International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1678- 1682
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0231

Influence of Nano Silica On Properties of Cement Concrete

Rakesha K J[1], C. V. S. Nagendra[2], N. Jayaramappa[3]
[1]PG Student, Department of Civil Engineering, UVCE, Bangalore University, Bengaluru, Karnataka, India.
[2]Research scholar, Department of Civil Engineering, UVCE, Bangalore University, Bengaluru, Karnataka, India.
[3]Professor Department of Civil Engineering, UVCE, Bangalore University, Bengaluru, Karnataka, India.
Emails: *Rakesh.kj@campusuvce.in[1], chintalanagendra25@gmail.com[2], Jakasauj@gmail.com[3]*

Abstract
Concrete is a material that is extensively used in the building industry, whereas some flaws that cause it to lose performance and durability with time, including high permeability, microcracking, and uneven strength. Hence, to reduce these flaws, nanotechnology, specifically the incorporation of nanosilica (SiO2), addresses effectively. Nanosilica enhances concrete by promoting additional calcium silicate hydrate formation, refining the microstructure, and reducing permeability. These improvements make nanosilica beneficial for concrete properties and repair mortars. Hence The impact of nanosilica on different concrete qualities achieved by substituting different percentages of cement (0.5%, 1.0%, 1.5%, and 2.0%) for M25-grade concrete mix is demonstrated in this research work. To ascertain the mechanical Properties, such as compressive strength, split tensile strength, and flexural strength, specimens were cast using nano-Silica concrete. Split tensile and flexural strength are assessed at the age of 28 days, whilst compressive strength is assessed at 7, 14, 28, and 56 days. Results indicate that using nanosilica powder in concrete was able to increase the mechanical characteristics and reduce the density compared to a conventional mix of concrete. When 1.5% nanosilica is substituted for cement, the resulting material exhibits superior mechanical and durability qualities.
Keywords: *Nanosilica; Compressive Strength; Split Tensile Strength; Flexural Strength; Durability.*

1. Introduction
Concrete is now the most frequently used building material worldwide because to nanotechnology advancements, and this is one of the fastest-growing research topics with numerous applications in practically every sector. Concrete has been produced using nanotechnology, which has the potential to enhance concrete's performance. Researchers have been concentrating on changing the quality of concrete in recent years, which has resulted in the creation of innovative and sustainable materials. To investigate the mechanical and physical characteristics of concrete, nanoparticles have been created and used to concrete mix designs. The availability of local resources should be taken into consideration while implementing nanotechnology in concrete technology. Nanosilica, which is made from silica sand, is one substance that is fascinating to investigate. [1] Akash Kumar.et.al.,[2] Discussed about the effect of nanosilica on the characteristics of both fresh and hardened cement mortar. It has been discovered that increasing the weight of nanosilica by up to 3.5% while maintaining a 0.35 water-to-binder ratio strengthens mortar, particularly in the first phases. Between 0.2 and 0.3 microns in size, nanosilica can replace 1% to 6% of cement and improve several qualities, including initial and final setting periods, up to a 5% addition; after that, strength decreases. Mohan Raj et.al.,[3] Mar 2019 This study investigates the impacts of adding nano-Silica at 3%, 3.5%, and 10% for the replacement of cement in M20-grade concrete. Compressive strength is increased while density is decreased by nanosilica, according to tests on tensile, flexural, and compressive strengths. Higher percentages of nano-silica have a negative effect on a number of concrete qualities, while a 3% replacement increases strength and decreases permeability. Mohammed Ayub Ghori et.al.,[4] April 2021 explained about influence of nano-silica on concrete qualities, with

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1678- 1682
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0231

