

Durability Study of High Strength Concrete Using Collidal Nano SiO₂

Swapnil B. Walzade ¹, V.R.Rathi ²P.G. Student, Department of Civil Engineering, PREC Engineering College, Loni, Maharashtra, India¹HOD, Department of Civil Engineering, PREC Engineering College, Loni, Maharashtra, India²

ABSTRACT: The cement industry becomes one of the most energy consuming industries with the high rate of CO₂ emission (5%) every year. Many efforts have been taken to reduce the effect of cement industry on green house gasses by using supplementary cementitious materials, which makes the partial replacement to ordinary Portland cement such as GGBFS, SF, FA, NS etc. out of that one interesting material i.e. nano silica produced from silica sand. Past research work on concrete using nano silica has investigated that improved workability and the strength of the concrete also reduce the overall permeability of the hardened concrete.

In this study the effect of colloidal nano silica at different %, incorporating high strength concrete along with fly ash are studied. The test specimens are cured under an acidic medium of Sulphuric acid (H₂SO₄) and Hydrochloric acid (HCL). The test are conducted for 7, 28, 56 days, after 28 days curing in normal water.

The results shows that the concrete containing about 20% Fly ash and 3% CNS shows better performance of concrete against acid attack.

KEYWORDS: Colloidal Nano Silica, High Strength Concrete, Microstructure, Durability property, Mechanical property.

I. INTRODUCTION

During the recent years, nano technology is developing with the high rate. Now a day's use of nano materials in cement and concrete becomes global interest. The high strength concrete member commonly used in high rise building, multistoried building long span bridges due to its superior strength toughness, stiffness and durability.

Generally the specification restricts the replacement level of cement with fly ash to about 25-30 %. The colloidal nano silica incorporated with high strength concrete give superior strength and durability. Colloidal nano silica contains small particles of amorphous SiO₂, which are insoluble and uniformly dispersed in water with particle size of 5-8 nM, which are small enough to remain suspended in fluid medium without setting. The microstructure examination have verified the finer structure and drastically reduced porosity for the specimen containing nano silica powder.

In previous research it has been observed that addition of nano silica increases the compressive strength and reduces the permeability due to its high reactivity and pozzolonic property. The use of colloidal nano silica is expected to improve the packing effect; hence the concrete becomes denser and durable.

In this work it was planned to study and investigate effect of partial replacement of cement by Fly ash (FA) ranging from 0 % to 35 % and addition of nano silica ranging from 0 % to 5 % on physical and mechanical properties of high strength concrete subjected to an impact of different acids like Sulphuric acid (H₂SO₄) and Hydrochloric acid (HCL) with 5% concentration on M80 grade concrete at 7, 28 and 56 days curing in respective solution after 28 days normal curing.

II. LITERATURE REVIEW

In recent years experiments were carried out by adding or replacing nano silica. Here are some previous studies summarize below,

A.M. Said et al Studied, experimental study was conducted on concrete containing colloidal nano silica with aqueous solution of 50% amorphous silica content. The mean of nano particles was of 35nM. The result showed that, significant improvement in terms of reactivity, strength development, refinement of pore structure and densification of

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

ITZ. **Amrishi Nasution** et al. The silica used in the study having size 10-40 nM at different % (0%, 2.5%, 5%, 7.5%, 10%) by cement weight. The result showed that, the nano silica was able to increase the density as well as increase the mechanical properties of concrete. **Min-Hong Zhang** et al water permeability resistant behavior and microstructure of concrete with nano silica was studied. The nano silica can improve the resistant to the penetration. The microstructure of concrete is more uniform and compact as compared to normal concrete. **Binsar Hariandja** et al locally available

nano silica used on concrete with size 40-80 nM. The result shows that combined use of nano silica with silica fume can increase the compressive strength and durability.

Based on previous researches, this research is focused on the addition of colloidal in high strength concrete (M80) to improve the mechanical and durability of the concrete. The colloidal nano silica used in aqueous solution of 15% amorphous silica content with size of particles 5-8 nM. The purpose of this study is to investigate durability property of high strength concrete (M80).

III. METHODOLOGY

Materials required

Cement - The Ordinary Portland Cement (OPC) of 53 grade ultra tech cement is used. It has specific gravity of 3.15. The test conducted on cement was as per IS: 12269-1987.

