Effect of Waste Thermostone as an Aggregate in Concrete Containing Nano-SiO_2

Rami Joseph Aghajan Sldozian

Abstract - In this paper, the study included of adding waste thermosone as coarse aggregates with adding nano scale size of SiO2 as a replacement by the weight of cement, the ratios was (5%, 10%, 15% and 20%). Destructive and non-destructive tests was conducted on the samples, the results show in destructive test the compressive and tensile strength decrease in the samples include thermostone and increase when adding nano-silica, and also noted that the butter ratio in nano-silica is 15%. The results of non-destructive tests Ultra sonic (pules velocity) that the better quality was in 15% ratio of nano-silica, but comparison with the samples that contain thermostone aggregates, the quality decrease with samples contain normal aggregate. And also the density of samples that contain thermostone decreased clearly, and noted very little change in density when add non-silica.

Keywords ---- Concrete, Cement, Waste thermostone, Nano-SiO_2, Ultrasonic, Tensile strength, Compressive strength.

1 Introduction

Lightweight concrete (LWC) is a concrete which by one means or another has been made lighter than conventional concrete. Using concrete with a lower density can, therefore, result in significant benefits in terms of load-bearing elements of smaller cross-section and a corresponding reduction in the size of foundations. Furthermore, with lighter concrete , the formwork needs to withstand lower pressure than would be the case with normal weight concrete, and also the total mass of material to be handled is reduced with a consequent increase in productivity. Concrete which has a lower density also gives better thermal insulation than ordinary concrete and possesses good fire and frost resistance [1]. Nano materials have attracted much scientific interest due to the potentially new performance of the particles in nanometer (10^{-9} meter) scale. The nano scale particles can result in dramatically improved or different properties from conventional grain-size materials of the same chemical composition. Hence industries can re-engineer many existing products and design novel products that function at unprecedented levels. Nano particles can make traditional building materials stronger and harder, giving them enhanced ductility and formability. However, the present applications of these materials are mainly limited to produce antiaging, antiseptic, purified air composite paint or other ecological building materials using nano-TiO_2, nano-SiO_2 or nano-Fe_2O_3. There is little research on mixing nano-particles in cement-based materials [2].

2 Experimental Work

2.1 Materials:-

- **Cement**

Ordinary Portland cement manufactured by (tasluga factory \ Bazian) cement factory was used throughout this investigation. Table (1) and (2) show the physical and chemical properties.

Table (1) Chemical properties of the cement

Oxides composition	Content %	Limits of (Iraqi Standard) No.5/1984
CaO	52.21	-
SiO_2	20.18	-
Al_2O_3	5.00	-
Fe_2O_3	3.60	-
MgO	2.31	<5.00
SO_3	1.44	<2.80
L.O.I.	3.29	<4.00
Insoluble residue	1.11	<1.5
Lime Saturation Factor,L.S.F.	0.94	0.66-1.02
Main compounds (Bogue's equations)		
C_3S	57.04	-
C_2S	14.83	-

Oxides composition	Content %	Limits of (Iraqi Standard) No.5/1984
C_3A	8.60	-
C_4AF	10.95	-

Table (2) Physical Properties of the Cement

Physical Properties	Test results	Limits of (Iraqi Standard) No.5/1984
Specific surface area (Blaine method), m^2/kg	483	≥230
Setting time (Vicate apparatus), Initial setting, h:min Final setting, h:min	 2:50 4:30	 ≥00:45 ≤10:00
Soundness (Auto Clave) method, %	0.25	≤0.8

- **Fine aggregate:-**

AL-Ekadir in Karbala region sand was used as fine aggregate**,** Table (3) show the sieve analysis of fine aggregate.

Table (3) Sieve analysis of fine aggregate

Sieve Size (mm)	% Passing	% Passing according to limits of Iraqi Standard No. 45/1984
4.75	95	90-100
2.36	90	85-100
1.18	85	75-100
0.60	70	60-79
0.30	25	12-40
0.15	5	0-10
Fineness Modulus = 2.3		

- **Coarse Aggregate:-**

The coarse aggregate that crushed to12.5 mm maximum size was used. It was obtained from AL - Nebai source, Table (4) show the sieve analysis.

