IJEASM
International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 2 Issue 1, January 2021

A WORK PAPER- ‘’ ASSESSMENT OF CONCRETE BY DESIGN THE MIX FOR M25 WITH NANO SILICA

Ashish Anugrah[1], Ms. Kamini Laheriya[2]
M.Tech. Scholar, SSSUTMS, Sehore (M.P.), India[1]
Assistant Professor, SSSUTMS, Sehore[2]

Abstract: *There are two methodologies for the presentation improvement of concrete based materials, one is to discover appropriate other option materials to supplant cementitious materials, for example, geopolymers furthermore, another methodology is tuning the presentation of concrete by admixtures Concrete remains the selection of designers in development materials inferable from its momentous highlights like form capacity to different shapes, effectively accessible fixings, high quality and ease in resentment of its natural concern Nanomaterials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved. Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure The use of nanosilica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. It sets early and hence generally requires admixtures during mix design. Nano-silica mixed cement can generate nano-crystals of C-S-H gel after hydration. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving the permeability and strength of concrete.*

Keywords: *Concrete, Nano silica, Compressive strength, Microstructure.*

1. Introduction

Concrete can be depicted as a glasslike compound of calcium silicates and other calcium mixes having water driven properties (Intht). The four significant mixes that establish concrete (Bogue's Compounds) are Tricalcium silicate, abridged as C3S, Dicalcium silicate (C2S), Tricalcium aluminate (C3A), Tetracalcium aluminoferrite (C4AF) where C represents CaO, S represents SiO2, A represents Al2O3 and F for Fe2O3. Tricalcium silicate and dicalcium silicate are the significant contributers to the strength of concrete, together comprising around 70 % of concrete. Dry or anhydrous concrete doesn't have glue property and consequently can't tie the crude materials together to shape concrete. At the point when blended in with water synthetic response happens and is alluded to as 'hydration of concrete'. The results of this exothermic response are C-S-H gel and Ca(OH)2. Calcium hydroxide has lower surface zone and consequently doesn't contribute a lot to the strength of cement. On hydration of concrete aluminates an item is framed known as ettringite, which has needle like morphology and adds to some early strength of cement.

Concrete can be depicted as a glasslike compound of calcium silicates and other calcium mixes having water driven properties (Intht). The four significant mixes that establish concrete (Bogue's Compounds) are Tricalcium silicate, abridged as C3S, Dicalcium silicate (C2S), Tricalcium aluminate (C3A), Tetracalcium aluminoferrite (C4AF) where C represents CaO, S represents SiO2, A

represents Al2O3 and F for Fe2O3. Tricalcium silicate and dicalcium silicate are the significant contributers to the strength of concrete, together comprising around 70 % of concrete. Dry or anhydrous concrete doesn't have glue property and consequently can't tie the crude materials together to shape concrete. At the point when blended in with water synthetic response happens and is alluded to as 'hydration of concrete'. The results of this exothermic response are C-S-H gel and Ca(OH)2. Calcium hydroxide has lower surface zone and consequently doesn't contribute a lot to the strength of cement. On hydration of concrete aluminates an item is framed known as ettringite, which has needle like morphology and adds to some early strength of cement.

2. Literature Review

In this section crafted by different creators on the utilization of nanomaterials in cement has been examined to sum things up. An extraordinary number of investigates have been performed to comprehend the idea of nanomaterials and their impact on the properties of cement. Various Research and Development work managing the utilization of nanomaterials like Nano silica, colloidal Nano Silica (CNS), Al_2O_3, TiO_2, ZrO_2, Fe_2O_3, carbon nanotubes (CNT) in concrete based materials are examined in the writing. The pozzolanic movement of the material is fundamental in framing the C-S-H gel and henceforth the CH gems are kept from developing and their number decreases. Accordingly, the early age strength of solidified concrete glue is expanded. A similar examination of this work has been introduced in the synopsis of this part which will feature the meaning of each work. Out of the various work done in the field a couple of pertinent works have been featured in the following segment.

