International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 07 | July - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

REVIEW: AN EXPERIMENTAL STUDY ON EFFECT OF NANO MATERIALS ON STRENGTH OF CONCRETE AND PLANE STRESS ANALYSIS USING ANSYS SOFTWARE

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ABSTRACT

These days, making efficient and cost-effective use of resources has taken precedence. The main ingredient in concrete, cement has been under criticism in recent years for the quantity of CO2 released during production. Although cement has better mechanical properties, it hasn't been able to live up to the expectations in terms of durability. Owing to cement's shortcomings, scientists started looking into additives that would enhance concrete's qualities while also making it stronger and lighter. Fly ash, silica fume, and other micro particles were added to cementitious materials to improve their compactness, strength, and durability. These additives were also selected because they are eco-friendly by products of industrial waste that may be handled ethically. Fly ash has significant disadvantages because it is not good for initial strength increase and setting time. Because silica fume affects cementitious material performance, researchers have recently become interested in combining it with ceramic waste and rice husk ash. A more effective way to utilize rice husk ash, a by-product of rice cultivation, would be to replace 10% to 15% of cement. Studies have shown improvements in the durability performance of recycled ceramic waste concrete and rice husk ash concrete. There are issues since the RHA production process is quite time-consuming. With the discovery of nano-particles (NP) smaller than 100 nm, researchers have advanced the field of nanotechnology to new levels. The mechanical properties of many materials, including polymers and cementitious materials, can be enhanced by NP. NP is also helpful in the fields of food, engineering, and medicine. This led researchers to investigate the effects of nano-silica (NS) on concrete in further detail. Nano materials can improve the compressive strength and ductility of concrete. In this project an effort will be made to increase the compressive strength of concrete using Nano materials and waste product like GGBS. Also plane stress analysis of concrete cubes and cylinders is to be done using Ansys Software to find deformation, principal stresses and shear stresses.

Keywords: Nano –Silica, Nano Titanium dioxide, Ansys, GGBS, Compressive strength

I. INTRODUCTION

One of the most active research topics encompassing several disciplines, such as civil engineering and construction materials, is nanotechnology. Understanding, manipulating, and reorganizing matter at the nanoscale level to produce materials with essentially novel features and capabilities is known as nanotechnology. A concrete that contains Portland cement particles smaller than 500 nanometers as the cementing agent is known as nano-concrete. Concrete is a composite material with several phases and nanostructures that age with time. It is made up of bonded water, crystals that range in size from nanometers to micrometers, and an amorphous phase. Concrete is held together by the amorphous phase known as calcium-silicate-hydrate (C-S-H), which is also a nanomaterial. When seen from the bottom up, molecular assemblages, surfaces (aggregates, fibers), and chemical bonds interact with one another through intra-phase diffusion, intermolecular interactions, and local chemical reactions to form the composite that is concrete at the nanoscale. This scale is characterized

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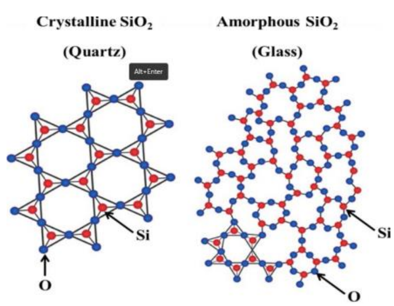
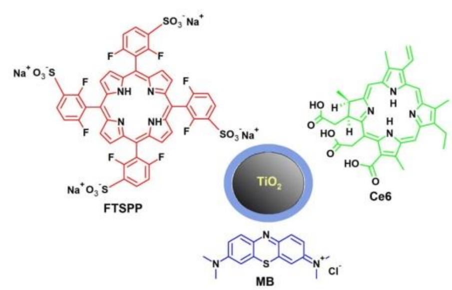
by the following properties: bond length, strength (energy), density, and molecular structure along with surface functional groups. Cement nano-engineering, or nano-modification, is a rapidly developing field. It is possible to create new cement additives, such as super plasticizers, nanoparticles, or nano reinforcements, through the synthesis and assembly of materials at the nano scale. These methods can be applied in an efficient bottom-up manner to regulate the performance, characteristics, and degradation processes of concrete to produce a better concrete as well as give the material new uses and intelligent properties that aren't found in it yet. Three regions can be used to engineer concrete at the nano scale: interfaces, such as those between solid and liquid phases, solid and liquid phases, and solid phases. Due to their large surface area to volume ratio, nano sized particles have a great deal of chemical reactivity potential. The majority of nanoparticle research to date has focused on nano silica (nano-SiO2) and nano titanium oxide (nano-TiO2).A few research have been done on the incorporation of nano clay, nano-iron (nano-Fe2O3), and nano-alumina (nano-Al2O3) particles. It has been discovered that Nano-SiO2 increases the strength and workability of concrete, increases its resistance to water penetration, and helps regulate the leaching of calcium, which is strongly linked to several forms of concrete degradation. Additionally, it was demonstrated that the broad and extremely reactive surface of the nanoparticles in nano-SiO2 speed up the hydration reactions of both C3S and an ash-cement mortar. It was discovered that silica fume was not as effective at increasing strength as nano-SiO2. In addition to helping to keep the environment clean, nano-TiO2 has shown to be incredibly effective at making concrete self-clean. Concrete that contains nano-TiO2 works by initiating the photo catalytic breakdown of pollutants from industrial and vehicular emissions, including aldehydes, carbon monoxide, NOx, and volatile organic compounds (VOCs). Many businesses are already producing self-cleaning and de-polluting concrete solutions to be used on building facades (like the Jubilee Church in Rome, Italy). Few studies have demonstrated that nano-TiO2 can improve compressive and flexural strengths, increase the abrasion resistance of concrete, and expedite the early-age hydration of Portland cement in addition to imparting self-cleaning qualities.



