High Strength Concrete Using Colloidal Nanosilica

Mrs. Nikita Rahul Kadu[1], Ms. Vaishali Somnath Mhaske[2]

[1] Lecturer, Civil Engineering Department, Padmashri Dr. Vitthalrao Vikhe Patil Institute of Technology & Engineering, Polytechnic, Loni
[2] Lecturer, Civil Engineering Department, Padmashri Dr. Vitthalrao Vikhe Patil Institute of Technology & Engineering, Polytechnic, Loni

***Abstract*: In addition to garnering a lot of interest from the media and financial community, nanotechnology has recently emerged as one of the "hottest" fields in research and development globally. In essence, it is about developing new methods of production by comprehending and manipulating the basic constituents of all physical objects, such as atoms, molecules, and nanostructures. Almost everything will probably be designed and manufactured differently as a result of this. Nanotechnology is rapidly becoming the 21st century's industrial requirement.**

***Keywords:* Atoms, Molecules, Nanosilica, Nanotechnology, Pozzolana.**

1. INTRODUCTIONs

Nano-particles are utilized in improving material characteristics and is applied in many fields. The term nanotechnology usually means investigation of a material for the behavior at scales between 1 and 100 nm. Nano-materials exhibit distinctive chemical and physical properties that can result in the improvement of material. Nano-particles may yield favorable characteristics due to their extremely fine size. Application of nano-scale science to construction material has already begun. Cement is the most widely used construction material in the world. However, cementitious materials are brittle in nature and have low tensile strength. The chemistry and physical behavior of hydration products are amenable to manipulation through nanotechnology. So there is a great potential to utilize nano-particle in producing new cement based composite materials. Nanotechnology can be used for design and construction processes in many areas since nanotechnology generated products have many unique characteristics. These characteristics can again significantly fix current construction problems, and may change the requirement and organization of construction process.

2. METHODOLOGY

2.1 MATERIALS

Pozzolana:

A pozzolana is a material which, when combined with calcium hydroxide (lime), exhibits cementitious properties. Pozzolans are commonly used as an addition (the technical term is “cement extender”) to Portland cement concrete mixtures to increase the longterm strength and other material properties of Portland cement concrete and in some cases reduce the material cost of concrete.

Fly Ash:

Fly ash is a byproduct from burning pulverized coal in electric power generating plants. During combustion, mineral impurities in the coal (clay, feldspar, quartz, and shale) fuse in suspension and float out of the combustion chamber with the exhaust gases. As the fused material rises, it cools and solidifies into spherical glassy particles called fly ash. Fly ash is collected from the exhaust gases by electrostatic precipitators or bag filters. The fine powder does resemble portland cement but it is chemically different. Fly ash chemically reacts with the byproduct calcium hydroxide released by the chemical reaction between cement and water to form additional cementitious products that improve many desirable properties of concrete. All fly ashes exhibit cementitious properties to varying degrees depending on the chemical and physical properties of both the fly ash and cement. Compared to cement and water, the chemical reaction between fly ash and calcium hydroxide typically is slower resulting in delayed hardening of the concrete. Delayed concrete hardening coupled with the variability of fly ash properties can create significant challenges for the concrete producer and finisher when placing steel-troweled floors.

Fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline) and calcium oxide (CaO). Toxic constituents include arsenic, beryllium, boron, cadmium, chromium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium.

Class F Fly Ash:

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). The glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds.

Class C Fly Ash:

Fly ash produced from the burning of younger lignite or subbituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO) [22]. Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.

2.2 METHOD

Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed.

The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete shall be noted.

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section (150X150X150 mm) and shall be expressed to the nearest N per sq mm. Average of three values shall be taken as the representative of the batch provided.

2.3 MIX DESIGN:

Concrete Mix Design is as per IS 10262-2009

A. Data for Design:

1. Type of cement : OPC 53 grade confirming to IS-12269-1987
2. Maximum Nominal Aggregate Size : 20mm
3. Minimum Cement Content : 360 kg/m³ (As per IS 456-2000 Table 4)
4. Maximum Water Cement Ratio : 0.45
5. Workability : 50-75 mm
6. Exposure Condition : Normal
7. Type Of Aggregate : Crushed Angular Aggregate

B. Test Data For Materials:

1. Cement Used: Birla Super Cement OPC 53 Grade
2. Sp. Gravity of Cement: 3.15
3. Sp. Gravity of Water: 1.00

4. Sp. Gravity of 20 mm Aggregate: 2.82
5. Sp. Gravity of Sand : 2.605
6. Water Absorption of 20 mm Aggreagte: 0.90%
7. Water Absorption of Sand: 1.01%
8. Sp. Gravity of Combined Coarse Aggregate: 2.80

C. Procedure For Design:

1. Target Mean Strength = 40 + (5.6 X 1.65) = 49.24 Mpa
2. Selection of water-cement ratio:

Assume water cement ratio = 0.42

3. Maximum Water Content 186 Lit. (As per IS 10262: 2009)
4. Calculation of cement content: 186/0.42 = 442.85 kg/m3
5. Proportion of volume of coarse and fine aggregate content:

Volume of coarse aggregate adopted: 0.62

Volume of fine aggregate adopted: 0.38

2.4 TEST CONDUCTED:

On Aggregate:

- Specific Gravity
- Water Absorption

On Cement:

- Standard Consistency.
- Initial and Final Setting Time.
- Compressive Strength on plain cement.
- Compressive Strength on cement by replacement of 40% flyash.
- Compressive Strength on cement by replacement of 10% micro-silica.
- Compressive Strength on cement by replacement of 40% flyash + 10% micro-silica.

