International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Effect of Mechanical Properties of Concrete using Nano Silica and Partial Replacement of Fly Ash in Cementitious Material

Dr. Ashwini. B [a], Ramprasath. R [b]

[a] *Assistant Professor, Dept. of Civil Engineering, E.G.S Pillay Engineering College (Autonomous), Nagapattinam, Tamilnadu, India.*
[b] *Under Graduate Student, Dept. of Civil Engineering, E.G.S. Pillay Engineering College (Autonomous), Nagapattinam, Tamilnadu, India.*
Doi: https://doi.org/10.55248/gengpi.5.0424.1099

A B S T R A C T

This research endeavors to assess the mechanical characteristics of concrete by synergistically employing nano silica and partially substituting fly ash in cementitious materials. By integrating nano silica as a supplementary cementitious material and selectively replacing a segment of conventional fly ash in the cement mixture, the study aims to yield significant enhancements. The study entails a thorough examination of how the addition of nano silica and the replacement of fly ash impact the mechanical properties of concrete. We seek to identify the optimal dosage for fly ash replacement and nano silica addition, pinpointing the ideal dispersion solution and method to ensure effective nano silica dispersion in the concrete mix. Through this investigation, we aim to contribute valuable insights into advancing the mechanical performance of concrete using innovative materials and techniques.

Keywords: Concrete, Nano silica, Fly ash replacement, Mechanical properties, Dispersion method

1. Introduction

The construction industry continually seeks innovative ways to enhance the mechanical properties of concrete, a crucial material in various infrastructure projects. This study focuses on the combined effects of nano silica and fly ash replacement on concrete, exploring their potential synergy in improving strength and durability. The choice of OPC 53 grade cement, class F fly ash, and M-Sand reflects the contemporary construction practices emphasizing sustainability and performance.

Fig. 1 Concrete

Fig 2. Cement

1.1 Concrete properties and composition

Concrete is a composite material consisting of cement, aggregates, water, and other additives. Understanding the fundamental properties and composition of concrete is essential for assessing the impact of nano silica and fly ash on its mechanical characteristics. OPC 53 grade cement is known for its high early strength and durability, making it a preferred choice in construction projects.

1.2 Cement

Cement is a binding material used in construction that sets and hardens to adhere to other materials, binding them together.

1.2.1 Composition of Cement

The chemical composition of cement, particularly in terms of the main compounds found in clinker, can be represented by chemical equations. The major compounds in cement clinker are calcium silicates (C3S and C2S), tricalcium aluminate (C3A), and tetra calcium aluminoferrite (C4AF). The chemical equations for the formation of these compounds during the cement manufacturing process are as follows:

1. Formation of Tricalcium Silicate (C3S)

$$3CaO + SiO_2 \xrightarrow{Heat} 3CaO\ .\ SiO_2$$

2. Formation of Dicalcium Silicate (C2S)

$$2CaO + SiO_2 \xrightarrow{Heat} 2CaO\ .\ SiO_2$$

3. Formation of Tricalcium Aluminate (C3A)

$$3CaO + Al_2O_3 \xrightarrow{Heat} 3CaO\ .\ Al_2O_3$$

4. Formation of Tetracalcium Aluminoferrite (C4AF)

$$4CaO + Al_2O_3 + Fe_2O_3 \xrightarrow{Heat} 4CaO\ .\ Al_2O_3\ .Fe_2O_3$$

These equations represent the key chemical reactions that occur during the high-temperature processing of raw materials in the cement kiln, leading to the formation of clinker. The clinker is then ground to produce the final cement product. Additionally, gypsum (CaSO4 · 2H2O) is often added during the grinding stage to control the setting time of the cement:

$$Clinker + 2CaSO_4 \xrightarrow{Grinding} Cement$$

These equations provide a simplified representation of the chemical transformations involved in cement production. The actual process involves multiple reactions and intermediate compounds, but the equations above capture the essence of the main reactions leading to the formation of the key cementitious compounds.

