

# A Work Paper on “Experiment of Fly-Ash with the mix of Nano-Silica for Variation of Strength in Nano Concrete”

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**Abstract**— Fresh fly ash-based Nano-Silica concrete has been able to remain workable up to at least 120 minutes without any sign of setting and without any degradation in the compressive strength. Providing a rest period for fresh concrete after casting before the start of curing up to five days increased the compressive strength of hardened concrete. The elastic properties of hardened fly ash-based Nano-Silica concrete, i.e. the modulus of elasticity, the Poisson’s ratio, and the indirect tensile strength, are similar to those of ordinary Portland cement concrete.

**Keywords:** Fly-Ash Mix Nano-Silica, Compressive Strength, Tensile Strength, Portland cement, Variability

## I. INTRODUCTION

The various materials used in the production of concrete, cement plays a major role due its size and adhesive property. So, to produce concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to concrete improve its properties. Some of these are fly ash, blast furnace slag, rice husk, Nano-Silica fumes and even bacteria. Of the various technologies in use, Fly-Ash-technology looks to be a promising approach in improving the properties of concrete.

The stress-strain relations of fly-ash based Nano-Silica concrete fit well with the expression developed for ordinary Portland cement concrete. The types and relative amounts of incombustible matter in the coal determine the chemical composition of fly ash. This work primarily deals with the compressive strength characteristics such as water absorption super plasticizer used in high performance concrete a set of 4 different concrete mixture were cast and tested with different cement replacement levels of Fly ash (FA) with nano Nano-Silica (NS) as addition by wt of Cement and/or each trial super plasticizer has been added at constant values to achieve a constant range of slump for desired work ability with a constant water-binder (w/b) ratio of 0.30.

## II. LITERATURE REVIEW

A comparative analysis of this work has been presented in the summary of this chapter which will highlight the significance of each work. Out of the numerous work done in the field only a few relevant works have been highlighted in the next section.

[Ali Nazari et.al. (2016)] studied strength and percentage water absorption of SCC containing different amount of GGBFS and TiO<sub>2</sub> Fly-Ash particles. The findings of the experimentation are that replacement of Portland cement with up to 45% weight of GGBNS and up to 4% weight of TiO<sub>2</sub> Fly-Ash particles gives a considerable increase to the compressive, split tensile and flexural strength of the blended concrete.

[Swami r. al. (2016)] The author studied effect of CuO Fly-Ash particles on SCC and observed that increased percentage of polycarboxylate admixture content results in decreased compression strength. The CuO Fly-Ash particles of average particle size 15nm content with up to 4% weight increased the compressive strength of SCC. CuO Fly-Ash particles up to 4% could accelerate the first peak in conduction calorimetric testing.

[Sekari and Razzaghi (2017)] studies the effect of constant content of Fly-Ash ZrO<sub>2</sub>, Fe<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub>, and Al<sub>2</sub>O<sub>3</sub> on the properties of concrete. The results showed that all the Fly-Ash particles have noticeable influence on improvement on durability properties of concrete but the contribution of Fly-Ash Al<sub>2</sub>O<sub>3</sub> on improvement of mechanical properties of HPC is more than the other Fly-Ash particles.

[A.M. Said et.al. (2017)] studied the effect of colloidal Fly-Ash Nano-Silica on concrete by blending it with class F fly ash and observed that performance of concrete with or without fly ash was significantly improved with addition of variable amounts of Fly-Ash Nano-Silica. The mixture containing 30% FA and 6% CNS provides considerable increase in strength. Porosity and threshold pore diameter was significantly lower for mixture containing Fly-Ash Nano-Silica.

## III. METHODOLOGY

The details of the properties of the materials used, the method followed to design the experiment and the test procedures followed. The theory is supplemented with a number of pictures to have a clear idea on the methods.

