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Strength And Durability Characteristics of Concrete By using Nanosilica- Nanovanadium Mixture As Partial Replacement of Cement

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Abstract. **A** fast growing interest in applying nanomaterials in various fields has been observed in recent years. Nano-silica and Nano-vanadium are widely used nanomaterials in adhesives, surface coatings, defoamers, cement-based building materials and rubber composites**.** 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: Nano-silica; Nano-vanadium; Compressive strength; split tensile strength; Ordinary Portland Cement.

1.Introduction

Concrete is the material of present as well as future. Due to the rapid population explosion and the technology boom to cater to these needs, there is an urgent need to improve the strength and durability of concrete. Out of the various materials used in the production of concrete, cement plays a major role due its size and adhesive property. So, to produce concrete with improved properties, the mechanism of cement hydration has to be studied properly and better substitutes to it have to be suggested. Different materials known as supplementary cementitious materials or SCMs are added to concrete improve its properties. Some of these are fly ash, blast furnace slag, rice husk, silica fumes and even bacteria. Of the various technologies in use, Nanotechnology looks to be a promising approach in improving the properties of concrete. Thus, the basic concept behind Nano modification of materials is that of bottom-up engineering, starting with engineered modifications to the molecular structure with an aim to affect the bulk properties of the material.

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 manometers to millimetres. 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 information in regards to the nanoproducts content; surprising expenses; the unknows of wellbeing dangers related with nanomaterials.

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The nano particles also make the cement more environmentally friendly and reduce the impact of the construction industry on the environment, hence leading to a more sustainable future. The cement manufactured using this method will not only be more economical than ordinary cement polymers, but will also have a fire resistance. Hence the structure built using nano particles will be stronger and more durable than conventional concrete, which in turn increases the service life of the building.

Nano silica is outstanding amongst other Nano material to enhance the distinctive quality, physical, and mechanical properties of cement than the other Nano material. The use of Nano silica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. 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 estimating 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.

1. Objective

1. To study the effect of mixture of Nano Silica and Nano Vanadium in various ratio on strength and durability characteristics of concrete.
2. Chemical synthesis and size characterization of Silica and Vanadium nano-particles in laboratory.
3. Concrete mix will be prepared by partial replacement of cement by 1-3% by weight with Nano Silica and 0.1% with Nano Vanadium along with required aggregates.
4. The fresh properties of nano-concrete mix will be tested and then casted into cube and cylindrical moulds.
5. The casted cube and cylindrical specimens will be cured and tested for strength and durability characteristics.
6. The effect of nano particles on microstructure of the hardened cement concrete will be studied.

2. Literature Study

Various literature studied are listed below:

- **Li et.al (2004)** incorporated Nano silica into ordinary traditional concrete and reported 3days compressive strength increase and also at later stages same trend was observed with 4% nano-Silica in high volume fly ash concrete. Same results were obtained for Split tensile and flexural strength test. An increase of about 23-38 % and 7-14% at 7days and 28days respectively.
- **Tao Ji (2005**) experimentally studied the effect of Nano SiO2 on the water permeability and microstructure of concrete. The findings show that incorporation of Nano SiO2 can improve the resistance to water of concrete and the microstructure becomes more uniform and compact compared to normal concrete.
- **M.Saravanan et.al (2016)** replaced the Nano-silica in various proportion such as 5%, 10%, 15%, 20% to the weight of cement. When concrete is reduced to Nano level its properties are strongly influenced so that it increases strength and durability. The mechanical properties of concrete such as compressive strength, tensile strength and flexural strength of respective specimen were tested after 7days and 28 days curing.
- **Billa et.al (2017**) deals with Partial replacement of Waste Plastics and waste rubber as partial replacement in concrete at an increment of 5% each time. They observed an increase in compressive strength on addition of a certain minimum quantity of Nano silica. Also, there is a substantial increase in the early-age strength of concrete compared to 28 days strength of concrete. Test results shows that the quality of concrete gets slightly affected on addition of Nano silica but overall quality of concrete is preserved.

