ISSN No:-2456-2165

Experimental Study on Strength and Durability Characteristics of Concrete with Partial Replacement of Nano-Silica, Nano-Vanadium Mixture

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Abstract:- In the present work an attempt has been made to evaluate the effect of Nano-Silica (NS) Nano-Vanadium mixture on strength and durability characteristics of concrete. Different mixes were made by replacing OPC with different percentages of NS and NV and hydrated for 3, 7 and 28 days. Compressive strength and split tensile strength were determined and test results obtained were confirmed by SEM techniques. For 1% of NS and 0.1% of NV replacing OPC by weight, an improvement in compressive strength and split tensile strength was observed and loss of weight and compressive strength is less for both acidity and alkalinity test when compared with normal concrete.

Keywords:- *Ordinary Portland Cement; Nano-Silica; Nano-Vanadium; Compressive Strength; Split Tensile Strength.*

I. INTRODUCTION

Nanotechnology is the building at nano-scale to create materials with novel properties that can't be accomplished utilizing conventional materials. For heterogeneous composite, for example, solid, expansion of nano molecule makes it a perfect contender for the utilization of nanotechnology. The mechanical conduct of cement relies upon the wonders that happen at small scale or nano scale. Hydrated bond glue which is the fastener in cement is shaped by a synthetic response with water and has structure on scales that extend from nanometers to millimeters. Subsequently, its structure can be adjusted and the hydration responses can be controlled and changed.

Nanomaterials can be characterized as those physical substances with no less than one measurement between 1… 150 nm (1 nm = 10– 9 m). Presently, the utilization of nanomaterials in development is decreased, mostly for the accompanying reasons: the absence of learning concerning the appropriate nanomaterials for development and their conduct; the absence of explicit measures for plan and execution of the development components utilizing nanomaterials; the diminished offer of nanoproducts; the absence of itemized informations in regards to the nanoproducts content; surprising expenses; the unknows of wellbeing dangers related with nanomaterials.

Nano silica is outstanding amongst other Nano-material to enhance the distinctive quality, physical, and mechanical properties of cement than the other Nano material. Nano silica is adequately high Pozzolanic material. The measure of Nano-silica is multiple times littler than the normal size of concrete molecule. Expansion of Nano-Silica (NS) in bond glue and in cement can prompt totally extraordinary impacts. One is estimate impact, i.e. essentially dependent on their molecule nature, which makes it helpful as filler material and second is the trade Pozzolanic action (ability of responding with calcium hydroxide and water) of the group mixes. There are numerous approaches to blend nano silicon dioxide they are unit Sol-gel technique, Electric-Arc-strategy, organic procedure, precipitation philosophy and different creation systems. Nano SiO2 might be specifically arranged from bio squander like Rice, Husk, powder. Nano SiO2 has a to a great degree nebulous nature. Nano silicon dioxide in cement can expand the thickness, lessens porosity, and enhances the bond between concrete lattice and totals with higher compressive and flexural quality. Nano-SiO2 have been found to help solid usefulness and quality, to expand protection from water infiltration, and to help control the filtering of calcium, which is firmly identified with different sorts of solid debasement.

Transition– metal oxides are an intriguing class of materials as far as the electronic, mechanical and optical properties related with their auxiliary stage changes. The nano-scale scopes of these metals have demonstrated better properties in numerous fields because of its upgraded surface to volume proportion. Vanadium being the third component of 3d progress bunch component is outstanding for its quality and oxidation reactant property. By and by Nano-Vanadium is utilized in carbon dioxide adsorption (J. Am. Chem. Soc., 2004, 126 (11), 3616-3626), hydrogen stockpiling (December 2011, Volume 13, Issue 12, pp 6333– 6338) decrease of NO by NH3. Electrochemical and photochemical properties nano zymes, tranquilize conveyance framework and its antifungal, bacterial exercises. In this undertaking work we have dissected the synergist conduct of vanadium pentoxide nanoparticle in the arrangement of tri-calcium silicates. The fulfillment of the different quality of cement inside the normal days demonstrates the early arrangement of tri-calcium silicate. The combination of nano vanadium pentoxide is completed by sol-gel auto-combustion.

B.-W Jo et. al [3] studied the characteristics of cement mortar with Nano SiO2 particles experimentally and observed higher strength of these blended mortars for 7 and 28 days. The microstructure analysis showed that SiO2 not only behaves as a filler to improve microstructure, but also as an activator to the Pozzolanic reaction. Surya Abdul Rashid et. al [4] worked on the effect of Nano SiO2 particle on both mechanical properties (compressive, split tensile and flexural strength) and physical properties (water permeability, workability and setting time) of concrete which shows that binary blended concrete with nano SiO2 particles up to 2% has significantly higher compressive, split tensile and flexural strength compared to normal concrete.

