstract

The effect of adding SBR to cement mortar was studied experimentally It was added at 2.5%,5%,7.5% and 10% by weight of cement. The tests which were performed to evaluate the action of this admixture were :flow table, compressive strength , flexural strength , ultrasonic pulse velocity , porosity and drying shrinkage of cement mortar. It was found that the compressive strength and ultrasonic pulse velocity are not affected by the addition of (SBR) , While the use of (SBR) in all concentration causes increase in flexural strength , also it reduces porosity and drying shrinkage of cement mortar .

الخلاصة

تم دراسة تاثير اضافة مادة (ستايرين– بيوتادين– مطاط) (SBR) على خواص مونة السمنت مختبريا .لقد اضيفت هذه المادة بالنسب التالية 2.5%, 5%,7.5% و10% من وزن السمنت . الفحوصات التى استخدمت لتقييم تاثيرهذه المادة :منضدة الانسياب , مقاومة الانضغاط ,مقاومة الانثناء , سرعة الامواج فوق الصوتية . المسامية وانكماش الجفاف لمونة السمنت . لقد وجد من خلال البحث ان مقاومة الانضغاط وسرعة الامواج فوق الصوتية لاتتاثر باضافة هذه المادة . بينما استخدام مادة (SBR) لجميع النسب تسبب زيادة في مقاومة الانثناء وكذلك تقلل من المسامية وانكماش الجفاف لمونة السمنت .

Introduction

Nowadays, research on cement matrix materials is focused on the inclusion of admixtures to improve certain physical and mechanical properties, low cost and capacity to fill almost any shape.

Polymeric admixtures are defined as polymers used as a main ingredient effective at modifying or improving cement – based material properties –such a polymeric compound can be a polymer latex, redispersible polymer powder ,water – soluble polymer or liquid polymer .Among the different presentations of polymer admixtures, polymer latex is in most widespread use .Floor and bridge overlays , repairing mortars and bonding ceramic tile agents are some of the actual latex modified mortar (LMM) uses .Recently, new uses have been proposed in precast elements and as precast elements joining material { **Ohama,1998**} .

Polymer latex modification of cement mortar is governed by both cement hydration and polymer film formation processes in their binder phase .A co-matrix is formed by both processes{ **Sakai,j.Svgita 1995**}. In general , the polymer modified mortar properties depend significantly on the polymer content rather than W/C , when compared to ordinary cement mortar { **Silva, 2001**}.

Literature Review

There are limited researches which studied the effect of using SBR emulsion in different dosage and different purpose on cement mortar and concrete properties and the efficiency of this admixture to increase durability of hardened concrete .

{Abdul Amir ,2008} concluded that the best concentration of adding (SBR) to the concrete to lead a considerable improvement in all mechanical properties was (25% by volume of water).

{AL Bderriy,2001} investigated the ability of produce high performance concrete by using SBR emulsion ,high range water reducing agent (HRWRA) +SBR emulsion and high range water reducing agent (HRWRA) only .The compressive, splitting tensile and flexural strength , dynamic modulus of elasticity, initial surface absorption , total absorption, porosity ,permeability and penetration of sulfate ion tests were investigated for reference , HRWRA ,SBR and (HRWRA+SBR) concrete .The tests results indicate that using 7%(SBR) emulsion by weight of cement leads to considerable improvement in all mechanical and physical properties of concrete mixes. The compressive strength in 28 days reached 64.4 Mpa. While the percentage of reduction in drying shrinkage after drying age of 90 days was 47.2% compared with reference concrete . Also this concrete has high resistance to penetration of sulfate ions and excellent improvement in durability properties .

{Ohama 1985} studied the effect of monomer ratio in SBR latex_ on the strength of latex – modified concrete. The strength of SBR – modified concrete increases with the increase of bound styrene content. The tensile strength increases sharply when the bound styrene content is raised, and there is a positive correlation between the strength of the film and flexural strength of the SBR –modified mortar with a polymer- cement ratio above 10%.

{Folic and Radonjanin 1998} studied the properties of latex- -modified concrete containing (SBR) and thy tested concrete 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.

