Review Article

In-Depth Literature Review Concerning the Application of Nano Silica and Nano Graphene Oxide to improve the Performance of Concrete

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ABSTRACT

In this research paper the Graphene oxide, which is generated from graphite, is characterized by its remarkable electrical conductivity, large surface area, and extraordinary mechanical strength. The addition of this substance to concrete matrices has the potential to greatly improve the mechanical qualities of the concrete, including its compressive strength, flexural strength, and abrasion resistance. In addition, GO has the capacity to reduce the spread of cracks and enhance the longevity of concrete buildings by preventing the diffusion of chloride ions and carbonation. On the other hand, silica nanoparticles have certain characteristics that set them apart from other particles. These characteristics include a large surface area, pozzolanic activity, and enhanced packing density inside the asphalt matrix. When SiO2 nanoparticles are mixed with graphene oxide (GO), they further increase the dispersion of graphene sheets, which ultimately results in enhanced interfacial bonding and overall mechanical characteristics. In addition, the pozzolanic reaction that takes place between silica nanoparticles and calcium hydroxide is a contributor to the densification of the cement matrix, which ultimately leads to an increase in strength and a decrease in permeability. In this Research article, some of the researcher's studies have been incorporated in order to enhance and have strengthen the properties of Concrete for the structures.

KEYWORDS

Nano Silica, Graphne Oxide and Blast Furnance Slag

1. INTRODUCTION

Graphene Oxide (GO) has garnered a lot of attention in the scientific community due to the fact that it may be used as a precursor for the manufacture of graphene and because it has a variety of polar groups that can be altered, which makes it possible to exert control over the characteristics of the materials. In point of fact, graphene oxide (GO) may be used as raw materials for the synthesis of nanoparticles-graphene composites as well as various other types of polymers-graphene composites. These composites can be made using materials such as epoxy, polystyrene, polyaniline, polyvinyl alcohol, and polyurethane. Today, GO is also being investigated for its potential use as a reinforcing ingredient in cement composites (cement paste, mortar, and concrete), and several authors have reported positive results regarding this use. In instance, in the most recent years, studies have been published in the literature that demonstrate an increase in the compressive strength of more than 10% and in the flexural strength of 40%. These findings are very important and have piqued the attention of the cement industries. There is a lack of complete comprehension and description of the process that enables this remarkable increase in the mechanical characteristics. Shengua et al. [1] proposed a regulatory mechanism of GO on cement hydration products.