In view of these advances, the aim of this study is to investigate the influences of Nano-Silica and Nano-Vanadium as partial replacement of cement on strength and durability properties of concrete.

II. MATERIALS AND METHODS

A. Materials

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. In the present work, OPC 43 grade cement with a specific gravity of 3.16; fineness of 9.22%; standard consistency of 32%; initial setting time of 40min; final setting time of 285min.

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	L.O.I	Total
OPC	21.30	3.58	5.05	63.48	1.39	2.05	0.26	0.22	2.57	99.90

Table 1: Chemical analysis of OPC and Nano-Silica (mass %)

Nano-Silica was purchased from Astra Chemicals, Chennai having size of 20-40nm with 99.99% of SiO_2 and Nano-Vanadium was prepared in the laboratory by sol-gel process having a size of 420nm confirmed by SEM technique are used for the study.

Element	Weight %	Atomic %	Net Int.	Error %	Kratio
C K	16.50	24.87	36.66	12.99	0.0437
O K	43.78	49.53	249.50	7.53	0.2465
SiK	39.72	25.60	260.50	3.60	0.3485

Table 2: Chemical properties of Nano-Silica obtained by XRD+EDS test

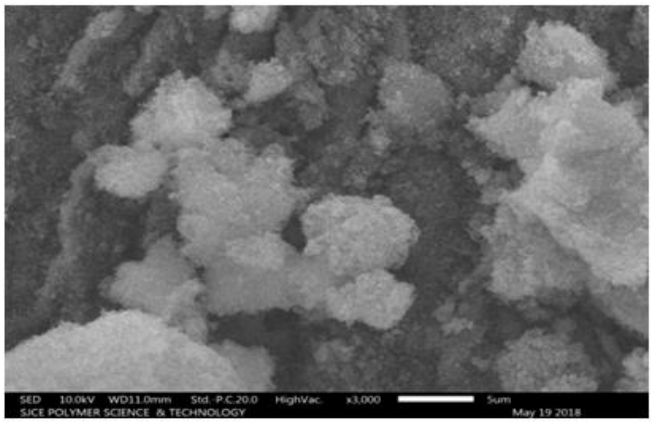


Fig 1:- SEM Photographs of Nano-Silica

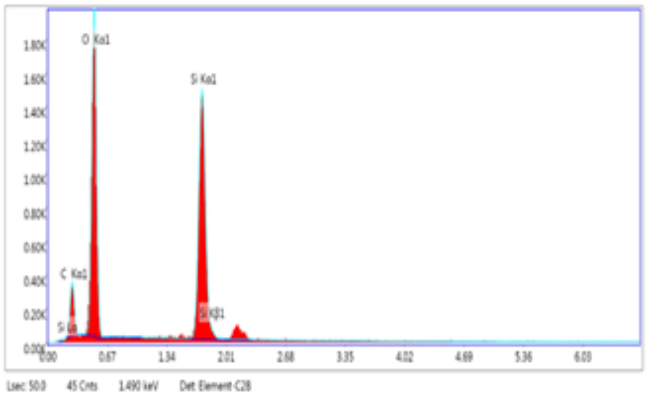


Fig 2:- XRD of nano-silica.

Element	Weight %	Atomic %	Net Int.	Error %	Kratio
C K	4.08	10.94	22.26	12.30	0.0254
O K	19.47	39.15	61.40	13.36	0.0579
SiK	3.19	3.66	23.59	10.66	0.0301
V K	73.25	46.25	83.64	6.58	0.6649