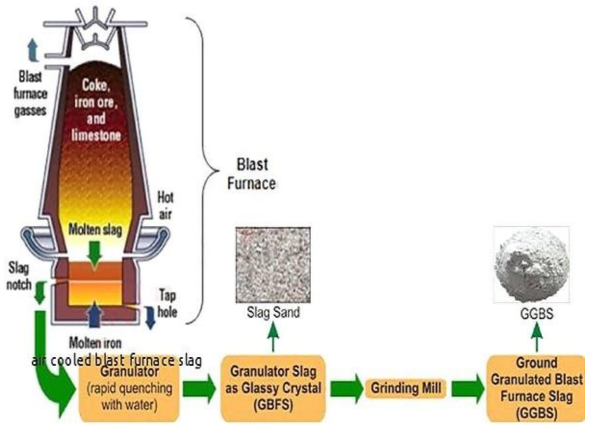
Nano Silica



Nano titanium dioxide (TiO_2)

Ground granulated blast furnace slag (GGBS)

Slag from ground granulated blast furnaces is a byproduct of the iron manufacturing sector. It is produced by quenching molten iron slag in water, a byproduct of blast furnace production of iron and steel. This molten slag's chemical makeup is almost the same as regular Portland cement, consisting of 10% to 20% silicon dioxide (SiO2) and 40% calcium oxide (CaO). The furnace is supplied with iron ore, coke, and limestone. When these ingredients melt inside the furnace, two products are created. a) Iron that is molten b) slag that has melted. The initial iron ore's silicates and alumina, along with a few oxides from limestone, make up the majority of this molten slag. Because the molten slag is lighter than the molten iron, it floats on water. The molten slag is cooled using a high-pressure water jet after the molten iron is tapped off. This causes glassy granulate to form; this glassy granulate is subsequently dried and processed into GGBS, a very fine powder. Concrete made with GGBS will contribute to a decrease in CO2 emissions. In concrete, it can be substituted up to 50% with cement. GGBS has a much lower calcium concentration than cement, therefore setting and early strength development will take some time. Working with concrete in hot weather will benefit from this longer setting time.



GGBS Powder

Why Nano technology for Concrete?

1. Production of high-performance concrete and cement materials evaluated by their durability and mechanical qualities.
2. Establishing environmentally friendly concrete products and structures by designing for various harsh conditions, lowering cement manufacturing energy requirements, and improving safety.
3. Creation of intelligent concrete materials by combining cyber infrastructure technologies with materials that are self-powered and sensing thanks to nanotechnology.
4. Production of new concrete materials by creatively treating cement and cement paste using nanotechnology.
5. By means of sophisticated characterization and modeling of concrete at the nano, micro, and macro sizes, a foundational multiscale model or models for concrete are developed.
6. Enhances the bulk characteristics of the material.
7. The ability to regulate or work with materials at the atomic level.
8. To achieve quicker setting times and thinner finished goods.
9. Cost effectiveness.
10. Less amount of pollution in the environment.

