

The Effect of High Elevated Temperatures on Nano Silica High Strength Concrete [NSHSC]

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Abstract: The research aim is studying high elevated temperatures influence on NSHSC compressive strength . Effects of nanosilica (NS) content and several elevated temperatures [200, 400 and 600°C] At 2hours heat exposure time were studied. A constant water/binder equals to 0.40 and a constant binder content =500kg/m³ were used. NS percentages that replaced cement in this study were 0,1%,2% and 3%. 96 cubes 10x10x10 cm were examined under compressive loads. They were divided as following, 24 cubes without (NS)as a reference and 72 cubes were cast to study NS content effect at several high temperatures. It was found that, at high elevated temperatures the NS content posses a large influence on improvement high strength concrete [HSC] performance.

Keywords: compressive strength- nanosilica and high temperatures

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I. Introduction

It is significant to learn the concrete properties change owing to high elevated temperatures. To predict the structure performance after high temperatures exposure, it is necessary that the durability and concrete strength be understood[1]. high temperatures affect the concrete structures durability and may occur unwanted failures in structures. the concrete physical composition and concrete chemical composition change considerably at high temperatures exposure. Above 110 co Dehydration becomes significant. At 300c the matrix dehydration and aggregates thermal expansion cause internal stresses and micro – cracks begin to clear through the material. in cement paste Ca(OH)₂ is a main compound, dissociates at about 530 co , occurring concrete shrinkage of [2]. The elevated temperatures effects on durability and concrete strength are very important for studies of fire resistance and know pressure vessels ,containment vessels, nuclear reactor ,chimneys performance, through service and maximum conditions structures such as storage tanks of hot water ,crude oil and coal gasification. So that the differentiation of performance and compressive strength, are the main factors to be checked as concrete structures are exposed to high elevated temperatures[1]. HSC has several benefits ,it is used in the bridges construction and rise buildings [2]. The high temperature influences on the concrete properties have been checked since 1950s [3].Also, from 1950s HSC is made as god alternate for normal strength concrete (NSC)[4,5].HSC is produced using a decreased water/cement ratio. Commonly silica fume[SF] is also put in the concrete to improve the strength .Through exposure to elevated temperatures, concrete properties (volumetric stability, elastic modulus, and strength) are considerably reduced. When concrete structures are subjected to elevated temperatures, they may damage in many different ways [6].In addition, elevated temperatures will decrease [HSC and NSC] strengths. The strength reduction degree is dependent upon the temperature reached and the time of exposure [7,8]. Other factors which affect the strength loss are aggregate type and concrete strength [9]. Further, while exposure to elevated temperatures, concrete chemical composition and the physical structure change [10].The differences of behavior between[NSC and HSC]are observed in two important regions: (1) the strength relative loss in the average temperatures [100 °C to 400 °C] and (2) the explosive spalling happening in HSC samples at similar temperatures. Strength loss studies have illustrated that, for average temperatures [100 °C to400 °C], the HSC compressive strength be decreased by about 40 percent of strength of room-temperature ,a decrease of approximately 20% to 30% points over NSC subjected to the similar temperatures .The HSC tendency for explosive spalling means that HSC structural elements may be more incline than NSC to loss the cover of concrete that gives the steel reinforcement by thermal protection[11,12,13,14].

II. Materials

Local materials are used and tested according to American Standard of Testing Materials ASTM and Egyptian Standard Specifications ESS in this study. Dolomite with maximum size = 19 mm and approximately angular shape was used. Natural sand was used as a fine aggregate in this search. Ordinary cement was used and its content equal to 500kg/m³ for all concrete mixes . Supper-plasticizer was used to give the water/ cement = 0.40 with slump equals to (6–11) cm.. this search used NS with content of solid more than 99%, its content was 0%,1%,2% and 3% replacement from cement weight . The NS was brought from Nanotech Egypt. The color of NS was white, powder appearance, spherical shape, and average size =56□ 8 nm.

III. Concrete Mixes Proportions

Mixes proportions are illustrated in Table (1).

