THE EXPERIMENTAL STUDY OF EFFECTS OF NANO SILICA ON COMPRESSIVE STRENGTH OF CONCRETE

[1]A.Gayathri, [2]G.Veerababu, [3]P.Ramu, [4]SK.Aleem, [5]S.Vishwanath

[1, 2, 3, 4] B. Tech, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Parvathapur, Uppal, Hyderabad, Telangana, India
[5]Sr. Assistant Professor, Dept. of Civil Engineering, Aurora's Technological and Research Institute, Parvathapur, Uppal, Hyderabad, Telangana, India

Abstract:

The application of nano technology in concrete has added a new dimension to the efforts to improve its properties. Concrete is the most common material for construction. The total production depends upon the cement content only. Due to the usage, large amount of cement produces increasing the CO2 emissions, to reduce the cement percentage in concrete mixes the nano silica (nSiO2) is used as the replacement of the cement.
The use of alternative materials and techniques in concrete production has gained significant attention in recent years due to need for sustainable and durable construction practices. This project aims to provide a comprehensive understanding of the concrete incorporating nano silica, exploring its performance in terms of strength.
Keywords: Concrete, Nano silica, Compressive strength, Tensile strength and Workability.

1.0 INTRODUCTION

Concrete is the material of present as well as future. Out of 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.
The increased use of cement is essential in attaining a higher compressive strength. But, cement is a major source of pollution. The use of nanomaterials by replacement of a proportion of cement can lead to a rise in the compressive strength of the concrete as well as a check to pollution.

Motivation of the study

The increased use of cement is essential in attaining a higher compressive strength. But, cement is a major source of pollution. The use of nanomaterials by replacement of a proportion of cement can lead to a rise in the compressive strength of the concrete as well as a check to pollution. Since the use of a very small proportion of Nano SiO2 can affect the properties of concrete largely, a proper study of its microstructure is essential in understanding the reactions and the effect of the nanoparticles. This study is an attempt to explain the impact of a nano-silica on the compressive strength of concrete.

Objective of the study

The main objectives of the present study are as mentioned below:

- To study the effect of nano-silica on the compressive strength of concrete.
- To study the effect of nano-silica on the tensile strength of concrete.
- To explain the change in properties of concrete.

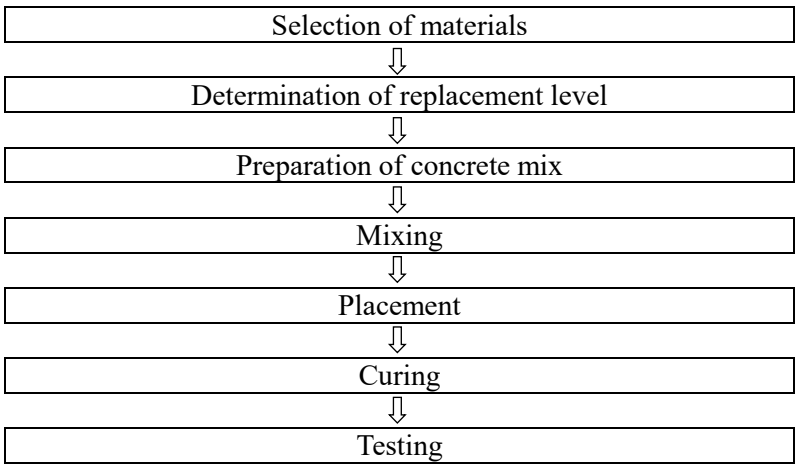
Scope of work

The present study incorporates mix design based on the guidelines as per Indian Standard code IS 10262-2009. The nano-silica used is imported from a supplier. The use of any kind of admixture is strictly prohibited in the mix design. The water content has been kept constant to facilitate a better comparison for different samples. The compressive strength measurements are carried out for 7-day and 28-day.

