

Enhancement of Mechanical Properties of Concrete by using Nanoparticles

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Abstract:- The Nano Technology is one of the emerging field in Civil Engineering as well as other domains too. The Nano technology offers us sustainable materials which are cost effective and eco friendly, can be used in various forms. In present scenario many researchers are working for construction material to enhance the durability and mechanical strength of existing material by using nano material like nano silica, Alumina etc.

Nano technology can be utilized for many applications in construction but mainly used in Structural Engineering. We can enhance the production of industry by reducing the problems faced at present time with a cost effective manner. Construction Industry is one of the major sectors where this can be very beneficial on broad scale.

Keywords:- Nano-technology; Nano-Silica; Mechanical Properties; Compressive Strength; Split Tensile Strength.

I. INTRODUCTION

The nanotechnology is new emerging technology. In this new emerging technology, the particles have been used which having size in between 1 to 100 nano meter. These are used enhance the workability and stability of concrete. Nano size particles are made up of thousands of atom combined in the form of a particular group. We can control the size, shape and % of content in mix design for better outcome of the study. This technology basically deals with the micro structure of concrete and bonding between the different elements used to prepare it. The molecular study of design mix is carried out by advance techniques and technology.

The physical and chemical properties of nano particles having impact on performance of concrete. The main advantage of nano particles is to increase the surface area of concrete as comparison with normal design mix. It is the multidimensional approach to get the better out come and based on pure trial and error method. Many researchers have been working on this new technique and trying to expand the scope and uses of concrete in construction industry. It requires definitely a multidisciplinary approach by the experts, scientist and researchers etc.

One of the main advantages of using this concrete is that it reduces the energy consumption and the overall performance of concrete also increases by incorporating nano particles. The Nano technology is mainly based on two criteria i.e. Self Sensing Capacity and Self Powered Property. By adding nano particles, various mechanical

properties of concrete can be improved like compressive strength, ductility, tensile strength etc. The enhancement of durability takes place because of using very tiny particles which are capable to improve the surface area of concrete. Along with that there will be reduction of permeability of concrete and enhancement of shrinkage property too.

In the series of nano particle, the nano silica and aluminum oxide are predominantly used to enhance the physical and chemical properties of concrete. That also provides greater stability against few phenomenons like sulphate attack, abrasion of material, corrosion etc. The Nano Technology is having lead role in the development of concrete and improving the feasibility area of using concrete with greater advantages.

II. MATERIALS

A. Materials

a) Nano Material:

Nano Silica (SiO_2) have been used in this study because of having excellent bonding property and its mechanical strength as well. The reactivity of nano material is very high therefore the high surface area to volume ratio is the key value that we need to consider in mix design.

The uses of nano material with concrete are increasing widely. Further there is much need to observe and make it possible for industry ready. By trial and error and observing ample amount of observation, trying to reach as per the vision to adopt this new technology.

Density of Nano Silica: 2634 kg/m³
Size of particles: Less than 15 Micron
Molar Mass of SiO_2 : 59.0843 g/mol

Nano silica is used because of having excellent add as your property and further add this to sealant can be converted into net structure. The particles of Nanosilica are too small therefore it is used to improve the effect of bonding between the particles used in the mix. Because of the development of new material like hydrophobic Silicon oxide these address can be easily joined with different material like plastic magnesium and iron.

The nano silica particles having large specific area. The porosity of the nano silica particles also very high and good surface activity. it has power to use this as a catalyst to enhance the performance of concrete in extraordinary manner. As reinforcing agent Silicon dioxide nanoparticles are used. it is also anti aging and changes color and can produce different color adhesive material.

The Silicon dioxide having some rheological properties therefore it is used to protect the material from corrosion phenomena and silica is highly Effective bonding material which having ingredient including pozzolonic element which is very fine material and this material can also have a good impact on concrete to increase durability and mechanical strength of concrete.

b) Cement:

Portland cement of good quality is required to fulfill requirement of designing concrete using Nano silica. The good quality of cement enhances the workability and strength of concrete. If there is some fault in the cement quality then there will be definitely fluctuations in achieving compressive strength and its performance. The criteria of the cement which is the basic requirement are given below:

Maximum Fineness: 4000 gm/cm².

