Construction and Building Materials 80 (2015) 116–124

Contents lists available at ScienceDirect

Construction and Building Materials

journal homepage: www.elsevier.com/locate/conbuildmat

Effect of using different types of nano materials on mechanical properties of high strength concrete

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HIGHLIGHTS

- We studied effect of NS and NF on Mechanical Properties of HSC.
- NS used in HSC can improve its mechanical properties more than NF.
- Increase of NS and NF more than optimum dose degrades the mechanical Properties.
- HSC containing granite gave better results than similar-containing dolomite.

ARTICLE INFO

Article history:
Received 15 May 2014
Received in revised form 3 November 2014
Accepted 27 December 2014
Available online 31 January 2015

Keywords:
Nano silica
Cu-Zn ferrite
Ni ferrite
Silica fume
High strength concrete
Compressive strength
Splitting tensile strength
Flexural strength

ABSTRACT

This study evaluates the effect of addition of nano silica, $Cu_{0.5}Zn_{0.5}Fe_2O_4$ (Cu-Zn ferrite) and $NiFe_2O_4$ (Ni ferrite) on the compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete. Nano-silica (NS), Cu-Zn ferrite and Ni ferrite, was added in five percentages (1%, 2%, 3%, 4% and 5%) of weight of cementitious materials (cement and SF). We use two types of coarse aggregate (dolomite and granite) and the study of the effect on the mechanical properties of concrete containing nanomaterials. Results indicated that the optimum dose of nano-silica was 3% by weight and the optimum dose of Ni ferrite and Cu-Zn ferrite was 2% by weight. The samples of concrete-containing nano-silica gave better results from samples of concrete-containing nano ferrite and the approximate rate of about 10%. Also, the samples of concrete containing granite gave better results than similar-containing dolomite and the approximate rate of about 10%.

1. Introduction

During the period of the second half of the previous century, the terms "nano-science" and "nono-technology" were not yet familiarly used as today. However, they were really practiced and successfully applied to the progress in the field of material science and technology.

Nanotechnology is based on synthesizing nano-particles with specified characteristics to be used in different applications related to the industry, medicine, agriculture, etc. A nano-particle is a microscopic particle whose size is measured in nano-meters (nm). It is defined as a particle with at least one dimension less than 200-nm. During the last ten years, not only the nano-products were utilized to improve the quality and durability of products, but also new approaches were developed to handle traditional problems. Concrete is one of the most common and widely used construction materials. Its properties have been well studied at macro or structural level without fully understanding the properties of the cementitious materials at the micro level. The better understanding of the structure and behavior of concrete at micro/nano-scale could help to improve concrete properties [1].

Most of the published studies on the use of nano-particles in cement and concrete have utilized nano-oxides, especially SiO_2 and Fe_2O_3 [2–6]. Safan et al. studied the compressive strength of Portland cement pastes and mortars containing Cu-Zn nano-ferrite and found that the optimum dose of nano-ferrite was one percent of cement by weight and the increase in compressive strength of cement paste and mortar was increased by an average of 45% [7]. Zaki and Ragab studied the effect of NS on SCC. They used NS at

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http://dx.doi.org/10.1016/j.conbuildmat.2014.12.075
0950-0618/

different ratios of cementitious materials replacements (0.5%, 0.7% and 1%). They measured compressive strengths at ages 7, 28, 90 and 365 days. The results showed that 0.5% of NS replaced cementitious materials gave the higher compressive strengths through all ages [8]. Abbas carried out an investigation to study the influence of nano-silica addition on properties of conventional and ultra-high performance concretes and found that nano-silica (NS) concretes requires additional amount of water, since each kilogram of NS added required 0.4 kg of water to maintain the same workability. Also nano-silica addition resulted in significant early increase in compressive, splitting and flexural strengths of concrete in case of high cement content and low w/c ratio. Also, the addition of 5% nano-silica leads to an increase of 50% in 7-day compressive strength and 40% in 28-day compressive strength when compared with the same concrete without nano-silica [9]. Ji studied the water permeability of concrete containing nano-silica and found that the microstructure of concrete containing nano-silica is more uniform and compact, leading to reduction in water permeability [10].

2. Experimental work

In this work, the well known performance of concrete without nano particles was compared with that after the addition of nano particles for both fresh and hardened states. The used materials in the current research – except nano silica – were chosen from the available materials in Egypt.

2.1. Materials

2.1.1. Cement

Ordinary Portland Cement (OPC) produced by Sina Company was used in all mixes. The grade used was CEM I 52.5 N. Testing of cement was carried out according to the Egyptian Standard Specification (ES: 2421/2009). Table 1 shows the physical and mechanical properties of the used cement.

2.1.2. Aggregates

The aggregates used in this research work consisted of Crushed dolomite, siliceous sand, and Granite. To avoid the effect of fine materials in the coarse aggregate, it was washed 48 h before being used and left to dry.

2.1.2.1. Coarse aggregates. Local natural coarse aggregate from Ataka Mountain in Suez City was used in the experimental work. Two sizes of coarse aggregates were used. The coarse aggregates had nominal maximum size of 10 mm. Testing of coarse aggregate was carried out according to Egyptian Standard Specification (1109/2002). Table 2 shows physical properties of the used coarse aggregates.