Table 3:- Chemical properties of Nano-Vanadium obtained by XRD+EDS test

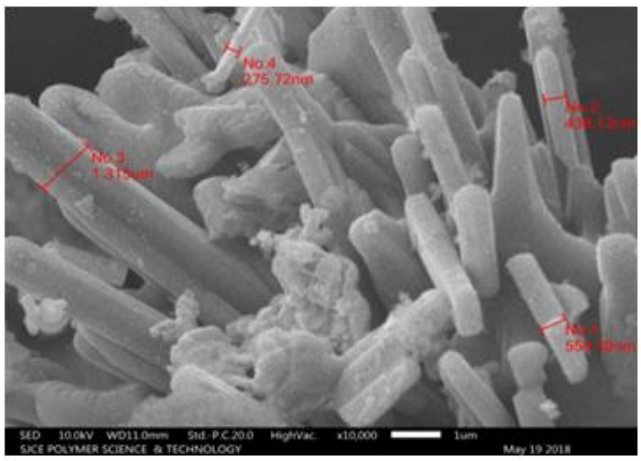


Fig 3:- SEM Photographs of Nano-Vanadium

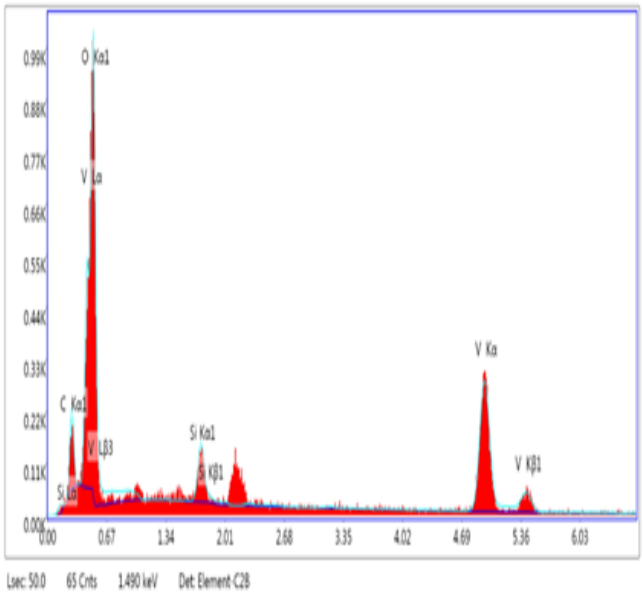


Fig 4:- XRD of Nano-Vanadium

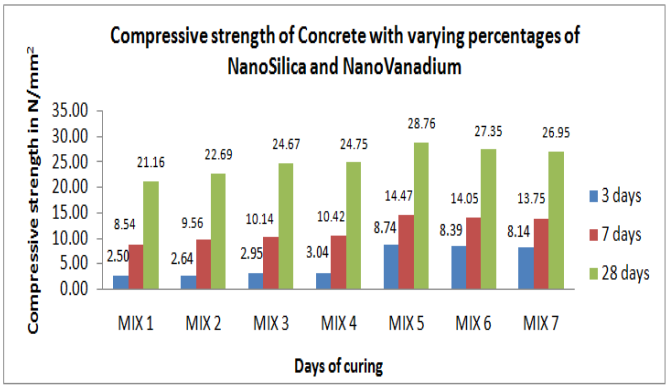
Manufactured sand confirming to IS: 383-1970 with a specific gravity of 2.32; fineness modulus of 4.1; water absorption of 1% and coarse aggregate obtained from stone crusher 20mm downsize with a specific gravity of 2.6; fineness modulus of 4.72; water absorption of 0.5%.

B. Methods

NanoSilica used in the present work is purchased from Astra Chemicals Chennai. Based on the literature survey NanoVanadium is synthesized by sol-gel auto-combustion method. The obtained nanoparticles were characterized through using UV, SEM, EDS and XRD. Basic tests i.e., specific gravity, fineness, standard consistency, initial setting and final setting is conducted for cement; specific gravity, fineness modulus and bulk density is conducted for fine aggregate and coarse aggregate based IS code specifications.

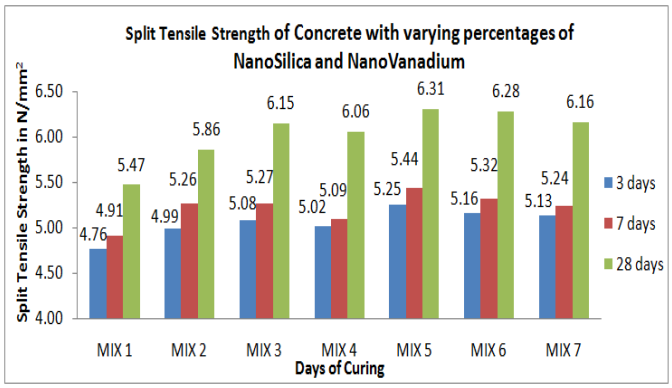
Concrete mix proportion is calculated for M20 grade concrete based on IS 10262:2009 code provisions for 7 mixes i.e., NC (Normal Concrete), NC+1%NS, NC+2%NS, NC+3%NS, NC+1%NS+0.1%NV, NC+2%NS+0.1%NV and NC+3%NS+0.1%NV and for each mix concrete is casted into 9 cubes and 9 cylindrical moulds. The cubes and cylinders are tested to determine the compressive and split tensile strength after 3, 7 and 28 days of curing. Out of 7 mixes optimum mix which exhibits higher strength is again casted into 6 cubes and cured for 28days. After 28 days of curing, cubes are taken out and allowed to dry for 1 day and then out of 6, 3 cubes are immersed in bucket of water containing 5% of H2SO4 by weight of water and another 3 cubes are immersed in bucket of water containing 5% of NaOH by weight of water for acidity and alkalinity test. Before immersing the cubes dry weight of cubes are taken and after 28 days of immersion, cubes are tested for 3, 7 and 28 days to determine the loss of weight and compressive strength and results are tabulated.