Experimental Work

Materials

1-Cement

Ordinary Portland cement manufactured by united cement company commercially known (TASLUJA- BAZIAN) was used. The chemical composition and physical properties of this OPC are given in Tables(1) and (2),respectively-test result indicate that the adopted cement conforms to Iraqi specifications (IQS NO.5/1984).

Table (1): Chemical composition of the cement

Oxide	%	IQS No. 5: 1984 Limits
CaO	62.06	-
SiO_2	20.94	-
Al_2O_3	5.52	-
Fe_2O_3	3.64	-
MgO	3.15	≤ 5.0
SO_3	2.47	≤ 2.8
Free lime	1.0	-
L.O.I	1.74	≤ 4.0
Compound Composition	%	IQS No. 5: 1984 Limits
C_3S	40.10	-
C_2S	29.78	-
C_3A	8.47	-
C_4AF	11.07	-
L.S.F	0.88	0.66-1.02

Table (2): physical properties of cement

physical proposition	Test results	IQS No. 5:1984 Limits
Fineness, Blaine, Cm^2/gm	3100	≥ 2300
Setting time, Vicat's method		
Initial hrs : min	2 : 20	≥ 00:45
Final hrs : min	3 : 55	≤ 10:00
Compressive strength Mpa		
3 days	18	≥ 15
7 days	27	≥ 23

2- Sand

The sand used was natural, silicious sand with maximum size of 2.36 mm (100% passed 2.36 mm sieve).Sieve analysis and other properties of this sand are listed in Table (3) .

Table (3) :Grading and other properties of fine aggregate.

Sieve size mm	Cumulative passing %	Limits of Iraqi Specification IQS No. 45/1984 for zone (3)
9.5	100	100
4.75	100	90 – 100
2.36	100	85 -100
1.18	88	75 -100
0.6	67	60 -79
0.3	32	12 -40
0.15	8	0 -10
Physical properties	Test results	Limits of Iraqi Specification IQS No. 45/1984
Sulfate content as SO_3	0.39 %	≤ 0.5%
Fine materials	0.95 %	≤ 5%
Fineness modulus FM	2.05	

3- Cempatch SBR

Cempatch SBR is a single component styrene butadiene rubber latex . Cempatch SBR is designed to improve the physical properties of cement mixes and slurries. SBR is ideally designed for use in the following application .

* Bonding of new to old concrete when used as a slurry coat .
* To produce polymer modified screed and floor toppings.
*Bonding of thin polymer modified screeds and /or toppings to old substrates.
* To provide a mechanical key prior to rendering of various plaster mixes on concrete , brick and block surfaces .
*To produce a repair mortar for patching of honeycombed concrete , internally and externally .
* To produce water – proof renders.

The chemical and physical properties of Cempatch SBR used are given in Table (4) { **Cempatch SBR , DCP** }

Table (4) Typical properties of SBR admixture

Color	White
Shape and appearance	Emulsion
Solid in aqueous	45%
Specific gravity	Around 1 at 25c°
Fire	Non-flammable
PH	9.5
packaging	5liter,25liter,200liter

PREPARING MIXES

(SBR) was used as admixture to cement mortar (1:3) (cement: sand) in dosage of (2.5%,5%,7.5% and 10%) by weight of cement with initial WIC=0.5 . After word , the W/C ratios were adjusted to maintain a flow of (100±10) percent . The flow table was adopted for measuring the workability of the mixes .Table (4) summarizes W/C ratios for flow (100±10) percent for all mixes.

Table(4):w/c ratio with different percentages of SBR for flow (100±10) percent.

% SBR	W/C
0	0.5
2.5	0.495
5	0.485
7.5	0.47
10	0.455

Testing Procedures

1-Flow Table Test

The flow table of fresh mortar mixes was determined according to ASTM C230-1989

2-Compressive Strength Test

Compressive strength of cement mortar specimens was conducted on (70.7mm) cubs according to B.S.1881-part 4 , by using 200KN capacity testing machine. The compressive strength of the mortar specimens was tested at the ages of 7,28 and 60 days , The specimens were moist cured until the age of testing , The average of three specimens in each age was taken.