Table (1): Concrete Mixes Proportions

Mix No.	NS content		Cement kg/m ³	Dolomite kg/m ³	Sand Kg/m ³	Water lit/m ³	Super plasticizer kg/m ³
	%	kg/m ³					
1	0	0	500	1133	567	200	9
2	1	5	495	1133	567	200	9
3	2	10	490	1133	567	200	9.25
4	3	15	485	1133	567	200	9.25

Four mixes were used as follows, one mix without silica fume as a control mix, three mixes with different contents of (NS) to study NS content effect on the compressive concrete at high elevated temperatures . These mixes are identical except for the percentage of NS. For all samples ,the binder content[cement plus nanosilica] were 500 kg/m³ and the water /cement equals to 0.4 by weight. Super – plasticizers per m³ were also used.

IV. Description Of Tested Specimens

96 cubes 10x10x10cm were cast for compressive strength .Concrete was poured vertically in the forms ,and was mechanically compacted to ensure complete compaction of concrete inside the forms. The samples were examined by using 2000KN compression machine.

V. Test Results And Discussions

table (2) and fig (1) show compressive strength results for all concrete mixes at room temperature ,the cement replacement by 1% , 2% and 3%NS improves the 7and 28-days compressive strength approximately 2%,15%,10% at 7 days and 3%,16%,6% for 28-days respectively. Table (3) and Figure (2) give compressive strength results of all concrete mixes at 200Co ,at 7days age plain concrete[PC] compressive strength was 327 kg/cm² as was 328 , 365 and 352 kg/cm² for NSC with NS content 1% , 2 % and 3% respectively with increase of about 1 % , 12 % and 8% with respect of PC, also for 28 days age, the PC compressive strength was 477 kg/cm² as was 536 , 549 and 532 kg/cm² for NSC of NS content 1 % , 2 % and 3 % respectively with increasing of about 12 % , 15 % and 12 % with respect of PC at the same temperature[200Co] . Table (4) and figure (3) give compressive strength results of all concrete mixes at 400 Co, at 7days age the compressive strength of PC was 310 kg/cm² as was 325 , 338 and 369 kg/cm² for NSC with NS content 1% , 2 % and 3% respectively with increase of about 5 % , 9 % and 19% with respect of PC, also for 28 days age , the compressive strength of PC was 422 kg/cm² as was 442 , 445 and 430 kg/cm² for NSC with NS content 1% , 2% and 3% respectively with increase of about 5% , 6% and 2% respectively with respect of PC at the same temperature[400Co]. Table (5) and figure (4) give compressive strength results of all concrete mixes at 600 Co, at 7days age the PC compressive strength was 240 kg/cm² as was 281 , 269 and 303 kg/cm² for NSC with NS content 1% , 2 % and 3% respectively with increase of about 17 % , 12 % and 26 % with respect of PC, also for 28 days age the PC compressive strength was 300 kg/cm² as was 340 , 345 and 330 kg/cm² for NSC with NS content 1% , 2% and 3% respectively with increase of about 13% , 15% and 10% respectively with respect of PC at the same temperature[600Co].

Table (6) and figure (5) summarize the results of the NSC compressive strength at 7 days, for 200 Co , the PC compressive strength increases with about 18% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength increases with about 17%,15% and 16% respectively. For 400 Co , the PC compressive strength increases with about 12% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength increases with about 16%,7% and 22% respectively. . For 600 Co , the PC compressive strength decreases with about

13% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength decreases with about 0%,15% and 0% respectively.

Table (7) and figure (6) summarize the results of the NSC compressive strength at 28 days, for 200 Co , the PC compressive strength increases with about 19% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength increases with about 30%,19% and 26% respectively. For 400 Co , the PC compressive strength increases with about 6% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength increases with about 7%,4% and 2% respectively. . For 600 Co , the PC compressive strength decreases with about 25% with respect of the compressive strength at 0Co as for NSC with NS content 1% ,2% and 3%, the compressive strength decreases with about 18%,25% and 22% respectively.