3. Material Properties

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.

Compounds	Mass (%)
SiO_2	21.30
Al_2O_3	3.58
Fe_2O_3	5.05
CaO	63.48
MgO	1.39
SO_3	2.05
Na_2O	0.26

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K_2O	0.22
L.O.I	2.57
Total	99.90

Table1: Chemical analysis of OPC (mass %)

Nano-Silica was purchased from Astra Chemicals, Chennai having size of 20-40nm with 99.99% of SiO2 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	C K	O K	SiK
Weight %	16.50	43.78	39.72
Atomic %	24.87	49.53	25.60
Net.Int.	36.66	249.50	260.50
Error %	12.99	7.53	3.60
K ratio	0.0437	0.2465	0.3485

Table2: Chemical properties of Nano-Silica obtained by XRD+EDS test

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

Table3: Chemical properties of Nano-Vanadium obtained by XRD+EDS test

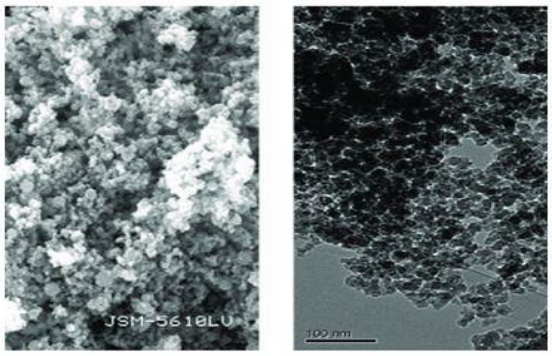

Fig 1: SEM Photographs of Nano-Silica

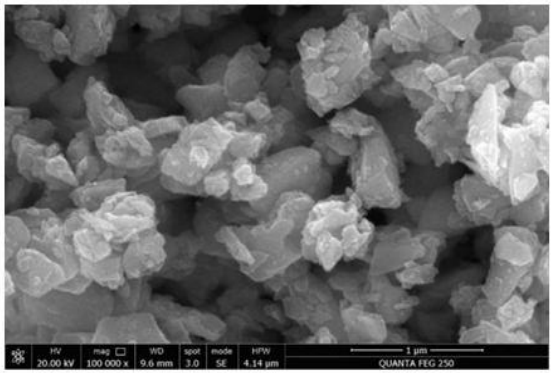

Fig 2: SEM Photographs of Nano vanadium

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%.

4. Methodology

Nano Silica used in the present work is purchased from Astra Chemicals Chennai. Based on the literature survey Nano Vanadium is synthesized by sol-gel autocombustion 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.

5. Procedure

1. Sample have toprepare for M20 grade concrete based on IS 10262:2009 code provisions for 7 mixes i.e., NC (Normal Concrete), NC+1%NS(Nano-silica), NC+2%NS, NC+3%NS, NC+1%NS+0.1%NV(Nano-vanadium), NC+2%NS+0.1%NV and NC+3%NS+0.1%NV.
2. 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.
3. Out of 7 mixes optimum mix which exhibits higher strength is again casted into 6 cubes and cured for 28days.
4. 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.
5. 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.