### A. Physical Properties of Nano-Silica:

Physical properties	Nano-Silica
Particle shape	Multifaceted
Appearance	Black & glassy
Type Air	Cooled
Specific gravity	3.51
Bulk density at 250 C (Ton/m <sup>3</sup> )	1.8 - 2.2
Hardness	5 – 7 Mohs
pH	6.5
Conductivity at 250	Nil
Moisture Content	< 0.1%

### B. Chemical Properties of Nano-Silica:

Chemical component	% of Chemical component
SiO <sub>2</sub>	33-35 %
Fe <sub>2</sub> O <sub>3</sub>	40-44%
Al <sub>2</sub> O <sub>3</sub>	4-6%
CaO	0.8-1.5%
MgO	1-2%

**C. Properties of Fly-Ash**

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA ( m <sup>2</sup> /g)	200 + 20	202
PH VALUE	3.7 – 4.5	4. 12
LOSS ON DRYING @ 105 DEG.C (5)	< 1. 5	0. 47
LOSS ON IGNITION @ 1000 DEG.C (%)	< 2.0	0.66
SIEVE RESIDUE (5)	< 0. 04	0. 02
TAMPED DENSITY (g/L)	40 – 60	44
SiO <sub>2</sub> CONTENT ( % )	> 99. 8	99. 88
CARBON CONTENT (%)	< 0. 15	0. 06
CHLORIDE CONTENT (%)	< 0. 0202	0. 009
Al <sub>2</sub> O <sub>3</sub>	< 0. 03	0. 005
TiO <sub>2</sub>	< 0. 02	0. 004
Fe <sub>2</sub> O <sub>3</sub>	< 0. 003	0. 001

**D. Proportion of volume of coarse aggregate and fine aggregate content:**

- Volume of coarse aggregate per unit volume of total aggregate (ISC: 10262-1982) = 0.64
- (This is corresponding to 20 mm size aggregate and Zone III fine aggregate for water-cement ratio of 0.50)
- As the water-cement ratio is lowered by 0.05, the proportion of volume of coarse aggregate is increased by 0.01 (ref. Table 6 of IS: 10262-1982)
- Corrected volume of coarse aggregate per unit volume of total aggregate = (0.64+0.014) = 0.654
- Volume of fine aggregate per unit volume of total aggregate = 1-0.654 =0.346





Fig. 1: concrete cubes casted in the mould



Fig. 2: shows some concrete specimen cast in laboratory

#### E. Compressive Strength Test

The compressive strength of specimens is determined after 7 and 28 days of curing with surface dried condition as per Indian Standard IS: 516-1959. Three specimens are tested for typical category and the mean compressive strength of three specimens is considered as the compressive strength of the specified category.

### IV. EXPERIMENTAL RESULTS

7-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (ton)	Compressive Strength (MPa)
Specimen 1	6.68	43	18.75
Specimen 2	7.24	56	24.42
Specimen 3	7.35	52	22.67
Average Strength (MPa)			21.94

Table 1: Compressive Strength of M20 Grade with 15% Fly Ash

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c				
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength		
S-1	6.98	52	22.67	6.92	61	26.596	7.06	66	28.764	7.12	64	27.904		
S-2	7.11	63	27.468	7.28	64	27.904	7.64	69	30.084	7.72	68	29.648		
S-3	7.02	65	28.34	7.95	66	28.776	7.98	74	32.264	8.08	71	30.956		
Average Strength			26.16	Av. Strength			27.76	Av. Strength			30.37	Av. Strength		29.50

Table 2: 7 days Compressive Strength in (MPa) of M20 Grade with different % of Nano-Silica & 15% Fly Ash

14-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (tonne)	Compressive Strength (MPa)
Specimen 1	6.92	46	20.056
Specimen 2	7.18	56	24.416
Specimen 3	7.22	51	22.236
Average Strength (MPa)			22.236

Table 3: Compressive Strength in (MPa) of M20 Grade plain specimen for 14 day

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c				
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength		
S-1	7.24	56	24.416	7.18	70	30.52	7.24	76	33.136	7.08	73	31.828		
S-2	7.02	64	27.904	6.97	72	31.392	7.08	79	34.444	6.72	77	33.572		
S-3	6.91	69	30.084	7.36	74	32.264	7.41	82	35.752	7.11	80	34.88		
Average Strength			27.468	Av. Strength			31.392	Av. Strength			34.444	Av. Strength		33.42