1.2.2 Types of Cement

- Ordinary Portland Cement (OPC): Commonly used in general construction.
- Portland Pozzolana Cement (PPC): Contains pozzolanic materials like fly ash.
- Rapid Hardening Cement: Sets quickly and gains strength early.
- Portland Slag Cement (PSC): Includes granulated blast furnace slag.
- White Cement: Produced from raw materials low in iron and manganese.

1.2.3 Properties of cement

- Setting Time: Time taken for the cement to set.
- Strength: Determines the load-bearing capacity.
- Fineness: Particle size affects the surface area.
- Heat of Hydration: The heat produced during the curing process.

1.3 Aggregate

Aggregates are granular materials, such as sand, gravel, or crushed stone, used in concrete mixtures.

1.3.1 Types of aggregate

- Fine Aggregates (Sand): Particles smaller than 4.75 mm.

- 2. Coarse Aggregates (Gravel, Crushed Stone): Particles larger than 4.75 mm

Fig. 3 Types of Aggregate

1.3.2 Properties

- Grading: Distribution of particle sizes.
- Shape: Affects workability and strength.
- Specific Gravity: Ratio of the density of the aggregate to the density of water.
- Absorption: The amount of water absorbed by the aggregate.

1.4 Admixtures

Admixtures are chemicals added to concrete to modify its properties.

Fig. 4 Admixtures

1.4.1 Types of admixtures

- Water Reducers: Improve workability without increasing water content.
- Retarders: Delay setting time.
- Accelerators: Speed up setting time.
- Air-Entraining Agents: Introduce air bubbles to improve freeze-thaw resistance.
- Superplasticizers: Significant water reduction with improved workability.

1.4.2 Functions of admixture

- Workability Enhancement: Improves the ease of handling and placing concrete.
- Setting Time Control: Alters the time it takes for the concrete to set.
- Strength Enhancement: Can increase early or final strength.

1.5 Fly Ash

Fly ash is a by-product of coal combustion in power plants, and when mixed with cement, it enhances concrete properties.

1.5.1 Properties of fly ash

- Pozzolanic: Reacts with lime to form compounds contributing to strength.
- Fineness: Similar to cement, affects surface area.
- Chemical Composition: Influences reactivity and strength development.
- Spherical Particle Shape: Enhances workability.

1.5.2 Benefits of fly ash

- Improved Workability: Reduces water demand.
- Increased Durability: Enhances resistance to sulphate attack and alkali-aggregate reaction.

1.6 Nano Particles

Nano particles in concrete are very small particles, often less than 100 nano meters in size, used to modify concrete properties.

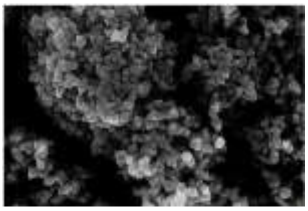

Fig. 5 Nano particle

1.6.1 Major types of nano particle

- Nano Silica (Nano-SiO_2): Enhances strength and durability.
- Nano Titanium Dioxide (Nano-TiO_2): Provides self-cleaning properties.

1.6.2 Properties of nano particle

- High Surface Area: Allows for better interaction with cement particles.
- Reactivity: Improves pozzolanic activity.
- Uniform Dispersion: Enhances the overall performance.

1.6.3 Applications of nano particles

- Strength Enhancement: Improves mechanical properties.
- Durability Improvement: Increases resistance to chemical and environmental factors.
- Self-Healing Properties: Repairs microcracks at a nanoscale level.

1.7 Role of OPC 53 Grade Cement

OPC 53 grade cement is characterized by its high compressive strength and reduced setting time compared to lower-grade cements. Its superior performance is attributed to the increased proportion of tri-calcium aluminate, promoting early strength development. This study leverages the benefits of OPC 53 grade cement to establish a strong foundation for assessing the impact of nano silica and fly ash on concrete properties.