Table (4) Sieve analysis of coarse aggregate

Sieve size (mm)	Selected % passing	% passing ASTM C330-87
12.5	95	90-100
9.5	70	40-80
4.75	15	0-20
2.36	5	0-10

- **Waste Thermostone**: -

Use waste thermostone as replacement of coarse aggregate and also crushed to 12.5 mm maximum size and sieved like particle size of coarse aggregate and the same table (4). The Physical properties of the Thermostone aggregate show in table (5).

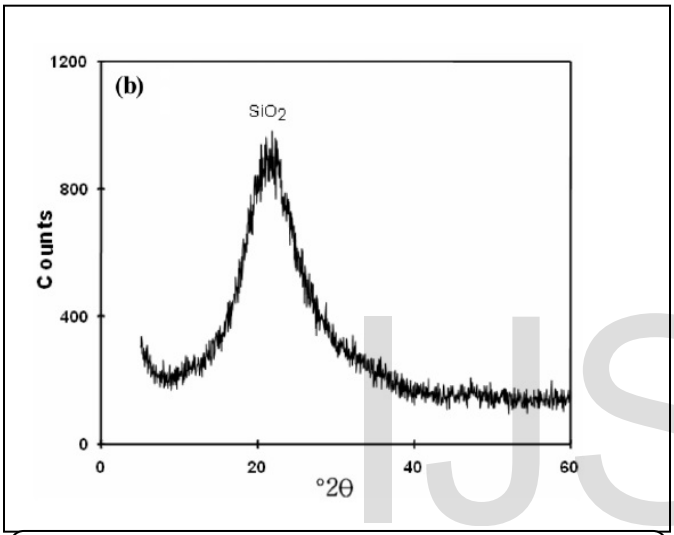
Table (5) Physical properties of the Thermostone

	Thermostone
Specific gravity	1.14
Absorption	53.6
Bulk density(dry loose)	560

- **Nano-Silica**: - Added (5%, 10%, 15% and 20%) by weight of cement and the physical properties show in table (6), and chemical properties show in table (7). And (fig1) show X.R.D of Nano-SiO2.

Table (6) Physical Properties

	Silica
Partical Size	20 to 500 nm
Density	31 kg/m3
Specific gravity	1.08



X.R.D SiO2
(Fig 1)

Table (6) Chemical Properties

Chemical Composition	Amorphous Silica %
SiO2	95.90
Fe2O3	1.30
CaO	0.41
MgO	0.38
Na2O	0.11
K2O	0.31
Loss of Ignition	1.58

2.2 Preparation of Concrete Specimens:-

- **Concrete Mixing:-**

The details of mix proportions are presented in Table (8). All mixes was adding Nano-silica as a partial replacement by cement weight content, and cast a samples as a cylinder mold (100×200) mm to compressive and tensile strength and cubic molds (150×150×150) mm to non-destructive tests.

Table (8) Details of the Mixes Used Throughout This Investigation

Mix designation	Mix Proportion	*(W/C)	SiO2
1	1:2:3	0.5	0
2	1:2:3	0.5	5%
3	1:2:3	0.5	10%
4	1:2:3	0.5	15%
5	1:2:3	0.5	20%
Mix designation	**Mix Proportion (Thermostone aggregate)**	**(W/C)***	**SiO2**
6	1:2:3	0.65	5%
7	1:2:3	0.65	10%
8	1:2:3	0.65	15%
9	1:2:3	0.65	20%

*W/C : **water/Cement** ratio

- **Mixing Procedure:-**

Adopted concrete mix 1:2:3 in the casting process from each mix. a total of 3 cylindrical concrete specimens 100 mm in diameter and 200 mm high[3] and 3 cubic specimens 150×150×150 mm[4]. The molds were oiled properly for easy out sample and then fill the mold with three layers of the mixture and with each layer instills by tamping rod to ensure out the bubbles and distribution. After casting and finishing, the specimens were demolded after 24 hours of casting and then they were transferred to a curing tank placed at the laboratory temperature of 18 to 20ºC. The specimens were cured in the water tank for 28 days, and then dried in the air to be tested.

3 .RESULTS AND DISCUSSION:-

3.1 Destructive tests

- **Compressive and Splitting tensile Strength:-**

Compressive and Splitting tensile Strength was calculated from examination of the dimensions of the cylinder (100×200 mm) Concrete containing thermostone aggregates and nano-silica that contain ratios (5%, 10%, 15% and 20%), the results are shown in Figure (2,3).