III. RESULTS AND DISCUSSIONS



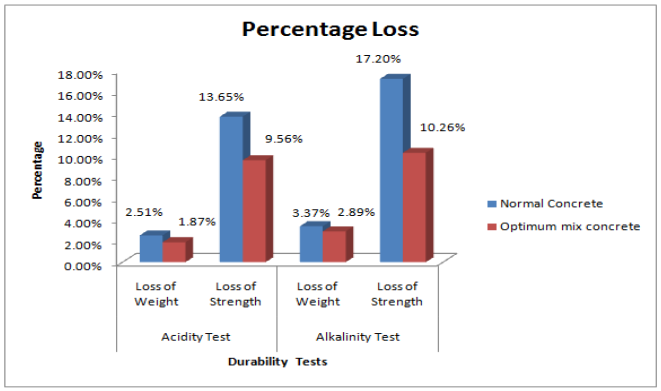
Graph 1:- Compressive strength of concrete with varying percentages of Nano-Silica and Nano-Vanadium

The above graph indicates the compressive strength of concrete for 7 mixes varies by 7.23%, 16.58%, 16.96%, 35.91%, 29.25% and 27.36% of normal conventional concrete after 28 days of curing.



Graph 2:- Split tensile strength of concrete with varying percentages of Nano-Silica and Nano-Vanadium

The above graph indicates the split tensile strength of concrete for 7 mixes varies by 7.12%, 12.43%, 10.78%, 15.35%, 14.8% and 12.61% of normal conventional concrete after 28 days of curing.



Graph 3:- Percentage loss of weight and Compressive strength of concrete with varying percentages of Nano-Silica and Nano-Vanadium

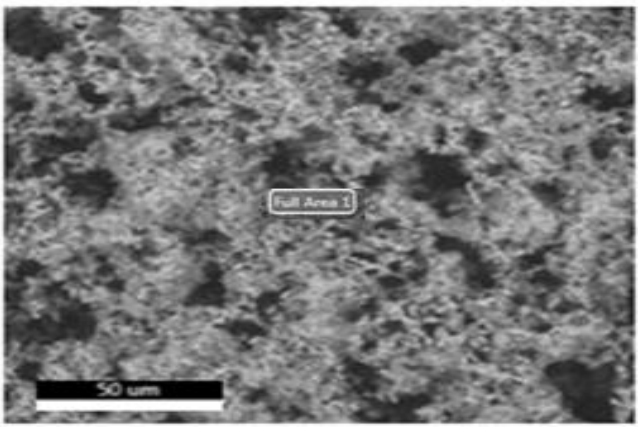


Fig5:- SEM image of Normal concrete mix

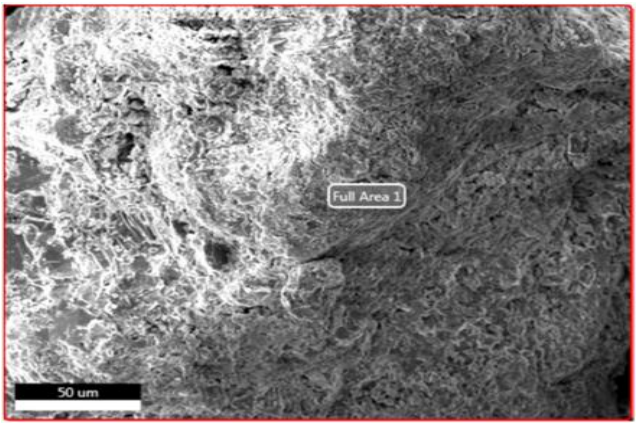


Fig6: SEM image of Concrete mix with Nanosilica and NanoVanadium

IV. CONCLUSION

- By Replacing 1% NS and 0.1% NV by weight of cement, Compressive strength and Split tensile strength is about 1.36 and 1.23 times more when compared to Normal Conventional concrete.
- By addition of NV along with NS to the concrete mix, Compressive strength of about 70% of design strength is achieved for 7 days of curing because of its catalytic nature.
- Therefore maximum compressive strength of concrete can be achieved within 18-20 days of curing instead of 28 days.
- For 1%NS and 0.1%NV by weight of cement, loss of weight and Compressive strength is less for both Acidity and Alkalinity test when compared with Normal Concrete.

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