Fine aggregate - Fine aggregate that is to be used for this entire study of investigation was local river sand confirming to zone-II of IS: 383-1970 and specific gravity is 2.60 and fineness modulus is 3.12.

Coarse aggregate - In the present study, locally available coarse aggregate of maximum size 10mm were used confirming to IS: 2386:1963(Part-III). Its specific gravity is 2.90 and fineness modulus is 6.78.

Water - Potable water confirming to IS: 456-2000 is used for casting and curing.

Nano Silica - High strength means better packing effect between different ingredients of concrete. Hence we used colloidal nano silica that fills the pore spaces of concrete, obtained from "Bee-chem". Chemicals ltd, Kanpur. It has 15-16% nano content which is in the form of water soluble type.

Table-1 Properties of colloidal nano silica

Parameter	Nano Solids	Particle Size	Specific gravity	Viscosity
Value	15-16%	5-8 nM	1.15	10-15 Sec.

The above table is showing the chemical properties of colloidal nano silica accordingly percentage of nano solid, particle size, specific gravity and viscosity.

Fly Ash - Fly ash of grade P-63 and P-100 are used as partial replacement to the cement. The fly ash is obtained from "DIRK India Pvt. Ltd.", Nashik, Maharashtra. The fly ash is replaced at P-63 (0%, 5%, 10%, 15%, 20%, 25%) and P-100 at constant rate of 10%.

Admixture - For increasing workability of concrete a super plasticizer, "AURAMIX-400" by FOSROC chemicals, Mumbai is used in this experimental work. Along with retarder "CONPLAST R" manufactured by FOSROC chemicals Mumbai, confirming to IS: 9103-1993.

Mix Design - To investigate the effect of nano silica on the durability and mechanical properties of conventional concrete the mix design is done according to IS 10262:2009.

Table-2 Proportion for Concrete Mix Design (M80)

Materials	Cement	C.A.	F.A.	Water	Admix.
Mass (Kg/m ³)	750	1047.6	626.2	142.7	11.25

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

After studying the physical and chemical properties of cement, fine aggregate, course aggregate and chemical admixture, the concrete mix design is made according to IS-10262:2009. The above table shows the quantity of material required for (M80) grade of concrete in Kg/m³. Hence the mix proportion then becomes - 1:0.834:1.396

Casting of Test Specimen - In this study the specimen of standard cubes (100 X100 X 100mm) were casted.

Mixing - Measured quantities of coarse aggregate and fine aggregate were spaced out over an impervious concrete floor. The dry OPC were spread out on the aggregate and mixed thoroughly in dry state turning the mixture over and over until the uniformity of color was achieved. Water was measured exactly by way and it was thoroughly mixed to obtain homogenous concrete. The mixing shall be done for 10 to 15 minutes.

Placing and Compacting - The cube mould and cylinder moulds are cleaned and all care is taken to avoid irregular dimensions. The joints between the sections of mould were coated with oil and similar coating of mould was applied between the contact surfaces during filling. The mix was placed in 3 layers and the layer was contacted using table vibrator to obtain dense concrete.

Curing - The test specimen cubes were stored in a place free from vibration in moist air at 90% relative humidity and at temperature of 27+/- for 24 ½ hours from the time of addition of water to dry ingredients. After 24 hours the specimens demoulded and immediately immersed in clean, fresh water tank for period of 28 days.

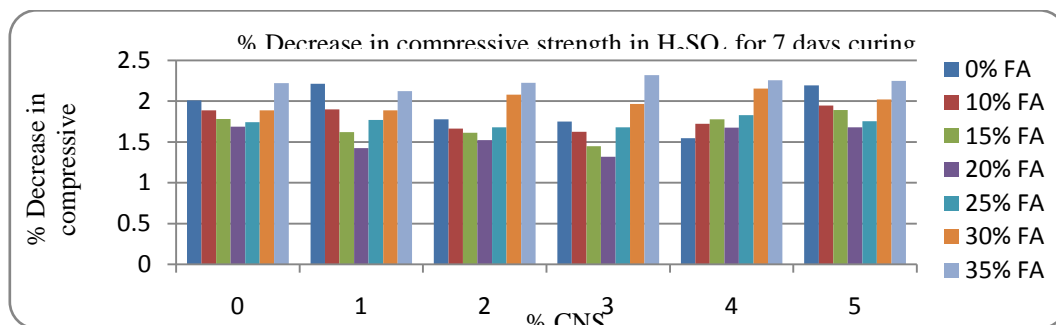
Compressive strength of HSC - Compressive strength of colloidal nano-SiO₂ and fly ash blended cement concrete cubes was determined after 28 days of curing as per I.S. 510-1959