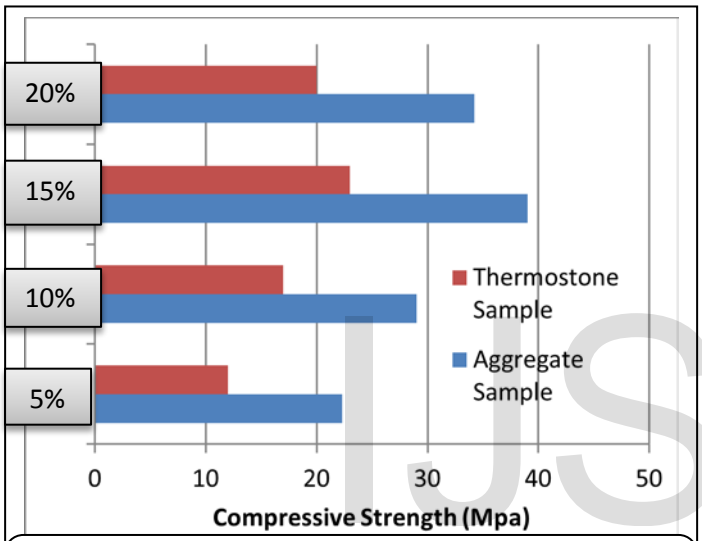


Fig 2. Show relation between compressive strength and the ratio of silica additives to samples contain thermostone and not contain thermostone

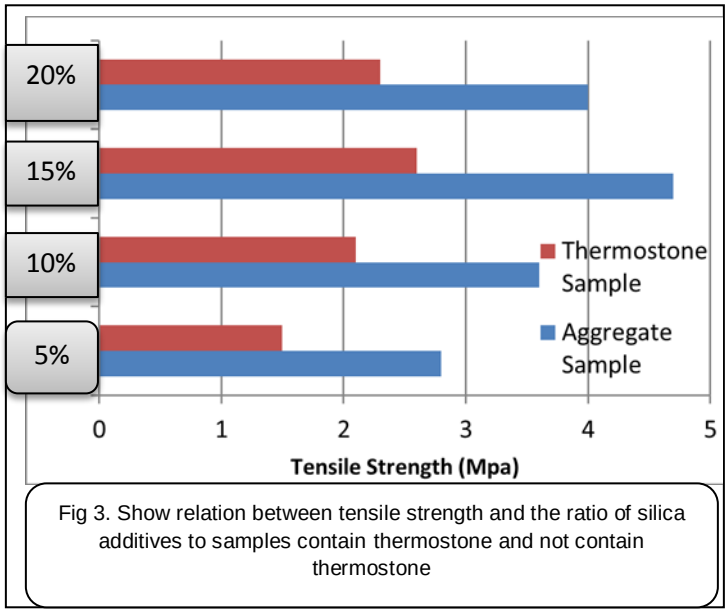


Fig 3. Show relation between tensile strength and the ratio of silica additives to samples contain thermostone and not contain thermostone

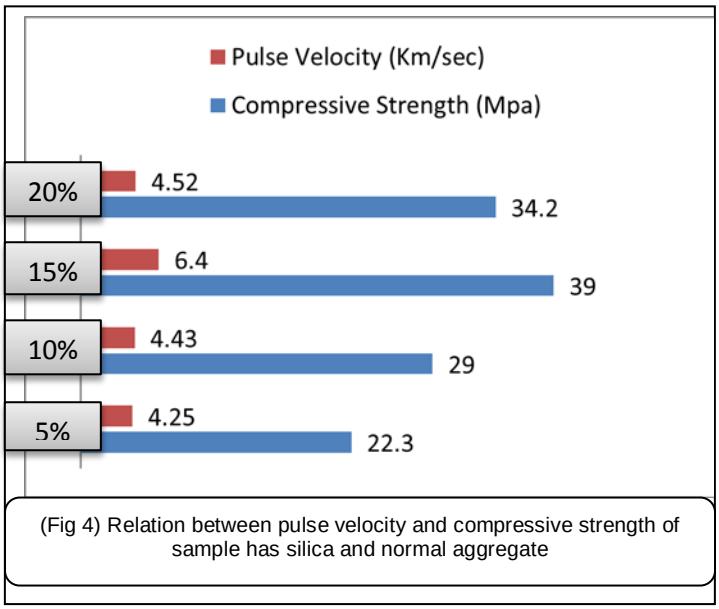
By comparison with sample without additives SiO2 (20 Mpa) in compression and (2.6 Mpa) in tensile, and the sample have thermostone aggregate but without SiO2 (12 Mpa) in compression and (1.6 Mpa) in tensile strength. Note from (Figures 2 and 3) that with adding nano-silica increase compressive and splitting strength of samples have waste thermostone aggregate and the samples have normal aggregate. And observed that the compressive and splitting strength increases at ratio15% of nano-silica, and also note the compressive and splitting strength in samples have waste thermostone aggregate lower than samples have normal aggregate.