3-Flexural Strength Test

The center point loading method was used in making flexural tests on the prism specimens .This test was performed according to ASTM C348 -1989 using (40x40x160) mm prism specimens . The specimens were tested at the age of 7,28 and 60 days .The specimens were moist cured until the age of testing .Flexural strength can be calculated from the following equations:

$$F_t = \frac{3pL}{2bd^2}$$

Where :

F_t = flexural strength (N/mm^2)

P= maximum applied load (N)

L=effective Length (mm)

b= width of prism (mm)

d=depth of prism (mm)

5- Ultrasonic Pulse Velocity Test

The velocity of the ultrasonic pulse of the cement mortar specimens was determined before finding the crushing compressive strength .This test was carried out according to ASTM C597.portable ultrasonic concrete tester known as (PUNDIT) was used for this purpose .

Calibration of the concrete tester was done before testing to check the accuracy of the transit time measurements .This was achieved by a calibration bar or reference bar .A thin layer of grease was applied to act as a couplant and to increase the transmitted energy. The pulse travelling path length was measured accurately and the time of its travelling was recorded .The cement mortar cubes at the age of 28 days was tested immediately after removing them from curing water .

The pulse velocity was determined as follows :

V=L/T

Where:
V=ultrasonic pulse velocity ,Km/sec
L=path length ,Km.
T=transit time ,sec.

4- Porosity

Cube specimens with(70.7) mm were used for the mortar porosity test. This test was conducted at 28 age of moist curing. These specimens were dried in an oven at(105 ±5 c˚) for 72 hours, then the specimens were immersed 1n water for (24 hours), moreover we need a third weight for specimen which represented the submerged weight . The porosity can be determined from the following equation.

$$\text{Porosity \%} = \frac{W_{sat} - W_{dry}}{W_{sat} - W_{sub}} * 100\ \%$$

Where :
W dry : the average weight of three dry specimens (g)
W sat : the average weight of three saturated specimens (g)
W sub : the average weight of three submerged specimens (g)

Saturated specimens submerged in water and measured their weights with a hydrostatic scale.

5- Drying Shrinkage Test

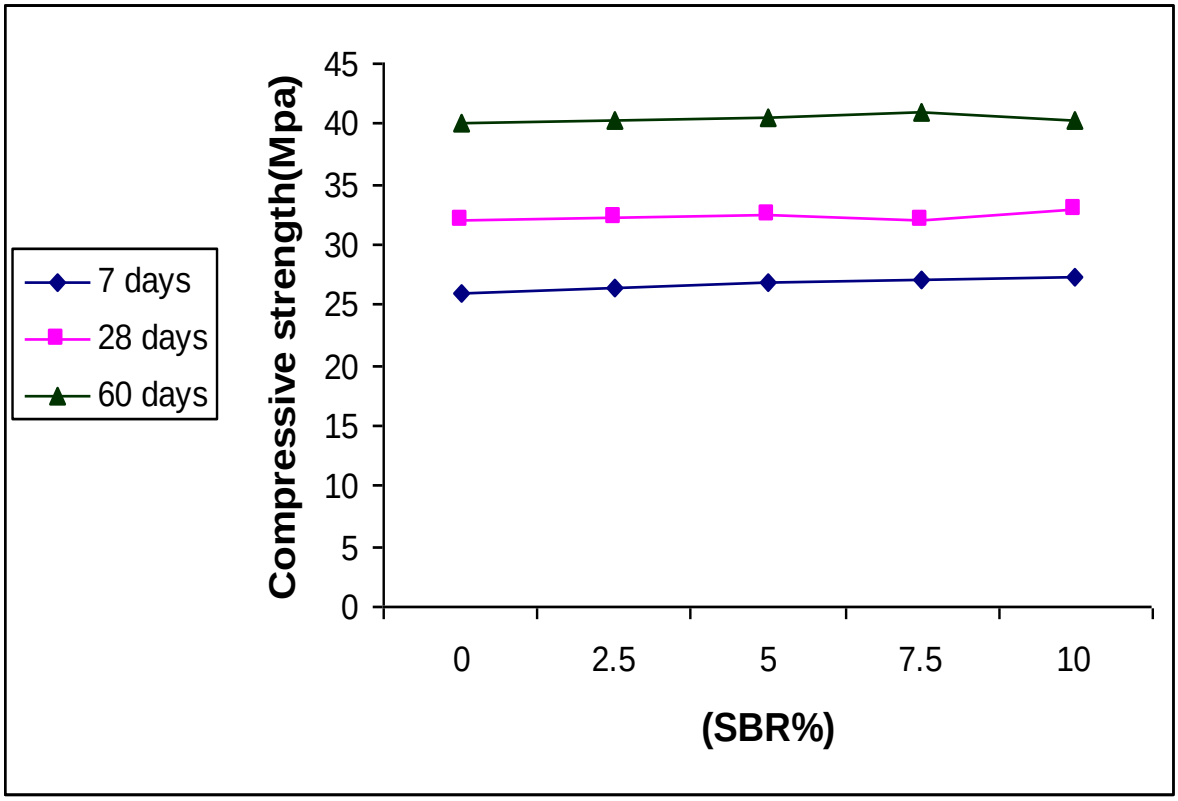
For each mix, three prisms of (25x25x285 mm) were casted for drying shrinkage .Which were kept in laboratory condition after they had been cured in water for 7 days. Stainless steel gage studs were used and fixed on each two ends of each specimen. This test was carried out according to ASTM C 157- 1989 . The change in length was monitored by using comparator at designated test times .