J. Comiletti et al. (2012) researched the impact of miniature and nano CaCO3 on the early age properties of super superior cement (UHPC) restored in cold and ordinary field conditions. The miniature CaCO3 was added from 0 to 15% b.w.c. furthermore, nano CaCO3 was added at the pace of 0, 2.5 and 5% b.w.c. Results show that by joining nano and miniature CaCO3 the stream capacity of UHPC is higher than the control blend which builds the concrete substitution level. The blend containing 5% nano CaCO3 and 15% miniature CaCO3 gives briefest setting time at 10 °C and at 20°C the most elevated 24 hrs compressive strength is accomplished by supplanting concrete with 2.5% nano and 5% miniature CaCO3 and most elevated compressive strength at 26 days was accomplished at 0% nano and 2.5% miniature CaCO3.

Min. Hong Zhang et.al. (2012) considered the impact of NS and high volume slag mortar on setting time and early strength and saw that pace of hydration increments with expansion of NS, compressive strength of slag mortar increments with increment in NS measurements from 0.5 to 2% by weight of concrete. 2% NS diminishes introductory and last setting time and compressive strength increments by 22% and 18% at 3 days and 7 days with expansion of half slag. NS with molecule size 7 and 12 nm are more viable in expanding concrete hydration and response contrasted and silica seethe.

G. Dhinakaran et al. (2014) investigated the microstructure and strength properties of cement with Nano SiO2. The silica was ground in the planetary ball plant till nano size came to and it was mixed in cement with 5%, 10% and 15% b.w.c.. The test results indicated acquire in compressive strength with most extreme strength for 10% substitution.

Mukharjee and Barai (2014) the compressive strength and charcteristics of Interfacial Transition Zone (ITZ) of cement containing reused totals and nano-silica. An improvement in the compressive strength and microstructure of cement was seen with the fuse of nano- silica.

3. Materials and Methods

The materials used to design the mix for M25 assessment of concrete can't avoid being solid, sand, coarse aggregate, water and Nano SiO2. The properties of these materials are presented underneath.

Table 3.1: Properties of Portland slag cement

Specific Gravity	Fineness by sieve analysis	Normal consistency
3.014	2.01%	33%

Table 3.2: Properties of coarse aggregate and fine aggregate

Property	Coarse Aggregate	Fine Aggregate
Specific Gravity	2.72	2.65
Bulk Density (kg/L)	1.408	-

Loose Bulk Density (kg/L)	1.25	-
Water Absorption (%)	4.469	0.0651
Impact Value	26.910	-
Crushing Value	26.514	-
Fineness Modulus	3.38	2.84

3.1 Properties of Water

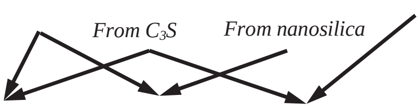
Tap water was used in this experiment. The properties are assumed to be same as that of normal water. Specific gravity is taken as 1.00.

3.2 Properties of Nano SiO_2

The average size of nano silica was found to be 236 nm from Particle Size Analyzer, the report of which has been presented in the Appendix. The properties of the material are shown in Table 3 and 3 Shows the nano silica used in the experiment.

Cement + H_2O + nano SiO_2

Ca^{2+} + ⟶ $H_2SiO\ ^{2-}$ + $H_2SiO_4^{2-}$ + OH^-



C-S-H **C-S-H** **$Ca(OH)_2$**

Further, the pozzolanic response of nanosilica with $Ca(OH)_2$, which is framed during the hydration of concrete, creates extra C–S–H which is the primary constituent for quality and thickness in the solidified cementitious framework. Simultaneously $Ca(OH)_2$, which scarcely adds to quality turn of events, is devoured.

Table 3.3: Properties of Nano SiO2

TEST ITEM	STANDARD REQUIREMENTS	TEST RESULTS
SPECIFIC SURFACE AREA (m2/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
SiO2 CONTENT (%)	> 99. 8	99. 88
CARBON CONTENT (%)	≤ 0. 15	0. 06
CHLORIDE CONTENT (%)	≤ 0. 0202	0. 009
Al2O3	≤ 0. 03	0. 005
TiO2	≤ 0. 02	0. 004
Fe2O3	≤ 0. 003	0. 001

3.3 METHODS

3.3.1 Mix Design

The mix design for M25 grade of concrete is described below in accordance with Indian Standard Code IS: 10262-1982.