- **Ultra Sonic (Pulse Velocity):-**

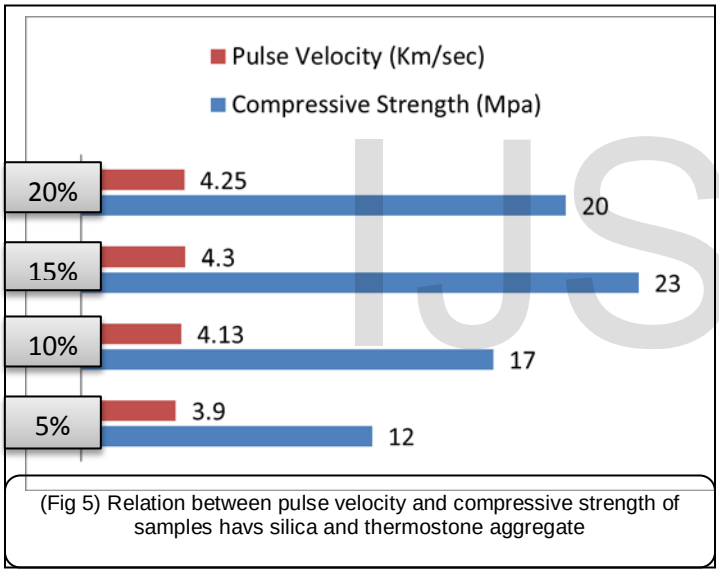
Samples tested by Ultrasonic (pundit lab – Proceq Company) to determine the quality of concrete. The pulse velocity of concrete sample without additives (SiO_2) is (4.24 Km/sec). And sample has waste thermostone and without SiO_2 is (3.56 Km/sec). And by determine the pulse velocity of concrete that contain SiO2 and normal aggregates show increase the pulse velocity by increase the additives, but noted that the high velocity was in 15% than the other ratio of SiO2 as show in (Fig 4). Noted in (Fig 5) pulse velocity of concrete has SiO_2 and waste thermostone aggregate increase by increase the additives, and the high velocity was 15% than other additives. And also can find the quality of concrete according to Neville, A.M. (Table 9) [5]

(Table 9) Classification of the quality of concrete on the basis of pulse velocity

pulse velocity (km/s)	Quality of concrete
> 4.5	excellent
4.5-3.5	good
3.5-3.0	doubtful
3.0-2.0	poor
<2.0	very poor



(Fig 4) Relation between pulse velocity and compressive strength of sample has silica and normal aggregate



(Fig 5) Relation between pulse velocity and compressive strength of samples havs silica and thermostone aggregate

- **Density of Samples:-**

The density of concrete decreases significantly with the replacement of the normal aggregates by waste thermostone aggregates, and noted very little change in the density by adding nano-silica to the concrete mix. Where the density of concrete contain normal aggregates (2.33 g/cm3), and the density of concrete contain thermostone aggregates (1.99 g/cm3).

4. Conclusions

Conclusion from this research, nano-silica is effect in concrete mix, where the silica show high mechanical properties and show high quality in non-distractive test (pulse velocity). And conclusion is the better added ratio is 15% in silica, and also noted by added waste thermostone as course aggregate decrease the mechanical properties of concrete and also the quality of concrete, but have weight lower than the concrete that they have normal aggregate, so we have light weight concrete by replace waste thermostone aggregates instead the normal aggregate, and we increased the weakness of mechanical properties of light weight concrete by adding nano-silica.

5. References:

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