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Volumetric Change of Concrete Containing Water Absorption Polymer Balls

Ikram Faraoun Ahmed[1], Ammar Sabah Abdul Ameer[2]

[1]Instructor at Civil Engineering Department/ University of Baghdad

[2]Building and Construction Department/ University of Technology

Abstract: ***Polymers have the ability to extract water after they have been added to the mortar or concrete mixture. They provide the absorbed water during hydration functioning as internal water source. Absorption polymers can absorb up to hundred times of their own weight of pure water.This research deals with the use of water absorption polymer balls in concrete and study the volumetric change of these mixes and compared the results with reference mix (without polymers). Samples were cured both in air and in water for the mixes to compare results which show that samples in air behave for expansion while sample in water acted for shrinkage.***

Keywords: internal curing; water absorption polymers; shrinkage of concrete

1. Introduction

Polymers have many characteristics such ascorrosion resistance, low density,excellent finishing for surfaces, poor resistance to temperature,they are economical and produced in different colors [6].The addition of polymers to cement mortar and concrete enhances many properties such as workability , increasing the flexural and compressive strengths , decreasing the water absorption, carbonation and chloride ions penetration and improve their characteristics to use for works in humid and industrial environments [8]. Dry water absorption polymer balls WAP addition can result in positive effect, including internal water curing, mitigation of autogenous shrinkage, and reduced susceptibility to damage due to freezing and thawing [9].

When chains of polymers are linked together by covalent bonds the produced polymer is harder and more difficult to melt. Generally as longer the chain of polymers, the stronger it become due to more forces between the chains which produce more contact points. Typical water absorption polymers may have a water absorption of 100 to 400 g/g dry [1]and they can be produced in almost any size and shape these polymers belong to the group called "smart materials" that can changed their properties in response to external effect [6].

Using absorbent polymers, may reduce autogenous shrinkage and early age cracking of concrete.Polymersinfluence the concrete by two different ways, depending on how they have been added to the mix. First, when they are added dryly, they extract water from the fresh mix so the density of the mix increases. Hence, they can consume high amounts of water which increase their diameter and produce air pores. Second,the absorbed wateris provided during hydration acting as an internal water source [7].

Shrinkage of concretemay become troubling issue in any type of constructiondue to the evaporation of water from the mixture which causes weakness to concrete and lead to cracks, warping and deflectionexternally [5].The loss of water in concretegel pores mainlyleadsconcrete to shrink the polymers provide the absorbed water during hydration functioning as internal water source. These polymers can absorb up to hundreds of their own weight of pure water [2]. Manyfactorscan affect shrinkage of concrete, such asdrying condition and the atmospheric humidity which is the most important factor.Water to cement ratio w/cinfluence the amount of shrinkage occurred, the process of swelling and drying also affects shrinkage of concrete.Shrinkage rate decreaseswith time, it occurs within two weeks from concrete mix have poured [3]. The typical percentageaddition of water absorption polymer balls (WAP) was 5% by weight of cementand air curing provides higher compressive strength since there is internal curing that keeps the hydration to be continue. While in water curing the compressive strength reduced because the balls continued absorbing water till they exploded and create pores in the concrete structure that reduces the compressive strengths with time [4].

2. Aim of the Research

As mentioned in the introduction, water absorption polymers have extreme water absorption characteristics; this makes them interesting in relation to concrete. Due to the water absorption, it may also be considered a means to control porosity, which is important characterin concrete. This research deals with the use of water absorption polymer, 5% of polymer balls added by weight of cement to the fresh mixture [4], and when the polymer balls bleed their water to the mixture they shrink leaving pores of their original diameter, this lead to volumetric change in the concrete samples depending on the methods of concrete samples curing. Half ofthe samples were curedin water for 120 days and show shrinkage behavior, other samples were cured in air for 120 days and introduce expansion behavior. The volumetric change of concrete samples were measured by means of extensometer device (see picture 2).

3. Experimental Work

This research deals with the use of ordinary Portland cement concrete that have water absorption polymer balls and study

the volumetric change and compressive strength of the specimens

Materials

1) Ordinary Portland cement (O.P.C) was used in this research it confirms with the Iraqi Specifications I.Q.S No.5/1984 and have fineness (by Blain method) of 309 m^2/kg, initial setting time 135 minutes and final setting time 3.45 hours (by vicate device). The chemical compositions are tabulated in table (1)

Table 1: Chemical compositions of O.P.C

Oxides	% by weight	Iraqi specification limits %
CaO	60.8	-
SiO_2	19.9	-
Al_2O_3	4.7	-
Fe_2O_3	3	-
MgO	1.5	< 5
SO_3	2.3	< 2.8
K_2O	0.46	-
Na_2O	0.11	-
Loss on Ignition	2.7	< 4
Insoluble Residue	1.3	< 1.5
Main compounds		
C_3S	53.7	-
C_2S	16.5	-
C_3A	7.4	-
C4AF	9.1	-

2) Aggregate

Two types of aggregate were used in this study for producing concrete.

