

# An Experimental Investigation on Strength Properties of Concrete Containing Micro-Silica and Nano- Silica

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**Abstract** - Concrete is one of the most common used material for construction industry and their design consumes almost the total cement production in the world. The excess use of cement produces increasing CO<sub>2</sub> emissions, and it leads to green house effect. The use of silica fines is a method to reduce the cement content in concrete mixes and one of the silica fines with high potential as a cement replacement in concrete additive is nano-silica. In this project an attempt has been made to improve the strength characteristics of concrete with the addition of Nano-silica resulting in the enhancement of the mechanical properties of the concrete mix which acts as a filler to improve the microstructure and also act as an activator to promote pozzolanic reaction. The experiments are conducted by replacing the cement by mixture of nano silica and microsilica at different percentages. A comparative study also carried with laterite sand and M sand with replacement of river sand. Different strength characteristics that are studied are compressive strength, tensile strength and flexural strength. The microsilica and nanosilica influences the mechanical properties of concrete compressive strength, tensile strength and flexural strength. The compressive strength, flexural strength and tensile strength is increases when the percentage of nanosilica at 1.5% and percentage of microsilica at 10% for both M sand concrete and M sand partially replaced by laterite sand. The strength is decreases when the percentage of nanosilica reaches 3%.

**Key Words:** Concrete, Micro Silica, Nanosilica, Pozzolana Compressive strength, tensile strength, flexural strength

## 1. INTRODUCTION

Concrete, as a constructive material, has been used in construction industry for about two centuries. Concrete is one of the building materials widely used in civil engineering construction and their design consumes almost the total cement production in the world. When concrete structures are exposed to severe environment, its performance becomes inferior, thereby leading to damage. Nanotechnology has immense potential and abilities to control the materials world including cement-based materials. Basic construction materials cement, concrete and steel will also benefit from nanotechnology. Addition of nanoparticles will lead to stronger, more durable, self-healing, air purifying, fire resistant, easy to clean and quick compacting concrete. Nano silica is most common nano additive to concrete. It is reported that nano silica was found

to be much effective than micron sized silica for improving the performance such as permeability, and subsequently, durability. Nano silica is most common nano additive to concrete. It is reported that nano silica was found to be much effective than micron sized silica for improving the performance such as permeability, and subsequently, durability.

### 1.1 Objectives

- The objective of this study is to find the strength characteristics of concrete with the addition of Nano-silica and microsilica
- To obtain the influence of the combined application of micro-silica and nano-silica on various strength properties
- Comparative study between M sand and Laterite sand as a replacement of river sand

## 2. MATERIALS AND METHODOLOGY

### Cement

In this experimental work, Portland Pozzolana Cement (PPC) conforming to IS: 8112 – 1989 was used.

### Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities.

### Coarse Aggregates

The maximum size of coarse aggregate is generally limited to 20mm. Aggregate of size 10 to12mm is desirable for structures having congested reinforcement.

### M Sand

Manufactured sand is a substitute of river for construction purposes sand produced from hard granite stone by crushing.

### Laterite Sand

Laterite, soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions.

### Nano Silica

Nanosilica is typically a highly effective pozzolanic material. It normally consists of very fine vitreous particles approximately 1000 times smaller than the average cement particles.

**Micro Silica**

Silica is the common name for materials composed of silicon dioxide (SiO<sub>2</sub>) and occurs in crystalline and amorphous forms. Silica fume or micro-silica (SF) is a byproduct of the smelting process in the silicon and ferrosilicon industry.

The experimentations are designed by replacing the cement by nanosilica and microsilica in various percentages. Also the fine aggregate is fully replaced by M sand and partially replaced by Laterite sand. Different strength characteristics that are studied are compressive strength, tensile strength and flexural strength. The specimens are tested after 28 days curing period.

**Compressive strength test**

In order to determine the compressive strength of concrete, cube specimen of dimension 150 x 150 x 150 mm were casted. After 28 days curing, these cubes were tested. Compressive strength was calculated as follows

$$\text{Compressive strength} = (P / A) \times 1000$$

**Tensile strength test**

Cylinder specimens of dimension 150 mm diameter and 300 mm length were casted. These specimens were tested after 28 days curing period. Tensile strength was calculated as follows

$$\text{Split tensile strength} = (2P/\pi dL)$$

**Flexural strength test**

In order to determine the flexural strength of concrete, beam specimens of dimension 100 x 100 x 500 mm were casted and tested after 28 days of curing period. Flexural strength was calculated as follows

$$\text{Flexural strength} = [(PL / bd^2) \times 1000]$$

**3. RESULTS AND DISCUSSIONS**

**3.1 Compressive strength test results**

The chart-1 give the variation of compressive strength test results of addition of nano silica and microsilica as fully replacement of natural sand by M sand and 80% of M sand and 20% of laterite sand. The compressive strength goes on increases with increasing with increasing the addition of nanosilica and microsilica. The concrete specimen contain 10% microsilica and 3% nanosilica have higher compressive strength. The addition of laterite sand and M sand also influences the strength of concrete specimen. The addition of laterite have less compressive strength than concrete specimen with M sand.