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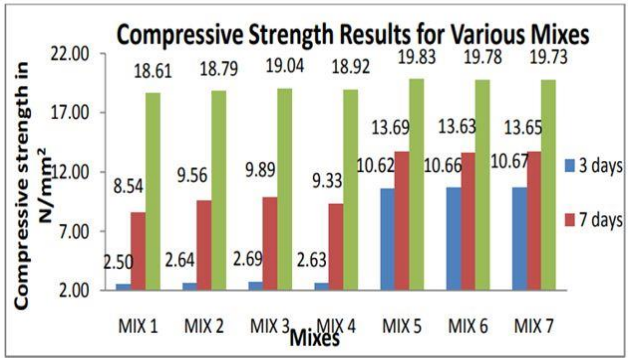
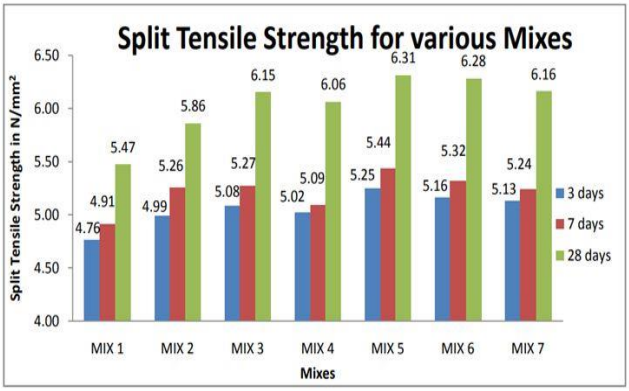
6. Results And Discussion

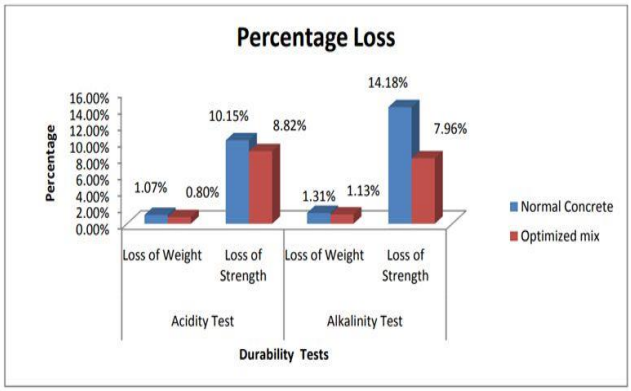
The compressive stress and split stress of concrete are determined by casting cubes and cylinders allowed for 7 and 28 days curing and the test results were obtained for various percentage of Nano silica and Nano vanadium are follows.



The above graph indicates the compressive strength of concrete for 7 mixes varies by 0.96%, 2.31%, 1.66%, 6.55%, 6.28% and 6.01% of normal conventional concrete after 28 days of curing.



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.



7. Scope for future work

1. Concrete with different sizes of Nano Silica particles can be mixed to study the strength and durability characteristics.
2. Nano Silica with different grades of concrete can be studied.
3. Present work can be done by using Mineral admixtures hoping the Nano Vanadium may influence the activation of Mineral admixtures.
4. Nano Silica with different percentage can be mixed with cement to study the Compressive strength of Mortar
5. Micro-biological activity of concrete can be studied.

8. CONCLUSION

1. By Replacing 1% NS and 0.1% NV by weight of cement, 6.55 % of Compressive strength and 15% of Split tensile strength is achieved when compared to Normal Conventional concrete
2. By addition of NV along with NS to the concrete mix, Compressive strength of about 65% of design strength is achieved for 7 days of curing because of its catalytic nature.
3. Therefore maximum compressive strength of concrete can be achieved within 18-20 days of curing instead of 28 days.
4. 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.

References

[1] Hui Li et. al. (2004) “Microstructure of cement mortar with nanoparticles”, Composites: Part B 35, 185-189.

[2] Tao Ji, (2005) “Preliminary study on the water permeability and microstructure of concrete incorporating nano-SiO2”, Cement and Concrete Research 35, 1943-1947.

[3] IS: 383-1970 "Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision)", Ninth Reprint September 1993.

[4] ASTM C94, "American Society for Testing and Materials - C94".

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[5] IS: 2386 (Part IV) - 1963 "Indian Standard Methods of Test for Aggregates for Concrete (Part IV) Mechanical Properties", Tenth Reprint March 1997.

[6] IS: 456-2000 "Indian Standard Plain and Reinforced Concrete - Code of Practice" (Fourth Revision).

[7] International Journal of Professional Engineering Studies, 2017, Vol.3, Issue

[8] Global Journal of Engineering Science and Research Management, 2016, Vol. 3(5)