

An Experimental Study on Improving Mechanical Properties of Concrete Using Nanoparticles

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Abstract- nanotechnology is the advanced and emerging technology which is not limited to only civil engineering field but also it is applicable to many technical fields. Using nanotechnology in civil engineering can have a great impact on increasing the mechanical properties of concrete like strength, durability, workability etc. can be enhanced using this emerging technology. In this study the nanoparticles have used like Nano Silica as a nano material. The size of nanoparticles are very small ranges from 1nm to 100 nm can be used as replacement of cement. Nanoparticles have used as a replacement of cement with certain percentage. On a different percentage the mix design was done using IS 10262 And the proportion of all the ingredients of concrete have decided and further study have done.

Keywords- Compressive Strength, Durability, Mechanical Property, Nano Silica, Workability etc.

I. INTRODUCTION

Concrete is widely used material in construction industry since very long. The ingredients of the concrete are cement, fine aggregate, coarse aggregate, water, admixtures, and nano particles are additional that we have used in this study. It has been the continuous process of searching the new material for construction for betterment of the performance and durability. Around year 1960 the technology was developed which was providing the strength between 40 Mpa to 60 Mpa of strength for the concrete. Now the present requirement of the construction industry is the material which can provide the strength as well as the durability with great performance in the long run of the structure.

To achieve this target the researchers and developers have been putting great efforts and they have succeeded in many attempts as well. They searched a new material named Nano Silica which having particle size very small less than 100 nanometer.

From the earlier studies using nano silica in the concrete as a replacement of cement did perform well in terms of durability and compressive strength of the concrete during the service life of the structure.

The Nano Silica have been used as a replacement of cement because the particle size of the Nano Silica is very small so it is very helpful to fill the gaps and pores between the cement and other ingredient of the concrete and provide great stability and durability. Nanoparticle provides structural stability against aggressive chemical like sulphate attack abrasion of material and corrosion of material.

Hence the nanotechnology plays a key role in the development of the concrete with high strength and low energy material. Before adding the nanoparticle, the feasibility of nanoparticle must be checked and tested properly to get ensure for maximum positive outcomes of the study.

There are many such areas or conditions where this technology cannot be used therefore to make this technology industrial friendly or as per the expectation of industry, we must kept in our mind to get clear conclusion.

II. EXPERIMENTAL STUDY

The nanomaterial used in this project is Nano Silica (SiO_2) because of their strong mechanical strength and bonding property. The Nano Silica is incorporated as a replacement of cement to improve the mechanical properties like compressive strength, tensile strength, flexural strength of concrete, service life of the concrete etc.

Nanosilica having very large surface area, high porosity, and good surface bonding quality.

An experimental study was arranged to get all the values of strength and durability. The properties of all the concrete ingredient like cement, sand, aggregate, water admixtures, nanosilica have been tested and as per the value obtained the amount of ingredients have decided and the mixer design was done as per is 10262. The properties of Nano Silica are mentioned below:

Density of Nano Silica: 2650 kg/m³

Size of particles: Less than 25 Micron

Molar Mass of SiO_2 : 60.05 g/mol

Crystal Structure: Cristobalite or Tridymite
 The Physical properties of the cement used in this study are as below:

- Maximum Fineness: 4000 gm/cm².
- Minimum 7 days Mortar cube strength: 29.27 N/mm²
- Mortar Air Content: 8-10 %
- Cement Grade: 53 (OPC)

The supplementary cementitious material that are used like Nano Silica (SiO₂) and aluminum oxide (Al₂O₃). The water cement ratio has used in the range of 0.2 to 0.4 to get the maximum result as per Indian standard recommendation. The result obtained on study of cement are:

Table 1: Cement Test Results on different Parameters

Cement Testing Parameters	Experimentally Obtained Value	Value Criteria per IS 12269:2013	IS Code Reference
Specific Gravity	3.10	-	IS 4031 -part 11
Normal Consistency (%)	33	-	IS 4031 -part 4
Initial Setting Time	29 mins	30 mins	IS 4031 -part 5
Final Setting Time	323 mins	600 mins	IS 4031 -part 5
Compressive Strength			
3 Days	28.44 N/mm ²	27 N/mm ²	IS 4031 -part 6
7 Days	42.20 N/mm ²	37 N/mm ²	
28 Days	55.65 N/mm ²	53 N/mm ²	

