# EXPERIMENTAL STUDY ON STRENGTH PROPERTIES OF CONCRETE BY USING NANO SILICA

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***Abstract:*** *Concrete is the most versatile material due to the persistent and continuous demands made on concrete, Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials like fly ash, silica fume, granulated blast furnace slag and steel slag etc. The use of large quantity of cement produces increasing $co_2$ emissions and consequence the green house effect. Nano technology is one of the most promising areas of science. The use of nano materials in concrete is new revolution. Nano materials like nano silica, nano titanium oxide, carbon nano tubes, nano alumina etc… which are presently used in concrete to modify its strength properties. In the present study strength properties such as compressive strength, split tensile strength and flexural strength of M20 grade of concrete with the use of nano silica (2%, 4%, 6%, 8%, 10%) as partial replacement of cement were studied. It was found from the experimental study that concrete composites with superior properties can be produced using nano silica.*

***Keywords:*** *Cement, Concrete, Nano silica and strength.*

## 1. INTRODUCTION

Concrete is the most widely used construction material in the world. In recent years, researchers have focused on the improvement of concrete quality regarding its mechanical and durability properties. These can be achieved by the application of the supplementary cementinious material. Recently Nano Technology has been introduced in Civil Engineering applications. One of the most used Nano material is Nano Silica (NS). This is the first Nano product that has replaced the micro silica. The advancement made by the study of concrete at nano scale has proved that nano silica is much better than silica fume used in conventional concrete. Nano silica possess more pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and durability to concrete.

## 2. LITERATURE REVIEW

Ajay et al, (2012) have studied the effect of micro silica and the strength of concrete with ordinary Portland cement. They observed that silica fume increases the strength of concrete and reduces capillary pores. Roy (2012) has investigated on the strength parameters of concrete made with partial replacement of cement by SF. Shanmugapriya (2013) studied the influence of silica fume on M60 concrete and found that 7.5% of silica fume replacement increases the maximum compressive strength, split tensile strength and flexural strength. Ji (2005) studied the water permeability resistant behavior and micro structure of concrete with NS and observed that NS concrete has a better water resistant permeability than ordinary concrete. Qing et al., (2007) studied the influence of silica fume and nano silica individually on fresh concrete and hardened concrete and found that consistency and setting times were different for NS and SF. NS makes cement paste thicker and accelerated the hydration process which improves the bond strength and compressive strength when compared with that of SF in concrete. Swami and SaiKiran (2013) have observed the mechanical properties of M60 and M70 grade concrete with micro silica and in combination with colloidal nano-silica. They found that concrete composites with superior properties can be produced with the combination of micro-silica and nano-silica. Mohammad et al (2013) have found that the concrete produced with Micro-$SiO_2$ and Nano-SiO2 show higher degrees of quality in their compressive strength than the concrete which only have Micro-$SiO_2$ in their mixtures. Specimens with 2% Nano-$SiO_2$ and 10% Micro-SiO2 had less water absorption and more electrical resistance. Hussain and Sastry studied the concrete with nano and microsilica and concluded that cement replacement up to 7.5% with SF and up to 2% with NS, leads to increasing compressive strength, split tensile strength and flexural strength for both M40 and M50 grade. Beyond 7.5% of SF and 2% of NS there is decreasing in compressive strength, split tensile strength and flexural strength for both M40 and M50 mixes. The maximum replacement level of silica fume is 7.5% and nano silica is 2% for both M40 and M50 grade concrete. The percentage increase in compressive strength, split tensile strength and flexural strength of concrete with combination of SF at 7.5% and NS at 2% is (25.807%, 25.766% and 18.9%).for M40 grade and (25.357%, 25.035% and

16.067%) for M50 grade concrete which is More when compared to normal concrete of M40 and M50 grades.
Iyappan and Jagannathan studied the properties and concluded with this results that use of 2% nano silica in SCC, it increase in compressive strength, flexural strength, Split tensile strength about 11.93%,10.51%,13.09% respectively. Use of 4% nano silica in SCC, it increase in compressive strength, flexural strength, Split tensile strength about 18.88%,16.01%,23% respectively.

## 2. MATERIALS USED AND THEIR PROPERTIES

In this present investigation materials used are Cement, Fine aggregate, Coarse aggregate, Silica Fume, Nano silica, Super plasticizer.

### 2.1 Cement:

Ordinary Portland cement (OPC) was used which satisfies the requirements of IS: 12269-1987. The properties of cement are shown in table 1.

**Table 1.** Properties of cement

| S No | Property of cement | Results |
|---|---|---|
| 1 | Normal Consistency | 26% |
| 2 | Initial setting time | 40 min |
| 3 | Final setting time | 170min |
| 4 | Specific gravity | 3.15 |

### 2.2 Aggregate:

**Fine Aggregate:** Locally available sand collected from Thamirabarani river bed was used. The sand was conforming to zone II as per IS: 383-1987. The properties of fine aggregate are shown in table 2.