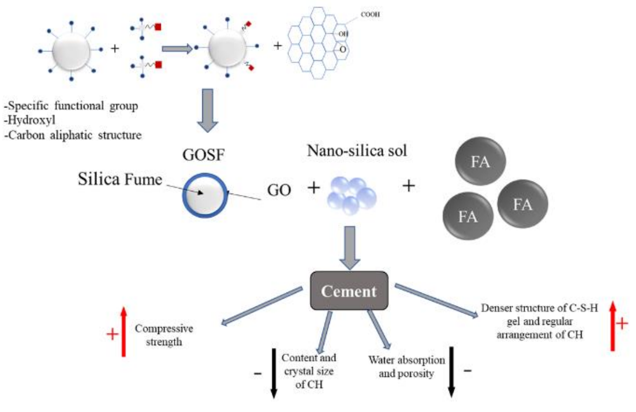

Figure 1 Shows Nano Silica Mixing in Cement Paste

They hypothesized that the grafene oxide induces the formation of more regular crystal structure (flower and polyhedron-like) due to the presence of oxygen functionalities on the GO, which act as nucleation sites for the hydration crystals. This was the mechanism that they proposed. This research does not give a precise approach for the investigation of this issue, nor does it provide a comprehensive description of the process that was used in this research. In the study presented, graphene oxide has been manufactured beginning from graphite powder, and it will be described utilizing a variety of methods, including the following: X-ray diffraction analysis, infrared and Raman spectroscopy, inductively coupled plasma optical emission spectrometry, thermogravimetric analysis, elemental analysis, transmission electron microscopy, and the selective area electron diffraction method are all examples of techniques that may be used. Following three, seven, and twenty-eight days of curing, the graphene oxide will be utilized in varying concentrations as a reinforcing additive in mortar samples. These samples will be mechanically characterized (compression and flexural resistance), observed with a scanning electron microscope, and analyzed with energy dispersive spectroscopy. We are going to make an effort to functionalize the graphene oxide with a molecule that can operate as a plasticizer for cement base composites. The dispersion of the graphene oxide in cement is a challenging process, and the addition of the graphene oxide to the paste causes a reduction in the workability of the mortar.

2. LITERATURE REVIEW

Changjiang Liu, Fulian Chen, and Yuyou Wu [1] reviewed new GO uses in cement-based materials. From earlier studies, we may conclude:

1) The high Ca^{2+} content and alkaline atmosphere cause GO to aggregate in cement. GO disperses mostly via physical and chemical alteration. Mechanical agitation and ultrasonic dispersion provide stable dispersion. After chemical treatment, GO disperses effectively but is expensive. Polycarboxylate superplasticizer and ultrasonic dispersion generate the most studied and effective dispersion effect.
2) GO reduces cement material functionality due to van der Waals force and specific surface area between layers. PCE's electrostatic repulsion and steric hindrance may reduce GO's negative impact on operational performance.
3) A little amount of GO improves cement-based materials' compressive, tensile, flexural, elastic modulus, and fracture performance. GO incorporation, oxidation (oxygen content), dispersion, lamellar dimension, and superplasticizers affect improvement.
4) GO improves pore structure and reduces porosity in cement-based composites. (ii) Controlling hydration product morphology to promote microstructure density and homogeneity. Filling the transition zone at the interface improves aggregate-paste adhesion. Notably, the method by which GO strengthens cement composites is unknown.
5) GO, NS, and CNTs' synergistic impact on cement-based materials is understood. Nanohybrids improve mechanical characteristics and durability more than single nanomaterials. The increased dispersion of nanohybrid materials may explain this.

In contrast, a stable network structure with hydration products and nanoparticle interaction facilitates homogeneous load transmission in the cement matrix.

GO's effect on cement composites is a hot topic in building. On May 25, 2021, Nationwide Engineering builds the first graphene concrete slab for sustainable commercial activities. The project might boost concrete strength by 30% and reduce carbon emissions by 2%. This is typical nanomaterial construction use. Since GO is a graphene derivative, it is expected to contribute to practical engineering soon.

The increased interest in graphene oxide (GO), a frequently used derivative of graphene, has shown its possibilities, according to Made Adi Supariarta, Anissa Maria Hidayati, and Silvia Gabrina Tonyes [2]. GO's potential to enhance cement-based materials is being studied, although large-scale manufacturing efficiency is still needed. GO's large surface area supports hydration and strong linkages between C-S-Hs and GO in composites, inhibiting fracture propagation and enhancing density, while its nanoscale properties reduce porosity and pore size. GO generally increases strength by 0.05 weight percent, but the ideal dose is unknown. GO may improve corrosion resistance as well as transportation. However, budgets, reputation, and promotion hinder GO's use in building. Industrial production requires better quality control, and awareness efforts about GO's advantages and construction industry adoption are essential.

