Egypt. J. Chem. **Vol. 64,** No. 12 pp. 6955 - 6959 (2021)

Egyptian Journal of Chemistry

http://ejchem.journals.ekb.eg/

The Effect of SAP Polymer on The Properties of Concrete

Nehaya Jameel Thamer*, Mohammed H. Al Maamori

Polymer and Petrochemical Industries Department, College of Material Engineering, University of Babylon, Iraq

Abstract

Superabsorbent polymer (SAP), also known as hydrogels, is a group of cross-linked, buffable polymeric materials. Due to the structure of the three-dimensional cross-linked polymeric network, it can absorb large quantities (can reach 1000g / g) of different activation fluids and swell up based on its specific chemical bonds. The Incorporation of superabsorbent polymer particles (SAP) into cement-based materials, is more convenient as the shape, size and distribution of voids and defects can be controlled. In this study we use a super absorbent polymer which is sodium polyacrylate (sp) in several forms, solid (powder) at a rate of (80-100) mesh and 1% of the cement weight, then in balls with a diameter from (2.61 mm) to (3.25 mm) saturated. . Samples were treated (with treated water and air) to compare the effect of the presence of the polymer on the internal treatment and to compare the experimental compressive strength with theoretical ultrasound examination. The results indicated that the samples containing powder and balls maintained good pressure resistance with significantly lightweight.

Keywords: concrete; lightweight; SAP; compressive strength ; ultrasonic.

1. Introduction

Because of the hot weather and the evaporation of the surface curing water quickly before the completing of the curing process, which affects the properties of the concrete negatively. Super absorbent polymer is used to provide internal water to the concrete during the curing period. SAPs are hydrophilic, multi-functional polymer materials [1][2], are a cross-linked structure, which absorbs water up to 500 times of its weight , members of the family of smart [3][4] can be described as a unique hydrogel, a material capable of absorbing and retaining moisture by osmotic pressure [5] [6]. Concrete is the second most consumed material in the world after water and it is used most widely in the construction industry due to its high compressive strength and other properties [7]. Superabsorbent polymers (SAPs) were first introduced into concrete as an internal curing material by Jensen and Hansen(2001) since SAPs can store water in advance in a gel network structure [8], and prolong the water release cycle and regulate the hydration process to ensure the continuous and uniform hydration of cementitious materials [9]. SAPs swell in cementitious materials shortly after mixing by absorbing the water in fresh cementitious mixtures [10]. formed macro-pores, due to water release by the SAPs is 2 to 3 times bigger in the system with SAPs added after water [11]. the SAP form empty cavities after they release the curing water and thereby increase the porosity of the concrete [12]. the edge of the spherical pore causes less internal stress concentration [13], which contribute to the mitigation of drying shrinkage [3].

The size of the SAP particles affects their performance in concrete in many ways, such as their mechanical stability during mixing, their influence on the rheology of the fresh concrete [14]. In the field of civil engineering, the performance of concrete can be improved by a variety of methods that involve the use of SAP as a new type of concrete admixture [13]. internal curing as "a process by which the hydration of cement continues because of the availability of internal water that is not part of the mixing water via pre-wetted lightweight aggregates, that readily release water as needed for hydration or to replace moisture lost through evaporation or self-desiccation" [15]. SAPs are most commonly used as internal curing agent [16].

swelling characteristics of a superabsorbent polymer vary depending on the inter-particle density, the chemical structure of the superabsorbent polymer, the pH of the absorbed liquid, the temperature, and the ion concentration [17].

Previous studies have focused on the use of SAP in the form of a powder of (0.2 - 0.6)% by weight of cement or in the form of balls with a diameter of (1.5 - 2 mm) in a dry or pre-saturated state that is randomly distributed in concrete to achieve internal curing while maintaining mechanical properties. In

*Corresponding author e-mail: rose77209@gmail.com (Nehaya J. Thamer)

Receive Date: 27 May 2021, Revise Date: 15 June 2021, Accept Date: 21 June 2021

DOI: 10.21608/EJCHEM.2021.77844.3805

our study, The super-absorbent polymer was used in the form of a dry powder with a size of (80-100) mesh and pre-soaked balls with a diameter ranging between (2-6) mm in 2 plays. The compressive strength of the samples and the effect of the gaps from SAP on them were compared, and the practical results were compared with the theoretical resistance from the ultrasound scanner.