Minimum 7 days Mortar cube strength: 29.27 N/mm²

Mortar Air Content: 8-10 %

c) Fine and Coarse Aggregate:

The quality of fine aggregate and coarse aggregate directly depends on the quality and property of the material. The mixing of fine and coarse aggregate must be in a particular manner; so, the target strength can be achieved. The concrete strength depends on the uniformity of material. The fineness modulus of the fine aggregate is in between 2.5 to 3.5. The Concrete must be given particular vibration for equal distribution of the material. The aggregate having sizes 10 mm are used in this study and that was locally available in the market.

Testing:

a) Compressive Strength Test:

The Following data were observed as per mix design and proportion calculated.

d) Admixture:

To increase the stability and higher Cohesion between the ingredients of the concrete, we used high water reducer and high performance admixture. The chemical admixtures must be added in the range of 0.2 to 1.5 % by weight of cement. The dose of admixture must not be added more or less than the requirement otherwise adverse effect on the concrete can be seen immediately or after some time. We have used Conproof Superplast R301 – Superplasticizer for reducing water and increasing the strength of Concrete.

III. METHODS AND EXPERIMENTAL DATA

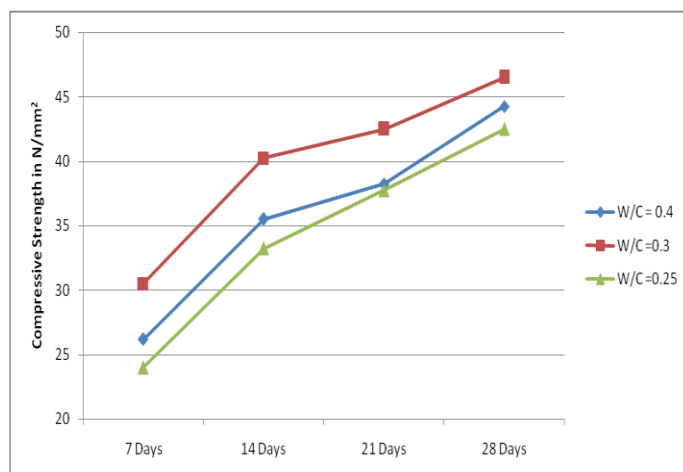
A. Concrete Mix Design

In the concrete mix design, the water cement ratio is the key factor which is having greater impact on the strength of the concrete we have used. Total three different water cement ratio has taken in this study for the development of durable and stable concrete. The value of water cement ratio is taken in this study as 0.4, 0.3 and 0.25 and for that we have casted nine cubes to determine the compressive strength after 7 days, 14 days, 21 days and 28 days to study the outcome and behavior of concrete for a particular mix that we have design. We also got the information and observation about effect of Nano silica on mechanical strength of the concrete.

The nano silica is added 10% and 15% with the replacement of cement. In both proportion concrete cubes were casted and tested the compressive strength. The compressive strength data have been taken after 7 days 14 days 21 days and 28 days. Further, comparative study was done and mix design was done as per Indian Standard 10262:2009 confirming all the criteria suggested in the code.

Mix Design Proportion	Nano Silica (%)	W/C Ratio	Compressive Strength of Concrete Cube (N/mm2)			
			7 Days	14 Days	21 Days	28 Days
M-50 (0.75:1:1.25) Conventional Concrete	0	0.4	26.2	35.5	38.2	44.25
		0.3	30.5	40.25	42.5	48.5
		0.25	24	33.25	37.7	42.5
M-50 (0.75:1:1.25)	10	0.4	27.5	37.25	42.5	45.25
		0.3	32.5	41.25	45.2	52.2
		0.25	25.2	35.2	39.5	43.25
M-50 (0.75:1:1.25)	15	0.4	25.3	35.2	40.2	42.25
		0.3	30.4	36.5	40.5	43.5
		0.25	25.5	34.6	40.5	42.5

Table 1: Compressive Strength Testing Observations of Concrete on different Proportion



Graph 1:- CS comparison graph with different W/C ratio

b) Split Tensile Strength Test:

This test is used to determine the tensile strength of concrete. The test is performed on concrete cylinder and the values are taken across the vertical diameter of that cylinder by applying loads as per the mix design. The specimen is

prepared first. The diameter of the cylindrical mould used in this test is 150 mm and length 300 mm as per Indian Standard specification. During the process various tools are needed like diamond, grinding machine, compressive testing machine, cap fixture, PI tape, ruler etc.