Akarsh P K, Shriram Marathe, and Arun Kumar Bhat [3] found that concrete with SF and GO slumped more than other combinations. Silica fumes and graphene oxide have a lower specific surface area than normal cement, therefore they need more water to wet. At 28 days, 0.15% GO and 7% silica fume concrete had 29.54% higher compressive strength than normal concrete. The CS3G3 specimen's flexural strength was 8.0 MPa, exceeding pavement requirements. Early strength increases more than later strength, which benefits pavement application. The finest concrete specimens have identical stress-strain curves (Modulus of elasticity values).The cylinder with CS3G3 mix resists compressive and tensile stresses better than any other combinations. Concrete specimens had decreased water absorption and permeable gaps due to nano and micro Graphene oxide and silica fumes filling holes. SEM study showed that the concrete with Silica gasses and Graphene oxide has the densest hydration products. Silica fume and PC-based superplasticizer disperse GO better than PC-only superplasticizer. The high-intensity peaks in the CS3G3 specimen may be owing to increased hydration products, while the vast number of peaks may be related to microstructure improvements. EDAX research showed graphene oxide in concrete, and e-ZAF quant findings suggest GO and silica fumes may enhance hydration products. Compared to standard concrete, the chosen concrete mixtures withstand sulphate and acid assaults better. Concrete with both SF and GO resists cyclic loads for a given stress ratio or can withstand more cycles than other test specimens. According to testing results, nanomodified concrete may be a successful pavement quality concrete for sustaining heavy vehicle movements since it meets IRC design standards. Dispersion and cement hydration product bonding should be considered to maximize nanomaterial potential. Vacancies may form from agglomerates. Thus, dispersion and mixing must be done properly. It may minimize slab thickness and material utilization. However, adding nanomaterials to pavement concrete might raise its cost. The economic advantage of this technology must be assessed using life cycle analysis.

Birkhede, Pujari, Purke [4] studied

1. Graphene oxide boosts compressive, tensile, and flexural strength.
2. Flexural strength requires 0.1 percent GO, or 4% of a PPC matrix's compressive strength of 11%.
3. Adding GO increases oxidation, which increases cement paste hydration and cement matrix density, making the product more durable.

Rehab Emad, Ibrahim M. Ibrahim. A. Radwan [5] conducted this investigation in phases. First, analyzing and preparing the raw materials for actual work and the sample's curing and workability time. Be particular with the ratios "1:02,1:04, 1:06", "1:04:04, 1:04:06, 1:04:08", and "1:02:02, 1:02:04, 1:02:06" to continue working with compressive.

Rahul Divekar, Dr. R. M. Sawant [6] found that various nanomaterials replace cement at different amounts in the literature.

M. J. Karthikeyan [7] and Devasena researched this work.

1. Graphene oxide increases compressive, tensile, and flexible strength.
2. 0.1% GO improves PPC matrix flexural strength by 4%. 11 percent compressive strength.
3. The use of GO boosts cement paste hydration and density of the cement matrix, making it stronger.

Pooja Kaushik, Prof. Gauhar Mehmood [8] found that graphene oxide increases the compressive and tensile strengths of numerous concrete classes.

The compressive strength of M15, M20, M25, M30, M35, and M40 concrete with 0.10%, 0.12%, 0.14%, 0.16%, and 0.2% Graphene Oxide (GO) replacement increased by 9.29%, 11.23%, 12.41%, 15.11%, and 8.42%, while the tensile strength increased by 9.0%, 11%, 12%, 15%, and 8%.

Vladimir Pershin and Ali Mashhadani [9] found that graphene-modified concrete has 16% higher bending strength at three points and 33% higher compressive strength than unmodified concrete. Few-layer graphene's particle count per unit volume may increase concrete strength more than its mass concentration. This assumption requires further study because a decrease in the mass concentration of few-layer graphene in concrete while maintaining its strength action opens a new path to large-scale industrial use of environmentally friendly and inexpensive technology to improve concrete performance.

Priyanka Dutta, Dr. Biman Mukherjee [10] reviewed recent industry developments and how nanotechnology in civil engineering spurs high-performance, smart/multifunctional concrete. Reconstructing or modifying nano-scale material structure units by understanding material genetic code and drawing nano-scale property blueprints gives novel theory and technology to build high-performance, durable, and environmentally friendly concrete. Nanotechnology helps understand concrete behavior, control and design concrete performance, decrease concrete production and ecological cost, increase engineering infrastructure service life, and minimize concrete demand. It is crucial to lead sustainable concrete material and infrastructure development.