TARGET STRENGTH FOR MIX PROPORTIONING:
Characteristic compressive strength at 28 days: fck = 20 MPa
Assumed standard deviation (Table 1 of IS 10262:1982): sd = 4

MPa

Target average compressive strength at 28 days: ftarget = fck + 1.65sd =31.6 MPa

i. SELECTION OF WATER-CEMENT RATIO:

From Table 5 of IS: 456-2000, maximum water-cement ratio = 0.50 To start with let us assume a water-cement ratio of 0.43

ii. SELECTION OF WATER CONTENT:

Maximum water content per cubic metre of concrete (refer Table 2 of IS: 10262- 1982): Wmax = 186L (for 50 mm slump). Since, the slump was less than 50 mm, no adjustment was required.

iii. CALCULATION OF CEMENT CONTENT:

Mass of water selected per cubic metre of concrete = 186 kg. Mass of cement per cubic metre of concrete = 186/0.43 = 433 kg.

Minimum cement content = 300 kg/m3 (for moderate exposure condition, Table 5 of IS 456:2000)

Maximum cement content = 450 kg/m3 (Cl. 8.2.4.2 of IS 456:2000) So, the selected cement content is alright.

iv. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT:

Volume of coarse aggregate per unit volume of total aggregate (Table 3 of IS: 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

v. MIX CALCULATIONS

i. Volume of concrete = 1 m^3
ii. Volume of cement = 433/(3.01×1000) = 0.144 m^3
iii. Volume of water = 186/1000 = 0.186 m^3
iv. Volume of all aggregates = 1-0.144-0.186 = 0.67 m^3
v. Mass of coarse aggregate = 0.654×0.67×2.72×1000 = 1192 kg
vi. Mass of fine aggregate = 0.346×0.67×2.65×1000 = 614 kg

MIX PROPORTION:

For a batch of 6 cubes of 150mm side, the volume of concrete required = $(0.15)^3$×6×1.2 = 0.024 m^3 (taking into account 20 % extra forlosses)
Cement required= 0.024x433 = 10.4 kg
Fine aggregate required= 0.024x614 = 14.7 kg Coarse aggregate required= 0.024x1192 = 28.6 kg Water required= 0.024x186 = 4.5 kg

4. Experimental Evidence and Microstructure Analysis

This chapter is concerned with the presentation of results of the experiments carried out towards the objective of the project. It includes results from compressive strength test, UPV Test and FESEM. The results are supplemented with graphs in order to have a better analysis of the results.

4.1 Experimental Results

4.1.1 UPV Test Results:

Fig 4.1-4.8 show UPV test results for specimen for 7 day and Fig 4.5-4.8 show UPV test results for specimen for 28 days.

Table 4.1: UPV Test for control specimen for 7 day

7-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
1	8.10	4678	32.2
2	8.34	4702	31.9
3	8.36	4777	31.4

Table 4.2: UPV Test for specimen with nano-silica 0.3% b.w.c for 7 day

7-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (µs)**
1	8.18	4491	33.4
2	8.22	4491	33.4
3	8.24	4386	34.2

Table 4.3: UPV Test for specimen with nano-silica 0.6% b.w.c for 7 day

7-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	8.26	4630	32.4
2	8.08	4630	32.4
3	7.98	4702	31.9

Table 4.4: UPV Test for specimen with nano-silica 1% b.w.c for 7 day

7-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	8.24	4491	33.4
2	8.14	4360	34.4
3	8.30	4559	32.9

Table 4.5: UPV Test for control specimen for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	8.42	4808	31.2
2	8.36	4854	30.9
3	8.14	4777	31.4

Table 4.6: UPV Test for specimen with nano-silica 0.3% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	**8.06**	**4673**	**32.1**
2	**8.32**	**4732**	**31.7**
3	**8.22**	**4854**	**30.9**

Table 4.7: UPV Test for specimen with nano-silica 0.6% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	8.18	4702	31.9
2	8.24	4777	31.4
3	8.22	4777	31.4

Table 4.8: UPV Test for specimen with nano-silica 1% b.w.c for 28 day

28-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Velocity (m/s)**	**Time (μs)**
1	8.30	4658	32.2
2	8.30	4702	31.9
3	8.28	4808	31.2