**Table 2.** Properties of Fine aggregate

| Sno | Properties | Results |
|---|---|---|
| 1 | Bulk density, kg/m$^3$ | 1650 |
| 2 | Specific gravity | 2.6 |
| 3 | Fineness modulus | 3.275 |
| 4 | Free surface moisture (%) | 2.2 |

**Coarse Aggregate:** The crushed aggregate was used from the local quarry. In this experiment the aggregate was used of 20mm down and tested as per IS: 2386-1963(I, II, III) specification. The properties of coarse aggregate are shown in table 3.

**Table 3.** Properties of Coarse aggregate

| Sno | Property | Results |
|---|---|---|
| 1 | Maximum nominal size | 20mm |
| 2 | Bulk density (kg/m$^3$) | 1800 |
| 3 | Specific gravity | 2.78 |
| 4 | Fineness modulus | 5.2 |

**2.4 Nano Silica:** The properties of nano silica are shown in table 4.

**Table 4.** Properties of Nano Silica

| State | Dispersed in water |
|---|---|
| Active nano Content (%) | 40.00-41.50 |
| $_p$H (20° C) | 9.0-10.0 |
| Specific gravity | 1.30-1.32 |
| Particle size | 5-40 nm |

## 3. EXPERIMENTAL PROGRAMME

The experimental program was designed to compare the mechanical properties i.e. compressive strength, split tensile strength, and flexural strength of high strength concrete with M20 grade of concrete and with different replacement levels of ordinary Portland cement with nano silica (2%, 4%, 6% , 8% and 10%).

**3.1 Mix Proportions:** Concrete mix was designed to a compressive strength of M20 grade with water cement ratio of 0.49 as per IS code 10262-2009. The cement was replaced by SF (2%, 4%, 6%, 8% and 10%). proportion of constituent materials for the Mix is presented in table 5.

**Table 5.** Mix proportion of concrete

| Sl.No | Content | Amount (kg/m$^3$) |
|---|---|---|
| 1 | Cement | 425.77 |
| 2 | Water | 191.58 |
| 3 | Fine aggregate | 574.35 |
| 4 | Coarse aggregate | 1246 |
| 5 | Water cement ratio | 0.49 |

The specimens of standard cubes (150mmx150mmx150mm), standard cylinders (150mm Dia x300mm height) and standard beams (150mmx150mmx700mm) were cast with various percentage replacements of NS. Compression testing machine (CTM) was used to test 28 days compressive strength and split tensile strength of specimens.

Universal Testing Machine (UTM) was used to test 28 days flexural strength of specimens

## 4. RESULTS AND DISCUSSIONS

### 4.1. Compressive Strength:

The compressive strength of M20 grade concrete and NS concrete at the age of 7days and 28 days is shown in Fig.1. There is a significance improvement in the strength of concrete because of high pozzolanic nature of nano silica and their filling ability. Compressive strength of mix at 7 days age, with replacement of NS was increased gradually up to an optimum replacement level of 6% and then decreased. The maximum 7 days cube strength of M20 grade with 6% of NS was 23.60 N/mm$^2$. Compressive strength of concrete with NS at 28 days age also shows same trend of increase upto 6% replacement and then gradually decreased. The maximum 28 days cube strength of M20 grade with 6% of NS was 35.64 N/mm$^2$.

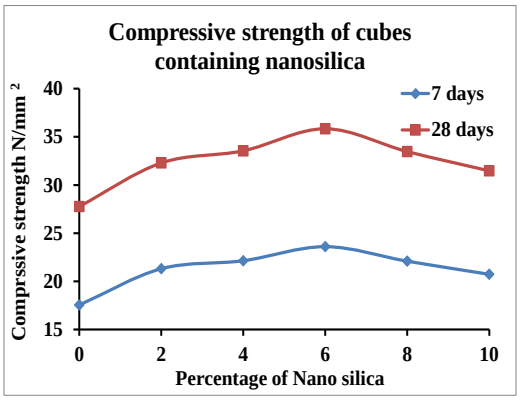


**Fig.1.** Compressive strength

### 4.2 Flexural Strength:

The flexural strength of M20 grade concrete and NS concrete at the age of 7days and 28 days is shown in Fig.2. Flexural strength of mix at 7 days age, with replacement of NS was increased gradually up to an optimum replacement level of 6% and then decreased. The maximum 7 days Beam strength of M20 grade with 6% of NS was 2.95 N/mm$^2$. Flexural strength of concrete with NS at 28 days age also shows same trend of increase up to 6% replacement and then gradually decreased. The maximum 28 days Beam strength of M20 grade with 6% of NS was 4.48 N/mm$^2$.