2.1.2.2. Siliceous sand. The sand used in this investigation was natural siliceous sand. Testing of the used sand was carried out according to Egyptian Standard Specification (1109/2002). Table 3 shows the sand physical properties.

2.1.3. Silica fume

The used silica fume was brought from Sika Company in Egypt. The physical and chemical composition is shown in Tables 4 and 5, respectively, as obtained from the manufactures sheet.

2.1.4. Superplasticizer

A high range water reducer (HRWR) of modified polycarboxylates was used in the experimental work of the study. This admixture is conforms to ASTM C494 (types F and G).

It is derived directly from the total Performance Control concept. Its particular configuration allows its delayed absorption onto the cement particles and disperses them efficiently. As compared with other PCE superplasticizers, it is possible to

Table 2
Physical properties of the coarse aggregates used.

Property			Limits*
	Crushed dolomite	Granite	
Specific weight	2.68	2.71	–
Bulk density (t/m^3)	1.62	1.65	–
Void ratio (%)	39.5	39.11	–
Water absorption (%)	2.00	0.3	Not more than 2.5%
Crushing value (%)	22.5	18.2	Not more than 25%
Coefficient of abrasion (%)	18.3	18	Not more than 30%
Coefficient of impact (%)	9.5	13.1	Not more than 30%

* The limits are according to Egyptian Standard Specifications No. (1109/2002).

Table 3
Physical properties of the sand used.

Test	Siliceous sand
Specific weight	2.66
Bulk density (t/m^3)	1.86
Fineness modulus	2.65
Void ratio (%)	36.84

Table 4
Physical properties of the silica fume used.

Property	Results*
Specific surface area (m^2/kg)	17.8×10^3
Particle size (μm)	7.00
Bulk density (kg/m^3)	345
Specific gravity	2.15
Color	Light gray

* By the manufacturer data sheet.

Table 5
Chemical composition of the silica fume used.

Oxide	Content (%)*
SiO_2	96.00
Fe_2O_3	1.45
Al_2O_3	1.10
CaO	1.20
MgO	0.18
K_2O	1.20
Na_2O	0.45
SO_3	0.25
H_2O	0.85

* By the manufacturer data sheet.

Table 1
Physical and mechanical properties of the Portland cement used CEM I 52.5 N.

Properties		Test result	Limits*
Percentage of water for standard consistency (%)		29.5	–
Specific surface area (Blain) (m^2/kg)		350	Not less than 275
Specific weight		3.15	–
Soundness (Le-Chatelier) (mm)		1.0	Not more than 10
Initial setting-time (min)		80	Not less than 45 min
Final setting time (min)		190	–
Compressive strength of standard mortar	2 days (MPa)	22.3	Not less than 20
	28 days (MPa)	54	Not less than 52.50

* The limits are according to Egyptian Standard Specifications (4756-1/2009).

Table 6
Technical Data/Typical Properties of the superplasticizer.

Form	Aqueous solution of modified polycarboxylates
Appearance	Light Brown
Density (20 °C)	1.06 kg/liter
pH value (20 °C)	4.3–4.7

obtain a high quality concrete mix with accelerated strength development and extended workability without delayed setting characteristics. The Technical Data/Typical Properties of the superplasticizer are shown in Table 6.

2.1.5. Nano materials

2.1.5.1. Nano-ferrite. Two types of nano-ferrite were used in this research work consisted of $NiFe_2O_4$ (Ni ferrite) and $Cu_{0.5}Zn_{0.5}Fe_2O_4$ (Cu-Zn ferrite). $NiFe_2O_4$ and $Cu_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles were prepared using a common coprecipitation technique from $NiSO_4$, $CuSO_4$, $ZnSO_4$ and $Fe_2(SO_4)_3$ chemicals according to the following equations:

$$NiSO_4 + Fe_2(SO_4)_3 + 8NaOH \Rightarrow Ni(OH)_2 + 2Fe(OH)_3 + 4Na_2(SO_4)$$
$$\Rightarrow NiFe_2O_4 + \text{sodium sulfate solution} \quad (\textbf{Equation of Ni ferrite production})$$

$$0.5CuSO_4 + 0.5ZnSO_4 + Fe_2(SO_4)_3 + 8NaOH$$
$$\Rightarrow 0.5Cu(OH)_2 + 0.5Zn(OH)_2 + 2Fe(OH)_3 + 4Na_2(SO_4)$$
$$\Rightarrow Cu_{0.5}Zn_{0.5}Fe_2O_4$$
$$+ \text{sodium sulfate solution} \quad (\textbf{Equation of Cu-Zn ferrite production})$$

The sulfates were mixed in required stoichometric ratios in deionized (DI) water. NaOH solution was then added dropwise while stirring until the pH value becomes 12. The mixture was continually stirred at 700 rpm for 2 h, while heated at 80 °C. A dark color was observed due to the formation of the ferrite particles. After that, it was allowed to settle the sediment and it was washed ten times to remove the sodium sulfate solution. Then, powder sample was dried at room temperature.