4.1.2 Compressive Strength Test Results

*Compressive Strength = (52 × 9.81 × 1000) ÷ (150 × 150) = 22.67 MPa

Table 4.9: Compressive Strength of control specimen for 7 day

7-DAY TEST RESULT			
Sample No.	**Weight (kg)**	**Load (tonne)**	**Compressive Strength (MPa)**
1	8.10	52	22.67 *
2	8.34	68	29.65
3	8.36	61	26.59
Mean			26.30

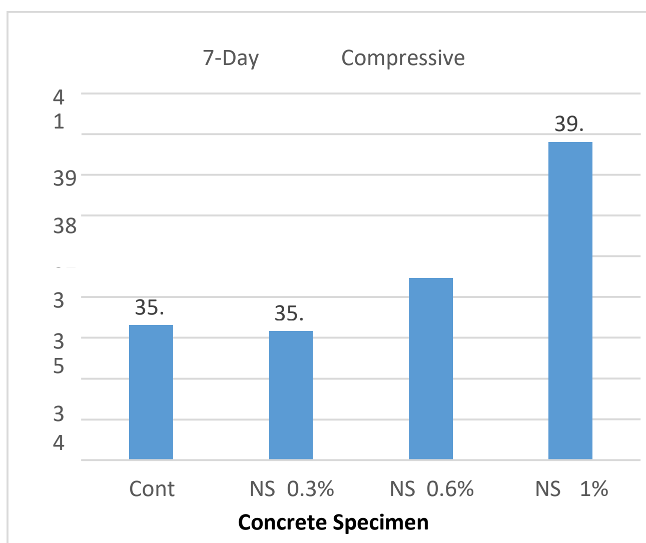


Fig. 4.1: 7-day compressive strength of four specimen

International Journal of Engineering Applied Science and Management
ISSN (Online): 2582-6948
Vol. 2 Issue 1, January 2021

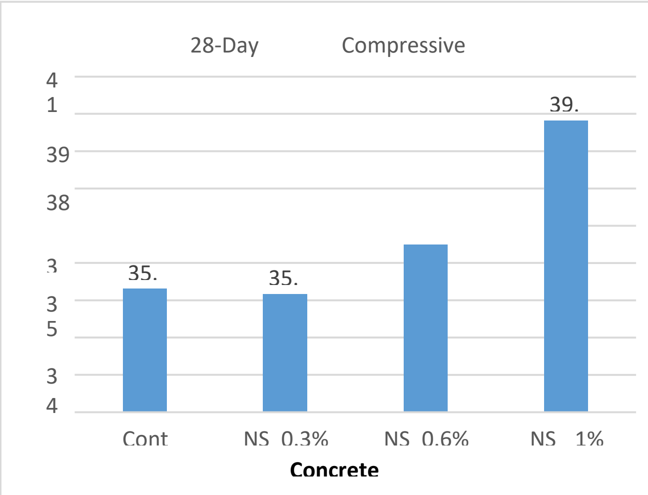


Fig. 4.2: 28-day compressive strength of four specimen

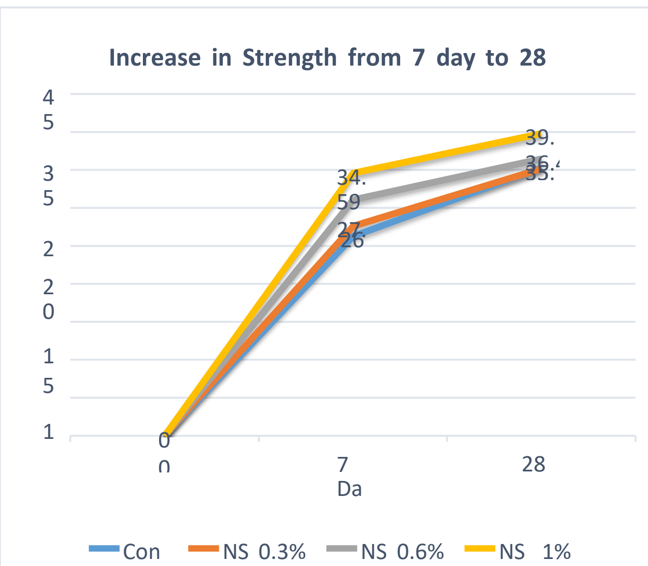


Fig. 4.3: Change in compressive strength of four specimens from 7 day to 28 day

The tables and graphs show that there is an improvement in the early strength of concrete blended with nano silica but later the increase in strength is subdued.