ANSYS Software for Plane Stress Analysis

ANSYS software is widely used for plane stress analysis in concrete structures due to its robust capabilities in finite element analysis (FEA). Here are some key uses and features of ANSYS in this context:

1. **Material Modeling:** ANSYS allows engineers to model concrete behavior accurately using various material models. Concrete is typically modeled using nonlinear material properties to account for its nonlinear stress-strain behavior, especially under compression and tension.
2. **Structural Analysis:** For plane stress analysis in concrete, ANSYS can simulate the behavior of structural elements such as slabs, walls, and beams subjected to different loading conditions. It considers the plane stress assumption where the stress in the thickness direction is assumed negligible compared to the stresses in the plane of the structure.
3. **Load Analysis:** ANSYS can handle complex loading scenarios including point loads, distributed loads, and thermal loads. Engineers can apply these loads to simulate real-world conditions and assess the structural response.
4. **Boundary Conditions:** ANSYS allows the application of various boundary conditions such as fixed supports, roller supports, and prescribed displacements. These boundary conditions are crucial for modeling the realistic behavior of concrete structures under different support conditions.

5. **Nonlinear Analysis:** Concrete exhibits nonlinear behavior, especially in the post-cracking regime. ANSYS supports nonlinear analysis capabilities such as large deformations, material nonlinearity, and contact analysis, which are essential for accurately predicting the response of concrete structures under varying loads.
6. **Failure Analysis:** ANSYS can predict potential failure modes in concrete structures such as cracking, yielding, and ultimate failure. Engineers can perform failure analyses to ensure that designs meet safety and performance criteria.
7. **Design Optimization:** Using ANSYS, engineers can perform parametric studies and optimizations to refine designs and improve performance metrics such as strength, stiffness, and durability of concrete structures.
8. **Post-Processing:** ANSYS provides comprehensive post-processing tools to visualize results such as stress distributions, displacements, and deformations. This helps engineers interpret analysis results and make informed design decisions.
In summary, ANSYS software is highly effective for plane stress analysis in concrete due to its advanced capabilities in modeling material behavior, simulating complex loading conditions, handling nonlinearities, and providing detailed post-processing of results. These features make ANSYS a valuable tool for engineers involved in the design, analysis, and optimization of concrete structures.

II. LITERATURE REVIEW

Different literatures are available on concrete with Nano materials and ggbs. Several researchers conducted test results are presented for review of past experiments works. Changjiang Liu investigated on the effect of nano-silica as cementitious materials-reducing admixtures on the workability, mechanical properties and durability of concrete. The influence of various dosages of NS on the setting time and mechanical properties of concrete was analyzed in order to achieve the goals of carbon peaking and carbon neutralization, along with the research idea of cementitious materials-reducing admixture for concrete, under the condition of reducing the amount of cement in concrete by 20%. The specimen's compressive strength and splitting tensile strength after 28 days of curing are the maximum at 40.87 and 3.8 MPa, respectively, indicating an increase of 6.6 and 15.15% under the same curing circumstances and ages when the NS dosage is 2.5%. Muhammad Atiq Orakzai studied on "Hybrid effect of nano-alumina and nano-titanium dioxide on Mechanical properties of concrete" The influence of the binary combination of nano-titanium dioxide (nano-TiO_2) and nano-alumina (nano-Al_2O_3) on the mechanical properties of concrete is examined in this research. Tests for compressive and splitting tensile strength were done on 100 x 200 mm cylinders, and after a 28-day curing period, flexural strength was tested on 150 x 150 x 450 mm beams. It was discovered that the ideal dosages of nano-Al2O_3 and nano-TiO_2 were 0.5% and 1% by weight of cement, respectively. The increases in compressive, splitting tensile, and flexural strengths were 42%, 34%, and 28%, respectively, in comparison to the control sample. V. Nagendra studied on "Ggbs and Nano Silica (Ns) effect on Concrete. There have been two phases to the experimental work. In the initial phase, the GGBS effect was investigated as a cement substitute in different ratios of 10, 20, 30, and 40%, with particle sizes ranging from 20 μm to 250 μm for each replacement. Initially, the findings indicated that a 20% cement replacement level achieves the best strength for particles with a size of 20 μm. In the second phase, the optimal dosage of GGBS and nanosilica was investigated. In this phase (the second), the amount of nanosilica was adjusted in steps of 2, 4, and 6% while the 20% of GGBS was assumed to be constant. Based on all the data, it can be observed that adding nanosilica to GGBS in concrete has produced the highest strength at 4%NS and 20% GGBS replacement for particles with a size of 20 μm. G. Ramachandran studied on "Experimental study on concrete by partial replacement of cement using ggbs and nanoparticles Cement is partially replaced by 30%, 40% of Ground Granulated Blast furnace Slag(GGBS), 3 % of Nano Silica and 3% of Nano Titanium dioxide by weight. The concrete that was made with 30% GGBS and 3% nano silica—an optimum mix—showed a noticeable increase in strengths, which was attributable to excellent particle packing. Author Dr. G Elangovan investigated on 'Plane Stress Analysis on Concrete Cube with Fragmentary Restoration for Cement by Alccofine" in this Study 36 cube samples of size 150 mm were cast for different percentages of Alccofine with partial replacement of cement at the percentages of 0%, 5%, 10%, 15%, 20%, and 25%. According to the test results, after 7 and 28 days of curing, the amount of Alccofine in the concrete enhanced strength. Pothala Vasudevareddy studied on "Effect of Nano-Titanium Dioxide and Amorphous Silica on Fresh and Hardened