The X-ray powder diffraction (XRD) data were collected using K_α radiation. Approximately 200 mg of powder were transferred to a glass XRD sample holder. This sample holder was then placed inside a X'Pert Graphics X-ray Powder Diffractometer. Fig. 1 shows the X-ray diffraction pattern of $NiFe_2O_4$ nanoparticles, which clearly shows the single phase of a spinel structure. Also, the mean particle size of around 25 nm was calculated from peak (2.51644 Å) of the X-ray diffract grams while employing Scherrer's Formula [11]. Fig. 2 shows the X-ray diffraction pattern of $Cu_{0.5}Zn_{0.5}Fe_2O_4$ nanoparticles, which clearly shows the single phase of a spinel structure. Also, the mean particle size of around 23 nm was calculated from peak (2.53304 Å) of the X-ray diffractograms while employing Scherrer's Formula [11].

2.1.5.2. Nano silica (NS). The used nano silica (Silicon Dioxide, 99.5%) was brought from the MK nano Company in (Divn. of MK Impex Corp – Mississauga, ON L5N 6X1, Canada). The physical and chemical properties are shown in (Company sheet) Table 7.

2.2. Concrete mix design with and without nano particles

High strength concrete "HSC" has been manufactured with and without nano particles in order to compare the well known performance of "HSC" without nano particles and with nano ones. So, high strength concrete with a cement content of 500 kg/m^3 was manufactured in all concrete mixes as shown in table 8. The water to cementitious materials ratio was equal 0.20 for all mixes.

A proper dosage of superplasticizer is 20 kg/m^3 for all mixes. The composition of high strength concrete with and without nano particles is shown in table 8.

Nano-silica (NS), Cu-Zn ferrite and Ni ferrite, were added in five percentages (1%, 2%, 3%, 4% and 5%) of weight of cementitious materials.

2.3. Mixing procedure

To get high strength concrete, water-cement ratio must be minimized. Therefore, special mixing procedure should be carried out. As illustrated in the previous studies and as resulted in through initial trials in the current experimental work, the following steps were conducted:

(1) Putting fine materials (cement – silica fume) in the mixer and mixing them together for one minute.
(2) Stirring a half of the superplasticizer required dosage for the mixture to half of the required amount of water and then adding them to the required amount of nano particles with high speed rate mixing for two minutes.
(3) Adding the mixed nano particles in step (2) to the dry mix in step (1) and mixing for two minutes.
(4) Stirring the rest half dosage of the superplasticizer to the rest half of the amount of water rest and then adding to the pan mixer gradually and mixing for other four minutes until getting homogeneous paste.
(5) Adding the fine aggregate gradually, followed by the coarse aggregate. Mixing continued for other 5 min until getting homogeneous concrete paste.

2.4. Specimen preparation

Three types of specimens were made: 70 × 70 × 70 mm cube, 150 × 300 mm cylinders, and 100 × 100 × 500 mm prismatic beams. After pouring the mixes into molds an electric vibrator was used to ensure good compaction. The specimens were then surface smoothed and covered with wet hessian. All specimens were remolded 1 day after casting. Thereafter, they were cured in standard water tank until testing at age 1, 7, 28 and 90 days.

3. Results and discussion

Table 9 demonstrates the compressive strength for all concrete mixes at the ages of 1, 7, 28 and 90 days and lists the splitting tensile strength, flexural strength and modulus of elasticity of all concrete mixes at the age of 28 day.

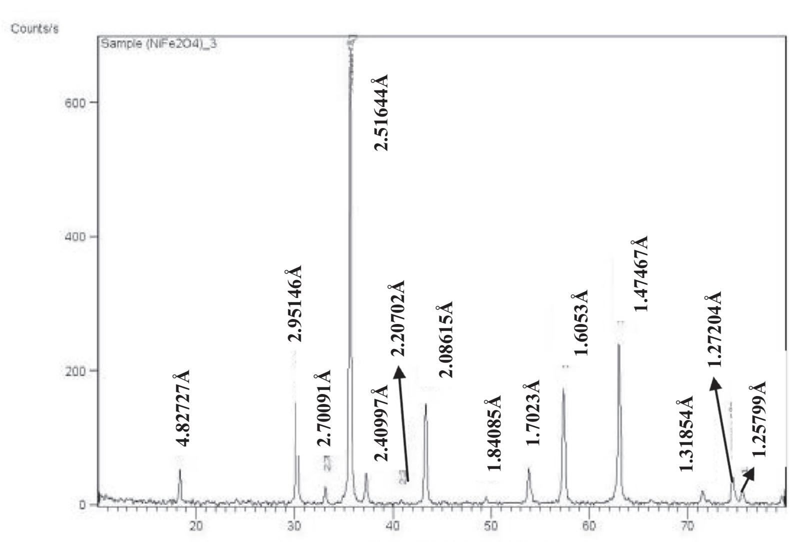

Fig. 1. X-ray diffraction pattern of $NiFe_2O_4$ nanoparticles.