Fig. 6 OPC 53 grade cement

Table 1

Name of compound	Values
Lime (CaO)	60% - 67%
Silica (SiO_2)	21% - 25%
Alumina (Al_2O_3)	4% - 7%
Iron Oxide (Fe_2O_3)	2% - 6%
Magnesia (MgO)	< 6%

1.8 Significance of Fly Ash in Concrete

Class F fly ash, a by-product of coal combustion, has gained prominence as a supplementary cementitious material in concrete production. Its pozzolanic properties contribute to improved workability, reduced heat of hydration, and enhanced long-term strength. The decision to replace 35% of the cement with fly ash in this study aligns with sustainable construction practices, aiming to mitigate environmental impact while enhancing concrete performance.

Fig. 7 Fly ash

1.9 Nano Silica in Construction Materials

Nano silica, with its ultrafine particle size, is known for its pozzolanic and pozzolanic-hydraulic properties. Its addition to concrete has shown promising results in enhancing strength, durability, and impermeability. The study incorporates 1.75% nano silica to explore its synergistic effects with fly ash, aiming to unlock the full potential of these supplementary materials in improving concrete properties.

Fig. 8 Nano silica powder

1.10 Effect of Fly Ash Replacement on Concrete Properties

Previous research has demonstrated that replacing a portion of cement with fly ash positively influences concrete properties. The interaction between fly ash and cementitious compounds leads to improved workability, reduced permeability, and enhanced strength. By replacing 35% of the cement with fly ash, this study seeks to build on existing knowledge and assess the combined effects of fly ash and nano silica on concrete performance.

1.11 Applications of M-Sand in Concrete

The use of Manufactured Sand (M-Sand) as a fine aggregate in concrete production is gaining traction due to its availability, consistent quality, and environmental benefits. M-Sand reduces the dependency on natural river sand, addressing concerns related to sand mining and environmental degradation. Incorporating M-Sand in the concrete mix ensures a sustainable approach to construction while maintaining desired workability and strength.

Fig. 9 M-sand

1.12 Poly-Carboxylic Ether Solutions

Poly-Carboxylic Ether (PCE) solutions are widely employed as superplasticizers in concrete to enhance workability without compromising strength. The choice of PCE for dispersing nano silica ensures uniform distribution within the concrete matrix. This section explores previous studies highlighting the effectiveness of PCE in improving dispersion and the consequent impact on concrete properties.

1.13 Magnetic Stirring for Nano Silica Dispersion

Achieving a homogeneous dispersion of nano silica is crucial for realizing its benefits in concrete. Magnetic stirring has been recognized as an effective method for dispersing nanomaterials in cementitious matrices. This section reviews studies showcasing the advantages of magnetic stirring in achieving uniform distribution and improved properties in nano-enhanced concrete.

1.14 Silicon Dioxide Nanoparticles

- Average Particle Size: 20-50 nm
- SSA: ~220 m2/g Molecular Weight: 231.533 g/mol
- Molecular Formula: SiO_2 Bulk Density: 0.25 g/cm 3
- Physical Form: Powder
- Morphology: Spherical Color: White

1.14.1 Silicon Dioxide Nanoparticles Description and Specifications

Silicon Dioxide (SiO_2) is a molecule made from Silicon and Oxygen, sometimes known as Silica, and the components are held together by a covalent connection. It is one of the sand's constituents and is present naturally in Quartz. It is typically white or colorless, insoluble in water or ethanol. It produces the silicate family by combining with minerals. Silicon Dioxide nanoparticles or Silica nanoparticles as a substrate are most common for proteins and enzymes and as a modified surface to immobilize cells and tissue. Surrounding a central Silica core, the nanoparticles have a unique hexagonal "waffle-iron" crystal structure. The negatively-charged surface of the particles is naturally attracted to positively-charged DNA molecules. The consumption of Silicon Dioxide as a natural mineral necessary for life on earth is vast. The nanostructured Silica with unique geometric properties forms biomaterials conjugates with various hybrid nanomaterials. It helps produce innovative results for sensing and imaging DNA.

