



Experimental Study On Mechanical Properties Of Concrete By Using Nanovanadium-Nanosilica Mixture As A Partial Replacement Of Cement

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Abstract: In this study a trial attempt is done to assess the observation and the effect of nano silica and nano vanadium make sure on the strength of the concrete with with durability. As per a mix design, different mixes were prepared by replacing the cement with certain percentage of nano silica and nano vanadium and the testing was done on 7 days 14 days and 28 days to assess the behavior of concrete after adding these ingredients. The compressive strength value, split tensile strength value, non-destructive test values were observed and comparative analysis was done in this study. The replacement of cement with Nano Silica by 8% and Nano Vanadium by 2% showed best outcome for this study. The non-destructive test like ultrasonic pulse velocity and rebound hammer showed best outcome of this study on the same percentage replacement as we found in compressive and split tensile strength test.

Index Terms - Ordinary Portland Cement; Mix Design, Nano-Silica; Nano-Vanadium; Compressive Strength; Non-Destructive Test.

I. INTRODUCTION

Concrete is the second most consumed material in the world and it has been using since very long time and we can see around us each day in the construction of roads, buildings, and other infrastructure development this material has been using. To improve the characteristic of the concrete the scientist and researchers have made many attempts using nanotechnology in the concrete. There are many materials in Nano Technology these have been into trial period of using with the concrete mix and researchers are continuously trying to check the feasibility of using nano material in the concrete that gives great strength and durability to the concrete. Concrete is a versatile material that can be converted in any of the shape as per the mould and requirement of building.

The Nano Technology allows researchers to use nanometer which having particle size very low as compared to the regular building materials. The size of Nanoparticles is very small and this can be used to make interlock between ingredient of concrete. The main objective of the using nanometer into the concrete mix is to eliminate the air voids in the concrete mix and to make good interlocking between the building materials to fill the pores remains as it is while doing the casting work. For using Nano materials, it is very challenging to decide the percentage to be added in the concrete mix because it must be very precise for better results. Concrete paste hardens to convert into rock-like hard mass. Concrete is widely used man-made material which creates many job opportunities every year. It is very Popular concrete material which have been used in constructions work where high strength and durability required. Concrete is used to build very complex structure like skyscrapers, highways, dams, house etc. concrete is weak in tension and puzzles very good property against compression. The major limitation of the concrete is tension because concrete puzzles weak strength against tension loading. Concrete is having brittle in nature and very sensitive to against such chemical as a sulfate and chlorides. Concrete having adverse impact on the environment specially in the manufacturing of cement. The manufacturing of the cement increases carbon dioxide emission and hence consequences result into the greenhouse effect which is very harmful for the living animals and human.

Nano technology is the growing technology and recent technology used in the field of research and its application can be seen in the many areas of building construction and engineering. Now construction field is the major field adopting this technology to mitigate the shortage in the construction material and improving the mechanical strength of the concrete and durability. Concrete itself for Nano structured material which consists of interfacial transition zone, aggregate phases, amorphous paste phase which is bounding with water. Using Nanotechnology, the binding between the ingredient of concrete can be enhanced. Nanotechnology is also given the equal opportunity to gain deeper understanding about the concrete mix and gradient of concrete. this development of the concrete

contains multiple length scales starts with nano ending with micro. There are many ways of applying nanotechnology in the field of civil engineering.

The addition of the admixtures like Nanoparticles of silica fume and Flyash can have great impact on the properties of concrete. By using Nano size particles, we can improve the mechanical properties of concrete like compressive strength, durability, tensile strength etc. By using these particles, we can increase the surface area of the concrete that having direct impact on the strength of the concrete and durability. Nanotubes made up of carbon, are one of the promising and emerging development made through nanotechnology process. Carbon nanotube can be developed using either a single wall or multiple walls and it is a long fiber like a structure which is made up of carbon. Carbon nanotube gives extraordinary properties to the concrete and it is a flexible molecular scale tube and having a very complex structure.

A. Sadrmomtazi et.al [8] have studied the effect of adding polypropylene with nanoparticles of silica. The nanoparticle was replaced by 7%. Which enhanced the compressive strength of mortar by 6.5%. If the amount of polypropylene beyond 0.3%, will give a reduction in the compressive strength of the concrete. Polypropylene increases the flexural strength and effectiveness of using nano silica particles. When we add polypropylene fiber up to 0.5% then absorption decreases which shows poor refinement of the cement mortar.

II. MATERIALS AND METHODS

A) *Materials:*

In this experimental analysis I have used Nano Silica (SiO_2) and Nano Vanadium (V_2O_3) as a nano material for adding into the mix as a replacement of cement. These ingredients are added to increase the mechanical property of the concrete and improving the binding strength of the concrete. nano Silica is one of the nano materials categories which can be used in versatile manner. It has many uses in different industries. The properties of Nano Silica are:

Density of Nano Silica: 2

Size of particles: Less than 18 Micron

Molar Mass of SiO_2 : 58.2301 g/mol

Crystal Structure: Quartz

The Nano particles are used as per the high surface area and the volume ratio required in the mix or expected study and the amount of that material adding is to be very sensitive. Nano vanadium nanomaterial appears in the form of powder which is a black powder having spherical surface. Nano material is available in ample amount in the nature so there is no big concern about the availability of nanomaterial because once the industry will give remark conclusion about this product, we can use it for the further production and continuous uses.