The physical property test observations on fine and coarse aggregate are mentioned in below table:

Table 2: Coarse Aggregate Test results on Various parameters

Sr. No.	Parameter	Result values (20 mm)	Result values (10 mm)
1.	Specific gravity	2.76	2.71
2.	Water absorption %	3.34	4.28

3.	Fineness modulus	3.28	4.35
5.	Bulk density (compacted) (kg/m ³)	1580	1535
6.	Impact Value	24.92	26.78

Table 3: Fine Aggregate Test Results on Various Parameters

Sr.No.	Properties of fine aggregate	Values Observed in test
1	Specific gravity Value	2.67
2	Water absorption (%)	0.41
3	Fineness modulus Value	2.69
4	Bulk density (loose) (kg/m ³)	1640
5	Bulk density (compacted) (kg/m ³)	1910

III. RESULTS AND DISCUSSION

Table 4: Compressive Strength Values as Mix Designs

Mix	Nano Silica (%)	W/C	Compressive Strength (N/mm ²)			
			7 th	14 th	21 st	28 th
M-50	0	0.35	24.5	34.5	41.2	49.9
		0.3	31.1	39.2	40.2	49.7
		0.25	24.6	35.1	38.9	47.3
M-50	10	0.35	26.4	38.5	43.2	48.3
		0.3	31.5	40.2	47.9	55.9
		0.25	26.2	38.1	40.0	44.1
M-50	15	0.35	26.2	36.0	41.9	42.5
		0.3	31.3	39.7	42.9	46.9
		0.25	27.6	35.5	39.5	41.2

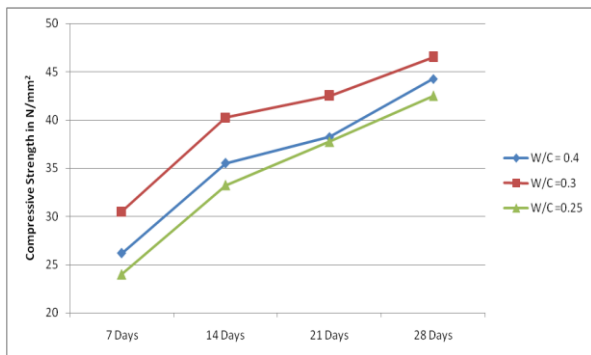


Fig1: - Compressive Strength results Comparison Graph
The observation found in the Split Tensile Strength Tests are as below:

Table 5: Split Tensile Strength results on various mix

Mix Design	Nano Silica (%)	Split Tensile Strength Value (N/mm ²)		
		7 Days	14 Days	28 Days
M-50 Conventional Concrete	0	4.8	6.2	6.9
M-50	10	4.9	6.4	7.7
M-50	15	4.3	6.5	7.3

The Result obtained in NDT - Ultra Sonic Pulse Velocity Tests are as below:

Sample No.	Pulse Velocity Value (Km/Sec)			
	Direct Method	Average Value and Grading	Semi Direct Method	Average Value and Grading
1	4.02	4.06 (Excellent)	4.11	3.96 (Good)
2	4.17		3.11	
3	3.93		3.9	
4	4.23		4.2	
5	3.97		3.7	

IV. CONCLUSIONS

The Following conclusion are made as per the observation obtained in this study:

1. The Nano Silica can enhance the stability and performance of the concrete.

2. As per the experimental analysis of the concrete the compressive strength found maximum i.e, 55.9 MPa when we add 10% of Nanosilica as a replacement of cement.
3. The split tensile strength found maximum i.e., 7.7 Mpa when we replace cement by 10% of the Nano silica.
4. The cost-effective analysis shows that using Nano silica as a replacement of cement not only protect environment from the carbon dioxide emission but also reduces 8% to 10% costing in the execution work.
5. The Non-destructive test shows that the dispersion of ingredients of concrete are in good condition. The NDT test also shows the results are better.
6. The Value of Flexural Strength after 28 days also found maximum by adding 10% Nano Silica. When we increase the amount of nano silica from 10%, the results show negative impact.

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