ADVANCES in NATURAL and APPLIED SCIENCES

ISSN: 1995-0772
EISSN: 1998-1090
2016 September 10(13): pages 112-124

Published BY **AENSI Publication**
http://www.aensiweb.com/ANAS
Open Access Journal

Preparation and Characterization of Concrete Reinforced by the Super-Absorbent Hydrogel Nano Composites (SAHNCs) Used for Construction Applications

[1]Sihama I. Salih, [1]Fadhel A. Hashem, [2]Auda J. Braihi

[1]Materials Engineering Department, University of Technology, Baghdad, Iraq.
[2]Babylon University-College of Materials Engineering, Babylon, Iraq.

Received 7 June 2016; Accepted 12 September 2016; Available 20 September 2016

Address For Correspondence:
Sihama I. Salih, Materials Engineering Department, University of Technology, Baghdad, Iraq.
E-mail: sihama_salih@yahoo.com

ABSTRACT

In this research cementinoushybrid composites werepreparedby addition of super-absorbent hydrogelnano composites (SAHNCs) tothe concrete and mortar pastes.The SAHNCs iscomposed of carboxymethyle cellulose / starch blend loaded with 0.3 wt % of nano graphite oxide and its absorbency reaches to 69 g/g. Concert cubes have dimensions of 15x15x15 cm with a fixed cement: sand: gravel ratios (1:1.18:1.86) and the ratio of water to cement is 0.4.The SAHNCs was added to concrete cubes with 0.2, 0.4, 0.6, 0.8 and 1wt%.Mortar cubeshave dimensionsof 70.7×70.7×70.7 mm with 1:3 ratio of cement:sand and 0.40 ratio of water:cement.The SAHNCs loading in mortar are 0.1, 0.2, 0.4and 0.6 wt%. Compression and ultrasonic pulse velocity(UPV) tests were used to evaluate the compressive strength for these hybrid cementinouscomposites.UPV was also used to evaluate theirelastic constantsandqualities. Consistency and setting times of mortar paste were measured by Vicat apparatus. Acoustic impedance, portions of the energy reflected and the energy transmitted were calculated using the steel as the second medium. Results showed that compressive strength for bothconcrete and mortar decreased firstly and then exceeds their initial valueswhen the addition ratio of SAHNCs exceeds 0.6 wt% in concrete , and exceeds 0.3wt % in mortar. The additional amount of water to get the standard consistency seems to be reasonable. Initial and final setting times of mortar increased with SAHNCscontent except at 0.2 wt%.Elastic modulusexceeds its initial value at 0.6 wt% for concrete and at 0.5wt% for mortar.Shearmodulusfor concrete increased at higher ratios and there is some fluctuations in mortar shear modulus. Most values of Poisons ratios are within the typical range for standard concrete.Concrete quality for all samplesisexcellentaccording to the BS, 1881, 1983 code because all the longitudinal velocities are more than 4500 m/sec.The acoustic impedance increased, whilethe energy reflected reaches to its minimum value at higher SAHNCs ratios and the energy transmitted reaches to its maximum value.

KEYWORDS: Superabsorbent hydrogel nanocomposites,Concrete,Compressive strength, Ultrasonic pulse velocity,Acoustic impedance.

INTRODUCTION

Superabsorbent polymers (SAPs)are hydrophilic networks that can absorb and retain huge amounts of water or aqueous solutionsand the absorbed water is hardly removed under some pressure[1].Superabsorbent hydrogel nano composites (SAHNCs) are formed from incorporation of clays and oregano-modified clays into superabsorbent polymers formulations [2]. These materials consist of a network of polymer chains that are

To Cite This Article: Sihama I. Salih, Fadhel A. Hashem, Auda J. Braihi., Preparation and Characterization of Concrete Reinforced by the Super-Absorbent Hydrogel Nano Composites (SAHNCs) Used for Construction Applications. **Advances in Natural and Applied Sciences**. 10(13); Pages: 112-124

cross-linked to avoid dissolution. Usually there are ionic functional groups along the polymer chains to encourage diffusion of water within the network[3].

The hydrophilic groups are hydrated in an aqueous environment, thereby creating a hydrogel structure[4]. Due to theirswelling properties,so,these hydrogelscan be utilized in many applications, such asin drug delivery systems[5], agriculture [3], separation processes [6] and others.In cementinous hybrid composites (concrete and mortar), SAHNCs used as additives to:

1- Improve concrete performance by acting as a water-reducing agent.

2- Eliminate the negative effect of water on the hardening of cement.

3- Act as an air-entraining agent by virtue of its polar nature which may reduce surface tension and hence stabilize the fine foam of bubbles originating from the mixing process[7].

4- Prevent or reduce self-desiccation(orautogenous shrinkage) during hydration [8]. They rapidly absorb water(forming water-filled cavities), then release it when cement paste self-desiccates or is exposed to drying [9].

5- Promote internal curing of concrete to mitigate its autogenous shrinkage [10]. The water gel created in the fresh concrete by the use of SAP provides cushioning and lubrication in the concrete mass, which in turn improves the concrete workability as well as concrete stability[11].

Consistencyof standard paste for any given cement determines the water content of the paste which will produce the desired consistency.

Setting process involves losing of plasticity with time and becoming dense and stiff. It refers to a change from a fluid to a rigid state and happened in two stages; initial setting and final setting [8]. Initial setting time refers to the beginning of solidification, while final setting time refers to the beginning of hardening process.

Setting is important in concrete work to keep fresh concrete plastic for enough time which helps the processes of transporting, casting, and compaction. Setting times influences by many factors, such as: fineness types of cement, age, water content, temperature, and humidity.

Ultrasonic pulse velocity(UPV)method used toevaluate the quality of concrete and mortar as well as to calculate the elastic constants.The idea is to project the sound inside a material and measure the time necessary for thewave to propagate through it [12]. The ultrasonic pulses depend on the density and elastic properties ofthe material.