Chemical Attack on concrete - To find the effect of various chemicals on the various mixes, the chemicals used are Acids (H₂SO₄ and HCL), Sulphates (MgSO₄ & Na₂SO₄) and Alkali (NaOH) with each have been mixed with 5% by

weight of water after 28 days curing of the specimen. The samples were kept in various chemicals for 7 days, 28 days and 56 days and then after the effect of above chemicals were studies on percentage weight loss and percentage reduction in compressive strength.

IV. EXPERIMENTAL RESULTS

1. Sulphuric acid (H₂SO₄) –



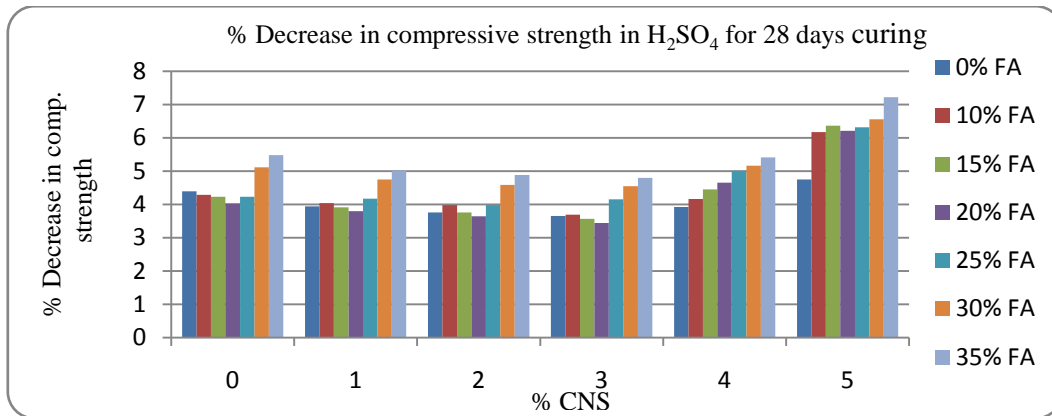
Graph 1- % Decrease in compressive strength in H₂SO₄ for 7 days curing

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement is 1.319% 7 days which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

International Journal of Innovative Research in Science, Engineering and Technology

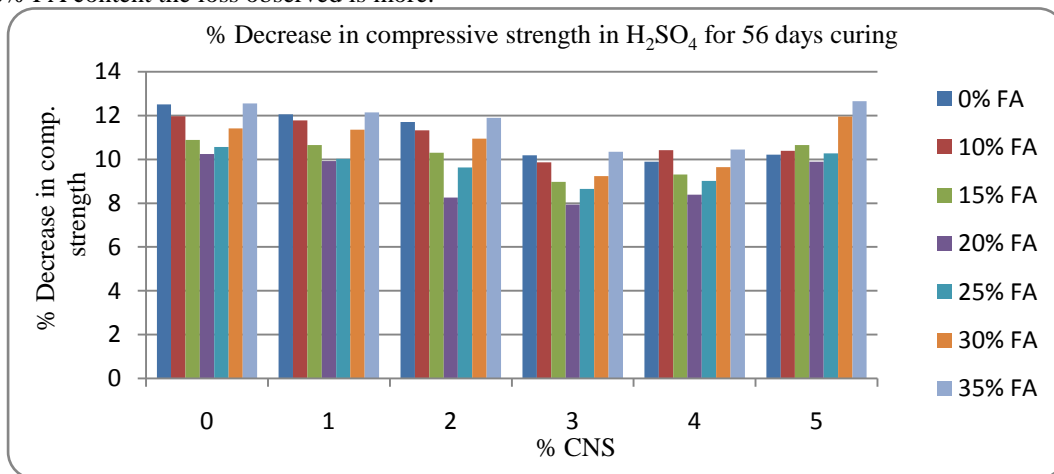
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016