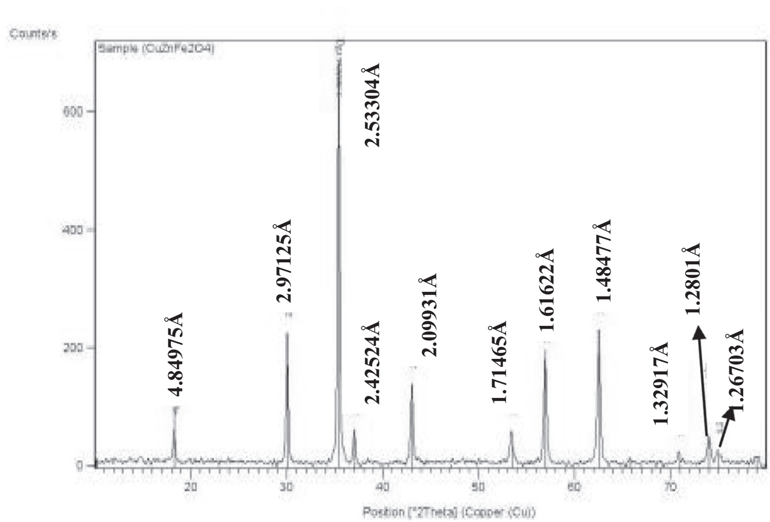

Fig. 2. X-ray diffraction pattern of $CuZnFe_2O_4$ nanoparticles.

Table 7
Physical and chemical properties of nano-silica.

Description	Results
Appearance form	Powder
Particle size	15 nm
Color	colorless (White)
Density (25 °C)	2.2–2.6 g/mL
Molecular	Sio_2

3.1. Compressive strength

3.1.1. Nano silica

Results are compared to conventional mixes and mixes incorporating silica fume. Fig. 3 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added nano silica (NS) ratios with **Crushed dolomite**. It can be seen that compressive

Table 8
Composition of high strength concrete (HSC) with and without nano materials.

Mix	Cement (kg)		Fine aggregate (kg)		Coarse aggregates (kg)		Silica fume (kg)	Viscocrete10 (kg)	Water (kg)	Nano particles (kg)		
	Type	Content	Type	Content	Type	Content				NS	NiF	CuZnF
M0	Ordinary Portland Cement (OPC)	500	Siliceous	772	Crushed	1158	0	20	100	0	0	0
M1	CEM I 52.5 N	500	sand	701	dolomite	1051	100	20	120	0	0	0
M2		500		701		1051	95	20	120	5	0	0
M3		500		701		1051	90	20	120	10	0	0
M4		500		701		1051	85	20	120	15	0	0
M5		500		701		1051	80	20	120	20	0	0
M6		500		701		1051	75	20	120	25	0	0
M7		500		777	Granite	1166	0	20	100	0	0	0
M8		500		706		1058	100	20	120	0	0	0
M9		500		706		1058	95	20	120	5	0	0
M10		500		706		1058	90	20	120	10	0	0
M12		500		706		1058	85	20	120	15	0	0
M13		500		706		1058	80	20	120	20	0	0
M14		500		706		1058	75	20	120	25	0	0
M15		500		702	Crushed	1053	95	20	120	0	5	0
M16		500		704	dolomite	1056	90	20	120	0	10	0
M17		500		705		1058	85	20	120	0	15	0
M18		500		707		1060	80	20	120	0	20	0
M19		500		708		1062	75	20	120	0	25	0
M20		500		707	Granite	1061	95	20	120	0	5	0
M21		500		709		1063	90	20	120	0	10	0
M22		500		710		1065	85	20	120	0	15	0
M23		500		712		1067	80	20	120	0	20	0
M24		500		713		1069	75	20	120	0	25	0
M25		500		702	Crushed	1053	95	20	120	0	0	5
M26		500		704	dolomite	1056	90	20	120	0	0	10
M27		500		705		1057	85	20	120	0	0	15
M28		500		707		1060	80	20	120	0	0	20
M29		500		708		1062	75	20	120	0	0	25
M30		500		707	Granite	1060	95	20	120	0	0	5
M31		500		709		1063	90	20	120	0	0	10
M32		500		710		1065	85	20	120	0	0	15
M33		500		712		1067	80	20	120	0	0	20
M34		500		713		1070	75	20	120	0	0	25

Table 9
Properties of high strength concrete (HSC) with and without nano materials.

Mix	Compressive strength (MPa)				Splitting tensile strength (MPa)	Flexural strength (MPa)	Modulus of elasticity (GPa)	Notes
	1 day	7 days	28 days	90 days	28 days	28 days	28 days	
M0	38.5	55.3	74.4	82.6	4.1	12.9	33.1	Crushed dolomite + nano-silica
M1	53.5	75.1	94.4	98.2	5.1	15.1	38.2	
M2	53.2	88.7	112.7	115.2	8.6	18.1	46.2	
M3	53.0	91.9	115.2	120.2	9.1	19.2	50.3	
M4	52.4	93.9	119.2	122.5	9.4	19.8	52.4	
M5	50.8	86.6	108.1	116	7.6	18.4	45.1	
M6	48.6	83.0	103.9	109	6.9	17.3	43.6	
M7	41.2	59.0	80.1	88.1	5.3	13.3	33.6	Granite + nano-silica
M8	57.8	83.7	107.3	111	7.5	18.2	46	
M9	57.7	95.3	121	125.2	8.3	19.6	51.1	
M10	57.0	99.1	125	130	8.7	20.5	53.6	
M12	56.3	100	130.2	133.6	8.9	22	56.2	
M13	53.9	93.6	117	125	8.1	19.3	50.6	
M14	52.5	90.1	112	116	7.7	18.5	48.1	
M15	49.3	87.5	112.3	117.5	8.3	18.5	49.3	Crushed dolomite + Ni ferrite
M16	50.1	88.4	113.7	119	8.5	18.8	50.2	
M17	47.6	85.9	110.2	115.2	8.3	18.7	48.6	
M18	45.8	79.2	102.9	107.8	7.8	17.5	45.3	
M19	44.5	77.6	100.7	106	7.5	17.1	44.4	
M20	53.5	96.1	121.6	126.6	8.7	20.1	52.2	Granite + Ni ferrite
M21	54.7	98.7	123.5	129	9.3	22	55.3	
M22	51.2	95.3	119.1	125	8.5	19.8	49.9	
M23	49.1	86.8	111.2	116	8.2	19	49.1	
M24	47.0	85.2	107.5	114	8.0	18	48.1	
M25	49.3	87.0	111.3	116.5	8.3	19.2	50.1	Crushed dolomite + Cu-Zn ferrite
M26	52.7	92.8	116.8	121	8.5	19.7	51.1	
M27	49.2	87	112.2	117	8.3	19.4	50.3	
M28	46.8	85.1	105.5	113.6	7.9	18	47.6	
M29	45.0	77.9	101.2	107	7.7	17.4	45	
M30	53.0	93.2	118.7	122	8.7	20	52.2	Granite + Cu-Zn ferrite
M31	58.8	98.7	125.5	131	9.1	21	57.6	
M32	54.5	94.1	120.3	124	8.9	20.3	53.6	
M33	50.2	88	113.7	118	8.5	20	51	
M34	47.9	86	109	115	8.2	18.1	48.2	