UPV method was used to measure times required to transport the ultrasonic pulse wave in the longitudinal and transverse paths; t_l and t_T. Then, these two times were substituted in Equations1 to 6 to calculate the longitudinal and transverse ultrasonic velocities (V_L and V_T respectively) as well as the elastic constants such as, elastic modulus (E), shear modulus (G) and poison's ratio (ν) for both the concrete and mortar cubes [13].

$$V_L = (L/t_L) \text{ x}10 \quad (1)$$

$$V_T = (d/t_T) \text{ x}10 \quad (2)$$

$$\rho = W / V \quad (3)$$

$$E = \rho \text{ x } V_L^2 \quad (4)$$

$$G = \rho \text{ x } V_T^2 \quad (5)$$

$$\nu = (E/2G) -1 \quad (6)$$

Where

t_L: Time for longitudinal pulse (μs), t_T: Time for transverse pulse (μs)

L : Length of cube (15 cm for concrete and 7.07cm for mortar)

d : Width of cube (10.6 cm for concrete and 5cm for mortar)

ρ : Density (g/cm^3) , W: Weight (g)

V: Cube volume (3375 cm^3 for concrete and 353.4cm^3 for mortar)

As well as, UPV measurements can be used to:

1. Determine the uniformity of concrete in and between members.
2. Measures of changes occurring with time in the properties of concrete [14].
3. Evaluate concrete quality [12].
4. Using both the longitudinal velocity (V_L) and the density (ρ), the acoustic impedance (Z) was calculated by Equation7 [15].

$$Z = \rho V \quad (7)$$

The Aim:

This research aims to preparecementinoushybrid composites reinforced by the super-absorbent hydrogel nano composites (SAHNCs) and their characterization study.

Experimental Part:
Materials:
Super-absorbent hydrogel Nano composites (SHNCs):

This material is prepared fromcomposed of carboxymethyle cellulose (CMC) / starch blend cross-linked by alum and loaded with 0.3 wt% nano graphite oxide (GO). Free water absorbency of this material reaches to 69 g/g and reaches to 29 g/g under 2.068 KPa load.This polymeric blend contains 1.5 wt% alum cross-linker.

Ordinary Portland Cement (OPC):

used in this research, have the chemical composition shown in Table 1.

Sand: The Properties, grading and chemical composition of the used sand are shown in Table 2.

Gravel: The grading and properties of the used gravel showed in Table 3.

Preparations and testing:
1-Preparation and testing of concrete cubes:

Concrete cubic sampleshave dimensions(15x15x15 cm) were prepared with a fixed cement: sand: gravel ratio of 1:l.18:1.86 according to ASTM C 192-90a with water/cement ratio equal to 0.4. The weight percent of SAHNC used are 0.2%, 0.4%, 0.6% 0.8and 1 wt%.

Cubic samples were subjected to humid environment for 24 hr, immersed in the water for another 27day, then tested (compressive strength) according to ASTM C579-01 method B using impact machine of 2000 KN maximum capacity, resolution 1 KN, and loading rate 3KN/sec.

Table 1: Chemical composition of the used OPC

Oxide	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Loss on Ignition (L.O.1)
%	22.01	5.26	3.3	62.13	2.7	2.4	1.45

Table 2: Properties and grading of the used sand

Property	Value
Fineness Modulus	2.51
SO_3%	4.45
Sieve Openings Size (mm)	Passing%
10.0	100
4.75	94.76
2.36	88.38
1.18	79
0.6	65.55
0.3	17.17
0.15	3.79

Table 3: Grading and properties of the used gravel

Property	Value
SO_3%	0.095
Sieve Openings Size (mm)	Passing%
3.75	100
20	70
14	40
10	10
5	0

2-Preparation and testing of mortar Cubes:

Mortar cubic samples have dimensions(70.7×70.7×70.7 mm) were prepared according toBS 4550-3.4:1978with 1:3 ratio of cement:sand, 0.40 ratio of water:cement and the mass of water in the mix is 10 percent of the mass of the dry materials. The SAHNC loading ratios are 0.1, 0.2, 0.4and 0.6wt%, as shown in Table 4. These ratios were calculated as a percent to the cement weight.

Table 4: Ingredient of mortar samples

Cement	Sand	Water	SAHNC	
(g)	(g)	(ml)	%	(g)
200	600	80	0	0
199.8	600	80	0.1	0.2
199.6	600	80	0.2	0.4
199.2	600	80	0.4	0.8
198.8	600	80	0.6	1.2

Then, these ingredients were mixed for four minutes using a spark mixer and the resultant mixture was further mixed by a vibrating machine with a frequency of 200 Hz for another four minutes.Cubic samples were subjected to humid environment for 24 hr and immersed in the water for another 27 daybefore testingusingeitherimpact machine or UPV methods.

3-Preparation and testing for consistency and setting timespurposes:

In order to measure the consistency and the setting times by Vicatapparatus, neat cement pastes were prepared. These pastes include fixed weight of cement (400g) and variable amounts of water.These two components were mixedcarefully for four minutes and then moulded in the cylindricalmould before testing.

The consistency is measured using a 10 mm diameter plunger(BS EN 196-3: 2005). The plunger is brought into contact with the top surface of the paste and released. Paste is considered to be standardwhen the plunger penetrates the paste to a point 6 ± 1 mm from the bottom of the mould. The water content of the standard paste is expressed as a percentage by mass of the dry cement, the usual range of values being between 26 and 33 per cent[9].

The setting times of cement are measured using different penetrating attachments (BS EN 196-3 : 2005)[9]. For the initial set, a round needle with a diameter 1.13 ± 0.05 mm is used. When the paste stiffens sufficiently for the needle to penetrate no deeper than to a point 5 ± 1 mm from the bottom, initial set is said to have taken place. Final set is determined by a similar needle fitted with a metal attachment hollowed out so as to leave a circular cutting edge 5 mm in diameter and set 0.5 mm behind the tip of the needle. Final set is said to have taken place,when the needle, gently lowered to the surface of the paste, penetrates it to a depth of 0.5 mm but the circular cutting edge fails to make an impression on the surface of the paste.

Ultrasonic Pulse Velocity (UPV) Test:

In order to measure the elastic constants forhybrid cementinous composites, the non-destructive UPV test was adopted. This test uses the CSI type CC-4 testerwith 26000 Hz with aluminum reference bar which possess a 32.5 μs transition time. Test equipment generates a pulse which transmits through the concrete mass, then receiving the pulse to measure the elapsed time.UPV outputs was also utilized to evaluate the quality of concrete and mortar according to the IS code (BS, 1881, 1983) as well as to calculate the elastic constants[14].In thistest, two transducers arrangements were used;opposite faces (direct transmission) to measure $V_L$and adjacent faces (semi- direct transmission) to measure V_T.

RESULTS AND DISCUSSIONS

1- Compressive Strength (CS):

The effect of additionSHNCs toconcrete and mortaron the behavior ofcompressive strength (CS)are shown in Figures1 and 2 respectively. It is clearfrom figure 1 that CSof concrete was decreased from 40.2 MPafor pure concreteto 35.9 MPa when the addition of (SAHNC) in concrete reach to ratio of 0.4% wt.