2. Experimental

2.1 Materials

in this research, the super-absorbent polymer was purchased from the local market (made in China). We used raw cement from the local market and laboratory tests were performed to demonstrate its validity. sand washed Karbala (al akether) and stones (nebaii), graded from 5-20 mm, and their tests were carried out before starting work and include (gradient check, salt test). The mixing ratio was 1: 1.5: 3 (cement, sand, gravel), and the water to cement ratio (w / c) = 0.4.

fig.(1): Material used

2.2 preparation and Methods:

The standard sample was without any additives. As for the powder sample, the dry polymer powder was added at a percentage of (1%) of the weight of the cement and mixed with the dry cement material for 5 minutes. As for the samples, the balls have been immersed in water until they reach the required size (4 and 6) mm, and then they are dried from the residual water that permeates them to prevent their continued swelling. They were added to the samples (the same standard mixture) with two layers separating each ball from the other by a distance of (1 cm). The pouring conditions were applied for all samples.

fig.(2) : preparation of saturated balls

the molds used for casting are (15 * 15 * 15) cm cubes by three air curing cubes and three water curing cubes for each mixture. The number of mixtures was (5) mixtures divided between (standard, powder, 2 mm balls, 4 mm balls, 6 mm balls).

fig.(3): the mould of samples

The mixing method was as follows:

1. stones are added to Al-Khabata with 20% of the mixing water for a period of (5 minutes).
2. Sand is added to the khabata with 20% of the mixing water for a period of (5 minutes).
3. Cement is added with 60% of the mixing water for a period of (3 minutes), then the mixture is left for a period of (2 minutes) for a break, and then mixed for another (3 minutes).

The casting is done in three layers (one third of the mold) and after each layer, it is subjected to a vibration device.

3. Result and discussion :

The polymer powder was examined by an FTIR device to determine the identity of the polymer and the device diagram was as follows:

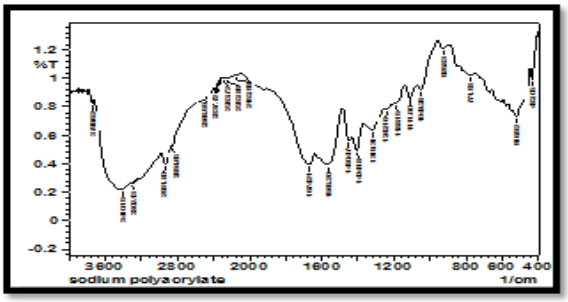

fig.(4): IR spectrum

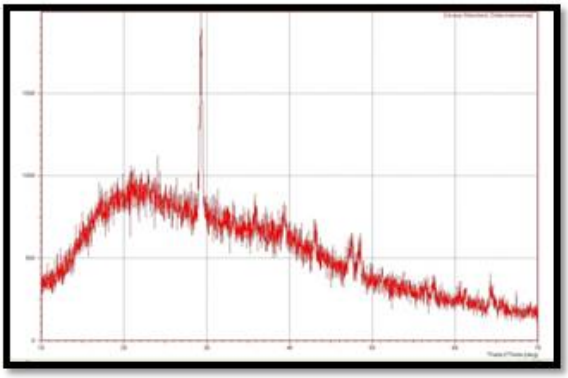

fig.(5): XRD spectrum

Through the FTI R spectrum, it is shown that The substance is hydrophobic, meaning it has the ability to absorb water. The band stretching frequency (O-H) is a wide band, meaning it takes a wide range of spectrum and lies between (3500-2500 cm^{-1}) and is clear in the spectrum between (3410-3302) cm^{-1}. The frequency of the C-H band is at 2931 cm^{-1} The frequency of the C-H2 band is located at 2831 cm^{-1} The frequency stretching of the bundle (C = O) is evident in 1674 $cm^{-1}$and it appears in the range between (1682-1685) and also in 1560 cm^{-1}Between (1406-1410 cm^{-1}), which is visible in the spectrum in the beam (1566 cm^{-1}) as well as in (1404 cm^{-1}) It is related to (C-O) stretching, (C = O) symmetric and asymmetric The curvature frequency of the compression (C-C) lies at (700 cm^{-1}). The frequency of curvature of the bundle (C-H) is at 1440 $cm^{-1}$and is apparent at 1450 cm^{-1} The fingerprint is in the region between (600-1400 cm^{-1}) and here are the bending frequencies of the C-O, C-N, C-H finger in the region of the fingerprint, which is visible in the following beams: 1319-1242-1188 1111- 925- 771 which is the fingerprint of the boat [18].

Also, an X-ray examination was performed to find out the composition of the polymer and the nature of its composition, is it random or crystalline, and the scheme was as follows:

From the x-ray diagram, we conclude that the polymer has a crystalline structure in a dry state due to the appearance of a tapered top at 2θ = 29. The degree of crystallinity (Xc) of the polymer can be found from the equation:

Xc = I c / I c + I a

I c: The intensity value of the crystalline region

I a: The intensity value of the amorphous region

Xc = 33%

The samples were examined by a non-destructive examination, which is an ultrasound examination to find the theoretical resistance in period of (14) days and then (28). The samples are subjected to a destructive examination with a compression strength measuring device for samples within (28) days to find the practical values of resistance, as shown in table (1).