Nano vanadium is binding agent which can be used in the concrete to improve the stability of the concrete. It is a very low-cost material that can have directly impact on the cost effectiveness of the concrete. It possesses very good adhesive property. So that the binding between all the ingredient will be very good.

The cement quality has direct on the performance and grading quality of the concrete. for getting good compressive strength and workability of concrete we need to use best quality of cement. Low quality of cement has what is left the direct impact on quality of concrete. following are the requirement of the cement that is to be used and that is to be mixed with the nanoparticles:

Maximum Fineness: 3700 gm/cm^2 .

Minimum 7 days Mortar cube strength: 29.17 N/mm^2

Mortar Air Content: 9-12 %

The cementitious material used in the study are nano silica, aluminum oxide and nano vanadium as per the requirement of the expected outcome. The water cement ratio kept very low for achieving great performance and high strength concrete as per Indian standard clause. Aggregate is the main ingredient that is used in the concrete. the role of aggregate is to give stability of the concrete mix and it occupies very large volume in the concrete mix in all the dimensions. The physical and chemical properties of fine aggregate and coarse aggregate are directly impact the strength and stability of concrete mix. The dispersion of coarse aggregate and fine aggregate must be in a proper way so it will boost us to achieve the expected strength of the mix.

The fine aggregate must have the fineness modulus in between the range of 2.4 to 3.3. The property of the concrete is directly proportional to the fine and coarse aggregate and their characteristic. When the concrete is poor in the mold or at the place where the homework is applied then vibration process must be applied to uniformly dispersion of the concrete material. The non-destructive test is the test which is used to perform without any physical disintegration of the specimen. These tests can be performed using advance equipment as per the requirement and as per the parameter. These tests are used to perform and calculate the uniformity and homogeneity of the mixture with distribution of ingredient in the concrete materials are dispersive or not. This method is performed without any physical disintegration or dismantling of the material. In this study, rebound hammer and ultra sonic pulse velocity tests have been carried out.

III . RESULTS AND DISCUSSIONS

As per the requirement of the study, many tests were conducted on the mix design. In this study, as a nano material nano silica and nano vanadium is used as a supplementary cementitious material. These tests are used to conduct and to identify the strength and durability of the concrete mix. It has been seen that adding nano silica and nano vanadium can improve the strength and stability of the concrete mixture. Test Results on Cement shown in table below:

	Experimentally Obtained Value	Value Criteria As per IS 12269:2013	IS Code Reference
Specific Gravity	3.14	-	IS 4031-part 11
Normal Consistency (%)	31	-	IS 4031-part 4
Initial Setting Time	28 mins	30 mins	IS 4031-part 5
Final Setting Time	322 mins	600 mins	IS 4031-part 5
Compressive Strength 3 Days 7 Days 28 Days	29.45 N/mm ² 41.30 N/mm ² 54.75 N/mm ²	27 N/mm ² 37 N/mm ² 53 N/mm ²	IS 4031-part 6

Table 1: Cement Test results Various parameter

The Observations based on experiment on Fine and Coarse Aggregate, the following results have been obtained.

Sr. No.	Testing Parameter	Result values (For 20 mm)	Result values (For 10 mm)
1.	Specific gravity	2.76	2.71
2.	Water absorption %	3.34	4.28
3.	Fineness modulus	3.28	4.35
4.	Bulk density (loose) (kg/m ³)	1540	1425
5.	Bulk density (compacted) (kg/m ³)	1580	1535
6.	Impact Value	24.92	26.78

Table 2: Coarse Aggregate Test results 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

Table 3: Fine Aggregate Test results Various Parameters

The Following observations found in compressive strength test after 7th, 14th, 21st and 28th day on different water cement ratios, Nano Silica content, Nano Vanadium Content:

CC	NS (%)	NV (%)	W/C	Compressive Strength (N/mm ²)			
				7 th	14 th	21 st	28 th
M 50	0	0	0.4	25.5	35.7	42.1	48.9
			0.3	30.5	40.15	42.5	49.2
			0.25	25.5	34.25	39.75	47.4
M 50	8	2	0.4	27.5	39.50	43	47.25
			0.3	32.5	41.25	46.2	53.8
			0.25	27.2	37.2	41.5	44.25
M 50	10	4	0.4	25.3	37.2	42.25	42.25
			0.3	32.4	38.5	42.5	45.5
			0.25	27.5	36.6	40.5	42.5