2.0 LITERATURE REVIEW

As mentioned earlier, need for the present study is ascertained on the basis of research reports that are available on compressive strength of concrete containing cement replacement with nano silica. In order to plan the experimental program and attain the objectives defined, a comprehensive literature survey is essential. Hence in the following text detailed literature review on compressive strength of concrete is presented. **Rajput & Pimplikar [1]:** He conducted research which showed that increasing the concentration of nano-silica in M30 and M40 grade concretes decreased the absorption of water. The addition of nano-silica to the cement composites improved the pore structure, resulting in reduced water absorption values and improved durability. **Mustakim Et Al. [2]:** He discovered that adding 1.5% nano-silica, in addition to silica fume, to geopolymer concrete improved the microstructure and resulted in outstanding strength under compression, presumably because of the quick alkali activation process of geopolymer concrete. **Alhawat and Ashour [3]:** He noted that adding 1.5% nano-silica to concrete instead of cement boosted bond strength and corrosion resistance. **Elkady Et Al. [4]:** He studied how different nano-silica dosages affected the structural behavior of concrete. The findings revealed that using a 4.5% dosage of nano-silica caused a 13.5% rise in the compressive strength after seven days, compared to the standard group. According to him, the study suggested that nano-silica particles agglomerated and prolonged the interaction time with the excess (CH), leading to the creation of CSH gel. These aggregated particles served as fillers, lowering porosity and boosting strength at an early age. **Balasundaram Et Al [5]:** He noticed that the influence of Nano-Silica on various properties of concrete is obtained by replacing the cement with various percentages of Nano Silica. Nano Silica is used as a partial replacement for cement in the range of 2.5%, 3%, and 3.5% for M25 mix. Results indicate that the concrete, strength increased by consuming Nano-Silica. **Mohammadmehdi Choolaei Et Al [6]:** In this study, the interaction of nano-SiO2 in cement-sand mortar was experimentally investigated. No additional water was used in the designed slurry accumulation. The results showed that the use of this nano-SiO2 shortened the curing time and stationary phase length of concrete. Also reported that the porosity of cements designed using nano-SiO2 showed a decrease in cement porosity as the amount of nano-SiO2 was increased in the investigated slurries.

3.0 METHODOLOGY



Materials used: The materials utilized in the test program are Cement, Coarse Aggregates, Fine Aggregates, Water, Nano Silica.

Nano Silica: Use of nano-materials, particularly nano-silica as supplementary cementitious material, in manufacturing of paste, mortar, and concrete offer the potential of producing materials with new and interesting properties, such as enhanced strength and durability properties.

Tests on cement:

Name of test	Obtained Results
Fineness	4.5%.
Consistency	32%
Initial setting	30 min
Final setting	600 min
Specific gravity	2.31

Fig 3.1: Tests on Cement

Tests on coarse aggregate:

Name of test	Obtained Results
Sieve Analysis	3.52
Flakiness Index	5.74%
Elongation Index	10.91%
Specific Gravity	2.569
Water Absorption	0.466%
Aggregate Crushing Value	9.24%
Aggregate Impact Value	16.25%

Fig 3.2: Tests on Coarse Aggregate

Tests on fine aggregate:

Name of test	Obtained Results
Sieve Analysis	6.3139.
Specific gravity	2.46.
Water Absorption	3.358
Bulking of Sand	5.26%

Fig 3.3: Tests on Fine Aggregate

4.0 MIX DESIGN

Concrete mix design is the process of determining the proportions of the various components that need to be combined to create a concrete mix with the desired properties. The mix design takes into consideration factors such as the strength, durability, workability and desired appearance of the concrete, as well as the specific materials being used.

Mix design for M25 grade of concrete

The mix proportioning for a concrete of M25 grade is given in following steps.

Stipulations for proportioning

Grade of designation	: M25
Type of cement	: OPC 53 grade
Maximum nominal size of aggregate	: 20 mm
Workability	: 100 mm (slump)
Method of concrete placing	: Pumping
Type of aggregate	: Crushed angular aggregate

As per the calculations of mix design following are the quantities of materials required for preparing the cubes and cylinders.

Water =7.388 kg
Cement =16.791 kg
Fine Aggregate= 19.826 kg
Coarse Aggregate =39.381 kg
Nano silica = 3%, 5%, 7% of cement quantity

Mixing of Concrete:

Mixing of concrete refers to the process of combining all the ingredients needed to make concrete in a uniform and consistent manner. It ensures an adequate mix proportion of concrete. Concrete is made from a mixture of cement, water, sand, and aggregates, such as gravel or crushed stone. The process of mixing these ingredients together ensures that the concrete will be strong, durable, and have the desired consistency for its intended use. The mixing of concrete typically takes place in a concrete mixer, a machine that agitates the ingredients to ensure that they are thoroughly blended.

Tests on Concrete Workability:

Concrete workability basically refers to how easily freshly mixed concrete can be placed, consolidated and finished with minimal loss of homogeneity.

