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Experimental Study on Partial Replacement of Cement with Nano Silica

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Abstract:
Cement is a building material made by grinding calcined limestone and clay to a fine powder, which can be mixed with water and poured to set as a solid mass. However it is expected that the use of Nano-silica in concrete improve the strength properties of concrete. Nano silica is used in concrete to enhance its properties such as compressive strength and tensile strength. When added to concrete, nano silica particles react with the calcium hydroxide to form additional calcium silicate hydrate, which helps to improve the concrete's strength. This can result in concrete with improved resistance to cracking and corrosion, and with a longer service life. An experimental objective has been carried out by replacing the cement with Nano silica by 0%, 0.5%,1.0%, 1.5%, 2.0%, 2.5% for M30 grade of concrete. The test conducted on it shows a considerable increase in early-age compressive strength and a Split Tensile strength of concrete on 7th day, 14th day and 28th day of curing. The final outcome of the project will have an overall beneficial effect on the utility of Nano-silica concrete in the field of civil engineering construction work.

Keywords: Nano silica, Compressive Strength, Tensile Strength.

INTRODUCTION

Partial replacement of cement with nano silica is a technique that is used in concrete production to improve its mechanical properties and durability. Nano silica, also known as nano silicon dioxide or colloidal silica, is a type of amorphous silica with particles that are typically less than 100 nano meters in size.

When nano silica is added to cement, it reacts with the calcium hydroxide produced during the hydration process to form additional calcium-silicate-hydrate (C-S-H) gel. This gel fills the micro-pores in the concrete matrix and enhances the overall strength and durability of the material.

Moreover, using nano silica as a partial replacement of cement can also reduce the porosity of the concrete, which helps to improve its resistance to water penetration, freeze-thaw cycles, and chemical attack. Additionally, the use of nano silica can also help to reduce the carbon footprint of concrete production since it requires less cement to achieve the desired properties.

However, it is important to note that the effectiveness of the partial replacement of cement with nano silica depends on several factors such as the quality of the nano silica used, the curing conditions, and the specific application requirements. Therefore, it is essential to conduct proper testing and evaluation to determine the optimal replacement level for each particular case.

1.2 OBJECTIVES OF THE PROJECT:

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 microstructure of the hardened cement concrete.
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1.3.MATERIALS:

The materials required for the partial replacement of cement with nano silica include:

a) Cement
b) Nano silica
c) Coarse Aggregates
d) Fine Aggregates
e) Water
f) Admixtures

Cement: The primary material in concrete production, which is partially replaced with nano silica.

Fig-1:CEMENT

Nano silica: A type of amorphous silica with particles that are typically less than 100 nano meters in size. Nano silica is added to the concrete mix as a partial replacement for cement.

Fig-2:NANO SILICA

Water: Water is added to the concrete mix to activate the cement and allow it to harden.

Fig-3:WATER

Aggregates: Coarse and fine aggregates such as sand and gravel are added to the concrete mix to provide bulk and stability to the material.

Fig-4:SAND&AGGREGATES

Admixtures: Chemical additives such as plasticizers and superplasticizers can be added to the concrete mix to improve its workability and reduce water content.

The type and quality of the materials used in the partial replacement of cement with nano silica can have a significant impact on the properties and performance of the resulting concrete.

Therefore, it is important to carefully select and test the materials used to ensure that they meet the specific requirements of the application. Additionally, the proper mixing, placement, and curing of the concrete are also important factors that should be considered to ensure optimal performance.

2. LITERATURE REVIEW

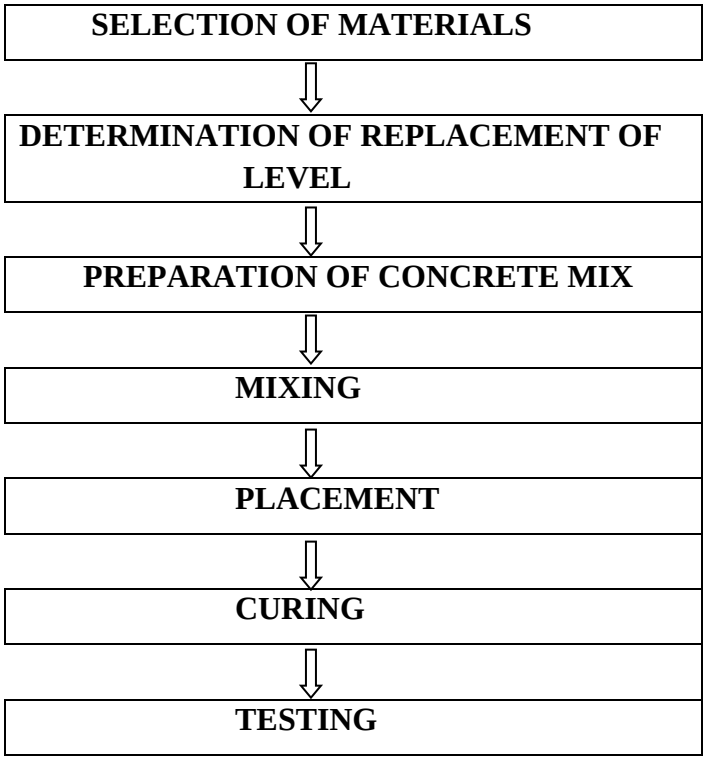
1.Nanotechnology is the science of engineering that deals with particle which are less than 100 nm in size. It is the study of manipulating matter on molecular and atomic scale. In civil engineering and construction, the nanotechnology is applied in (I) concrete for reducing segregation in self compacted concrete, the use of copper nano-particles in low carbon HPS is remarkable, the use of nano sensors in construction phase to know the early age properties of concrete is very useful. Amit Srivastava, Kirti Singh, 2011.