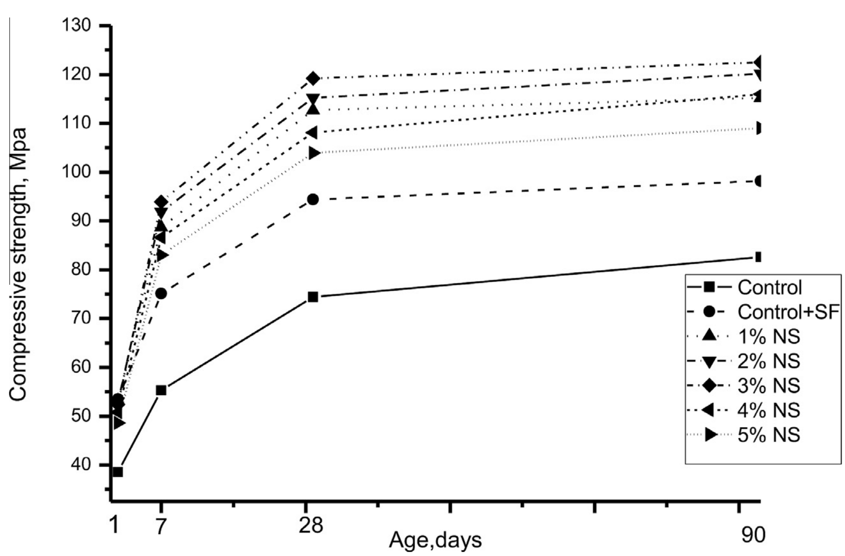

Fig. 3. Effect of NS with Crushed dolomite on compressive strength for different mixes.

strength of concrete with nano-silica was improved at 28 up to 90 days, and the optimum amount of nano-silica is 3% by weight of the cementitious content (M4). The improving percentage of compressive strength reaches about 21% with respect to the control mixes. Fig. 4 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added nano silica (NS) ratios with **granite**. It can be seen that compressive strength of concrete with nano-silica was improved at 28 up to 90 days and the optimum amount of nano-silica is 3% by weight of the cementitious content (M12). The improving percentage of compressive strength reaches

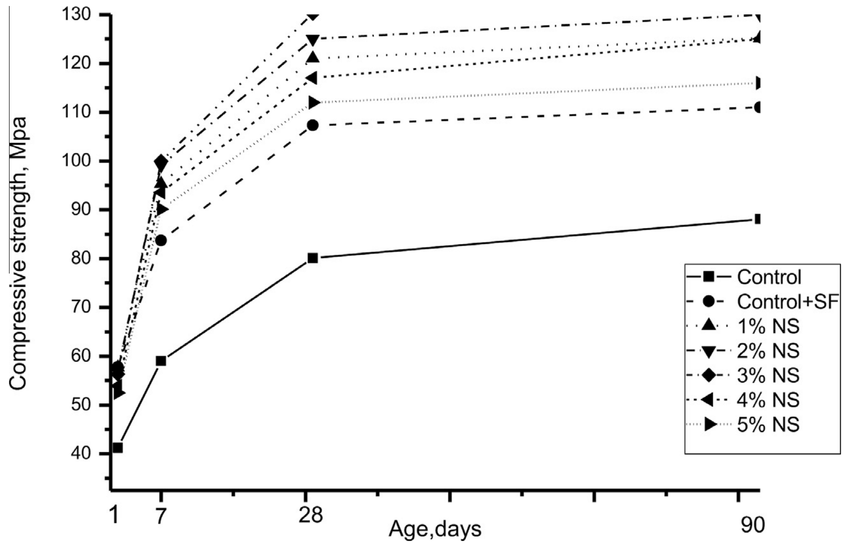

Fig. 4. Effect of NS with granite on compressive strength for different mixes.