Results And Discussion

Table (5) and Fig(1) show the relationship between compressive strength of the cement mortar and the percentage of SBR addition . It can be seen that compressive strength was practically constant for any percentage of SBR ,that's because the inclusion of SBR latex in cement mortar produces a decrease of compressive strength , due to the lower mechanical capacity of latex with regard to cement mortar , for a fixed consistency. This decrease is compensated by the reduction of W/C due to the plasticizer effect of latex . Both phenomena together maintain compressive strength constant for any percentage of latex.

Table (5) : Compressive strength test results of SBR containing mortar

SBR by weight of cement %	Compressive strength (Mpa)		
	7 days	28 days	60 days
0	26.0	32.0	40.0
2.0	26.4	32.2	40.4
5	26.9	32.5	40.6
7.5	27.1	32.0	40.9
10	27.3	32.8	40.3

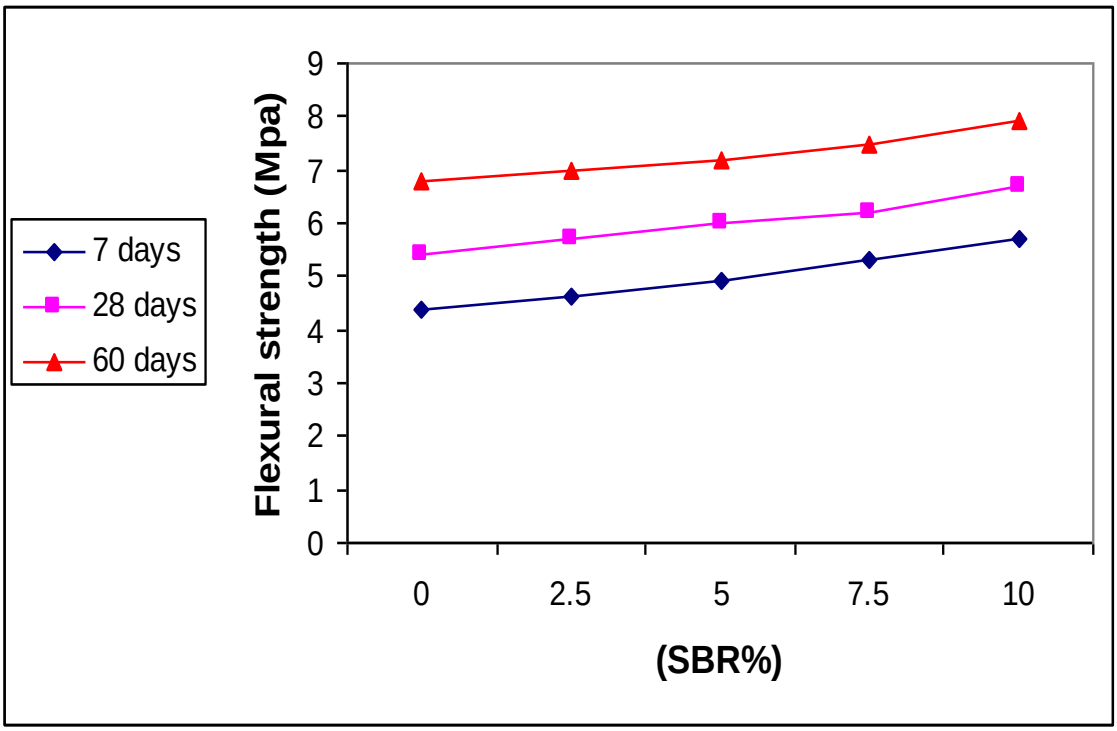


Fig(1): Effect of SBR on the compressive strength of cement mortar

From Table (6) and Fig (2) it can be seen that the cement mortar with (SBR) recorded an increase in flexural strength , this behavior may be related to the contribution of polymer to produce high flexural strength by polymer itself and an overall improvement in cement –sand bond .

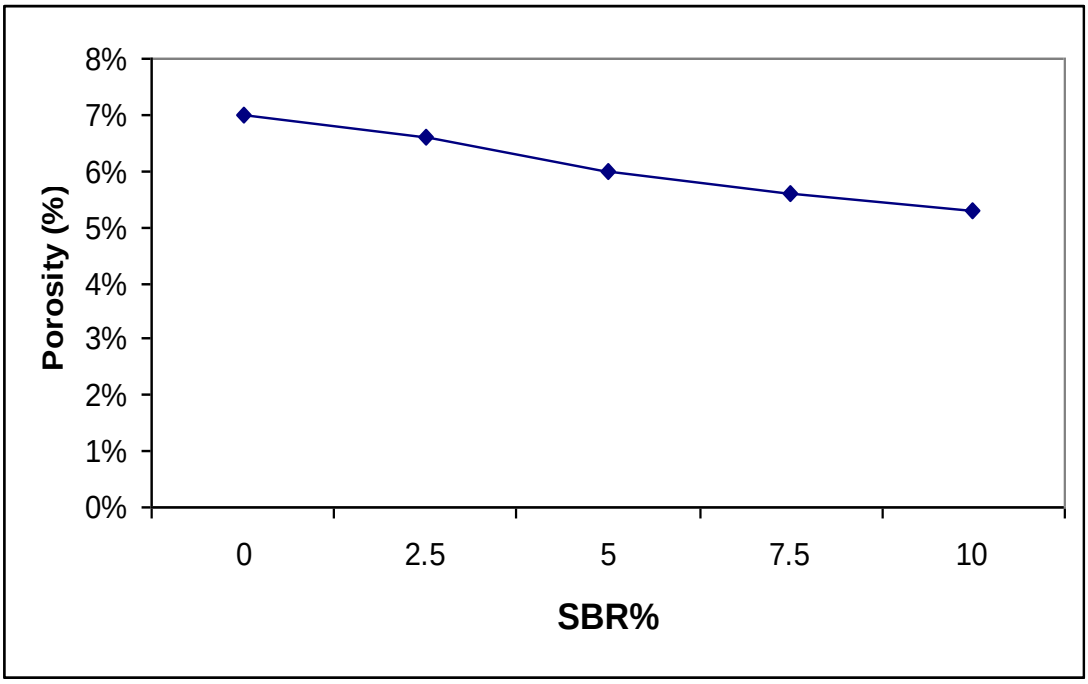
Table (6) : Flexural strength test results of SBR containing mortar

SBR by weight of cement %	Flexural strength (Mpa)		
	7 days	28 days	60 days
0	4.4	5.4	6.8
2.0	4.6	5.7	7.0
5	4.9	6.0	7.2
7.5	5.3	6.2	7.5
10	5.7	6.7	7.9