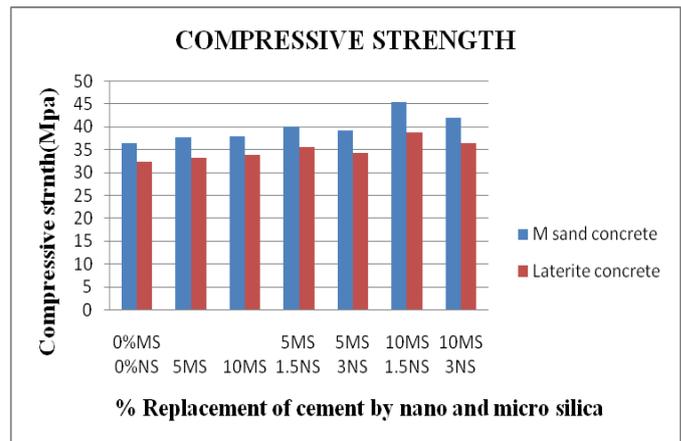


Chart -1: Variation of Compressive strength

**3.2 Tensile strength test results**

The chart-2 gives the variation of tensile strength test results of addition of nano silica and microsilica as fully replacement of natural sand by M sand and 80% of M sand and 20% of laterite sand. The tensile strength goes on increases with increasing with increasing the addition of nanosilica and microsilica. The concrete specimen contain 5% microsilica and 3% nanosilica have higher tensile strength. The addition of laterite sand and M sand also influences the strength of concrete specimen. The addition of laterite have less tensile strength than concrete specimen with M sand.

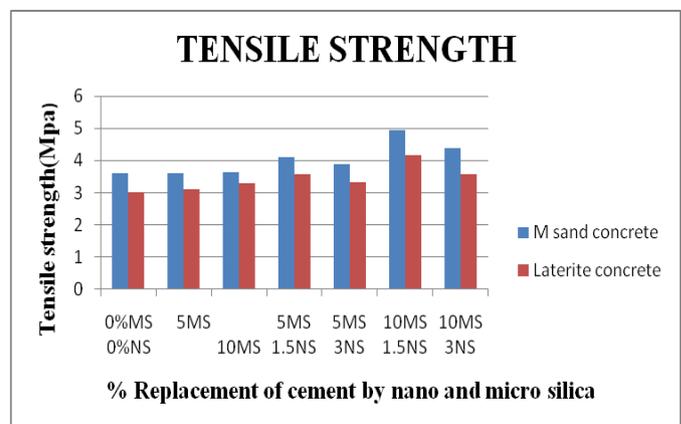


Chart -2: Variation of Tensile strength

**3.3 Flexural strength test results**

The chart-3 give the variation of compressive strength test results of addition of nano silica and microsilica as fully replacement of natural sand by M sand and 80% of M sand and 20% of laterite sand. The flexural strength goes on increases with increasing with increasing the addition of nanosilica and microsilica. The concrete specimen contain 5% microsilica and 3% nanosilica have higher flexural strength. The addition of laterite sand and M sand also influences the strength of concrete specimen. The

addition of laterite have less flexural strength than concrete specimen with M sand.

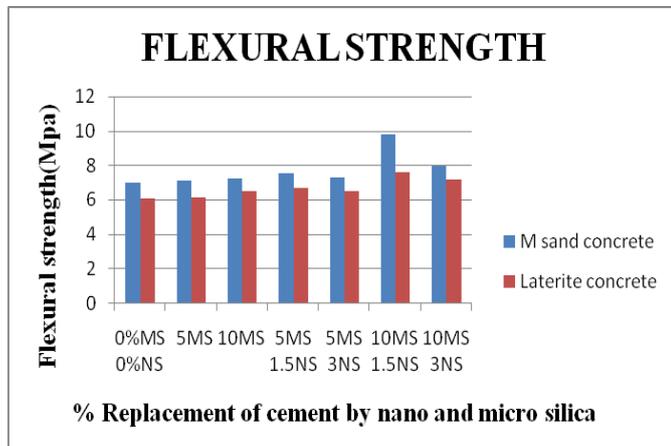


Chart -3: Variation of Flexural strength

#### 4. CONCLUSIONS

- The strength of concrete specimen is influenced by the addition of nano and microsilica. The workability of concrete containing microsilica and nanosilica increases while the percentage of nanosilica is increases. The M sand concrete and 20% replacement of laterite sand by M sand has the same effect on workability.
- Both M sand concrete and Laterite concrete as a partial replacement of cement by 10% of microsilica and 1.5% of nanosilica will yield higher compressive strength. The M sand concrete contains 24% increase in compressive strength compared to reference concrete. The 20% replacement of M sand by laterite sand concrete contains an increasing compressive strength of 20%.
- The M sand concrete and Laterite concrete as a partial replacement of cement by 10% of microsilica and 1.5% of nanosilica have a increase in flexural strength. The M sand concrete contains 40% increase in flexural strength compared to reference concrete. The 20% replacement of M sand by laterite sand concrete contains an increasing flexural strength of 25%.
- The M sand concrete and Laterite concrete as a partial replacement of cement by 10% of microsilica and 1.5% of nanosilica have a increase in tensile strength. The M sand concrete contains 38% increase in tensile strength compared to reference concrete. The 20% replacement of M sand by laterite sand concrete contains an increasing tensile strength of 39%.
- Based on the experimental investigation the strength properties of concrete can be improved by

the addition of 1.5% of nano-silica and 10% of microsilica by weight of cement. Hence it can be concluded that the cement content can be reduced for the preparation of concrete by the use of nano silica and micro-silica as cement replacement and considerable percentage increase in various strength properties of concrete can be obtained.

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