Table 4: 14 days Compressive Strength in (MPa) of M20 Grade with different % of Nano-Silica & 15% Fly Ash

28-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (tonne)	Compressive Strength (MPa)
Specimen 1	7.38	76	33.136
Specimen 2	7.21	74	32.264
Specimen 3	6.96	68	29.648
Average Strength (MPa)			31.68

Table 5: Compressive Strength of M20 Grade plain specimen for 28 days

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c				
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength		
S-1	6.86	76	33.136	7.36	81	35.316	7.48	84	36.624	7.42	82	35.752		
S-2	7.14	71	30.95	7.52	88	38.368	7.56	91	39.676	7.54	89	38.804		
S-3	7.04	80	34.88	7.24	86	37.496	7.30	94	40.984	7.28	91	39.676		
Average Strength			32.99	Av. Strength			37.06	Av. Strength			39.09	Av. Strength		38.077

Table 6: 28 days Compressive Strength in (MPa) of M20 Grade with different % of Nano Nano-Silica & 15% Fly Ash

7-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (tonne)	Compressive Strength (MPa)
Specimen 1	8.65	62	27.032
Specimen 2	8.81	84	36.624
Specimen 3	8.92	75	32.7
Average Strength (MPa)			32.11

Table 7: Compressive Strength of M30 Grade plain specimen for 7 day

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c				
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength		
S-1	9.04	76	33.136	9.10	78	34.008	9.18	84	38.368	9.08	82	35.752		
S-2	9.12	80	34.88	9.14	84	36.624	9.45	89	38.804	9.38	86	37.496		
S-3	9.0	84	36.624	9.14	87	37.932	9.26	95	41.42	9.20	91	39.676		
Average Strength			34.88	Av. Strength			36.188	Av. Strength			39.53	Av. Strength		37.641

Table 8: 7 days Compressive Strength in (MPa) of M30 Grade with different % of Nano-Silica & 15% Fly Ash

14-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (tonne)	Compressive Strength (MPa)
Specimen 1	8.78	68	29.648
Specimen 2	8.86	86	37.496
Specimen 3	9.06	78	34.008
Average Strength (MPa)			33.717

Table 9: Compressive Strength of M30 Grade plain specimen for 14 day

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c				
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength		
S-1	9.36	82	35.752	9.78	92	40.112	9.84	95	41.42	9.81	93	40.548		
S-2	9.13	87	37.932	9.41	95	41.42	9.67	97	42.292	9.56	96	41.856		
S-3	8.98	92	40.112	9.84	96	41.856	9.96	99	43.164	9.88	97	42.292		
Average Strength			37.93	Av. Strength			41.13	Av. Strength			42.292	Av. Strength		41.56

Table 10: 14 days Compressive Strength in (MPa) of M30 Grade with different % of Nano-Silica & 15% Fly Ash



28-DAY TEST RESULT			
Sample No.	Weight (kg)	Load (tonne)	Compressive Strength (MPa)
Specimen 1	8.82	72	31.392
Specimen 2	8.89	89	38.804
Specimen 3	9.06	82	35.752
Average Strength (MPa)			35.316

Table 11: Compressive Strength of M30 Grade plain specimen for 28 days

Sample	0.5% b.w.c			1% b.w.c			2% b.w.c			2.5% b.w.c					
	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength	weight kg	load ton	Comp. strength			
S-1	9.39	85	37.06	9.91	94	40.984	9.96	97	42.292	9.91	95	41.42			
S-2	9.21	89	38.80	9.64	96	41.856	9.97	98	42.728	9.64	97	42.292			
S-3	9.08	94	40.984	9.96	98	42.728	9.98	99	43.164	9.96	99	43.164			
Average Strength			38.94	Av. Strength			41.856	Av. Strength			42.728	Av. Strength			42.292

Table 12: 28 days Compressive Strength in (MPa) of M30 Grade with different % of Nano-Silica & 15% Fly Ash