A- Coarse Aggregate

The coarse aggregate have a maximum size of (10mm) and confirm to (Iraqi specification No. 45/1984).see table (2)

Table 2: Physical and Chemical properties of coarse aggregate

Properties	Test Results	I.Q.S.45:1984:Limits
Apparent Specific Gravity	2.65	------
Bulk Density (kg/m^3)	1700	------
Absorption %	0.75	------
Sulphate Content (SO_3)	0.08	0.10 (max.)

B-Fine aggregate

Well-graded natural sand were used as fine aggregate in all concrete mixes. The grading is lied in (zone No.1) andthe sand properties confirmed to the (Iraqi specification No. 45/1984) and were tabulated in table (3).

Table 3: Physical and Chemical properties of sand

Properties	Test Results	I.Q.S.45:1984: Limits
Grading Zone	one	------
Fineness Modulus	2.488	------
Apparent Specific Gravity	2.58	------
Bulk Density (kg/m^3)	1580	------
Sulphate Content (SO_3)	0.31	0.5 (max.)

4. Water Absorption Polymer Balls

Water absorption polymer balls (WAPB) are small spherical polymers have the ability to absorb water 102 times their own size. The dry water absorption polymer balls (WAP) were immersed in water for one day then they will used in concrete as shown in picture (1)**.**Concrete mixes of this research have used 5% polymer balls by weight of cement as a typical percentage [4]

Picture (1): Water absorption polymer balls

Picture (2): measuring volumetric change by extensometer device

Specimen's preparations:-

Cylindered specimens of (100x200)mm were used for testing compressive strength for reference mix (figure 1) and for mixes contains polymer balls (figure 2) after 28,60,90 days of water curing. Prisms of (37x7.5x7.5) cm were used for testing volumetric change of concrete (in air curing and in water curing) see figures 3&4.

5. Results and Discussion

The strength of polymers increase due to the reasons that the Longer chains forming polymers are more tangled and have more forces between the chains because there are more points to contact and if the chains are closely packed in a regular way they said to be crystalline the more crystalline the polymer, the stronger and less flexible it becomes [6]. Figure (1) shows the compressive strength of plain concrete which is lower than compressive strength of concrete containing water absorption polymers(WAP) in figure (2) due to the internal curing from the balls during the hydration period of concrete.