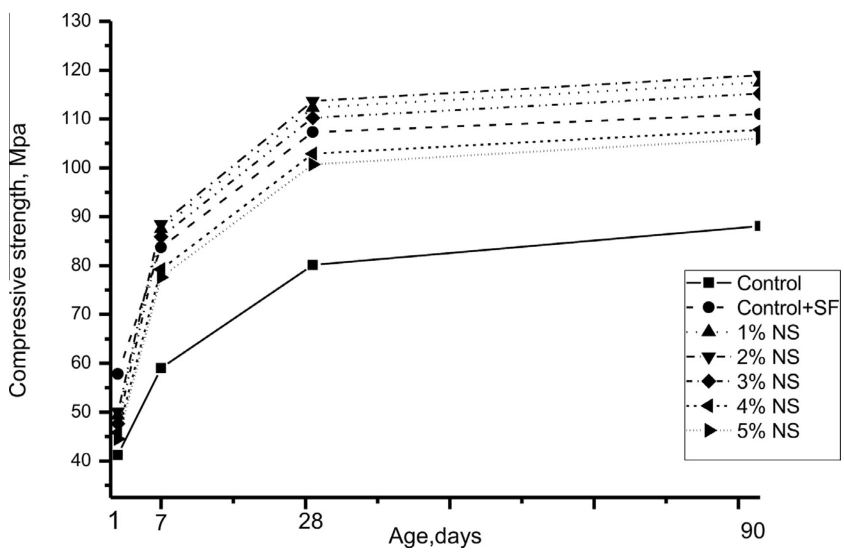

Fig. 5. Effect of Ni ferrite with Crushed dolomite on compressive strength for different mixes.

about 18% with respect to the control mixes. The increase can be due to the fact that calcium hydroxide compounds existing in lime solution react with nanoparticles in their surface areas to form additional C–S–H gel thereby increasing compressive strength [12].

3.1.2. Ni ferrite

Results are compared to conventional mixes and mixes incorporating silica fume. Fig. 5 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added Ni ferrite (NiF) ratios with **Crushed dolomite**. It can be seen that compressive strength of concrete with Ni ferrite was improved at 28 up to 90 days and the optimum amount of Ni ferrite is 2% by weight of the cementitious content (M16). The improving percentage of compressive strength reaches about 17% with respect to the control mixes. Fig. 6 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added Ni ferrite (NiF) ratios with **granite**. It can be seen that compressive strength of concrete with Ni ferrite was improved at 28 up to 90 days and the optimum amount of Ni ferrite is 2% by weight of the cementitious content (M21). The improving percentage of compressive strength reaches about 13% with respect to the control mixes. The reason for overall in-crease in the compressive strength in the presence of M series is the same as discussed in the preceding Section 1.

3.1.3. Cu-Zn ferrite

Results are compared to conventional mixes and mixes incorporating silica fume. Fig. 7 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added nan Cu-Zn ferrite (CuZnF) ratios with **Crushed dolomite**. It can be seen that compressive strength of concrete with Cu-Zn ferrite was improved at 28 up to 90 days and the optimum amount of Cu-Zn ferrite is 2% by weight of the cementitious content (M21). The improving percentage of compressive strength reaches about 13% with respect to the control mixes. Fig. 8 shows the compressive strength of the concrete mixes at age 1, 7, 28 and 90 days with added Cu-Zn ferrite (CuZnF)) ratios with **granite**. It can be seen that compressive strength of concrete with Cu-Zn ferrite was improved at 28 up to 90 days and the optimum amount of nano-silica is 2% by weight of the cementitious content (M31). The improving percentage of compressive strength reaches about 17% with respect to the control mixes. The reason

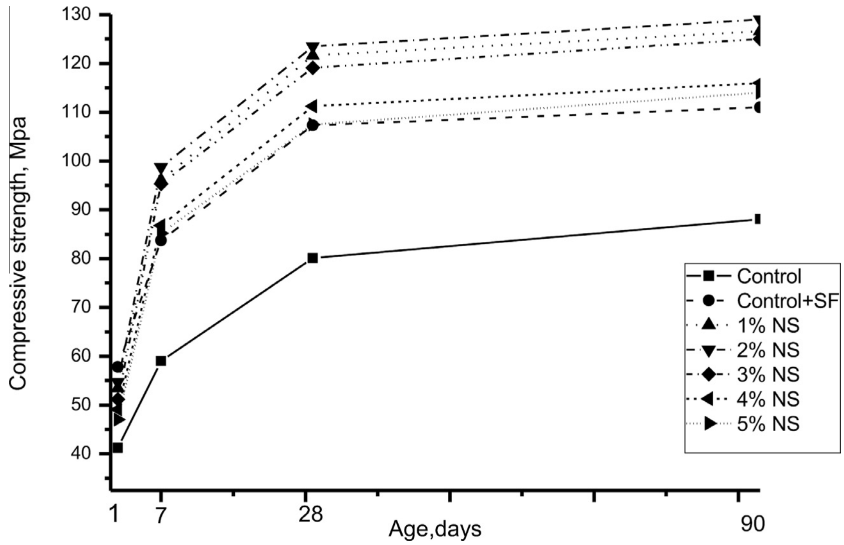

Fig. 6. Effect of Ni ferrite with granite on compressive strength for different mixes.