Nanotechnology in civil engineering and construction: a review on state of the art and future prospects, indian geotechnical society, 1077-1080 methodology:

2.Nanotechnology is one of the most active research areas that encompass a number of disciplines, including civil engineering and construction materials. The potential for application of many of the developments
in the nanotechnology field in the area of construction engineering has been growing. It also discusses the
application of instruments to reach material properties of nano-scale. Furthermore, it has been observed that better understanding and engineering of complex structures made by cement, steel or composite materials at nano-level will definitely result in a new generation of construction materials with higher

performance in strength, durability, and other properties.
Ali Akbar Firoozi, Mohd Raihan Taha, Ali Asghar Firoozi,2014, Nanotechnology in Civil Engineering, EJEG, volume -19 ,4673-4682.

3.METHODOLOGY



Selection of materials: The first step is to select the appropriate materials for the concrete mix, including cement, nano silica, aggregates, and water. The quality of these materials should be carefully evaluated to ensure that they meet the specific requirements of the application.

Determination of replacement level: The next step is to determine the optimal replacement level of cement with nano silica. This can be determined through a series of tests on concrete samples with varying levels of nano silica.

Preparation of concrete mix: Once the replacement level is determined, the concrete mix can be prepared by adding the appropriate amounts of cement, nano silica, aggregates, water, and any admixtures needed to improve workability.

Mixing: The concrete mix should be thoroughly mixed to ensure that all components are evenly distributed and that the nano silica is uniformly dispersed throughout the mix.

Placement: The concrete mix can then be placed into the desired formwork or molds using standard construction techniques.

Curing: After placement, the concrete should be cured for a period of time to allow it to harden and develop its full strength and durability. Proper curing is essential for achieving optimal performance.

Testing: Finally, the resulting concrete should be tested to evaluate its mechanical properties and durability. This can include tests such as compressive strength, tensile strength, and permeability tests.

Overall, the methodology for partial replacement of cement with nano silica in concrete involves careful selection and testing of materials, determination of the optimal replacement level, preparation and mixing of the concrete, proper placement and curing, and thorough testing to evaluate performance. Proper implementation of these steps can result in a high-quality concrete with enhanced properties and improved sustainability

4. RESULTS

TEST RESULTS ON THE CEMENT

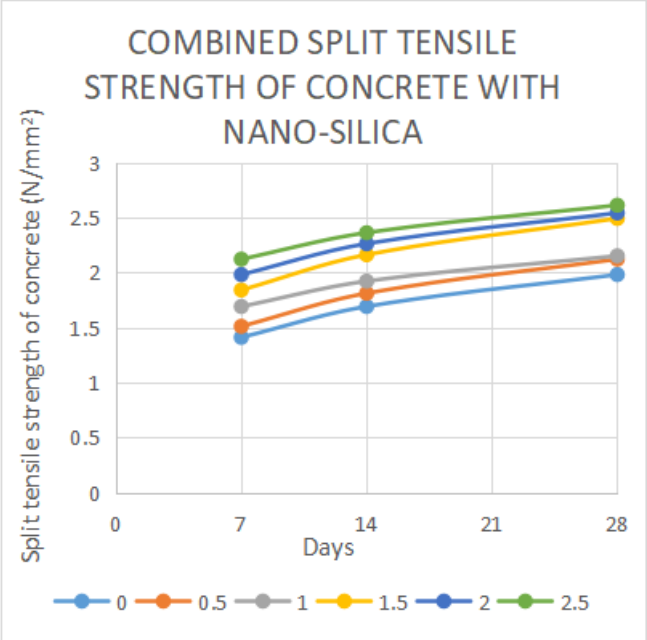
CEMENT TEST	RESULT
Initial Setting Time	30 Min
Final Setting Time	9Hrs
Fineness %Test	5%
Normal consistency	28

TEST RESULTS ON AGGREGGATES

AGGREGATE TEST	RESULT
Bulk Density	1960kg/m^3
Specific gravity of Coarse Aggregate	2.78
Specific gravity of fine Aggregate	2.64
Aggregate Impact Value	20