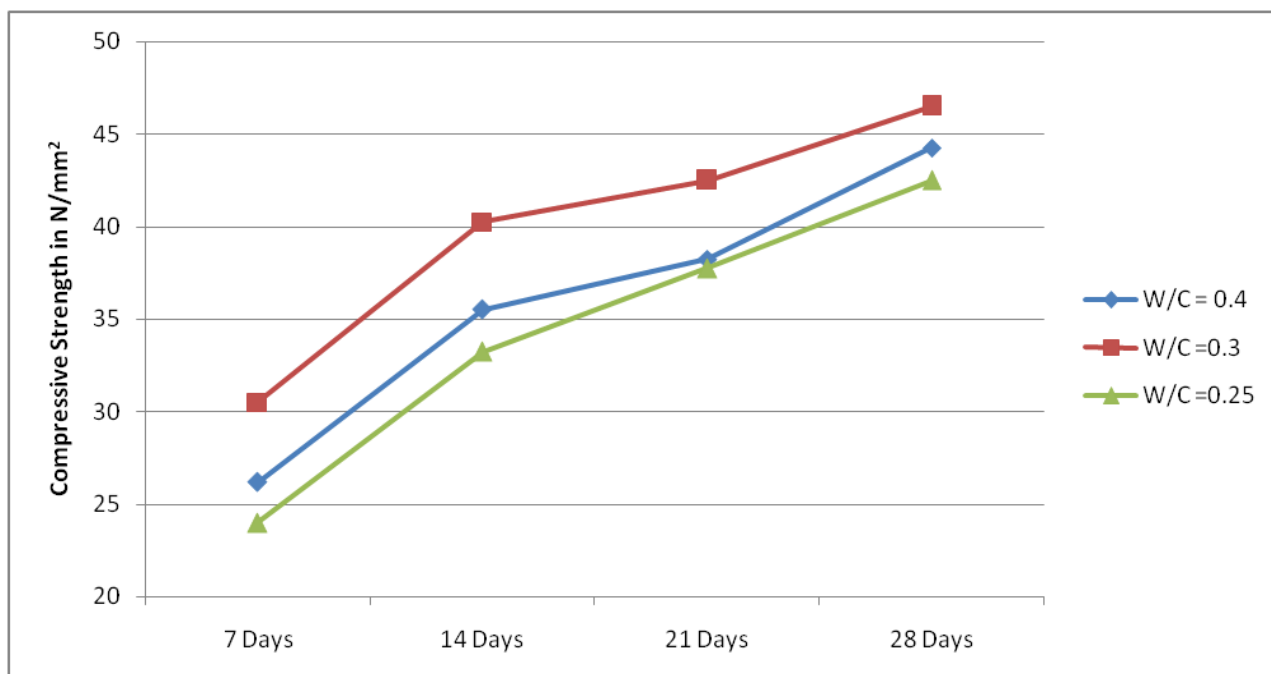


Fig 1: - Compressive Strength results Comparison Graph

The observation found in the Split Tensile Strength Tests are as below:

Mix Design	Nano Silica (%)	Nano Vanadium (%)	Split Tensile Strength Value (N/mm ²)		
			7 Days	14 Days	28 Days
M-50 (0.8:1:1.15) Conventional Concrete	0	0	5.8	7.2	7.9
M-50 (0.8:1:1.15)	8	2	5.9	7.4	8.7
M-50 (0.8:1:1.15)	10	4	5.3	6.8	7.2

Table 5: Split Tensile Strength results on various mix

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	4.04	4.06 (Excellent)	4.13	3.96 (Good)
2	4.15		3.9	
3	3.95		3.9	
4	4.21		4	
5	3.98		3.9	

Table 6: Pulse Velocity Test results

IV CONCLUSIONS

- Nano Silica and Nano Vanadium can improve the Stability and Performance of Concrete.
- As per based on experimental analysis of concrete, the compressive strength test at 28 days, maximum result obtained is 53.8 MPa on adding 8% Nano Silica and 2% Nano vanadium.
- The 8% of Nano Silica and 2% Nano vanadium provides better resistance to sulphate attack and Chemical attack as compare to zero Nano Silica and Nano Vanadium content in the mix as replacement of cement.
- The Split tensile strength observed 8.7 MPa on adding 8 % Nano Silica and 2% Nano vanadium that is best among all the mix proportion of both Nano materials. When we increase the content of nano silica and nano vanadium, the strength getting decreases after maximum value achieved.
- The Value of Flexural Strength found 11.7 MPa when we add 8 % of Nano Silica and 2% Nano vanadium as a replacement of cement. The Strength starts getting decreases as the amount of nano silica and Nano vanadium added more best outcome. The Best outcome found at 8% Nano silica and 2% Nano vanadium.
- In the present study, the cost-effective analysis plays vital role in overall costing. When we add nano silica and Nano vanadium, the overall amount gets reduces by 10-12% which is very effective in cost cutting for industrial purpose.
- Non-Destructive Test also shows the uniformity and homogeneity of concrete mix as we got the results under good status for both nano particles.

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