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Concrete" Anatase Nano Titanium Dioxide (TiO2) and Amorphous Silica (AS) nanoparticles are added to cement at different weight proportions in the current investigation: 0.5% & 2.5%, 1% & 5%, 1.5% & 7.5%, 2% & 10%, and 2.5% & 12.5%. Specimens of concrete were cured and cast. Durability values were obtained after 90 days of curing in acidic (5% H2SO4) water, and mechanical properties after 7, 14, and 28 days of curing in normal water. Results are better with TiO2 with AS combined at 1.5% and 7.5% as with regular concrete.

III. RESULTS FROM LITERATURE

Sr. No	Name of Paper	Name of Author's	Mix proportions	Compressive Strength in Mpa		Split Tensile Strength in Mpa		Flexural Tensile Strength in Mpa	
				7 Days	28 Days	7 Days	28 Days	7 Days	28 Days
01	GGBS and nano silica (ns) effect on concrete	V. Nagendra	2% NS and 20% GGBS Replacement	19.60	32.10	NA	NA	NA	NA
			4% NS and 20% GGBS Replacement	20.30	35.40	NA	NA	NA	NA
			6% NS and 20% GGBS Replacement	18.60	33.30	NA	NA	NA	NA
02	Experimental study on concrete by partial replacement of cement using GGBS and nanoparticles	G.Ramachandran	67% PPC +30% GGBS + 3% N.S	18.00	32.50	2.22	2.86	2.08	6.16
			67% PPC +30% GGBS + 3% N.T	12.00	30.00	2.00	2.35	1.40	3.83
			57% PPC+ 40% GGBS + 3% N.S	14.93	21.30	2.12	2.64	2.30	5.58
			57% PPC+ 40% GGBS + 3% N.T	11.00	25.80	1.64	2.20	1.33	3.58
03	Performance of concrete by using titanium dioxide	Dr.K. Chandramouli	40%GGBS+1%TIO2	32.84	47.74	3.50	5.02	NA	NA
04	Effect of Fly Ash and Nano Titanium Dioxide on Compressive Strength of Concrete	Sumit Sharma	20% fly ash+ 1% nano TiO2	NA	40.3	NA	NA	NA	NA
			20% fly ash+ 1.5% nano TiO2	NA	42.7	NA	NA	NA	NA
			20% fly ash+ 2% nano TiO2	NA	38.4	NA	NA	NA	NA
05	Effect of Nano-Titanium Dioxide and Amorphous Silica on Fresh and Hardened	Pothala Vasudevareddy	0.5 %Titanium dioxide + 2.5% Amorphous silica	18.92	33.12	2.24	3.46	2.34	3.73
			1.00 %Titanium dioxide + 5 % Amorphous silica	20.61	36.43	2.52	3.85	2.41	3.81