Mix Proportion	Replacement of Cement by Nano Silica (%)	Split Tensile Strength Values in (N/mm ²)		
		7 Days	14 Days	28 Days
Mix-50 (0.75:1:1.25) Conventional Concrete	00	4.47	6.08	7.29
Mix-50 (0.75:1:1.25)	10	4.85	6.18	7.78
Mix-50 (0.75:1:1.25)	15	4.35	5.50	6.30

Table 2: Split tensile strength on different trials

c)

d) Flexural Strength Test:

This test is used to calculate the tensile strength of concrete. Mainly we calculate how much load can be resisted by a beam under bending. For performing this experiment, a mould is taken having size 150 mm x 150 mm and length 700 mm. This test is mainly performed on three point loading phenomena. The loads are applied at one third

and two third span of the total length of the specimen. Beam is tested as per the wet standard of the concrete.

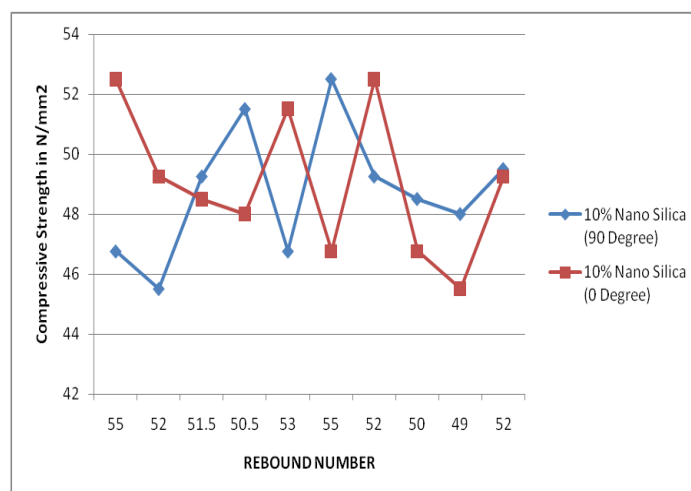
The Ultimate load is observed where the specimen fails under given loading condition and finally modulus of rupture is calculated.

Mix Proportion	Nano Silica (%) Replacement	Flexural Tensile Strength Value (N/mm ²)		
		7 Days	14 Days	28 Days
Mix-50 (0.75:1:1.25) Conventional Concrete	00	6.10	8.00	9.70
Mix-50 (0.75:1:1.25)	10	6.50	8.25	10.55
Mix-50 (0.75:1:1.25)	15	6.00	7.30	8.70

e) Rebound Hammer test:

Rebound hammer test is the Non Destructive Test which is used to calculate compressive strength of the concrete member without dismantles. This is also called as

Schmidt hammer with controlled spring mass that slide on the instrument member that is called plunger.



Graph 2:- Comparison between Rebound Hammer Result

f) Ultrasonic Pulse Velocity Test:

This test is performed to assess the quality of concrete in terms of uniform mass, mass density, equal distribution of material. This method is mainly based on Ultrasonic waves passes through to the concrete member and the time taken in this process shows the quality of

concrete and it's uniformity of ingredient. If the higher velocities achieve that means the concrete mass is not good enough and if the lower velocity achieved that means the concrete mass having uniformity in all the dimensions. This test is performed without any physical disintegration of concrete member.

Specimen No.	Pulse Velocity Value (Km/Sec)		Quality Grade
	Direct Method	Semi Direct Method	
1	4.1	4.1	Good
2	4.2	3.9	Good
3	3.9	3.7	Good
4	4.0	4.1	Good
5	4.0	3.2	Good

Table 4: Pulse Velocity Test observations and Result

IV. CONCLUSIONS

The Following conclusions are made as per the data observed during this study:

- By adding nano silica (SiO_2) the mechanical strength and Performance of concrete can be enhanced.
- The compressive strength of concrete found maximum 52.2 MPa at 28 days by adding 10% of Nano silica as a replacement of cement.
- By adding 10% Nanosilica in the concrete can provide better resistance to sulphate attack.
- The observed value of split tensile strength is 7.8 N/mm² by adding 10% Nanosilica as we increase the amount of silica the value of tensile strength got started decreasing.
- The value of flexural strength was 10.5 N/mm² by adding 10% of nanosilica further this strength getting decreases when we increase the amount of nanosilica than 10%.
- The observation based on non destructive test shows the Concrete possesses good quality of Homogeneity and equal Distribution of particle. The Dispersion and matrix of Ingredient found was perfect.
- The cost of this concrete is justifiable in mass production. It will be worth for construction industries using it in mass execution work.

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