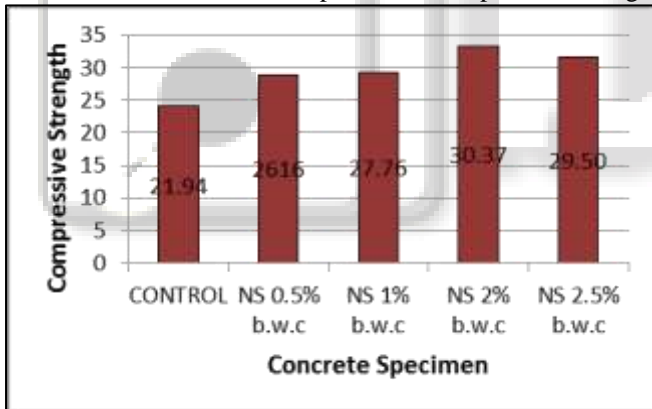
A. Comparison of Compressive Strength Results:

The change in compressive strength for the blended sample (in %) for 7, 14 and 28 day is shown in Table respectively.

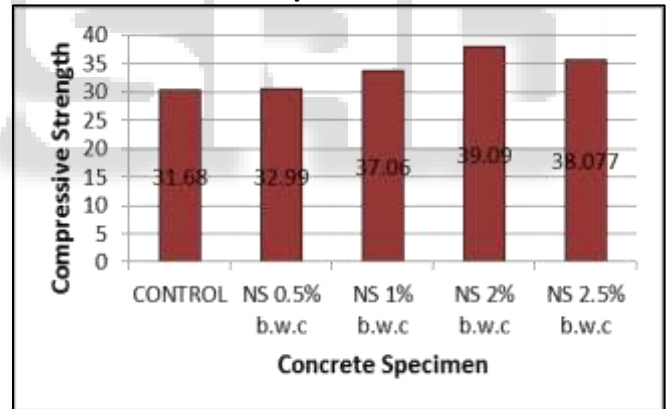
A graphical representation of this result is shown in Fig. The change in compressive strength from 7 days 14 days to 28 day is shown.

different % of Nano Nano-Silica & 15% Fly Ash	7days		14 days		28 days	
	strength (mpa)	increase in strength (%)	strength (mpa)	increase in strength (%)	strength (mpa)	increase in strength (%)
CONTROL	21.94	-	22.236	-	31.68	-
NS 0.5% b.w.c	26.16	19.23	27.468	23.52	32.99	4.13
NS 1% b.w.c	27.76	26.52	31.392	41.17	37.06	16.98
NS 2% b.w.c	30.37	38.42	34.444	54.90	39.09	23.39
NS 2.5% b.w.c	29.50	34.45	33.42	50.30	38.077	20.19

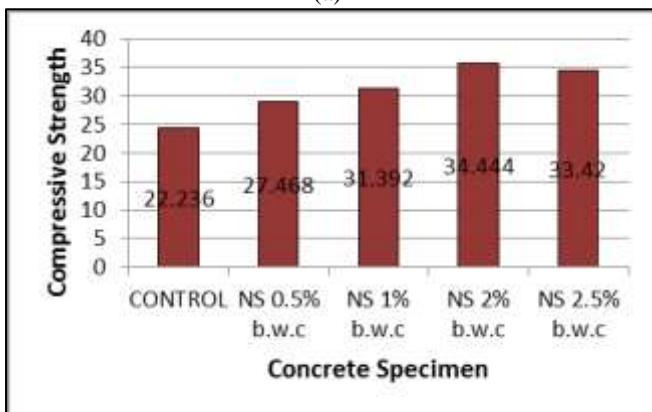
Table 13: Comparison of compressive strength for M20 Grade and 15% of Fly-ASH of Concrete



(a)



(c)

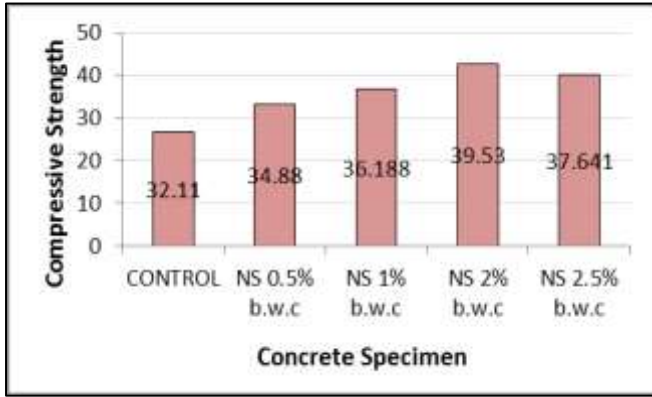


(b)