The Silicon Dioxide nanopowder, also known as Silica nanoparticles or nano-silica, is the foundation for much biological research. According to their structure, the classification of nano-silica particles includes P-type or S-type. Compared to the S-type, the P-type particles feature numerous nanopores with a pore rate of 0.61 ml/g and higher UV reflectivity. The latter also has a significantly smaller surface area.

1.14.2 Reaction

Silicon Dioxide nanopowder does not react with water and is acid-resistant. The substance's chemical formula is SiO2. Silicon oxide, the group of acidic glass-forming oxides, interacts with alkalis and basic oxides as temperature rises, generating a supersonic fusion, indicating that glass is an excellent dielectric. The Chemical Co-Precipitation technique creates the suspension of nanoparticles. At ambient temperature, these Silica nanoparticles are ultra-stable in aqueous solutions and may be easily tailored to typical biological buffers such as phosphate-buffered saline (PBS).

1.14.3 Analysis

Our analytical-grade non-functionalized SiO2 nanoparticles are suitable for many scientific applications. For example, 100 nm Silicon Dioxide (Silica) nanoparticles are standard for aggregation tests and colloidal behavior research. In contrast, non-functionalized Silica nanoparticles are excellent for chemical deposition and other biological applications. Many applications rely on Silica nanoparticles with ultra-narrow size distributions as a size reference.

1.14.4 Properties

- It is a white powdery particle.
- It is translucent and has a density of 2634 kg/m3.
- It has a molar mass of 60.0843 g/mol.
- The surface temperature is 1986 °K, whereas the boiling temperature is 2503 °K.
- Quartz, cristobalite, and tridymite are crystal structures.
- It is manufactured in various concentrations ranging from 0.1% to 5%.
- Highly monodisperse: the particle size distribution is narrow, CV< 3%. • Roundness > 0.980: particles pack well to form a dense and smooth powder.
- They are prepared by the sol-gel process based Stuber method: high quality, low cost, short preparation time.
- Surface chemistry: Hydroxyl (-OH): chemically stable in many environments

1.14.5 Applications of Silicon Dioxide Nanoparticles

Silicon Dioxide (SiO2) has a variety of industrial applications, including its use as a food ingredient. It serves as a beverage clarifier, anti-binder, viscosity controller, anti-foaming agent, desiccant, and pharmaceutical and vitamin excipient. Silicon Dioxide Nano powder is common for detecting DNA and the nucleic acid that contains genetic information. It proves beneficial in different techniques like PCR (polymerase chain reaction) to amplify only incomplete or damaged DNA strands. Moreover, researchers utilize the powder in cytometry flow to isolate cells with specific markers.

The utilization of SiO2 nanoparticles is famous as a rubber and plastic additive, strengthening filler for concrete and other building composites, and a stable, non-toxic platform for biomedical applications such as drug administration and theragnostic. Although it is not a micronutrient, Silicon (Si) identification has been beneficial for plants due to its favorable effects on plant development and production and tolerance to biotic and abiotic stress factors. It has enhanced surface adsorption and energy properties, excellent chemical purity, excellent dispersion, ultrafine molecule size, and high thermal resistance. Silicon Dioxide nanoparticles (SiO2 NPs) are presently being probed as one of the most interesting new inorganic accoutrements.

1.14.6 How to Use?

- The dispersion of Silicon Dioxide nanoparticles is the latency of nanoparticles in water or various organic solvents such as mineral oil or ethanol.
- Use appropriate solvent of choice to disperse the product.
- Use amagnetic stirring for dispersion.

1.14.7 Safety Measures

Personal safety precautions, protective equipment, and emergency response protocols

- Wear personal safety equipment.
- Avoid the production of dust.

- Breathe no fumes, mist, or gas.
- Make sure there's enough airflow.
- Personnel should be evacuated to safe regions.
- Avoid inhaling dust.

1.14.8 Precautions for the Environment

- Do not allow the products to enter the drainage system.
- Containment and clean-up methods and materials
- Pick up and dispose of items in a dust-free manner.
- Sweep and scoop the floor. For disposal, keep inappropriate and closed containers.