partially replacement of cement such as 0.5%, 1%, 1.5%, and 2% nano-silica in M30 mix .In addition to saving resources and decreasing CO2 emissions, nano-silica improves the strength, hardness, durability, permeability. Mechanical properties were measured on cast concrete specimens after seven and twenty-eight days. The use of nanosilica in concrete has significant advantages over conventional concrete. Peng Zhang .et.al., [5] focused on the different properties;of coal fly ash concrete after adding nano-silica particles (NS). With ideal values of 2 to 3%, NS (one to five percentages by binding percentage) significantly increased mechanical strength. The concrete's brittleness remained unchanged but impact resistance improved. At 2-3% NS, durability, including resistance to freezing and thawing and penetration of chlorides, was at its optimum. Elevated levels of NS may have an adverse effect on several attributes. The most significant impacts are obtained with a 2.5% NS dosage; compressive and tensile strength increase by 6.6%/ and 15.15 percent after 28 days respectively. When added to concrete at 2.5% and 2% dosages, NS increases the material's resistance to chloride ions and enhances its impermeability. In particular, NS enhances the interfacial transition zone, encourages hydration, and improves pore structure. It provides a sustainable way to cut down on cement usage and increase the longevity of concrete, especially in coastal projects. [6] 2021 HishamShah.et.al.,[7] 2022 concentrated on the various amounts of colloidal nanosilica (CNS) influenced the properties of cement composites reinforced with coconut coir. It was found that adding 4% CNS considerably improved the fibre/matrix bonding and pozzolanic methods, which in turn improved the flexural strength and microstructure of the samples. Higher CNS doses, however, reduced performance because they prevented hydration. With excellent findings at 4% CNS, CNS addition decreased CH content while boosting C-S-H gel formation. After this focus, no more advantages were noticed. Paktiawal.A.et.al.,[8] 2020 provides a critical overview of how Nanosilica (NS) affects cement concrete's characteristics. Results from experiments show that adding NS to concrete in part instead of cement increases hydration, decreases porosity, and greatly increases strength and durability. When compared to smaller particles, medium-sized NS (40 nm) performs better, offering higher dispersion and compressive strength. By using waste materials, NS can also support sustainable building practices. Additionally, by learning more about steam curing techniques, its uses may grow. The present research project focused on the effects of adding nano silica to concrete of grade M25. The primary goal is to comprehend the effects of varying nanosilica concentrations on the mechanical features of concrete. After testing various mixes and assessing their mechanical properties, the goal is to identify the mix with the best overall performance and compare it to others.

2. Materials

Preliminary testing was done on cement, fine Aggregate, and Coarse Aggregate; test results were obtained.

2.1 Cement

The OPC 43 grade Zuari Cement is utilize for specimen. It confirming to IS 8112: 1989. The test outcomes as displayed in the table 1.

Table 1 Properties of Cement

Sl No.	Properties	Values obtained
1	Fineness	225 m^2/kg
2	Setting time	35mins {Initial setting time} 410mins {Final setting time }
3	Standard consistency	32
4	Soundness	1.5mm
5	Compressive strength 3 days 7 days 28 days	22.47Mpa 34.05Mpa 48.23Mpa
6	Specific gravity	3.01

2.2 Fine Aggregate

M-sand that conforms with IS 383-1970 zone II and is easily accessible locally. The features of the fine aggregate are displayed in Table 2. Manufactured sand has a particle size of less than 4.75 mm.

Table 2 Characteristic of Fine Aggregate

Sl No	Properties	Fine Aggregate
1	Specific gravity	2.53
2	Fineness Modulus	2.31

2.3 Coarse Aggregate

The coarse aggregate maximum particle size of 12.5 mm is utilized, Table 3 represents the outcome of the experiment studies conducted for figure out the features of the coarse aggregate in accordance with IS 2386-1983 & IS 383-1970.

Table 3 Characteristics of Coarse Aggregate

Sl No	Properties	Coarse Aggregate
1.	Specific Gravity	2.61
2.	Fineness Modulus	7.71

2.4 Nanosilica

Astra Chemicals Chennai supplied the nanosilica, which is seen in Figure 1, and has indicated that it consists of 99.88% pure SiO2.The Table 4 lists the physical characteristics that have been gathered from the supplier's data sheet.

Figure 1 Nanosilica

Table 4 Physical Characteristics of Nanosilica

Property	Nature or value
Color	White
Surface Area (m^2/g)	202
PH	4.12
Particle size	10-20 nm
Specific gravity	2.4
Unit weight kg/m^2	505

2.5 Water

The water used was potable (tap water obtained from the university laboratory) and fulfilled IS: 456-2000 standards. During the concrete mixing process, the required quantity of water was calculated and added to the dry mixture using a graduated jar.

3. Discussion of Test Results

3.1 Compressive Strength

The IS516-1959 standard code was followed for conducting the testing. The compressive strength results for all different concrete mixes pro duced on a standard cube specimen size 150 mm b y 150 mm by 150 mm and cured for 7, 14, 28, and 56 days are shown in figure 2. The (figure 3) below illustrates how the percentage of nanosilica in the concrete mix impacts the compressible strength of concrete. It has been demonstrated that strength increases noticeably in concrete by adding nanosilica with a limited percentage in place of cement. However, when the percentage increases, the strength decreased and optimal percentage of nanosilica which enhanced the strength properties is about 1.5%. As shown in figure 2. the optimum strength of about 38.23 MPa and 42.53 MPa at 28 days and 56 days respectively obtained for 1.5% of nanosilica compared to all other mixes.