Graph 2 - % Decrease in compressive strength in H₂SO₄ for 28 days curing

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement are 3.44% for 28 days which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



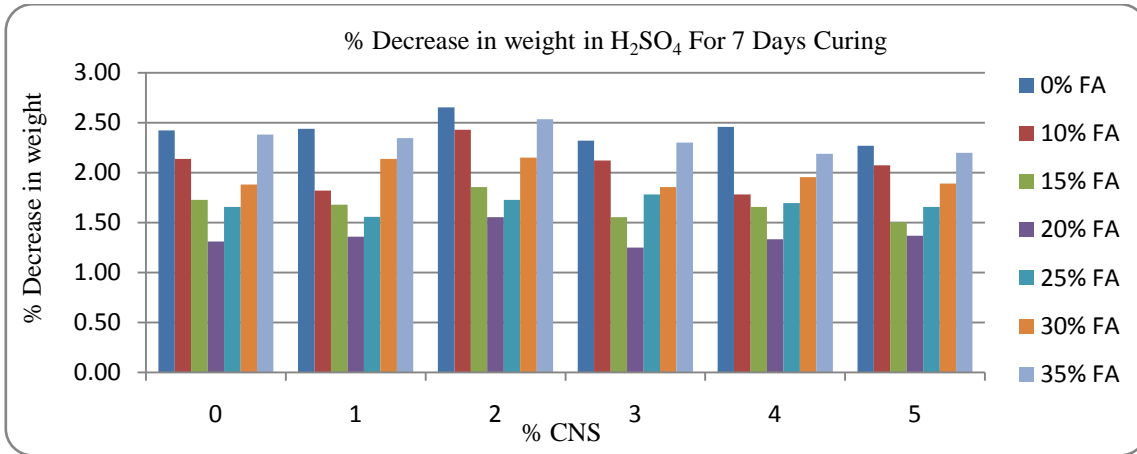
Graph 3 - % Decrease in compressive strength in H₂SO₄ for 56 days curing

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement are 7.94% for 56 days which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

International Journal of Innovative Research in Science, Engineering and Technology

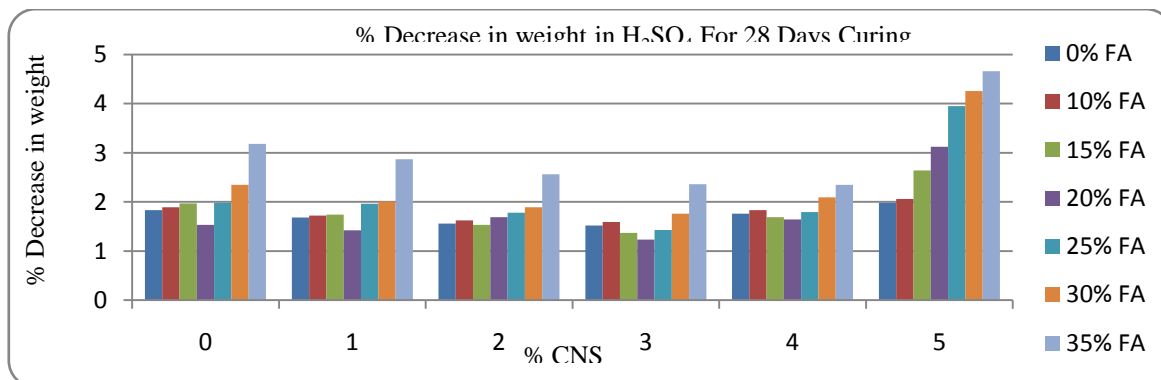
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016