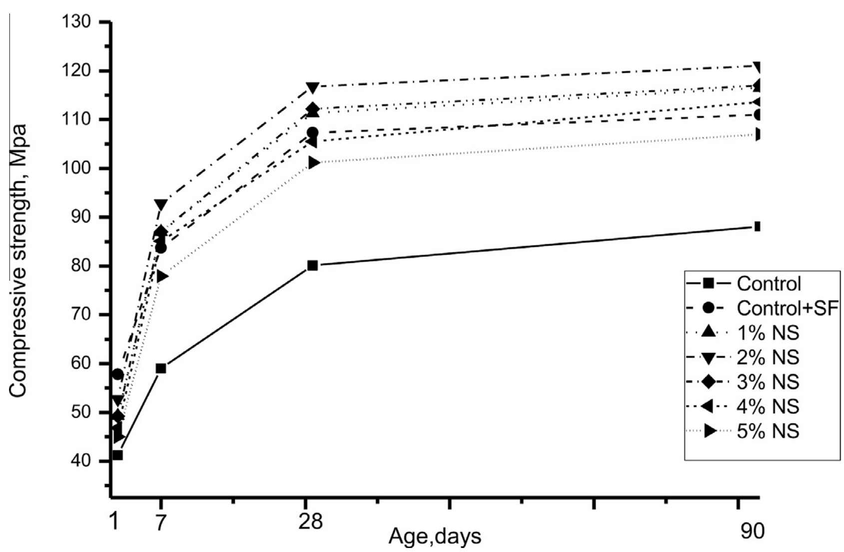

Fig. 7. Effect of Cu-Zn ferrite with Crushed dolomite on compressive strength for different mixes.

for overall in-crease in the compressive strength in the presence of M series is the same as discussed in the preceding Section 1.

3.2. A comparison of the results of compressive strength for nano-materials

The comparison between the results of the compressive strength test for concrete containing (nano silica, Cu-Zn ferrite and Ni ferrite) is shown in Fig. 9. The samples of concrete-containing nano-silica give better results from samples of concrete-containing other types of nano-materials used in research and the approximate rate of about 10%.

Figs. 9 and 10 show that the samples of concrete containing granite give better results than similar-containing dolomite and the approximate rate of about 10%. The reduction of the early strength of concrete with NS and NF contents higher than 3% and 2% by weight of the cementitious content could be attributed to the negative effects on the early hydration process.

3.3. Splitting tensile strength

Table 9 shows the splitting tensile strength of the different concrete mixtures which has improved due to the addition of NS, Cu-Zn ferrite and Ni ferrite in particular mixtures of M4, M16 and M26 respectively, show an increase of splitting tensile strength of 44%, 60% and 60%. The enhanced extent of the splitting tensile strength of concrete decreases with increasing the content of nano-materials. This may be due to the fact that the quantity of nano-particles present in the mix is higher than the amount required to combine with the liberated lime during the process of hydration thus leading to excess silica leaching out and causing a deficiency in strength as it replaces part of the cementitious material but does not contribute to strength [13]. Also, it may be due to the defects generated in dispersion of nanoparticles that causes weak zones. The higher the split tensile strength in the concrete containing nano particles are due to the rapid consuming of $Ca(OH)_2$ which was formed during hydration of Portland cement specially at early ages related to the high reactivity of nano particles.

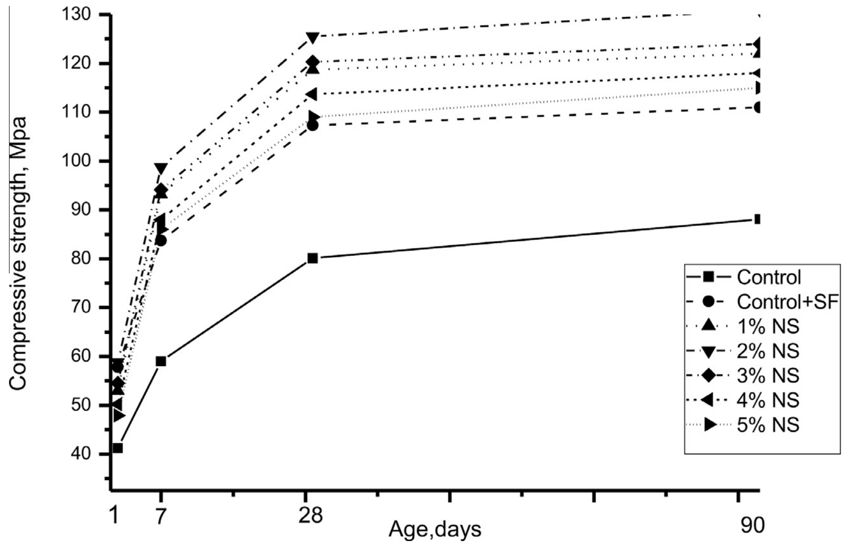

Fig. 8. Effect of Cu-Zn ferrite with granite on compressive strength for different mixes.