	Concrete		1.5 %Titanium dioxide + 7.5% Amorphous silica	24.25	42.04	2.67	4.12	2.57	3.99
			2 %Titanium dioxide + 10% Amorphous silica	20.89	37.98	2.34	3.62	2.39	3.86
			2.5 %Titanium dioxide + 12.5% Amorphous silica	16.68	31.27	1.81	3.27	2.17	3.43
06	Behaviour of GGBS and Nanosilica on strength properties of concrete	Ramesh .N	30% GGBS And 2% N.S	29.37	48.92	29.37	48.92	-	4.63
07	Effect of Nanomaterial On mechanical properties Of High strength Concrete	P.mohan Vamsi Krishna	NC 1%	NA	107	NA	6.3	NA	6.9
			NC 2%	NA	104	NA	6.1	NA	6.8
			NC 3%	NA	103	NA	6.0	NA	6.1
08	Experimental Study on MEPS concrete and Brick using Nano Material	Shaikh Hakeem Thousif Ahmed	30% flyash 20% GGBS 15% Silica Fume 1% Nano MgO, 4% Nano TiO2 5% Nano fe2O3 Replaced to 40% PC	NA	15.7	NA	NA	NA	NA
09	Study on crumb Rubber concrete using GGBS and Nano TiO2	Shreyas L. Bedagkar	GGBS 30%, TiO2 5% , Crumb rubber 5% ,10%,15%,20%	27.59	54.32	NA	NA	3.942	5.807
			Flyash 25% TiO2 5% Crumb rubber 5% ,10%,15%,20%	26.84	55.998	NA	NA	3.942	6.429

			Flyash 25% GGBS 30% TiO2 5% Crumb rubber 5% ,10%,15%,20%	27.77	55.35	NA	NA	4.355	6.014
10	Influence of Nano materials in High strength Concrete	Abdul Rahim	CM	38.15	61.76	NA	3.20	NA	8.20
			CMG	47.10	64.71	NA	3.50	NA	9.00
			CNS3	51.20	72.60	NA	3.82	NA	10.50
			CNS4	56.80	80.40	NA	4.36	NA	12.50
11	Hybrid effect of nano alumina and nano titanium dioxide on nechanical properties of concrete	Muhammad Atiq Orakzai	Nano-Al2O2 0.5% Nano- TiO2 1%	NA	40.47	NA	4.58	NA	5.84
12	Experimental Investigation on Nano Alumina Based concrete	Kunchala Ashok	1)NC 30 NAC 30	25.9 37	39 46	3.05 3.52	3.28 3.93	3.05 4.4	3.28 4.61
			2)NC 40 NAC 40	31 44	48 55	3.29 3.84	3.64 4.44	3.69 4.51	4.13 5.08
			3) NC 50 NAC 50	38 48	58 66	3.63 4.22	4.62 4.75	4.19 4.64	5.38 5.72

IV.CONCLUSION

The use of Nano materials in concrete represents a promising avenue for enhancing the properties and performance of traditional concrete mixes. Here are some key conclusions drawn from the application of Nano materials in concrete:

1. **Improved Mechanical Properties:** Nano materials such as nanoparticles (e.g., silica nanoparticles, carbon nanotubes) and Nano fibers can significantly improve the mechanical properties of concrete. They enhance compressive strength, flexural strength, and durability by reducing pore size, increasing density, and enhancing the bonding between cementitious materials and aggregates.

2. **Enhanced Durability:** Nanomaterial's contribute to improving the durability of concrete by reducing permeability, enhancing resistance to chemical attack, and improving freeze-thaw resistance. This can lead to longer service life and reduced maintenance costs for concrete structures.

3. **Reduced Environmental Impact:** Certain nanomaterial's can contribute to sustainability in concrete production. For example, nanomaterial's like Nano-silica can be derived from industrial waste products, reducing the environmental footprint associated with concrete manufacturing.
4. **Challenges and Considerations:** Despite their benefits, the incorporation of nanomaterial's into concrete faces challenges such as cost-effectiveness, potential health and safety concerns during handling, and scalability of production. Ensuring uniform dispersion and avoiding agglomeration of nanoparticles in concrete mixes are critical challenges that need to be addressed.
5. **Research and Development:** Ongoing research and development efforts are crucial to fully understand the long-term effects of nanomaterial's on concrete performance and to optimize their dosage and application methods. Standards and guidelines for incorporating nanomaterial's into concrete need to be established to ensure reliable performance and safety.

In conclusion, while the use of nanomaterial's in concrete shows great promise in enhancing properties such as strength, durability, and sustainability, continued research, standardization, and careful consideration of economic and environmental factors are essential for their successful integration into mainstream concrete construction practices**.**

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