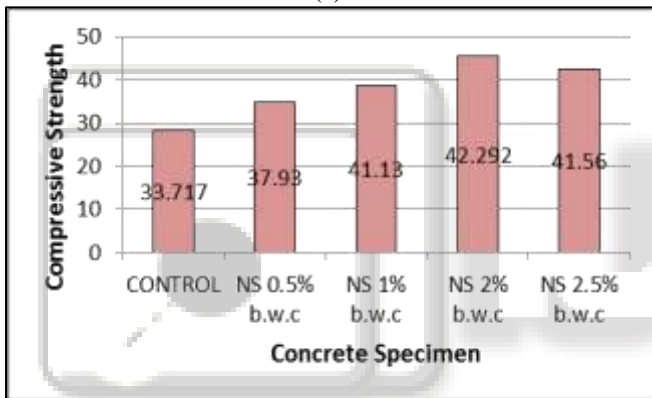
- (a) compressive strength in 7days with M20 Grade and 15% of Fly-ASH of Concrete
- (b) compressive strength in 14 days with M20 Grade and 15% of Fly-ASH of Concrete
- (c) compressive strength in 28 days with M20 Grade and 15% of Fly-ASH of Concrete

different % of Nano-Silica & 15% Fly Ash	7days		14 days		28 days	
	strength (mpa)	increase strength (%)	strength (mpa)	increase strength (%)	strength (mpa)	increase strength (%)
CONTROL	32.11	-	33.717	-	35.316	-
NS 0.5% b.w.c	34.88	8.62	37.93	12.49	38.94	10.26
NS 1% b.w.c	36.188	12.70	41.13	21.98	41.856	18.51
NS 2% b.w.c	39.53	23.11	42.292	25.43	42.728	20.98
NS 2.5% b.w.c	37.641	17.22	41.56	23.26	42.292	19.75

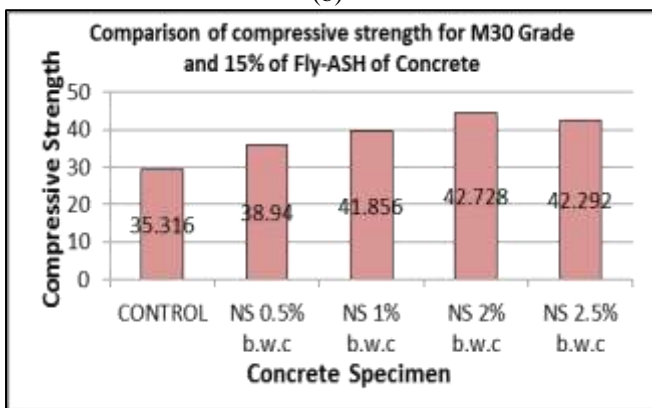
Table 14: Comparison of compressive strength for M30 Grade and 15% of Fly-ASH of Concrete



(a)



(b)



(c)

(a) compressive strength in 7days with M30 Grade and 15% of Fly-ASH of Concrete

(b) compressive strength in 14days with M30 Grade and 15% of Fly-ASH of Concrete

(c) compressive strength in 28days with M30 Grade and 15% of Fly-ASH of Concrete

The tables and graphs show that there is an improvement in the early strength of concrete blended with

Fly-Ash Mix Nano-Silica but later the increase in strength is subdued.

## V. CONCLUSION

From the test results, the conclusions are justified in this section. The conclusions drawn are:

From the compressive strength results, it can be observed that increase in compressive strength of concrete is observed on addition of a certain minimum quantity of Fly-Ash Mix nano SiO<sub>2</sub>. The increase in strength is maximum for NS 2% b.w.c and least for NS 0.5% b.w.c.

On addition of Fly-Ash Mix SiO<sub>2</sub> there is a substantial increase in the early-age strength of concrete compared to the 28 day increase in strength.

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