This behavior is due to the competition between the cement paste and SAHNC particles to absorb the available water. This competition leads to reduce the hydration reaction between cement and water (decreasing in H-bonds formed between cement paste and water), therefore CS will decrease. The reduction in the hydration reaction results also in the formation of entraining pores. These pores were initially filled with the curing water and then dried out; therefore, these voids affect the CS negatively.

Beyond the 0.4wt% SAHNCs, the CS increased up from 35.9 MPa to 45.8 MPa when the (SAHNC) content in the concrete reach to ratio of 1 wt % which means there are 14% increasing compared with the pure concrete. This new manner is due to the fact that the negative influence of additional voids induced by the addition of SAHNC particles was compensated by the improved degree of hydration and the self-curing effect in the matrix containing 0.4wt%SAHNC. Also, loading levels from 0.4 to 1wt% lowering the internal stresses due to the hindrance of shrinkage deformations by stiff aggregates[8].

Results of these two behaviors are in a good agreement with Dudziak and Mechtcherine conclusions which were reported in [10].Also, this overall enhancement in the compressive strength property results coincides with results of both Gao et al (12.3% increasing) and Hareendran et al(10.6% increasing) [10].

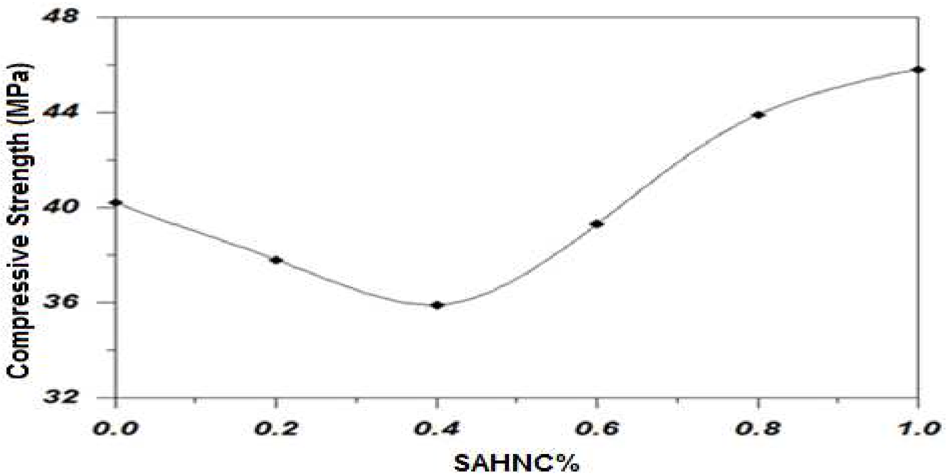

Fig. 1: Compressive strength of concretehybrid composites as a function of SHNCs content

Effects of SAHNCs addition on the mortar CS are shown in Figure 2. Through this figure, a decrease is noted at the first in CS, especially at 0.1wt% of SAHNCsfrom 41.5 MPa (for pure sample) to 40.1 MPa with the addition of 0.1wt% SAHNCs. After that, the CS increased with any increasing in the SAHNC contents. Highest CS value was obtained at the 0.5wt% ratio of SAHNCs (42 MPa), then it became stable.

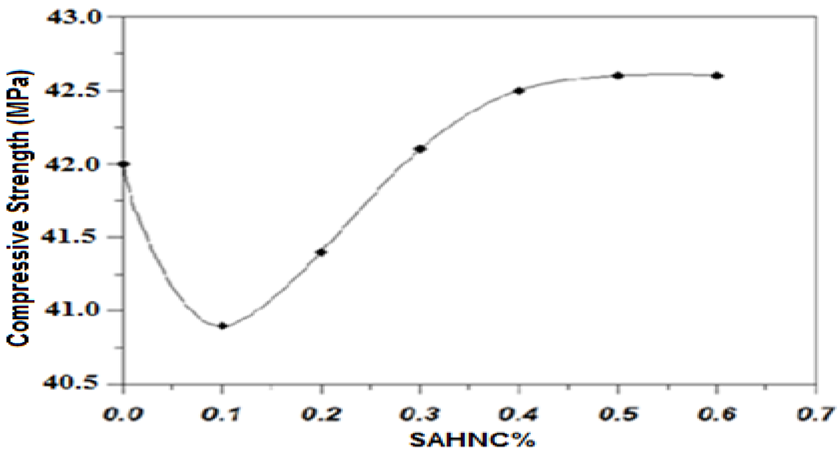

Fig. 2: Compressive strength ofmortarhybrid composites as a function of SHNCs content

By comparing the two previous curves in figures 1 and 2, asimilarity is observed in the concrete and mortar behaviors of the curves, except there is stability in the mortar compressive strength at higher SAHNC levels.

2. Consistency of Standard Mortar Paste Test:

Consistency ofcementinous paste is considered a critical property because of its strong relation with water amount in the paste. Certain quantity of water is required for hydration process and to obtain the desired rheological properties for proper mixing, compacting and transporting. Increasing water content causes segregation, bleeding, increased porosity of the hardened concrete, reduction in the mechanical performance, reduction in durability, increased shrinkage and increased creep deformations. Therefore, there is a real need to control the water content in the paste.

Figure 3 shows the effect of SAHNC ratios on the amount of additional water required to obtain the standard consistency of the mortar paste. From this figure, it was found that these additional amounts increased with the increasing SAHNC content, and reached to maximum level with 0.6 wt % SAHNC ratio. So, these amounts of the required water increased from 110 ml for the reference mortar paste (without SAHNCs) to 150 ml for the paste with 0.6wt% SAHNC.