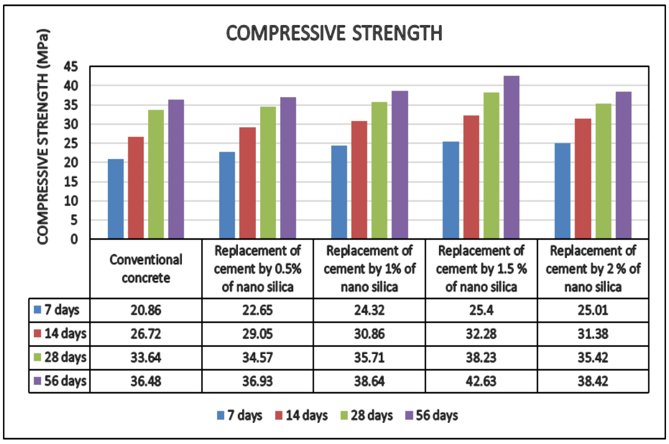

Figure 2 Compressive Strength Test Result

3.2 Split Tensile Strength

For cylindrical specimens (300 mm high by 150 mm wide), split tensile strength tests were performed at the age of 28 days. A compression testing equipment with an operating limit of 200 tons, places a cylindrical object between its loading

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1678- 1682
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0231

surfaces in a horizontal orientation, and then applies stresses until the cylinder breaks along its vertical diameter. Split tensile strength variation for distinct % of nanosilica at twentieth days are shown in figure3, the maximum strength was obtained for 1.5% replacement of nanosilica of about 3.95 MPa.

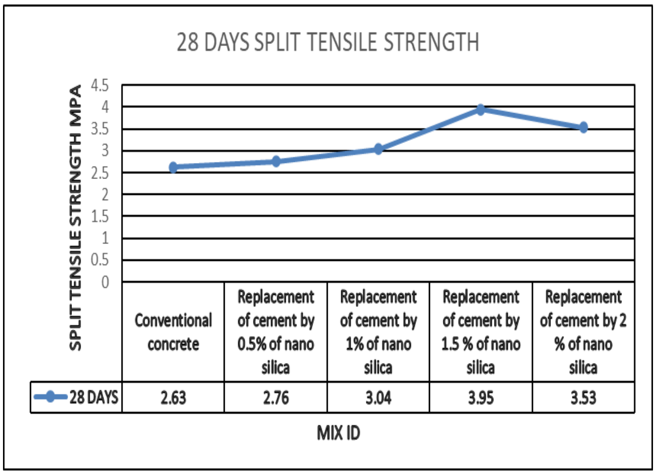

Figure 3 **Split Tensile Strength at 28 Days**

3.3 Flexural Strength

Concrete flexural strength was evaluated using prisms with dimensions of 100mm x 100mm x 500mm after a 28-days cure time. To evaluating the flexural strength of concrete prisms, 2-point loading stress was applying to the prisms and the failure stress was taken into account. The table 4 shows test results are.

Table 4 **Result for Flexural Strength Test**

Sl No	MIX ID	Flexural strength MPa
1	CS	5.54
2	N0.5	6.03
3	N1	6.76
4	N1.5	7.82
5	N2	7.43

Flexural strength variation for different percentages of nanosilica at twenty-eight days are shown in table (4), the maximum flexural strength of about 7.82 MPa obtained for 1.5% replacement of nanosilica compared to all other mixtures.

3.4 Water Absorption

Low permeability indicates high-quality concrete, particularly in terms of resistance to freezing and thawing. An absorption test was conduct with reference to the BS 1881: PART122:1983 standard code after twenty-eight days. Concrete cubes of dimension fifteen by fifteen-by-fifteen centimeters were used for the water absorption test. They must be dried for at least 24 hours at 100 degrees Celsius in an oven, then remove the oven and let it cool. To a temperature of 20 to 29 degrees in dry air to find their mass. If there is a difference between the values obtained from two sequential mass values that is greater than 0.5% of the total, then return the specimens to the oven for another 24 hours of drying. Figure 4 illustrates that Nanosilica concrete have a less water absorption of about 1.26%.