Fig(2): Effect of SBR on the flexural strength of cement mortar

From Fig (3) it can be seen that as the percentage of SBR increase , porosity decreases remarkably, this is due to reduction of permeability that because the larger pores can be filled by polymer or sealed by polymer films { **Ohama 1987**}

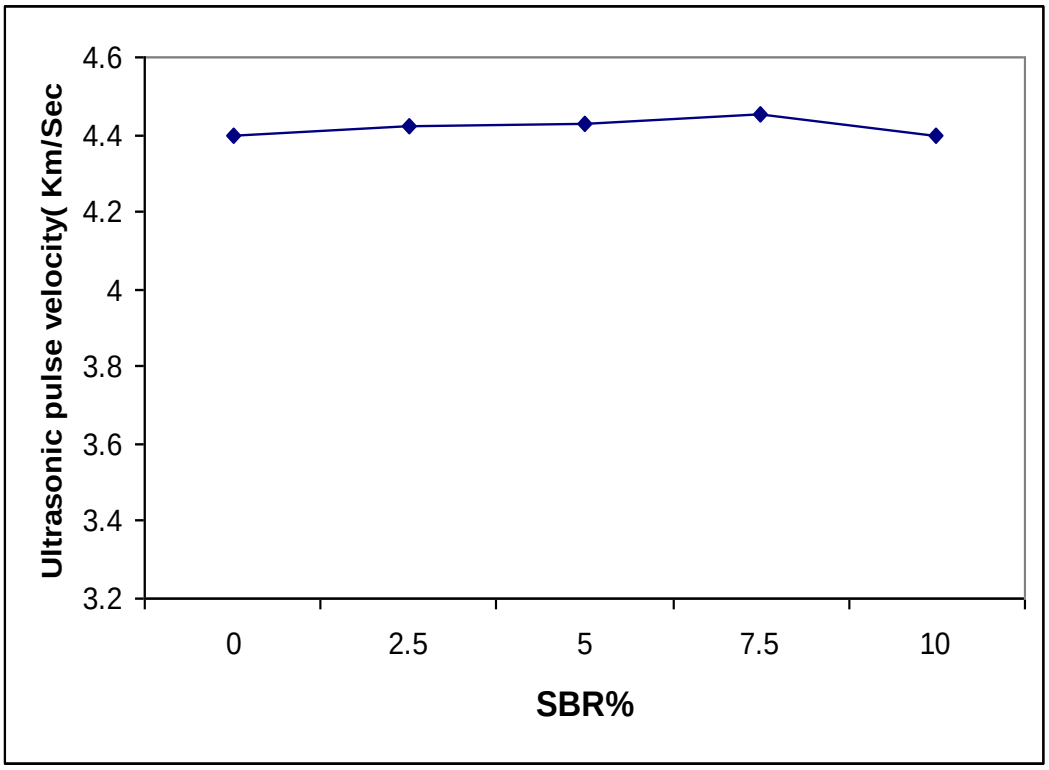


Fig(3): Effect of SBR on porosity of cement mortar

Form Table(7) and Fig (4) it can be seen that the influence of SBR on the ultrasonic pulse velocity is similar to that of compressive strength .