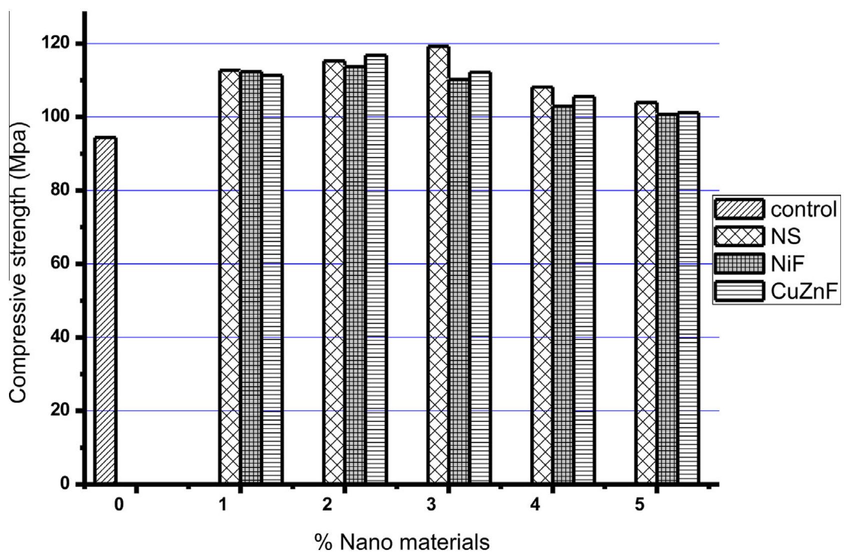

Fig. 9. Relationship between the compressive strength of concrete containing Crushed dolomite after 28 days and added nano materials with different ratios.

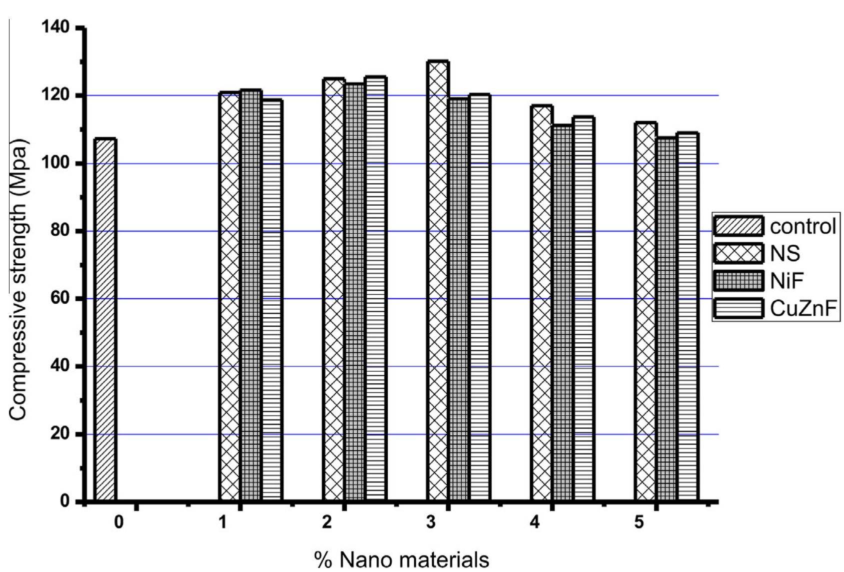

Fig. 10. Relationship between the compressive strength of concrete containing granite after 28 days and added nano materials with different ratios.

3.4. Flexural strength

The flexural strength results are shown in Table 9. Similar to the tensile strength, the flexural strength of the specimens increases with nano-silica up to 3.0% replacement and then it decreases, although the results of 4.0% replacement are still higher than those of the control concrete. Also the flexural strength of the specimens increases with Ni ferrite and Cu-Zn ferrite up to 2.0% replacement and then it decreases, although the results of 4.0% replacement still higher than those of the control concrete. Again, the increasing in the flexural strength is due to the rapid consuming of $Ca(OH)_2$ which was formed during hydration of Portland cement specially at early ages related to the high reactivity of nano particles.

3.5. Modulus of elasticity

The modulus of elasticity results of the specimens increases with nano-silica up to 3.0% replacement and then it decreases. Also the modulus of elasticity of the specimens increases with Ni ferrite and Cu-Zn ferrite up to 2.0% replacement and then it decreases. It means that concrete with nano particles has greater stiffness than concrete without nano particles. The values of stiffness in concrete containing nanosilica are due to the compactness of the paste bond with aggregates in concrete with nano particles that is greater than that without nano particles [14].

4. Conclusions

Based on the study reported here, the following conclusions are drawn:

(1) The optimum dose of nano-silica is 3% by weight and the optimum dose of Ni ferrite and Cu-Zn ferrite was 2% by weight.
(2) The improving percentage of compressive strength of concrete when nano silica and nano ferrite was added reaches 21% and 17%, respectively, with respect to the control mixes.
(3) With the addition of nano silica and nano ferrite the improving percentage of splitting tensile strength of concrete reaches approximate rate of about 44% and 60%, respectively, with respect to the control mixes.
(4) With the addition of nano silica and nano ferrite the improving percentage of flexural strength and modulus of elasticity of concrete reaches approximate rate of about 23% and 25%, respectively, with respect to the control mixes.
(5) Increasing the amount of NS and NF more than 3% and 2% by weight degrades the compressive strength, splitting tensile, flexural strength and modulus of elasticity of concrete.
(6) The samples of concrete-containing nano-silica give better results than samples of concrete-containing nano ferrite with an approximate rate of about 10%.
(7) The samples of concrete containing granite give better results than similar-containing dolomite and the approximate rate of about 10%.
(8) The use of a superplasticizer was necessary in the concrete mixes to improve the workability.

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