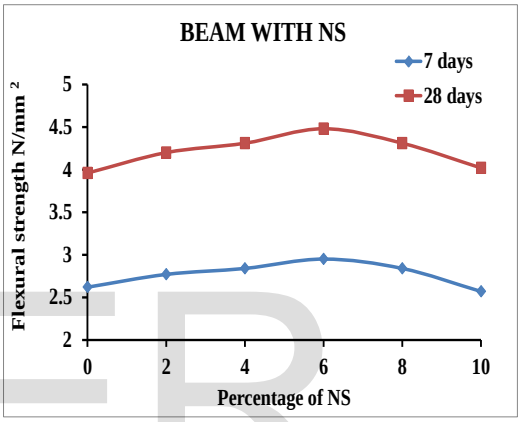


**Fig.2.** Flexural strength

### 4.3 Split tensile Strength:

The Split tensile strength of M20 grade concrete and NS concrete at the age of 7days and 28 days is shown in Fig.3. Flexural strength of mix at 7 days age, with replacement of NS was increased gradually up to an optimum replacement level of 6% and then decreased. The maximum 7 days Cylinder strength of M20 grade with 6% of NS was 2.75 N/mm$^2$. Split tensile strength of concrete with NS at 28 days age also shows same trend of increase up to 6% replacement and then gradually decreased. The maximum 28 days Cylinder strength of M20 grade with 6% of NS was 4.18 N/mm$^2$.

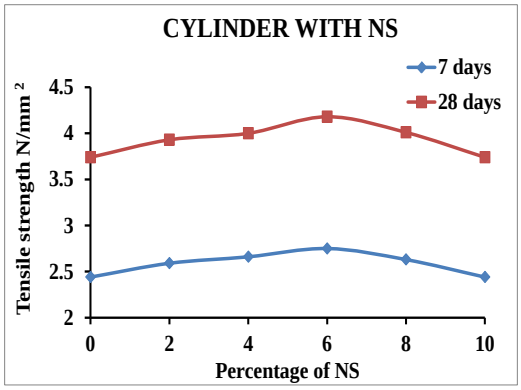


**Fig.3.** Split tensile strength

## 5. CONCLUSIONS

Based on experimental results the following conclusions are drawn

1. Cement replacement up to 6% with NS, leads to increasing compressive strength, split tensile strength and flexural strength for M20 grade of concrete. Beyond 6% of NS there is decreasing in compressive strength, split tensile strength and flexural strength for M20 mix.
2. The maximum replacement level of nano silica is 6% for M20 grade concrete.
3. The percentage increase in compressive strength, split tensile strength and flexural strength of concrete with combination of NS at 6% for 28 days is ( 30%,11.7%, 13%) which is More when compared to normal concrete of M20 grade.

**REFERENCES**

[1] Verma Ajay, Chandak Rajeec and Yadav R.K. "Effect of micro silica on the strength of concrete with ordinary Portland cement" Reaserch journal of Engineering Science ISSN 2278-9472 vol.1(3), 1-4, sept (2012).

[2] Dilip Kumar Singha Roy "Effect of Partial Replacement of Cement by Silica Fume on Hardened Concrete". International journal of engineering Technology and Advanced Engineering (ISSN 2250-2459, volume 2, issue 8, August 2012)

[3] T. Shanmugapriya, Dr. R. N. Uma "Experimental Investigation on silica Fume as partial replacement of Cement in High Performance Concrete". (IJES) 2013

[4] Ji Tao, 2005. "Preliminary study on the water permeability and microstructure of concrete incorporating nanoSiO2", Cement and Concrete Research, 35: 1943-1947.

[5] Ye Qing, Zenan Z., Deyu K. and Ch. Rongshen, "Influence of nano-SiO2 addition on properties of hardened cement paste as compared with silica fume", Constr. Build Mater., 21, 539–545 (2007)

[6] Jo Byung-Wan, Kim Chang-Hyun, Lim Jae-Hoon, "Characteristics of cement mortar with nano-SiO2 particles", ACI Mat. Jl., 104(4), 404-407 (2007).

[7] Lin D.F., Lin K.L., Chang W.C., Luo H.L and Cai M.Q., "Improvements of nano SiO2 on sludge/fly ash mortar", Waste Management, 28(6), 1081-1087 (2008).

[8] Yazdi A.D., Sohrabi M.R., Ghasemi M.R., Mohammad Danesh-Yazdi, "Investigation of Nano-SiO2 Effects on High-Volume Fly Ash Concrete", 1st International Conference on Concrete Technology, Iran (2009).

[9] Sadrmomtazi A., Barzegar A., "Assessment of the effect of Nano-SiO2 on physical and mechanical properties of self-compacting concrete containing rice husk ash", Second Intl. Conf. on Sustainable Construction Materials and Technologies, June 28-30, University Politecnica delle Marche, Ancona, Italy (2010).

[10] Mohammad Reza Zamani Abyaneh, Alireza Mehran, Seyed Mohammad Mahdi Hoseini, (2013) "Effects of Nano-Silica on Permeability of Concrete and Steel Bars Reinforcement Corrosion" Australian Journal of Basic and Applied Sciences, 7(2): 464-467, 2013 ISSN 1991-8178.

[11] IS 456-2000, "Indian Standard Code of Practice for plain and reinforced concrete" Fourth revision, BIS, New Delhi.

[12] IS 383-1970, "Indian Standard Specification for coarse and fine aggregate from natural source for concrete," 2nd Edition, BIS, New Delhi.

[13] IS 2386-1963, "Indian Standard Methods of tests for aggregate" BIS, New Delhi.

[14] IS: 12269-1987, "Indian Standard Ordinary Portland Cement 53 grade Specification" BIS, New Delhi.

[15] IS: 10262-1982, "Recommended guidelines for concrete mix design, "BIS, New Delhi.