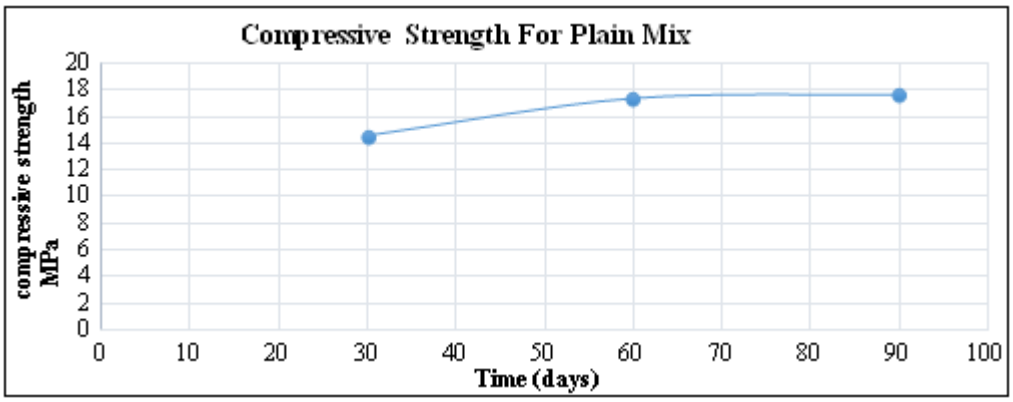

Figure (1): Compressive strength of reference mix

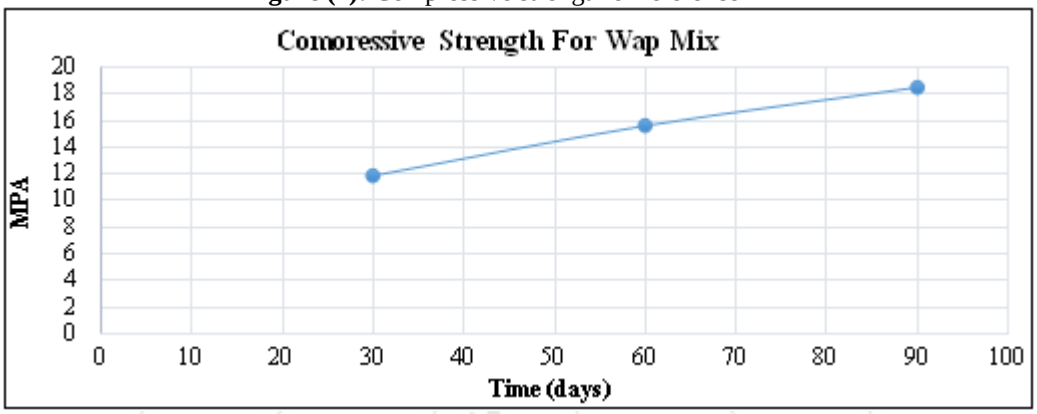

Figure (2): Compressive strength of water absorption polymer (WAP) mixes

Figure (3) and figure (4) present the volumetric change for both plain concrete and water absorption polymers(WAP) concrete,respectively, which show shrinkage in water curing and expansion in air curing.

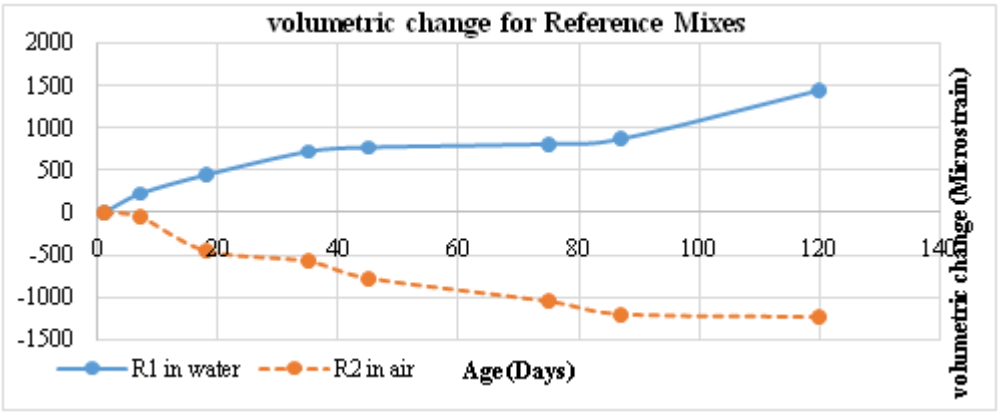

Figure (3): volumetric change of reference mix

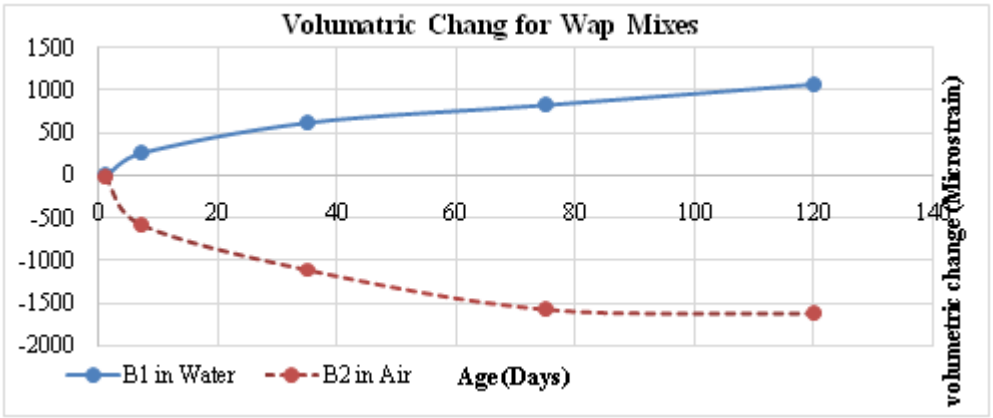

Figure (4): volumetric change of WAP mixes

Test results explained that when samples cured in water polymer balls continuing enlarge in size due to absorbing hydration water till they were exploded as shown in pictures 3&4.

Picture (3): water absorption polymer balls exploded in concrete

Picture (4): balls after curing and tests of water absorption polymer (WAP) mixes

6. Conclusions

The research aimed to investigate the behavior of concrete when using water absorption polymer balls for internal curing when samples were cured in water and in air for the same period. It can be concluded that:

- Curing samples have water absorbing polymers in water may lead to shrinkage behavior of concrete samples and show explosion of the polymer balls.
- Samples have water absorption polymer balls cured in air show expansion behavior when the polymer balls loses all its water in the internal curing and reduces their size leaving pores in the concrete structures.
- Compressive strength for samples containing water absorption polymers is higher than the compressive strength for the reference concrete samples due to the internal curing from the polymer balls.
- Volumetric change for samples containing water absorption polymers is lower than the volumetric strength for the reference concrete samples.

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