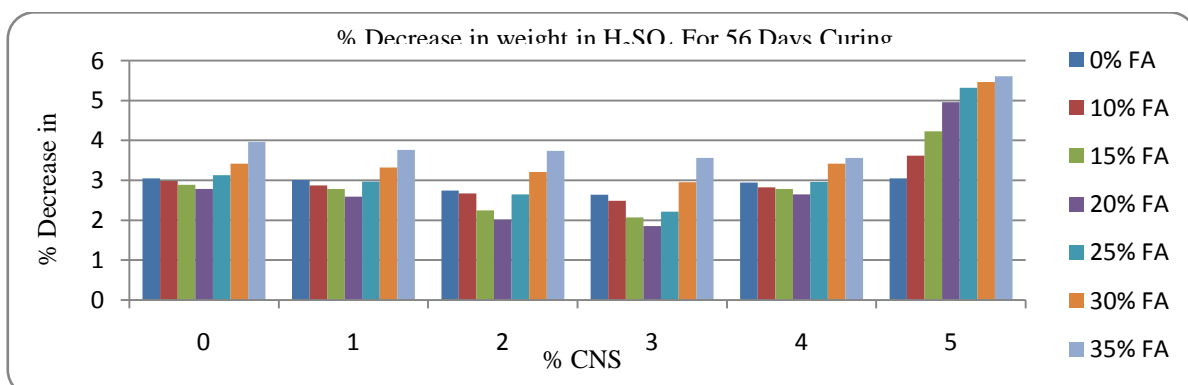
Graph 4 - % Decrease in weight in H₂SO₄ For 7 Days Curing

From experiment it is observed that percentage weight loss in H₂SO₄ at 3% CNS content with 20% FA replacement are 1.23% for 7 days which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



Graph 5 - % Decrease in weight in H₂SO₄ For 28 Days Curing

From experiment it is observed that percentage weight loss in H₂SO₄ at 3% CNS content with 20% FA replacement are 1.37% for 28 days which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



Graph 6 - % Decrease in weight in H₂SO₄ for 56 Days Curing

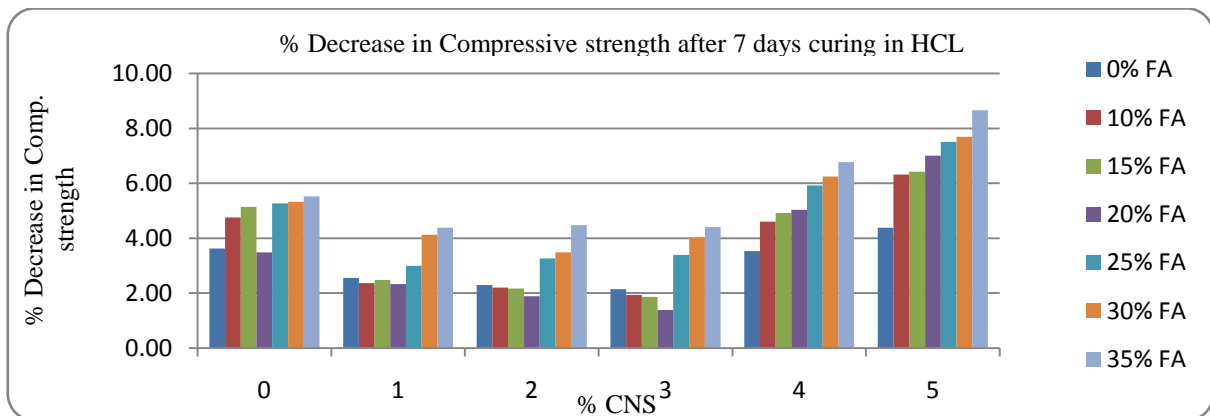
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

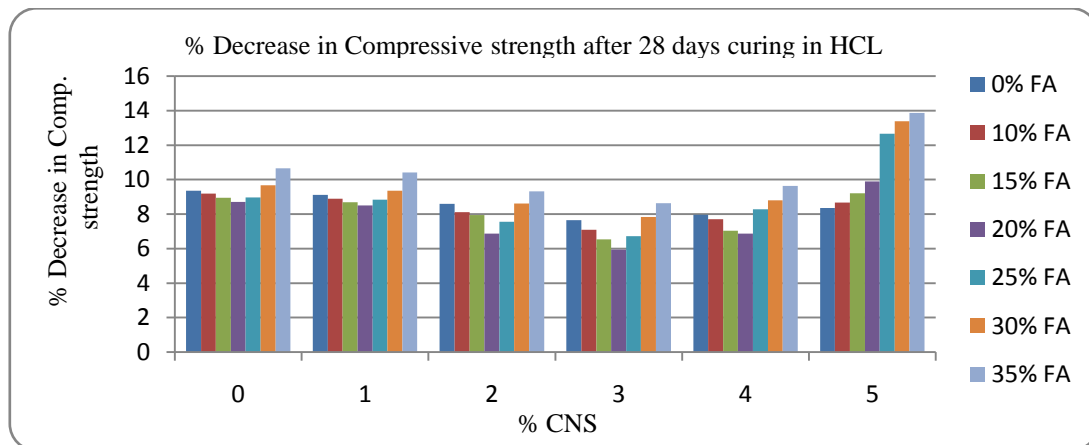
From experiment it is observed that percentage weight loss in H₂SO₄ at 3% CNS content with 20% FA replacement are 1.85% for 56 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