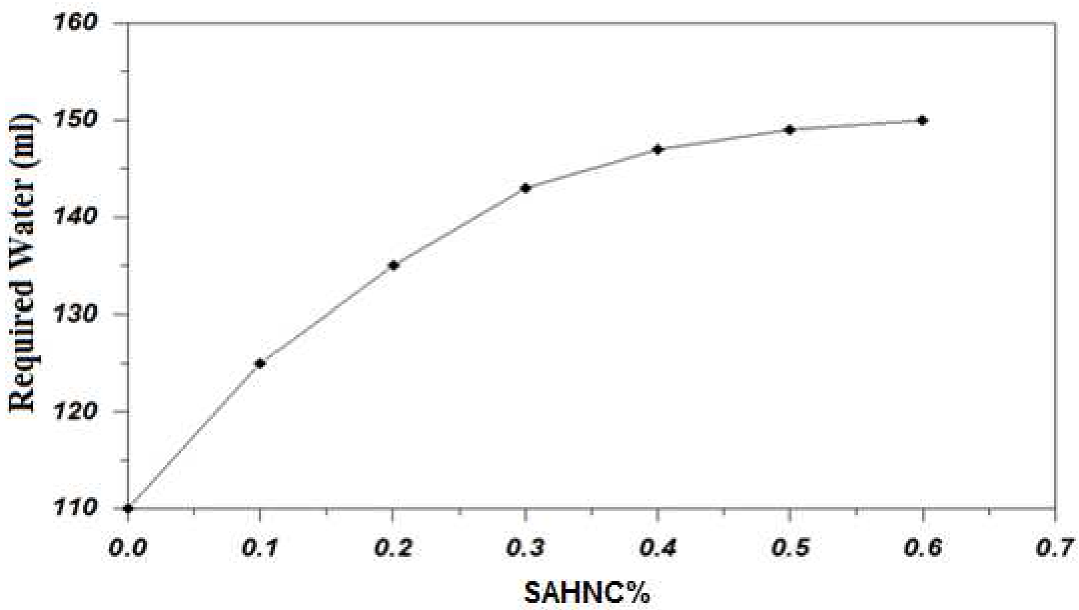

Fig. 3: The amount of additional water required to obtain the standard consistency of the mortar paste as a function of SAHNC content

This amount of additional water;40 ml, seems to be reasonable, since the excessive amount (more than 160 ml) added to the fresh concrete alters its properties (reduces both its strength and workability, increases its shrinkage). Also, it seems to be reasonable from economical viewpoint.

3.Setting TimesResults:

Setting time is an important factor in concrete work to keep fresh concrete plastic for enough time, which helps the processes of transporting, casting, and compaction. Initial setting time refers to the beginning of solidification, while final setting time refers to the beginning of hardening process. The initial and final setting times of the pure sample, and the effect of the addition of SAHNC with ratios of 0.2, 0.4, 0.6, and 0.8wt%are shown in Table 5. It is clear that these two times have the same behavior; they increased linearly with the SAHNC ratios except at 0.2 wt% SAHNC. This indicates that SAHNC materials act as retarder at high concentrations.

Table 5: SAHNC effects on the setting times of mortar paste

SAHNCs %	Initial Set Time (hr min)	Final Set Time (hr min)
0	3^{45}	5^{45}
0.2	3^{15}	5^{25}
0.4	4^{00}	5^{50}
0.6	5^{20}	6^{20}
0.8	5^{35}	6^{50}

The hydration of tricalcium aluminate ($3CaO.Al_2O_3$) is responsible for the setting of cement[8]. Therefore, small internal water sources (corresponded to low SAHNC ratio; 0.2 wt%) cannot complete the hydration reaction. During hydration process, insolublecalcium or aluminum compounds are formed and interspersed through the crystalline mass. These compounds are not removable from the stiffened mass, thus retard the rate of absorption of H_3O^+ ions on cement surface and slow down the setting reaction[11].

4. Ultrasonic Pulse Velocity (UPV) Results:

The longitudinal and transverse ultrasonic velocities (V_L and V_T)were calculated according to Equations 1 and 2 respectively,as well as the elastic constants, such as elastic modulus(E) eq. 4, shear modulus(G) eq. 5 and poison's ratio(ν) eq. 6 for both the concrete and mortar cubes, as shown in Tables 6 and 7 and figures from 4 to 9.

Table 6: Ultrasonic velocities and elastic constants for concrete cubes

SAHNC %	ρ g/cm^3	t_L μs	V_L Km/s	t_T μs	V_T Km/s	E MPa	G MPa	ν
0	2.318	30.60	4.90	33.65	3.15	55.655	23.000	0.209
0.2	2.316	31.25	4.80	34.19	3.10	53.360	22.256	0.198
0.4	2.315	31.50	4.76	34.52	3.07	52.452	21.818	0.202
0.6	2.320	30.30	4.95	34.08	3.11	56.845	22.439	0.266
0.8	2.331	30.00	5.00	33.54	3.16	58.275	23.276	0.251
1	2.364	29.82	5.03	33.12	3.20	59.811	25.743	0.161

It is clear from Table 6 that for concrete hybrid composites with low SAHNC contents (up to 0.4 wt. %), the ultrasonic waves elapsed increasing times when transported through concrete cubes in both longitudinal and transverse directions.

In contrast, for hybrid composites with high SAHNC contents (0.6-1wt %), the ultrasonic waves elapsed decreasing times. So, V_L decreased from 4.9 Km/s for pure sample to 4.76 km/s for hybrid composite with 0.4 wt% SAHNC, and then increased up to 5.03 when the SAHNC content increased up to 1 wt%. In similar manner, V_T decreased from 3.15 Km/s to 3.07 Km/s then increased up to 3.2 Km/s in the same ratio.

These opposite two behaviors are due to heterogeneity and voids in hybrid composites with low SAHNC contents (up to 0.4 wt%). This heterogeneity arises from the presence of both hydrated and anhydrated portions in the cementinouspastes; therefore the sound energy will dissipate and attenuate at the interfacial boundaries between these phases.

It was observed from Figure 4 that elastic modulusof concrete firstly

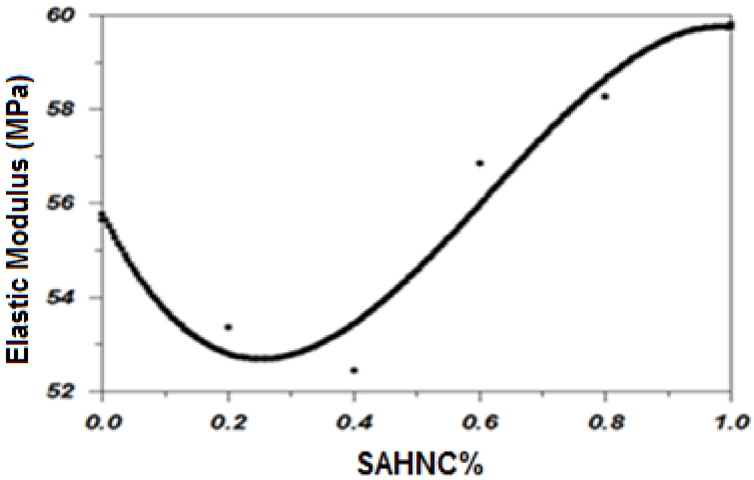

Fig. 4: Elastic modulusof concrete hybrid composites as a function of SAHNC content

decreased from 55.655MPa for pure sample to 52.6 MPa for hybrid composite with 0.25 wt% SAHNC, and then increased up to 59.811 MPa for hybrid composite with 1 wt% SAHNC. These behaviors are due to insufficient amount of stored water to complete the hydration process with SAHNC ratios up to 0.4 wt%, and then water amounts be enough to complete the setting reaction. Therefore, concrete became stiffer.