Table (2) : compressive strength of NSC (Kg/Cm2) at zero temperature

Nano silica %	The compressive strength[kg/cm ²] at 0C°	
	7 days	28Days
0	277[control]	400[control]
1	281[+1.45%]	412[+3%]
2	317[+14.45%]	462[+15.5%]
3	303[+9.4%]	423[+5.75%]

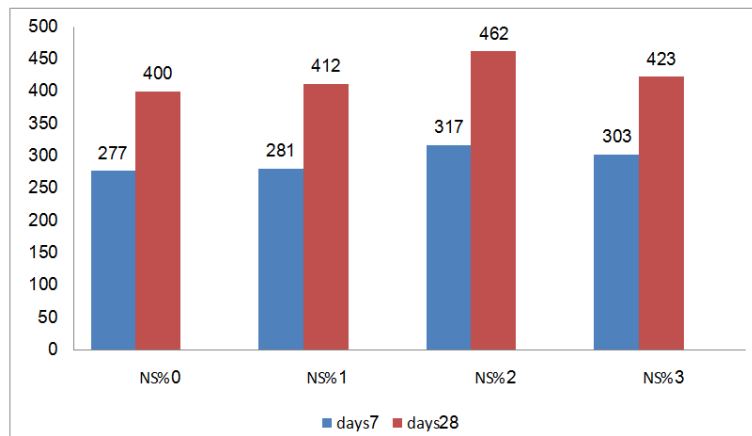


Fig. (1): The Compressive strength (Kg/Cm2) Of NSC at 0Co

Table (3): Compressive strength of NSC (Kg/Cm2) at 200 Co

Nano silica %	The compressive strength[kg/cm ²] at 200C°	
	7 days	28Days
0	327[control]	477[control]
1	328[+0.30%]	536[+12.37%]
2	365[+11.62%]	549[+15.1%]
3	352[+7.65%]	532[+11.53%]

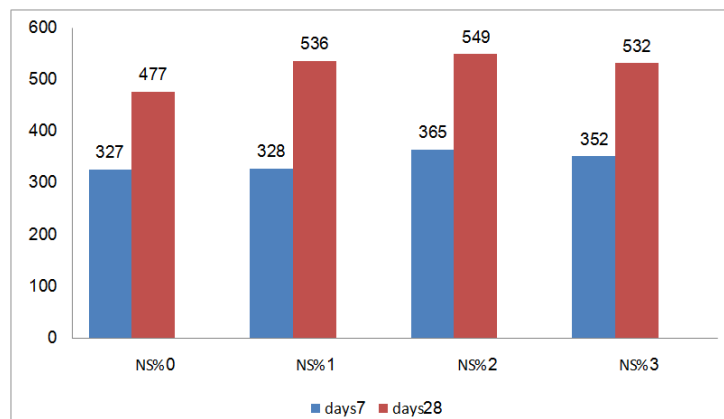


Fig. (2): The Compressive strength (Kg/Cm2) Of NSC at 200Co

Table (4): Compressive strength of NSC (Kg/Cm2) at 400 Co

Nano silica %	The compressive strength[kg/cm ²] at 400C°	
	7 days	28Days
0	310[control]	422[control]
1	325[+4.84%]	442[+4.74%]
2	338[+9.03%]	445[+5.45%]
3	369[+19.03%]	430[+1.9%]

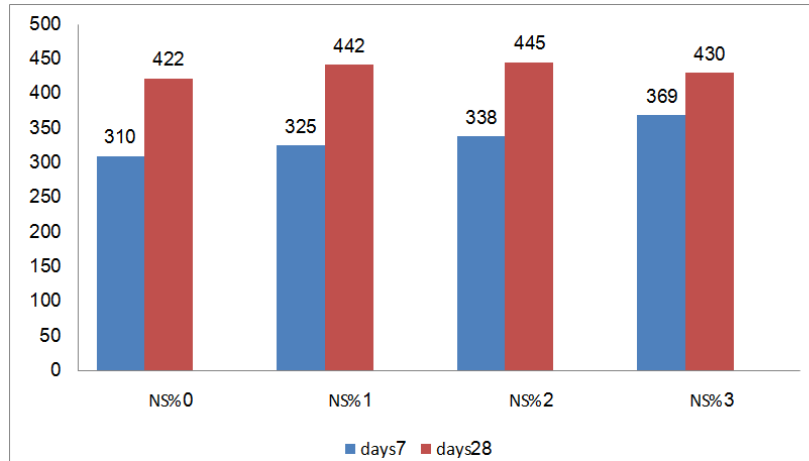


Fig. (3): The Compressive strength (Kg/Cm2) Of NSC at 400Co

Table (5): Compressive strength of NSC (Kg/Cm2) at 600 Co

Nano silica %	The compressive strength[kg/cm ²] at 600C°	
	7 days	28 Days
0	240[control]	300[control]
1	281[+17.08%]	340[+13.33%]
2	269[+12.08%]	345[+15%]
3	303[+26.25%]	330[+10%]