2. Hydrochloric acid (HCL) –



Graph 7 - % Decrease in Compressive strength after 7 days curing in HCL

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement are 1.39% for 7 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



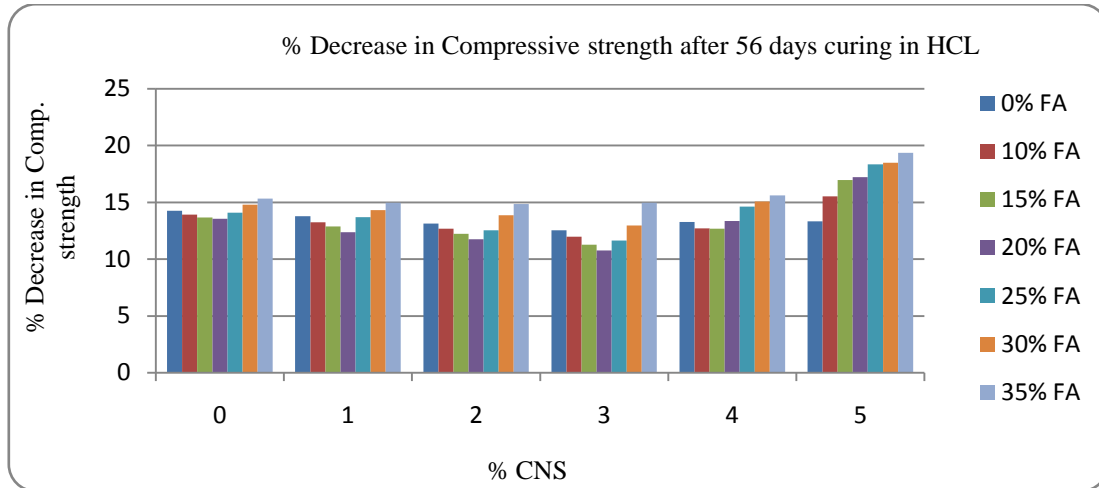
Graph 8 - % Decrease in Compressive strength after 28 days curing in HCL

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement are 5.94% for 28 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

International Journal of Innovative Research in Science, Engineering and Technology

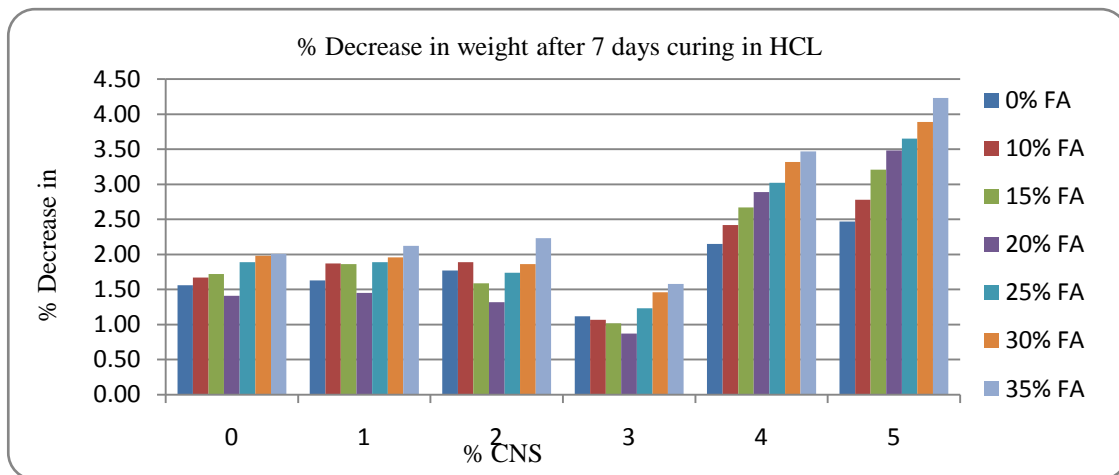
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016