Kaffayatullah Khan, Waqas Ahmad [11] conducted a keywords' review of nano-silica (NS)-modified concrete literature to evaluate major research areas. VOSviewer was used to examine 1015 Scopus papers. This study also covered key research areas and generated prediction models for NS-modified concrete strength. The following conclusions obtained from this study:

The examination of keywords identified the top five most often occurring terms. nano-silica, silica, compressive strength, concrete, cement. The evaluation keywords indicated that NS was mostly explored for durability. concrete mechanical and microstructural properties.

- Adding nano-particles like NS to cementitious materials requires the addition of water or super-plasticizers to maintain workability freshly mixed.
- NS affects cementitious materials based on particle size and type. (colloidal/powder), surface area, dosage, and mix w/c.
- Increasing NS concentration to 2% or 3% may improve mechanical properties. and cementitious materials' durability. Perhaps due to the pozzolanic reactivity, pore refinement, or filling.
- Increasing NS content enhances concrete mechanical strength. NS activation promotes hydration. But if the If NS concentration exceeds 3%, strength may decrease.
- Established models for predicting NS-modified concrete strength. was consistent with experimental findings owing to greater R2 and lower incorrect values. This approach might estimate needed parameters. of material, saving experimental study time and money.
- NS doses over 3% may worsen the properties of the material because NS granules accumulate, increasing porosity, microcracking, mechanical weakness.
- NS has much more pozzolanic activity than silica fume. All ages, NS-containing concrete was stronger than usual. concrete. The addition of NS enhanced the concrete's flexural and splitting strength.
- NS exerts filling action, pozzolanic activity, and a compact ITZ that reduces Ca(OH)2 crystal size and amount microstructure between cement paste and particles, resulting in extended matrix strength and durability.
- Inclusion of evenly dispersed NS particles improves the microstructure of concrete. Although NS has significant positive effects on durability metrics, and mechanical characteristics of cementitious materials in various. There are still disagreements over the size and kind of Methods of NS concentration and dissemination. A wide investigation in this topic is needed required to define basic prerequisites for realistic deployment such nanoparticle.

3. PROPOSED METHODOLOGY

The Nano Silica (NS) is frequently the first product to replace the MS. NS makes concrete more marketable and reduces its CO2 impact. NS's 2% residues are ignored. This research uses 98% NS. This study used 98% purity.

Graphene Oxide: - The first human-discovered two-dimensional crystal. Although it is composed of just one graphite sheet, its unique features are revolutionizing material science. No mass-production methods for defect-free monolayer graphene exist. Graphene nanomaterials are revolutionizing nano-biotechnology due to their nano-size, unique form, large surface area, and strong properties. Due to its unique properties, graphene and related nanomaterials may take on several shapes. [18]• The research used several molds to cast specimens, including cubes (150x150x150 mm), cylinders (150 mm diameter, 300 mm length), prisms (100 x 100 mm size, 500 mm length), and beams (230mm x 300mm size, 1.74m length). Steel or cast iron may be used for this mold. Close the bottom and sides of the mold to prevent mortar seepage. Clean and mineral oil all mould faces. Oil is used to prevent mold and concrete reactions. The usual specimen is fully crushed. After a day of curing in water, we took 36 specimens from the mold. Samples were tested for compression, split tensile, and flexural properties after 7 and 28 days.

IV. CONCLUSION

In conclusion, graphene oxide (GO) combined with silica nanoparticles (SiO2 NPs) in concrete may improve its performance. The synergistic impacts of these nanoparticles increase concrete construction mechanical characteristics, durability, and permeability. GO and SiO2 NPs reinforce the cement matrix, reduce fracture propagation, and prevent chloride ion migration and carbonation via increased dispersion, interfacial bonding, and pozzolanic reactions. This method can provide high-performance concrete and aid building sustainability. Further study and modification of concrete mixes using these nanoparticles are needed to fully benefit from them and progress nanotechnology-enhanced concrete.

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