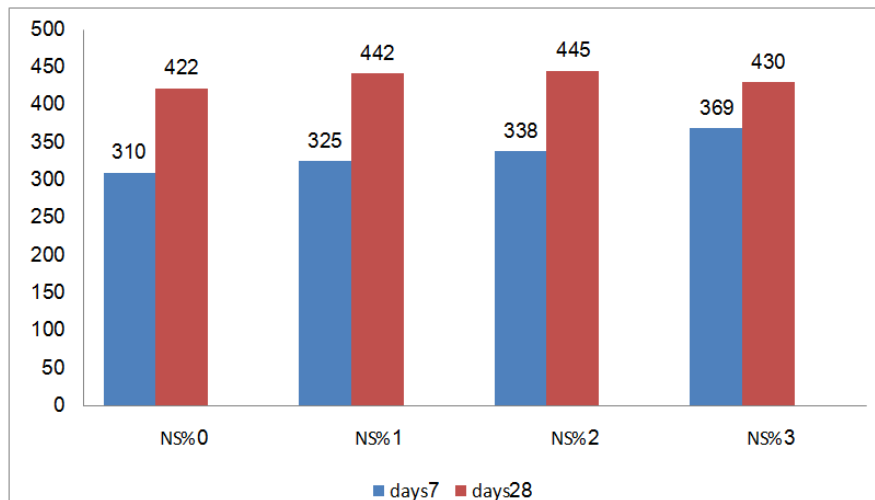


Fig. (4): The Compressive strength (Kg/Cm2) of NSC at 600Co

Table (6) : Summary of compressive strength[kg/cm2] results of NSC at 7days.

Nano silica %	The compressive strength[kg/cm ²] at			
	0C°	200 C°	400 C°	600 C°
0	277[control]	327[+18.05%]	310[+11.91%]	240[-13%]
1	281[control]	328[+16.73%]	325[+15.66%]	281[0%]
2	317[control]	365[+15.14%]	338[+6.62%]	269[-15.1%]
3	303[control]	352[+16.17%]	369[+21.78%]	303[0%]

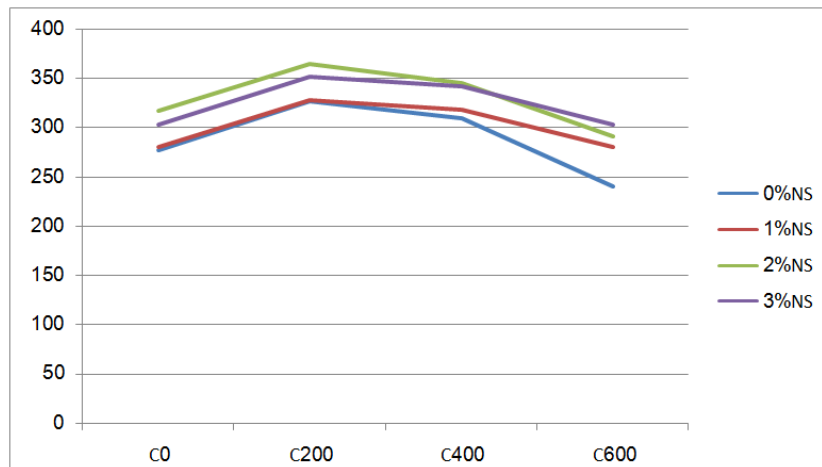


Fig. (5): The effect of high temperatures on the concrete mixes at 7 days age

Table (7) : Summary of compressive strength[kg/cm²] results of NSC at 28days.