Graph 9 - % Decrease in Compressive strength after 56 days curing in HCL

From experiment it is observed that percentage decrease in compressive strength in H₂SO₄ at 3% CNS content with 20% FA replacement are 10.78% for 56 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



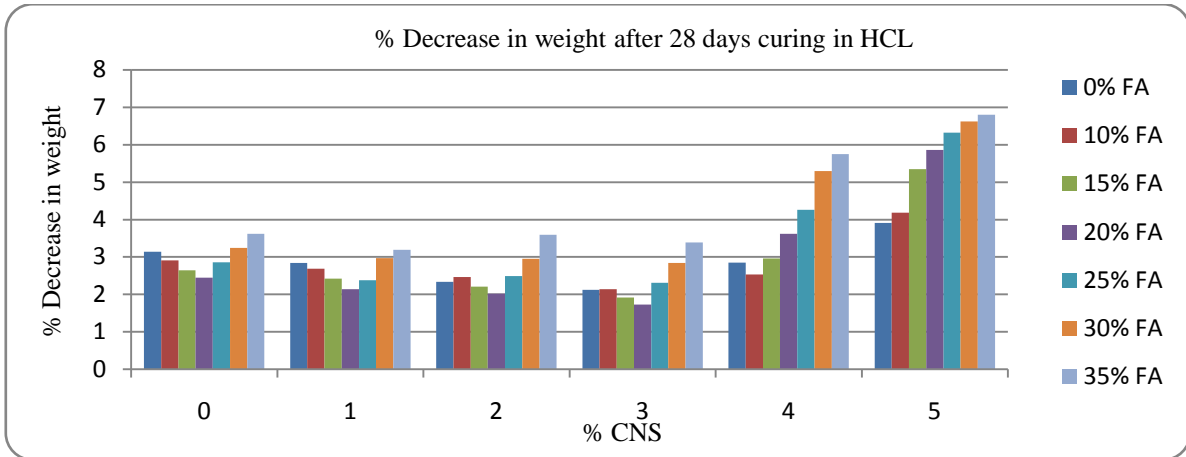
Graph 10 - % Decrease in weight after 7 days curing in HCL

From experiment it is observed that percentage weight loss in H₂SO₄ at 3% CNS content with 20% FA replacement are 0.87% for 7 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

International Journal of Innovative Research in Science, Engineering and Technology

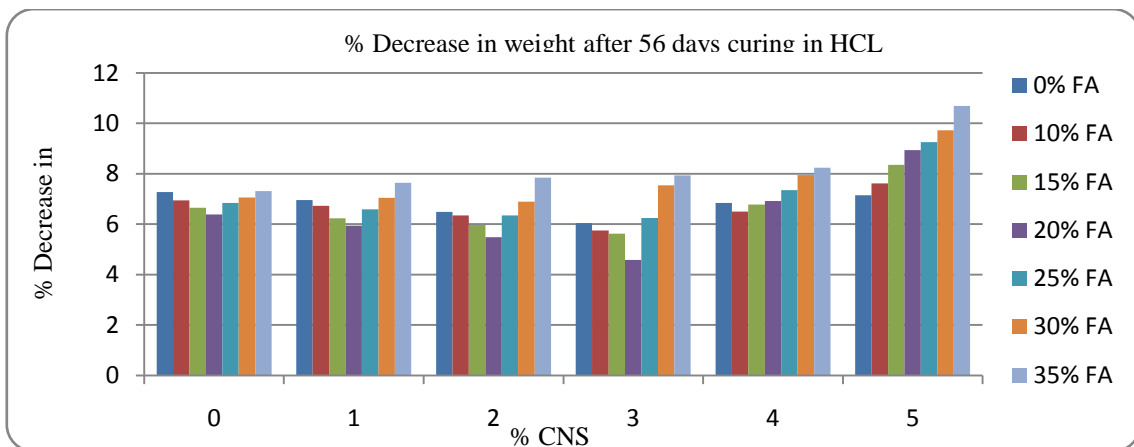
(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016



Graph 11 - % Decrease in weight after 28 days curing in HCL

From experiment it is observed that percentage weight loss in H_2SO_4 at 3% CNS content with 20% FA replacement are 1.73% for 28 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.