Figure 5 shows the shear modulus as a function of SAHNC contents in hybrid concrete. It is clear that the shear modulus decreased from 23 MPa for pure sample to 21.8 MPa for hybrid composite having 0.4 wt% SAHNC, then increased up to 25.743 MPa when SAHNC content increased up to 1wt%.

Declined values at low SAHNC contents are due the attenuation counter waves in voids which are available in the un-reacted zones.In contrast, when SAHNC contents areincreased(more than 0.4 wt %), chemical reaction occurs through chemical bonds. This bonding increases the homogeneity between the composite ingredients and reduces the phase separation. Thus, waves elapsed short time, wave velocity becomes high and the shear modulus increased.

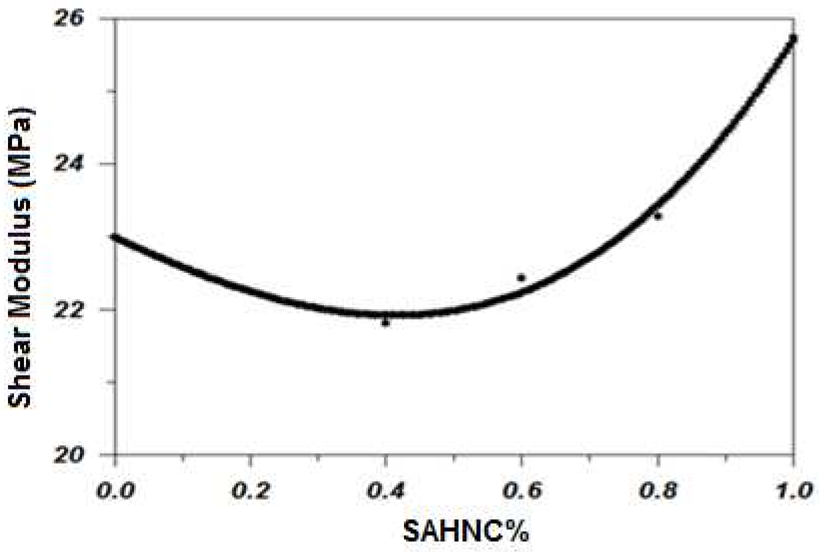

Fig. 5: Shear modulus of concrete hybrid composites as a function of SAHNC content

The effects of addition of SAHNCs on the Poisson's ratio of concretes hybrid composite was shown in Figure 6.It is clear from this figure that the variations inPoisson's ratio were limited to small range (0.161-0.252), which indicates that the longitudinal extension and the transverse contraction are equal.

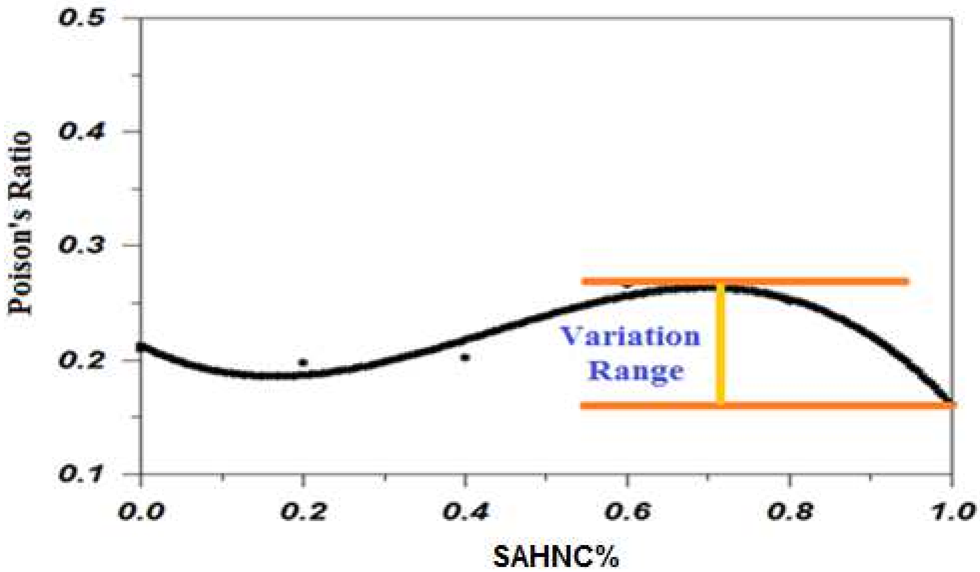

Fig. 6: Poison's ratioof concrete hybrid composites as a function of SAHNC content

Furthermore, since the Poisson's ratio values, for concrete are within the range of 0.2- 0.35, and the typical value reaches to 0.24 [8], therefore the obtained Poisson's ratios considered as acceptable values except that for 1 wt% SAHNC.

Table 7 shows the values of ρ,V_L,V_T, E, G and ν for the mortar hybrid composites with differentcontentratios of SAHNC.

Table 7: Ultrasonic velocities and elastic constants for mortar cubes

SAHNCs %	ρ g/cm^3	t_L µs	V_L km/s	t_T µs	V_T km/s	E MPa	G MPa	ν
0	2.223	14.34	4.93	16.0	3.125	54.03	21.71	0.244
0.1	2.153	14.40	4.91	15.8	3.164	51.90	21. 56	0.203
0.2	2.130	14.45	4.90	15.5	3.225	51.14	22.15	0.154
0.3	2.100	14.36	4.92	15.7	3.185	50.83	21.3	0.193
0.4	2.124	14.25	4.96	15.9	3.145	52.25	21.0	0.244
0.5	2.128	14.14	5.00	16.1	3.105	53.20	20.52	0.296
0.6	2.280	14.00	5.05	16.3	3.067	58.15	21.44	0.356

From Table 7, it is clear that the ultrasonic pulses elapsed times ($t_L$and t_T) in mortar cubes are less than times elapsed in concrete cubes mentioned earlier in Table 6. And, this is related to the dimensions of mortar cube that are less than the dimensions of concrete cube.