Nano silica %	The compressive strength[kg/cm ²] at			
	0C ^o	200 C ^o	400 C ^o	600 C ^o
0	400[control]	477[+19.25%]	422[+5.5%]	300[-25%]
1	412[control]	536[+30.1%]	442[+7.28%]	340[-17.5%]
2	462[control]	549[+18.83%]	445[-3.67%]	345[-25.3%]
3	423[control]	532[+25.77%]	430[+1.65%]	330[-22%]

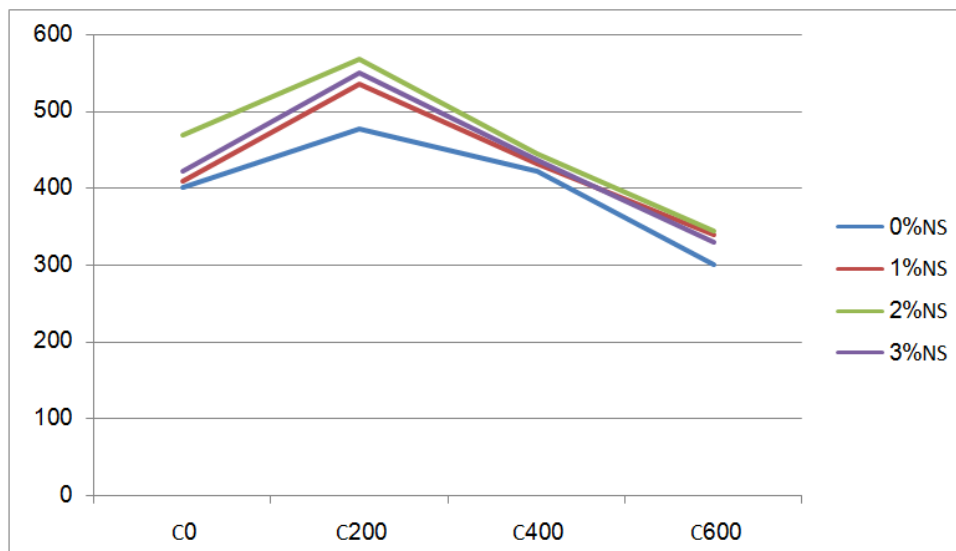


Fig. (6): The effect of high temperatures on the concrete mixes at 28 days age

VI. Conclusions

- 1) At room temperature, the replacement of cement by 1% , 2% and 3% NS increased the 7 days compressive strength approximately 2% , 14% and 9% respectively compared to PC.
- 2) At room temperature, the replacement of cement by 1% , 2% and 3% NS increased the 28 days compressive strength approximately 3% , 16% and 6% respectively compared to PC.
- 3) After subjected to 200 Co, significant increase occurred in the compressive strength of normal and NS concretes at 7 days ,the increase in compressive strength was 18%,17%,15% and 16% for PC and NSC [1% , 2% , 3%] respectively with respect of the compressive strength at 0Co.
- 4) After subjected to 200 Co, significant increase occurred in the compressive strength of normal and NS concretes at 28 days ,the increase in compressive strength was 19%,30%,19% and 26% for PC and NSC [1% , 2% , 3%] respectively with respect of the compressive strength at 0Co.
- 5) After subjected to 400 Co, significant increase occurred in the compressive strength of normal and NS concretes at 7 days ,the increase in compressive strength was 12%,16%,7% and 22% for PC and NSC [1% , 2% , 3%] respectively with respect of the compressive strength at 0Co.

- 6) After subjected to 400 Co, slightly increase occurred in the compressive strength of normal and NS concretes at 28 days ,the increase in compressive strength was 6%,7%,4% and 2% for PC and NSC [1% , 2%, 3%] respectively with respect of the compressive strength at 0Co.
- 7) After subjected to 600 Co, significant decrease occurred in the compressive strength of normal and NS concretes at 7 days ,the decrease in compressive strength was 13%,0%,15% and 0% for PC and NSC [1% , 2%, 3%] respectively with respect of the compressive strength at 0Co.
- 8) After subjected to 600 Co, significant decrease occurred in the compressive strength of normal and NS concretes at 7 days ,the decrease in compressive strength was 25%,18%,25% and 22 % for PC and NSC [1% , 2%, 3%] respectively with respect of the compressive strength at 0Co.

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