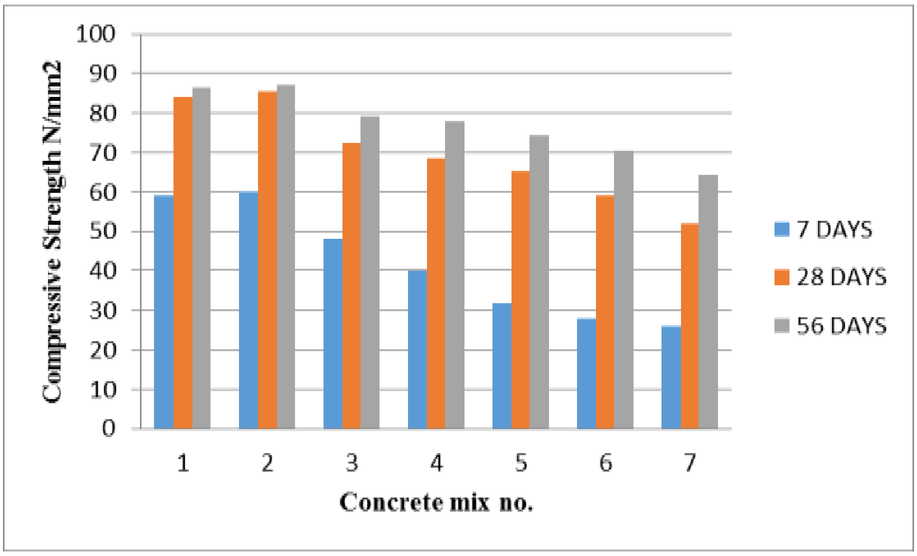
On Concrete:

- Compressive Strength using plain cement.
- Compressive Strength using 60% cement & 40% fly ash.
- Compressive Strength using 90% cement & 10% micro-silica.
- Compressive Strength using 50% cement & 40% fly ash + 10% micro-silica.
- Direct Tensile strength of cylindrical concrete specimens using plain cement.
- Direct Tensile strength of cylindrical concrete specimens using 60% cement & 40% fly ash.
- Direct Tensile strength of cylindrical concrete specimens using 90% cement & 10% micro-silica.
- Direct Tensile strength of cylindrical concrete specimens using 50% cement & 40% fly ash + 10% micro-silica.
- Flexural Strength of beam specimens using plain cement.
- Flexural Strength of beam specimens using 60% cement & 40% fly ash.
- Flexural Strength of beam specimens using 90% cement & 10% micro-silica.
- Flexural Strength of beam specimens using 50% cement & 40% fly ash + 10% micro-silica.

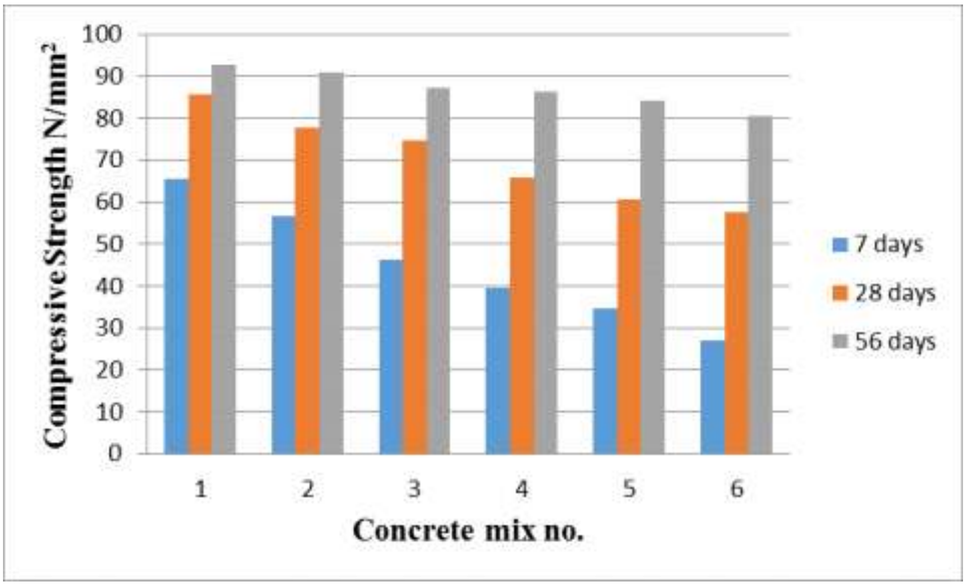
3. RESULTS

Compression Test Results

Table .4.1: Test results for compressive strength for 0% CNS



Graph 4.1 Variation in Compressive Strength with Fly ash Increase (0% CNS)



Graph 4.2 Variation in Compressive Strength with Fly ash Increase (5% CNS)

4. CONCLUSION

It is observed that compressive strength of Plain OPC 53 Grade Cement concrete at 3, 7 and 28 days Strength is greater than Fly Ash, Microsilica and Fly Ash plus Microsilica Concrete. Fly Ash Concrete and Fly Ash plus Microsilica concrete have low strength at 3 and 7 days. Hence, Fly Ash required time for strength development. Standard Consistency of fly Ash Cement is more than OPC 53 Grade Cement. For massive construction work we use Fly Ash and Microsilica economically by replacing cement content in concrete. Fly Ash Concrete is more economical than other concretes.

5. REFERENCES

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