Also, it is clear that V_L decreased firstly from 4.93 Km/s for the pure sample to 4.9 Km/s for hybrid composite with0.2 wt% of SAHNC,then increasedup to 5.05 Km/s for sample with 0.6 wt% of SAHNC. Such trend (increasing $V_L$with SAHNC content) is in a accordance with the works published byWinker and Nur,1982; Ohdaira andMasuzawa,2000 as well as by Veraara et al., 2001[10].

The behavior of mortar elastic modulus shown in Figure 7, this modulus continues its deceasing from its initial value; 54.03 MPa (for pure sample) to reach its minimum value; 50.7 MPa at 0.3 wt% of SAHNC, then increases gradually to reach 58.15 MPa at 0.6 wt% of SAHNC.The elastic modulus exceeds its initial value only with the later ratio; 0.6wt%SAHNC,which indicates that the hydration process completes only with this ratio.

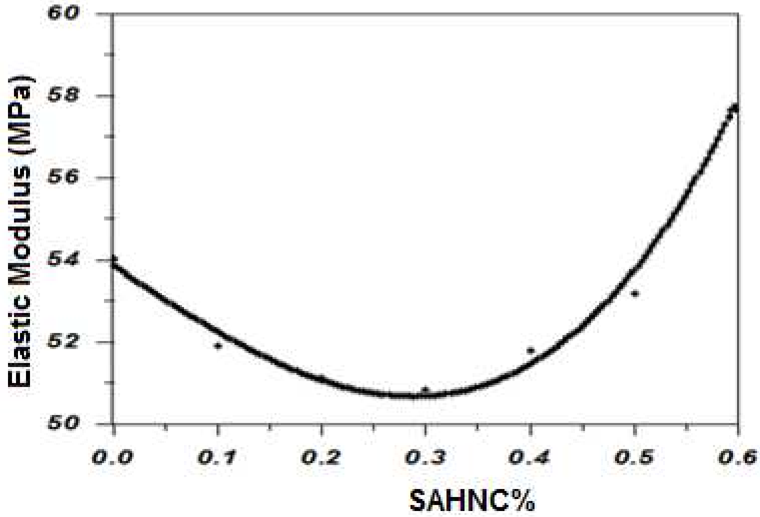

Fig. 7: Elastic modulusof hybrid mortarcomposite as a function of SAHNC content

Shear modulus values for mortar composite are shown in Figure 8.This figure shows the fluctuating behavior in shear modulus values with the increase SAHNC contents. Shear modulus reaches its maximum value at 0.2 wt% SAHNC, then reach its minimum value at 0.5 wt% SAHNC and then increased at 0.6 wt% SAHNC to reach21.44 MPa which is lower than its initial value. This means that the optimum SAHNC ratio in mortar paste is the 0.2 wt% from the shear modulus viewpoint.

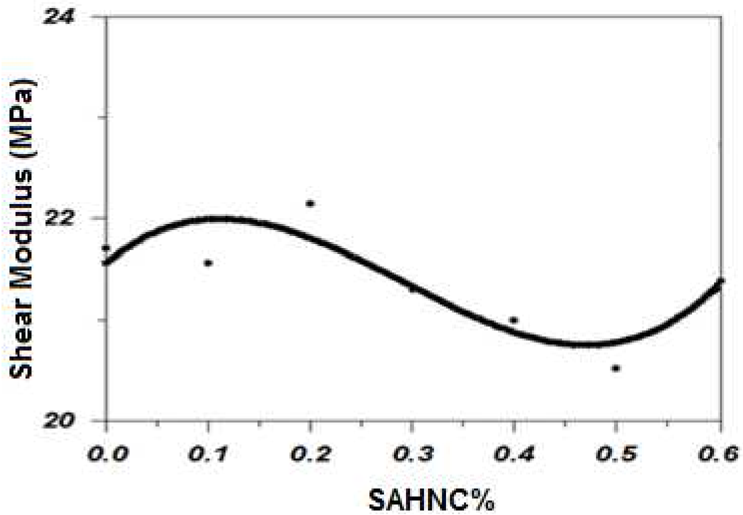

Fig. 8: Shear modulusbehaviorof mortarhybrid composite as a function of SAHNC content

Effects of SAHNCsaddition on the values ofPoisson's ratio for mortar hybridcomposites are shown in Figure 9.Firstly, there is a decrease from 0.224value (for pure sample) to 0.193value at 0.3wt% of

SAHNC.Then, the Poisson's ratio increased with the increasing of SAHNC ratios reaching to 0.356 at 0.6wt% of SAHNC.

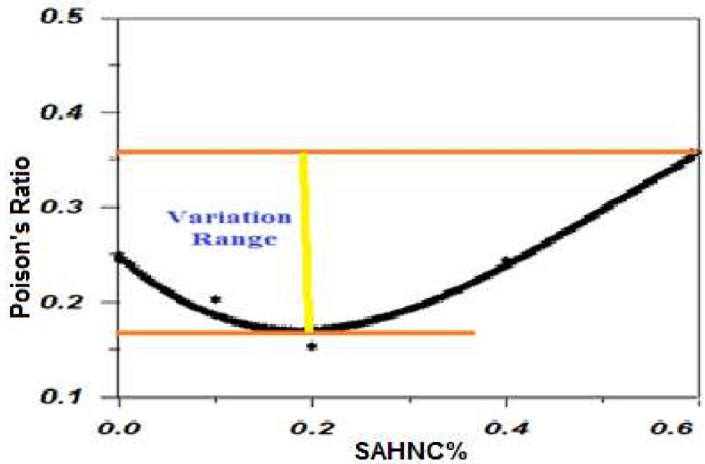

Fig. 9: Poisson's ratioof mortar hybridcomposites as a function of SAHNC content

So the Poisons ratios, seems to be more affected than those for concrete; its range extended from 0.154 to 0.356. The value corresponded to the 0.4wt% SAHNC; 0.244 seems to be a typical value.

5. Quality Evaluation:

All longitudinal velocities (V_L) for concrete and mortar hybrid compositesare more than 4.5 Km/s ; more than 4500 m/sec as shown in Tables 6 and 7.Therefore the quality for all samples seems to be excellent according to the BS, 1881, 1983 code (Table 8)[13].