TENSILE STRENGTH TEST

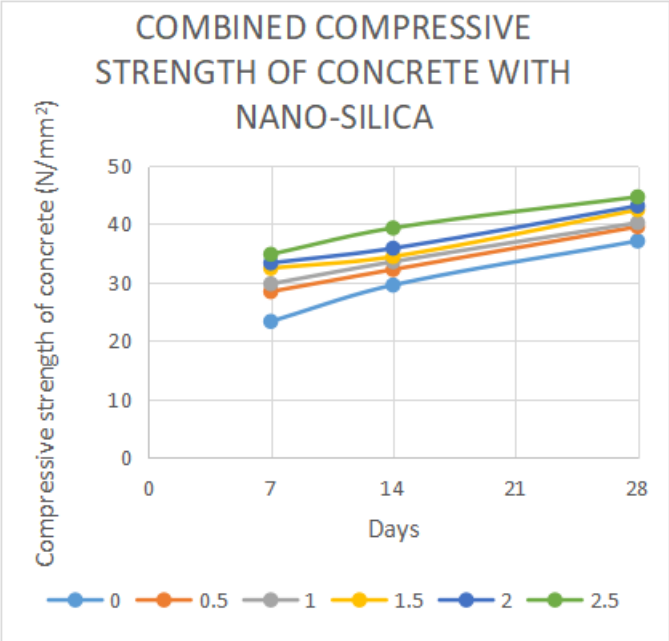
The combined graph 1 shows the variation of tensile strength from 7 days,14days, 28 days by replacing the cement with nano silica.The material has been collected and used as partial replacement of cement with nano silica.because the cement has a pozolana property.The mix proportions of nano silica replaced with ement are taken as 0%,0.5%,1%,1.5%,2%,2.5% and split tensile strength test results are 1.98N/mm ,2.12N/mm^2,2.15N/mm^2,2.49N/mm,2.54N/mm^2,2.61N/mm^2,on 28th day respectively the split tensile strength of concrete using nano silica increases up to use of 2.5% replacement of cement and after 2.5% strength of concrete deduces the maximum result is by replacing 2.5%of cement by nano silica2.12N/mm^2,2.36N/mm^2,2.67N/mm^2,on7th,14th and 28th day curing.



COMPRESSIVE STRENGTH TEST

The combined graph 2 shows the variation of compressive strength from 7 days ,14days 28 days by replacing the cement with nano silica.The material has been collected and used as partial replacement of cement with nano silica.because the cement has a pozolana property.

The proportions of nano silica replaced cement are taken as 0%,0.5%,1.0%,1.5%,2.0%,2.5% and compressive test is 37.11N/mm^2, 39.55N/mm^2,40.22N/mm^2,42.44N/mm^2,43.11N/mm^2,44.66N/mm^2 on 28th day respectively the compressive strength of concrete using nano silica increases upto use of 2.5% replacementof cement after 2% strength of concrete deduces.The maximum result is by replacing 2.5% of cement by nano silica is 34.88N/mm^2,39.33N/mm^2,44.66N/mm^2 on 7th day 14th day and 28th day curing.



5.CONCLUSION:

The partial replacement of cement with nano silica has been a topic of interest in recent years due to the potential benefits it can offer to the construction industry. Based on current research, it can be concluded that the use of nano silica as a partial replacement for cement can improve the strength and durability of concrete.

Nano silica has been found to fill the pores and voids in the cement matrix, resulting in a denser and more compact structure. This not only enhances the mechanical properties of the concrete but also improves its resistance to environmental factors such as water, chemicals, and abrasion.

Furthermore, the use of nano silica can reduce the amount of cement needed in concrete production, which can lead to a reduction in carbon emissions and a more sustainable construction industry.

However, it is important to note that the cost of nano silica is currently higher than traditional cement, which can limit its widespread use. Additionally, further research is needed to fully understand the long-term effects of using nano silica in concrete and to optimize its dosage and mixing procedures.

Overall, the partial replacement of cement with nano silica shows promise as a viable solution to improve the properties of concrete, but more research and development are necessary to fully realize its potential.

1.The Compressive Strength of partially replaced cement by nano silica concrete of grade M 30 for proportions of 0%, 0.5%, 0.10%, 1.5%, 2%, 2.5% and 37.11MPa, 39.55MPa, 40.22MPa, 42.44MPa, 43.11MPa, 44.66MPa and respectively at 28th day of curing. The Compressive Strength increases upto 2.5% use of nano- silica.

2.The Split Tensile strength of partially replaced

cement by nano silica concrete of grade M 30 for proportions of 0%, 0.5%, 0.10%, 1.5%, 2%, 2.5% are 1.98MPa, 2.12MPa, 2.15MPa, 2.49MPa, 2.54MPa, 2.61MPa and respectively at 28th day of curing. The Split tensile Strength increases upto 2.5% use of nano- silica further it starts decreasing.

3. With the use of 2.5% of Nano-Silica concrete gives the maximum result in compression as 34.83MPa, 39.33MPa and 44.66MPa at 7th day, 14th day and 28th day of curing respectively.

4.With the use of 2.5% of steel fibre gives the maximum result in Split Tensile Strength as 2.12MPa, 2.36MPa and 2.61MPa at 7th day, 14th day and 28th day of curing respectively.

5. Even a small amount of nano-silica particles can increase the strength of concrete.

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