S. No	Type of Test	Result	Remarks
1	Slump Cone Test	9.8 (mm)	Shear
2	Compaction Factor Test	0.96	Highly Workability

Casting of Cubes:

The specimen of standard cube of (150mm x 150mm x 150mm) were used to determine the compressive strength of concrete. Three specimens were tested for 7 days & 28 days with each proportion of replacements. Totally 24 cubes were cast for the strength parameters. The

constituents were weighed and the materials were mixed by hand mixing. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 days & 28 days and then tested for its compressive strength as per Indian Standards.

Casting of Cylinders:

The specimens of standard size of cylinder diameter of 150mm and height of 300mm were used to determine the Split Tensile Strength of Concrete. Two specimens were tested for 7 days & 28 days with each proportion of replacements. Totally 8 Cylinders were cast for the strength parameters. The constituents were weighed and the materials were mixed by hand mixing. The concrete was filled in different layers and each layer was compacted. The specimens were demoulded after 24 hrs, cured in water for 7 days & 28 days and then tested for its split tensile strength as per Indian Standards.

Curing of Cubes and Cylinders:

The cubes and cylinders were stored in a dry environment at a temperature and allowed to cure for an initial 24 hours. Then, they are removed from the forms and marked for identification. Then they are placed in curing baths and curing is continued for the required testing period.

Fig 4.1: Mixing of Materials

Fig 4.2: Filling the Moulds

Fig 4.3: Leaving the Moulds to Dry

Fig 4.4: Demoulding

Fig 4.5: Curing the Specimens

5.0 TESTING AND RESULTS

Compressive Strength Test:

The compression test was conducted according to IS 516-1959.This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of the concrete cube will meet the required compressive strength requirements or not. The following testing procedure was undertaken during the cube compression testing. For the compression test, the cubes of 15 cm x 15 cm x 15 cm were prepared. The measuring and testing of test specimens were undertaken as soon as possible after being removed from curing tank. All specimens were tested in a wet condition and excess water removed from the surface. The dimensions of the test specimens were measured and recorded. The platens were cleaned when necessary to ensure no obstruction from small particles or grit. These specimens were tested under universal testing machine after 7 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm^2 per minute till the specimen fails. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

Compressive Strength Test Results of Concrete Cubes

S. No	Sample	7-days strength	28-days strength
1	Nominal	27.7	34.81
2	3% cement replacement	29.5	35.55
3	5% cement replacement	27.8	39.8
4	7% cement replacement	24.5	31.3

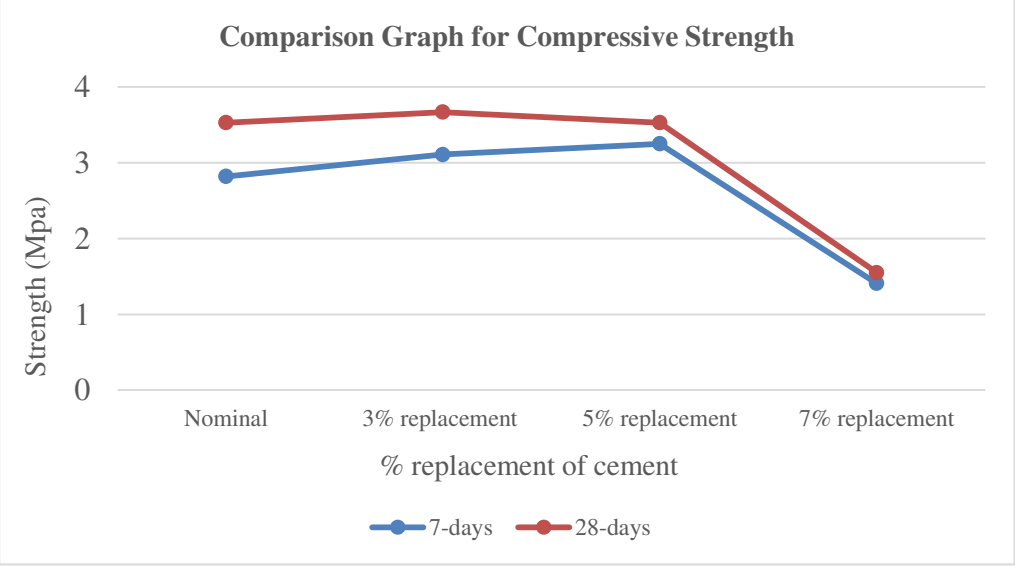


Fig 5.1: Comparison Graph for 7-days & 28-days Compressive Strength

Fig 5.2: Testing of Cubes

Split Tensile Strength Test:

The split tensile strength at which failure occurs is the tensile strength of concrete. In this investigation the test is carried out on cylinder by splitting along its middle plane parallel to the edges by applying the compressive load to opposite edges as per IS: 516-1959. The following testing procedure was undertaken during the cylinder split tensile strength testing. After curing, wipe out water from the surface of specimen and measure the dimensions of the specimen. Align the specimen in such a way that the ends are vertical and centered over the bottom plate. Apply the load continuously without shock and write the breaking load (P).