When drawing the relationship between the compressive strength versus the velocity of the ultrasound waves during the concrete sample, we notice the increase in velocity with the increase in the resistance of the samples, and there is also a convergence between the theoretical and practical value and this is evident through the curve. From drawing the relationship between the weight of the samples (the type of mixture) versus the compressive strength, we note that for the theoretical values of the ultrasound scanner, the compressive strength increases with the increase in the density of the samples and there is a convergence in behavior with the practical values except for the difference in some points. The practicality is more strongly than the theoretical curve, because the concrete defects are more affected by the practical resistance, while the ultrasound examination is not strongly affected by the defects in the sample.

Table (1): Compression strength from ultrasound examination and compression testing device

	sample	Ultrasonic strength 28 days Mpa	Experimental strength 28 days Mpa	Weight of Sample Kg	Vl Cm/µs
1	S/W	44.72	41.58	8.263	0.454
2	S/A	41.10	33.85	8.259	0.440
3	P/W	38.76	30.68	7.801	0.430
4	P/A	37.07	30.67	7.733	0.423
5	2B/W	43.34	40.51	8.238	0.449
6	2B/A	40.14	34.13	8.238	0.436
7	4B/W	43.13	40.40	8.254	0.448
8	4B/A	42.89	32.11	8.263	0.447
9	6B/W	44.50	39.26	8.275	0.449
10	6B/A	40.54	32.15	8.196	0.438

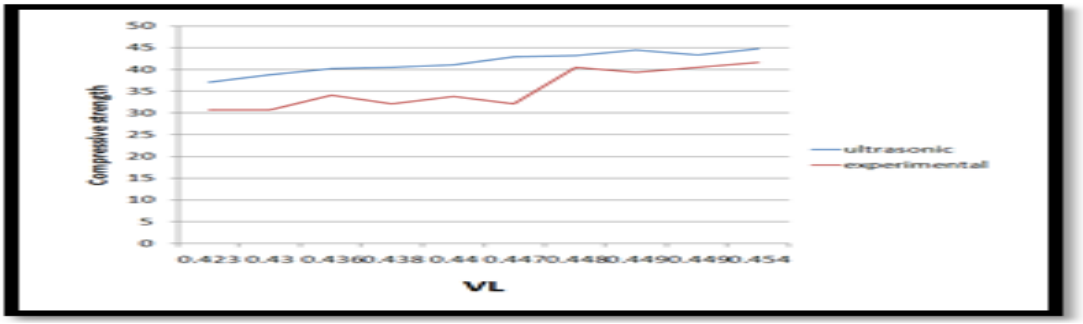

fig.(6): A comparison of practical and theoretical behavior with ultrasound velocity.

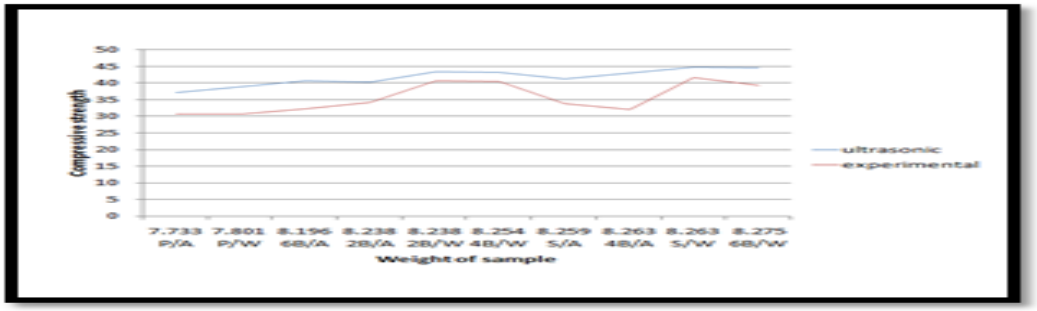

fig.(7): Comparison of practical and theoretical behavior with respect to sample weight

4. Conclusion:

From the observation of Table No. (1) and the weights of samples No. (3 and 4), we note a clear decrease in weight compared to the standard sample while maintaining good compressive strength. In addition, the mixture with the powder gave an additional 20% more than the standard mixture, which means that there is economic feasibility to use. This mixture can be used in several applications such as ceilings, walls and the manufacture of cement bricks, which adds lightness in weight in addition to durability.

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