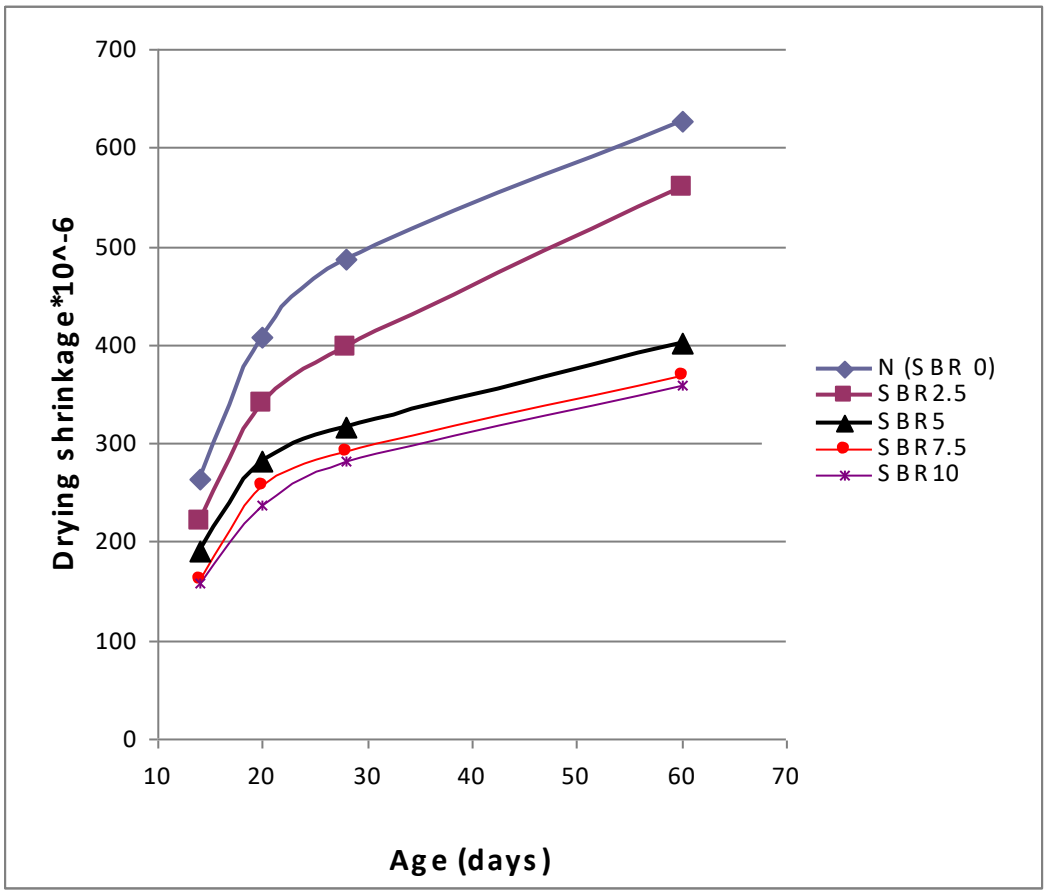
Table(7): Ultrasonic pulse velocity of SBR containing mortar

SBR by weight of cement %	Ultrasonic pulse velocity (Km/sec.) at 28 days
0	4.40
2.0	4.42
5	4.43
7.5	4.45
10	4.40



Fig(4):Ultrasonic pulse velocity of cement mortar versus additions of different percentages of SBR as an admixture to cement mortar

From Fig (5) it can be observed that the drying shrinkage decrease with increasing the concentration of SBR . This behavior may be attributed to two facts , first is the SBR mixes have less W/C ratio , and second the SBR emulsion itself has a lower shrinkage {**Litef,1998**}. { **Blaga, 1985**} found that the drying shrinkage of polymer cement concrete is generally lower than that of conventional concrete , the amount of shrinkage depends on the water –to- cement ratio , cement content , polymer content and curing conditions . It is more susceptible to higher temperatures than ordinary cement



Fig(5): Effect of SBR % on drying shrinkage in mortar

Conclusions

Base on the research conducted , several conclusions can be drawn as below :

1-The compressive strength dose not affected by the addition of(SBR) to cement mortar in a concentration of (2.5%,5%,7.5%,and 10%) by weight of cement .And the effect of SBR on the ultrasonic pulse velocity is similar to that on compressive strength .

2- The cement mortar including SBR with a concentration of (2.5%,5%,7.5% and 10%) cause increase in flexural strength .

3- Adding SBR to cement mortar cause a reduction in porosity by about (5.7%, 14.1% ,20% and 24.2%) by using the concentration (2.5% ,5% ,7.5% and 10%) consequently.

4- The cement mortar including SBR cause a considerable reduction in drying shrinkage .For the age 60 days the reduction was about (10.6% , 36% , 40.9% and 42.5%) for the percentage of (2.5% ,5% ,7.5% and 10%) consequently.

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