Split Tensile Strength Test Results of Cylinders

S. No	Sample	7-days strength (Mpa)	28-days strength (Mpa)
1	Nominal	2.82	3.53
2	3% cement replacement	3.11	3.67
3	5% cement replacement	3.25	3.53
4	7% cement replacement	1.41	1.55

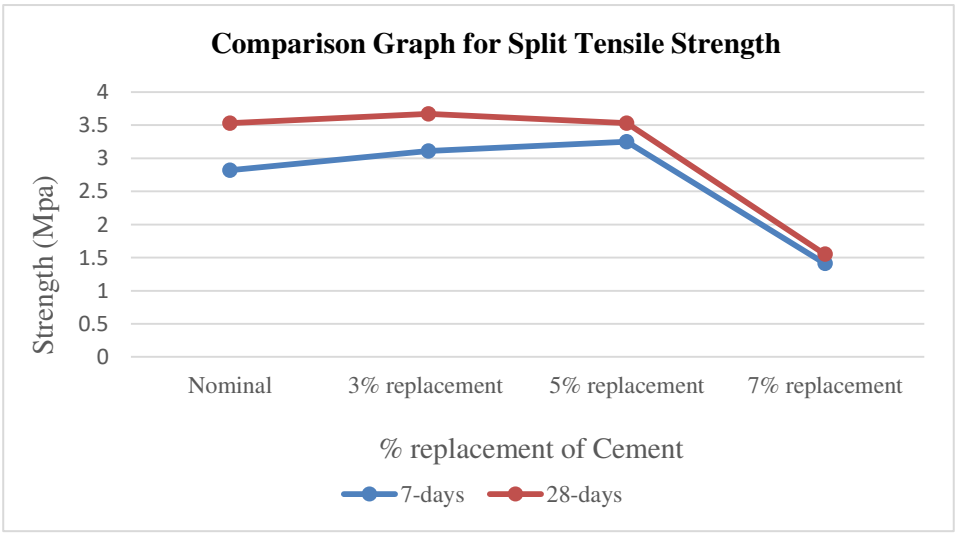


Fig 5.3: Comparison Graph for 7-days & 28-days Split Tensile Strength

Fig 5.4: Testing of Cylinders

6.0 CONCLUSION

- Based on current project, it can be concluded that the use of nano silica as a partial replacement for cement can improve the strength and durability of concrete.
- From the compressive strength results, it can be observed that increase in compressive strength of concrete is observed on addition of 3%, 5%, 7% quantity of Nano Silica ($NSio_2$).
- The increase in strength of concrete is maximum for 3% and 5% cement replacement with nano silica and least for concrete with 7% cement replacement with nano silica
- On addition of Nano silica ($nsio_2$) there is substantial increase in the early age-strength of concrete compared to the 28 day increase in strength.
- Even a small amount of nano-silica particles can increase the strength of concrete.

7.0 FUTURE RESEARCH

The following further works are suggested based on the evaluation.

1. It is important to assess the engineering characteristics of concrete with nano silica added, such as bond, creep, shrinkage, etc.
2. A standard mix design method for nano silica added concrete should be established to ensure consistency in the production process.
3. Thorough research is needed to optimize nano silica added concrete and create mathematical models that can predict concrete behaviour accurately.

8.0 REFERENCES

1. Balasundaram Et Al (2016), Influence of nano silica on various properties of concrete.
2. Mohammadmehdi Choolaei Et Al (2018), Investigation on the interaction of nano silica in cement-sand mortar.
3. D.S Teja Et Al (2019), Study of mechanical properties of concrete using nano silica as cement replacement.
4. Elkady Et Al (2019), The Structural behaviour of concrete with different dosage of nano silica.
5. Alhawat and Ashour (2020), Effect of nano silica on concrete and cement.
6. Rajput & Pimplikar (2022), Effect of concentration of nano silica on different grades of concrete.
7. IS: 456 – 2000 - Plain & reinforced concrete code of practice.
8. IS: 383-1970 – Specification for coarse and fine aggregate from natural sources for concrete.
9. IS: 10262 – 2009 – Concrete mix design
10. IS: 516 – 1959 – Methods of tests for strength of concrete. Indian Standards Institution, New Delhi.