Table 8: Concrete quality as a function of UPV (BS, 1881, 1983)[13]

UPV(m/s)	Concrete Quality
Above 4500	Excellent
3500 to 4500	Good
3000 to 3500	Medium
Below 3000	Doubtful

These high velocitiesalso indicate the high homogeneity and uniformity levels of pastes, which in turn meanthe good dispersion of the SAHNCs in the hybrid cementinous composites.

6. Acoustic Impedance Results:

Using both the longitudinal wave velocity (V_L) and the density (ρ), the acoustic impedance (Z) for concrete and mortar was calculated according to Equation 8[14].

$$Z = \rho V \quad (8)$$

So, the acoustic impedance (Z) for concrete and mortar are shown in Figures 10 and 11respectively.

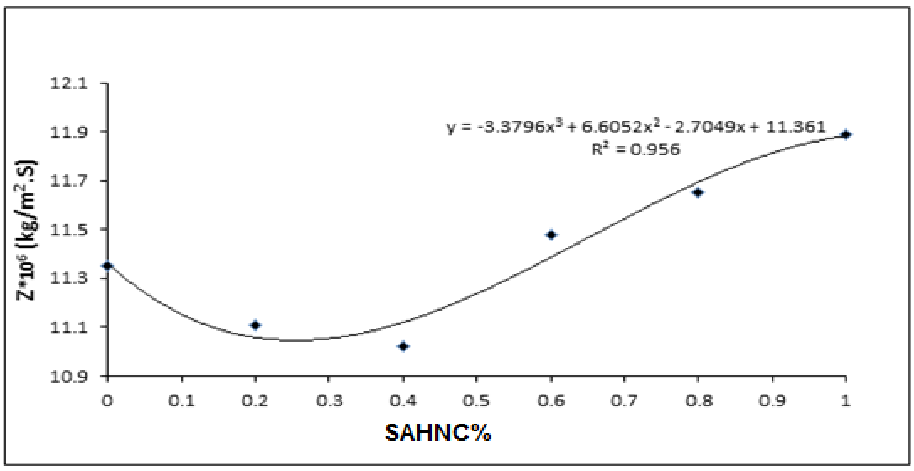

Fig. 10: Acoustic impedance for concrete as a function of SAHNC

The acoustic impedance of concrete samples (figure 10) decreased from (11.35× 10^6 kg/m^2. s) for pure sample to reach (11.02× 10^6 kg/m^2. s) for sample with 0.4wt% ratio of SAHNC, and then increased to its maximum value (11.89× 10^6 kg/m^2. s) at 1wt% of SAHNC. Theseopposite two behaviors give evidence about the completing of hydration process at high SAHNC ratios.

Whereas, the acoustic impedance of mortar samples (figure11) decreased from (10.95× 10^6 kg/m^2. s)for pure sample to reach (10.33× 10^6 kg/m^2. s) for sample with 0.3wt % of SAHNC, andthen increased to (11.5× 10^6 kg/m^2. s) at 0.6wt% SAHNC ratio.

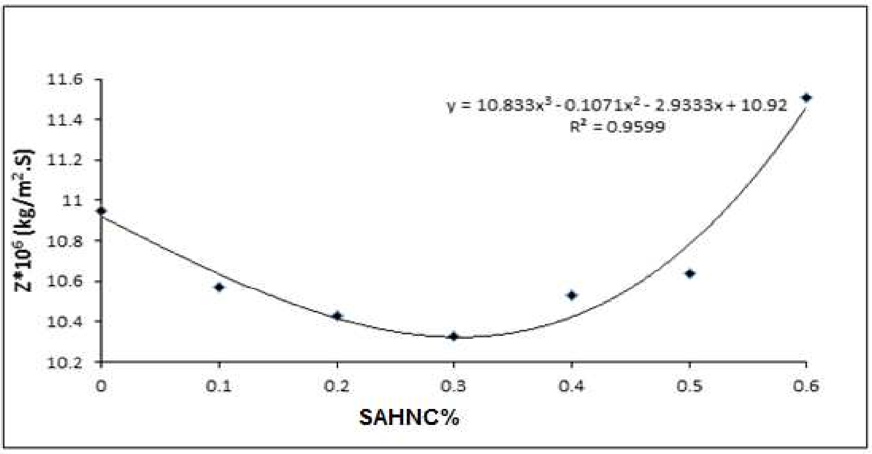

Fig. 11: Acoustic impedance for mortar as a function of SAHNC content

To determine the percentages of both the energy reflected (E_R) and the energy transmitted (E_T) when the wave projected on a plane between two media, steel (Z = 45.41) was used in this study as the second medium.

E_R and E_T were calculated according to Equations 9 and 10respectively [15].

$$E_R = [(Z_1 - Z_2) / (Z_1 + Z_2)]^2 \text{ X } 100 \quad (9)$$
$$E_T = (4Z_1Z_2) / (Z_1 + Z_2)^2 \text{ X}100 \quad (10)$$

The percentages of both the energy reflected (E_R) and the energy transmitted (E_T) are shown in Figures 12 and 13 for each of the concrete hybrid composite and mortar hybrid composite respectively. In both two figures, E_R reaches to their minimum values at higher SAHNCs ratios while E_T reaches to their maximum values at higher ratio of SAHNCs. This means that at higher SAHNCs ratios content, the energy will dissipate due to high porosity levels. Also, both figures contain a maximum point in both E_R and E_T which support that the maximum hydration levels occur at these points.

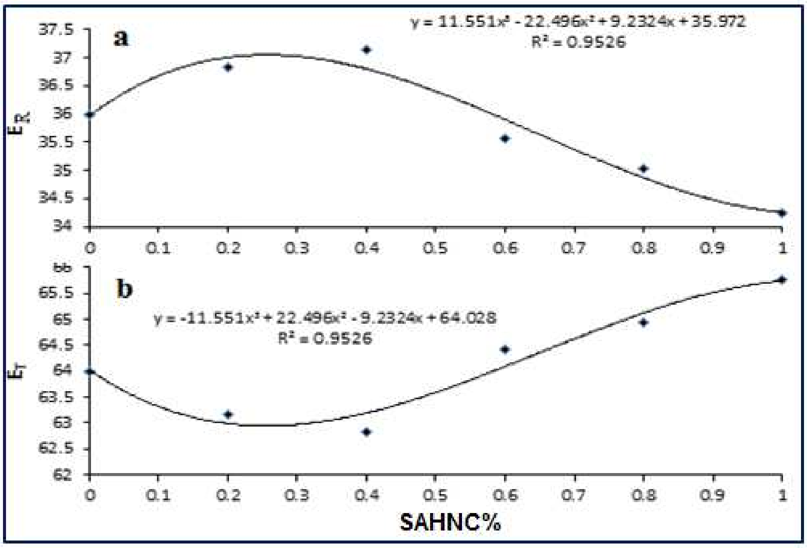

Fig. 12: Percentages of reflected (a) and transmitted (b) energies between steel and concretehybridcomposites