Graph 12 - % Decrease in weight after 56 days curing in HCL

From experiment it is observed that percentage weight loss in H_2SO_4 at 3% CNS content with 20% FA replacement are 4.59% for 56 days respectively which are less as compared with others. Then there after that is beyond 4% CNS and 20% FA content the loss observed is more.

V. CONCLUSION

The reduction in the compressive strength and weight of concrete specimen containing 0%, 1%, 2%, 3%, 4% and 5% colloidal Nano-SiO₂ are investigated.

- The minimum loss in compressive strength of concrete is observed at cement replacement by 10% P-63 FA+ 10% P-100 FA + 3% CNS in 5% solution of H_2SO_4 . The strength loss for the same is 1.319%, 3.44% and 7.94% w. r. to corresponding concrete and weight loss was observed as 1.23%, 1.37% and 1.85% for 7, 28 and 56 days curing in the solution respectively.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, Januray 2016

- The minimum loss in compressive strength of concrete is observed at cement replacement by 10% P-63 FA+ 10% P-100 FA + 3% CNS in 5% solution of HCL is 1.23%, 1.37% and 1.85% w.r.t to corresponding concrete and weight loss was observed as 0.87%, 1.73% and 4.59% for 7, 28 and 56 days curing in the solution.

REFERENCES

1. A.M. Said, M.S. Zeidan, M.T. Bassuoni, Y. Tian, "Properties of concrete incorporating nano-silica", Construction and Building materials, Vol-3, pp-838-844, 2012.
2. Amrish Nasution, Iswandi Imran, Mikrajuddin Abdullah, Saloma, "Experimental investigation on nanomaterial concrete, IJCEE-IJENS, Vol:13 No.3, 2013.
3. A. Lazaro , G. Quercia, H.J.H. Brouwers , J.W. Geus, "Characterization of morphology and texture of several amorphous nano-silica particles used in concrete", Cement and Concrete Composites, Vol- 44, pp-77-92, 2013.
4. A. Siva Sai, B.L.P. Swami, B.SaiKiran, M.V.S.S. Sastri, "Comparative studies on high strength concrete mixes using micro silica and nanosilica ", IJETR Vol. No.-1, Issue- 7, pp-29-34, 2013.
5. Binsar Hariandja, Iswandi Imran, Ivindra Pane , Jonbi , "The Use of Nanosilica for Improving of Concrete Compressive Strength and Durability", Applied Mechanics and Materials Vols.204-208, pp-4059-4062, 2012.
6. Bhuvaneshwari B., Kalaiselvam S ,Maheswaran, Nagesh R Iyer, Palani G.S., "An Overview on the Influence of Nano Silica in Concrete and a Research Initiative", Vol.2(ISC), pp-17-54, 2012.
7. Binsar Hariandja Iswandi Imran, Ivindra Pane , Jonbi , "The Use of Nanosilica for Improving of Concrete Compressive Strength and Durability", Applied Mechanics and Materials Vols.204-208, pp-4059-4062, 2013.
8. Dr. Shreenath Reddy, Madan Mohan, T. Ashwini Reddy,"Effect of nano silica on mechanical properties of conventional concrete: Case Study",ISSN 2320-3439, Vol-03,06, pp-36-39, November 2014.
9. G. Quercia, G. Hüsken, H.J.H. Brouwers , "Water demand of amorphous nano silica and its impact on the workability of cement paste", Cement and Concrete Research Vol- 42, pp-344-357, 2012.
10. H.J.H. Brouwers, R. Yu, P. Spiesz., "Effect of nano-silica on the hydration and microstructure development of Ultra-High Performance Concrete (UHPC) with a low binder amount", Construction and Building Materials Vol-65, pp-140-150, 2014.
11. Min-Hong Zhang, Jahidul Islam, Sulapha Peethamparan "Use of nano-silica to increase early strength and reduce setting time of concretes with high volumes of slag", Cement and Concrete Composites Vol- 34, pp-650-662, 2012.
12. Tao Ji , "Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO₂", Cement and Concrete Research Vol- 35, pp-1943-1947, 2005.