4.1.3 Comparison of UPV Test Results

From the UPV test results, we find that the quality of concrete is very good. The 28-day quality is better than the 7-day quality. The control specimen is found to have better quality compared to the blended concrete specimen.

5. Conclusion

i. The increase in compressive strength can be attributed to the filling of voids in the microstructure by the Nano SiO_2 particles which prevents the growth of $Ca(OH)_2$ crystals. In addition to it the nano silica reacts with calcium hydroxide crystals converting them into C-S-H gel. The reduction in the $Ca(OH)_2$ content is the reason for increase in compressive strength of concrete.

ii. $Ca(OH)_2$ crystals are present in the Interfacial Transition Zone (ITZ) which is between the aggregates and the hardened cement paste. Nano SiO_2 reacts with these crystals and decreases their concentration, hence, strengthen the ITZ. Due to lesser concentration Nano SiO_2 are consumed in the reaction and hence the increase in strength is inhibited with time.

iii. A study of relevant papers show that concrete blended with Nano SiO_2 sets quicker compared to normal concrete. Since, the mix design is carried out without the aid of supper- plasticizers, the mix dried up fast which affected the compaction of the mix using mechanical vibration. Lumps of the mix could be seen during the mixing of concrete. With increase in percentage of Nano SiO_2 the compaction gets tougher. This is the reason for degradation in its quality. It is advisable to use superplasticizers with nano silica.

iv. The Nano SiO_2 added to the mix filled up the pores in between the C-S-H gel, hence, making the microstructure more compact and uniform.

References

[1] IS:2386-1963 (Part-III). Methods of Test for aggregates for concrete Part III specific gravity, density, voids, absorption and bulking. Bureau of Indian Standards.

[2] IS:383-1970. Specification for coarse aggregate and fine aggregate from natural sources for concrete. Burea of Indian Standards.

[3] IS:455-1989. Portland Slag Cement- Specification. Burea of Indian Standards.

[4] IS:456-2000. Plain and Reinforced concrete- code of practice (Fourth Revision). Bureau of Indian Standards.

[5] Hui Li, Hui-gang Xiao, Jie Yuan and Jinping Ou. (2004). Microstructure of cement mortar with nanoparticles. Composites: Part B 35, 185-189.

[6] Ji, Tao. (2005). Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO2. Cement and Concrete Research 35, 1943-1947.

[7] Byung-Wan Jo, Chang-Hyun Kim, Ghi-ho Tae and Jang-Bin Park. (2007). Characteristics of cement mortar with nano-SiO2 particles. Construction and Building Materials 21, 1351-1355.

[8] Nilli, M., Ehsani, A. and Shabani, K. (2009). Influence of nano SiO2 and micro silics on concrete performance. Bu-Ali Sina University Iran.

[9] Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Embedded ZrO2 nanoparticles mechanical properties monitoring in cementitious composites. Journal of American Science 6(4), 86-89.

[10] Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Improvement of the mechanical properties of the cementitious composites by using TiO2 nanoparticles. Journal of American Science 6(4), 98-101.

[11] Ali Nazari, Shadi Riahi, Shirin Riahi, Saydeh Fatemeh Shamekhi and A. Khademno. (2010). Mechanical properties of cement mortar with Al2O3 nanoparticles. Journal of American Science 6(4), 94-97.

[12] Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz and Mohamad Amra Mohd Salleh (2010). Experimental investigation of the size effects of SiO2 nano particles on the mechanical properties of binary blended concrete. Composites: Part B 41, 673-677.

[13] G.Quercia and H.J.H.Brouwers (2010). Application of nanosilica(nS) in concrete mixtures. 8th fib PhD symposium in Kgs. Lyngby, Denmark.

[14] M.S. Morsy, S.H. Alsayed and M. Aqel. (2010). Effect of Nano clay on mechanical properties and microstructure of Ordinary Portland Cement mortar. International Journal on Civil Engineering & Environmental Engineering IJCEE-IJENS Vol. 10 No. 01.