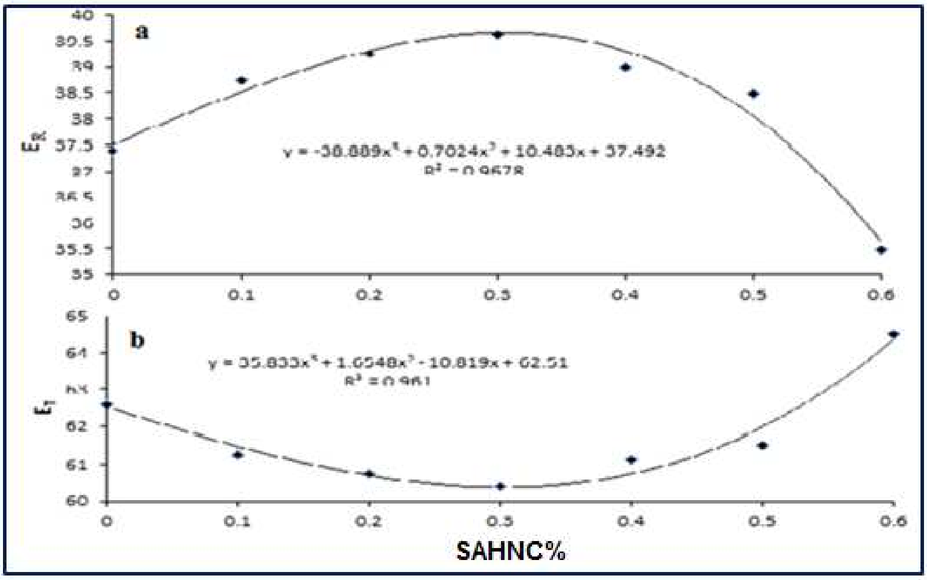

Fig. 13: Percentages of reflected (a) and transmitted (b) energies between steel and mortarhybrid composites

Conclusions:

In this research an attempt was down to improve the concrete and mortar properties by adding SAHNCs.Based on this, it was concluded the following:-

1- Compressive strength for concrete and mortar hybrid composites exceeds their initial values at higher SAHNCs ratios.

2- The additional amounts of water which is required to get the standard consistency in mortar seem to be reasonable.

3- Elastic modulus for these hybrid composites increased at higher ratios.

4- Shear modulus increased at higher ratios and there is some fluctuations in mortar shear modulus.

5- Most values of Poisons ratio within the typical range for concrete.

6- Initial and final setting times of mortar increased with SAHNCs loadings.

7- Concrete quality are excellent according to the BS, 1881, 1983 code.

8- The acoustic impedance increased, while the energy reflected reaches to its minimum value at higher SAHNCs ratios and the energy transmitted reaches to its maximum valueat this ratio.

REFERENCES

1. Xie, Y., Y. Wei, Y. Huang, J. Lin, J. Wu, 2012. " Synthesis and Characterization of Poly (Sodium Acrylate)/ Bentonite Superabsorbent Composite" Journal of Physics: Conference Series, 339.
2. Kabiri, K., H. Omidian, M.J. Zohuriaan-Mehr, S. Doroudiani, 2011."Superabsorbent hydrogel composites and nanocomposites: A review " www.ivsl.org,J.Polymer Composites, 32: 2.
3. Nnadi, F. and C. Brave, 2011." Environmentally friendly superabsorbent polymers for water conservation in agricultural lands" J. Soil Sci. Environ.Manage., 2(7).
4. Yui, N., R.J. Mrsny, K. Park, 2004." Reflexive Polymers and Hydrogels: Understanding and Designing Fast Responsive Polymeric Systems" CRC Press LLC.
5. Sadeghi, M., F. Soleimani, 2011." Synthesis and Characterization of Superabsorbent Hydrogels for Oral Drug Delivery Systems" International Journal of Chemical Engineering and Applications, 2: 5
6. Gao, D., 2003." Superabsorbent Polymer Composite(SAPC) Materials and their Industrial and High-Tech Applications"Freiberg : TU Bergakad.
7. Jensen, O.M., P.F. Hansen, 2002. "Water entrained in concrete-based materials-II.Implementation and experimental results. Cem Concr. Res., 32(6): 973-978.
8. Neville, M. and J.J. Brooks, 2010."Concrete Technology" Second edition,Trans-Atlantic Publications.
9. Mechtcherine, V. and H-W. Reinhardt, 2012." Application of Superabsorbent Polymers (SAP) in Concrete Construction" Springer, State-of-the-Art Report Prepared by Technical Committee 225-SAP, NewYork.
10. Hareendran, V., V. Poornima, G.Velrajkumar, 2014."Experimental Investigation Aspects of Internal Curing concrete Using Superabsorbent Polymer" International Journal of Advanced Structures and Geotechnical Engineering, 03: 02.

11. Daoud, M., M. Al-Nasra, 2014. "The Use of Super Absorbent Polymer as a Sealing Agent in Plain Concrete" American Journal of Engineering Research, 03(03): 132-137.
12. Lorenzi, A., F.T. Tisbierek and L.C.P. da Silva Filho, 2007. "Ultrasonic Pulse Velocity Analysis in Concrete Specimens"IVConferenciaPanamericana de END Buenos Aires.
13. Lawson, I., K.A. Danso, H.C. Odoi, C.A. Adjei, F.K. Quashie, I.I. Mumuni and I.S. Ibrahim, 2011." Non-Destructive Evaluation of Concrete using Ultrasonic Pulse Velocity" Res. J. Appl. Sci. Eng. Technol., 3(6): 499-504.
14. Panzera, T.H., A.L. Christoforo, F.P. Cota, P.H.R. Borges and C.R. Bowen, 2011. "Ultrasonic Pulse Velocity Evaluation of CementitiousMaterials"Advances in Composite Materials - Analysis of Natural and Man-Made Materials, pp: 411-436.
15. Long, R., 2000." The Improvement of Ultrasonic Apparatus for The Routine Inspection of Concrete", Ph. D Thesis, University of London.