$$\%WA = ((\Delta_2 - \Delta_1)/\Delta_1) * 100$$

Δ_1 & Δ_2 - Dry and wet weight of specimens

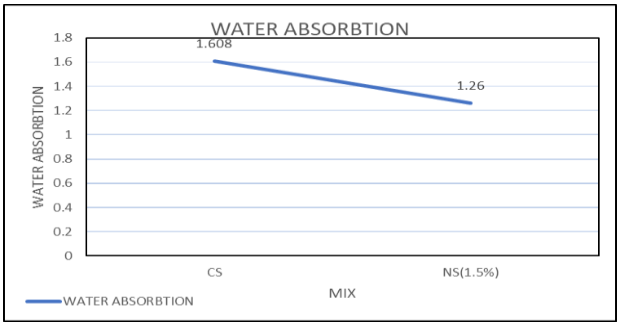

Figure 4 **Water Absorption at 28 Days**

3.5 Chlorination Test

A common technique for determining the amount of chlorine that has penetrated into a concrete sample is the calorimetric chlorination test. For each mix, a minimum of two cases of dimension 15cm x15cm x 15cm are taken into consideration. 28 days of water cure require removing the samples from the water. allowed to air dry, and then immersed in water containing roughly 3.5% sodium chloride (NaCl). The specimens are removed from the NaCl solution after 28 days. The samples are divided into two equal halves after being allowed to dry at room temperature. The specimens are immediately sprayed with a 0.1 M solution of silver nitrate ($AgNO_3$) (broken portion). As a result, a white

International Research Journal on Advanced Engineering Hub (IRJAEH)
e ISSN: 2584-2137
Vol. 02 Issue: 06 June 2024
Page No: 1678- 1682
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0231

precipitate formed on the samples. The test findings are shown in table 5.

Table 5 Chlorination Test Result

Sl No	Mix	Depth Of Penetration
1	CS	8.52 mm
2	N1.5	5.31mm

As mentioned in above table, replacement of cement with 1.5% of nanosilica found to be less depth of penetration of about 5.31mm.

Conclusions

Substantial new information about how nanosilica affects cement concrete aspects is provided by the test findings. Based on Mechanical and Durability properties of concrete,

1. It is observed that mineral admixtures like nano silica can be utilise as a partial replacement of cement in concrete production to enhance its features. The optimum percentage of about 1.5% of nano silica exhibited superior properties, including increased strength and durability.
2. Considering the concrete's mechanical characteristics, including its split tensile, flexural, and compression strengths, it is evident that replacement a modest amount (1.5% by weight of cement) of nanosilica to cement concrete increases its compressive, split tensile & flexural strength by 13.64 %, 50.19 % & 41.15 % respectively compared with conventional concrete (M25).
3. From the Durability tests, incorporating nanosilica into concrete significantly enhances its durability, observed by lower water absorption of about 1.26% and reduced chlorine penetration depth of about 5.31 mm compared to conventional concrete.

Acknowledgement

The present study was conducted at Bangalore University, UVCE, Bangalore, Karnataka-560056.

References

[1] S. Gopinath, P.Ch. Mouli ,A.R. Murthy.et.al., "Effect of Nano Silica on Mechanical Properties and Durability of Normal strength concrete" Archives Of Civil Engineering, Lviii, 4, 2012

[2] Akash Kumar, Gurpreet Singh "Effect of Nano Silica on the Fresh and Hardened Properties of Cement Mortar" International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 13 (2018) pp. 11183-11188

[3] MohanRaj.B,SugilaDevi.G "Experimental Investigation on Nano Concrete with Nano Silica and M-Sand" International Research Journal of Engineering and Technology (IRJET) Volume: 06 Issue: 03 | Mar 2019

[4] Mohammed Ayub Ghori, Syed Ahmed Uddin Fahad, Mohammad Zeeshan, Mr. K Sri Charan "An Experimental Investigation on the Effect of Nano- Silica Particles on the Properties of Concrete" International Research Journal of Engineering and Technology (IRJET) Volume: 08 Issue: 04 | Apr 2021

[5] Zhang, P.; Sha, D.; Li, Q, Zhao, S, Ling, Y "Effect of Nano Silica Particles on Impact Resistance and Durability of Concrete Containing Coal Fly Ash". Nanomaterials 2021, 11, 1296. https://doi.org/10.3390/nano11051296

[6] Changjiang Liu.et.al.,"Effect of nano-silica as cementitious materials reducing admixtures on the workability, mechanical properties and durability of concrete" Nanotechnology Reviews 2021; 10: 1395–1409.

[7] M. H. S. Hisham Shah, C. C. Lee .et,al., "Colloidal Nanosilica Effect on the Properties and Durability of Coir Reinforced Cement Brick" Hindawi Advances in Materials Science and Engineering Volume 2022, Article ID 7610297, https://doi.org/10.1155/2022/7610297

[8] A Paktiawal , and M Alam 'Silica and its Role on Performance of Cement Concrete a Review of Experimental Investigation" IOP Conf. Series: Earth and Environmental Science 614 (2020) 012085.