1.14.9 Safe-handling Precautions

- Avoid encounters with your skin or your eyes.
- Prevent the development of dust and aerosols.
- Provide enough exhaust ventilation in areas where dust forms.
- Keep the container firmly closed in a dry, well-ventilated location.

1.14.10 Advice in General – First Aid

- If the researcher inhales the product, get the individual some fresh air.
- If the product comes into touch with the researcher's skin, wash it off with soap and plenty of water.
- If the material touches the researcher's eyes, rinse them well with lots of water for at least 15 minutes.
- Rinse your mouth out with water.

1.15 Mechanical Properties of Concrete

1.15.1 Compressive Strength

- Definition: Compressive strength is the ability of concrete to resist axial loads or forces that tend to compress it.
- Testing: This property is typically determined by conducting compressive strength tests on cylindrical specimens. The test involves applying a load to the specimen until it fails.
- Factors Influencing: Factors affecting compressive strength include water-cement ratio, curing conditions, aggregate properties, and mix design.

1.15.2 Tensile Strength

- Definition: Tensile strength is the capacity of concrete to resist forces trying to pull it apart.
- Testing: Direct tensile strength testing of concrete is challenging, so flexural tests are often conducted to estimate tensile strength indirectly.
- Factors Influencing: Tensile strength is significantly lower than compressive strength in concrete. Factors like the quality of aggregates, curing conditions, and the presence of reinforcing materials impact tensile strength.

1.15.3 Flexural Strength

- Definition: Flexural strength, also known as modulus of rupture, is the ability of concrete to resist bending.

- Testing: This property is determined by testing beams subjected to a bending load. The test measures the maximum stress in the extreme fibers of the specimen.
- Factors Influencing: Similar to tensile strength, factors such as mix design, curing, and the use of reinforcing materials influence flexural strength.

1.15.4 Elastic Modulus

- Definition: Elastic modulus, or modulus of elasticity, represents the stiffness of concrete. It is a measure of how much deformation occurs under a given load.
- Testing: Elastic modulus is usually determined from stress-strain curves obtained during compressive testing.
- Factors Influencing: The elastic modulus is influenced by factors like aggregate type, water-cement ratio, and curing conditions.

1.15.5 Poisson's Ratio

- Definition: Poisson's ratio is the ratio of lateral strain to axial strain. It describes how much a material tends to contract laterally when compressed.
- Testing: Poisson's ratio can be determined experimentally through testing or estimated based on empirical relationships.
- Factors Influencing: The composition and proportions of concrete components affect Poisson's ratio.

1.15.6 Shear Strength

- Definition: Shear strength is the ability of concrete to resist forces that act parallel to the surface.
- Testing: Shear strength is usually determined through shear tests, such as the direct shear test or punching shear test.
- Factors Influencing: Factors like aggregate type, size, and shape, as well as the presence of shear reinforcement, influence shear strength.

1.15.7 Creep and Shrinkage

- Creep: Creep is the time-dependent deformation of concrete under sustained load. It is crucial for long-term structural performance.
- Shrinkage: Shrinkage refers to the reduction in volume of concrete due to drying and chemical changes.
- Factors Influencing: Both creep and shrinkage are influenced by factors such as humidity, temperature, mix design, and curing conditions.

Understanding these mechanical properties is essential for designing concrete structures that can withstand various loading conditions and environmental factors. Engineers consider these properties in combination to ensure the safety and durability of structures over time.

2.0 LITERATURE REVIEW

Anjeza Alaj’s 2023 research affirms the viability of sustainable concrete by replacing 30% of cement with low CaO content class F fly ash, showcasing positive environmental and quality outcomes over 600 days of testing. In 2023, MCK. Jamenraja’s experiment enhances concrete properties by incorporating polypropylene fibers (0.2-0.4%), alccofine (15%), and nanosilica (1%), resulting in improved compressive strength, elasticity modulus, flexural strength, acid resistance, and durability characteristics, showcasing a novel material that promotes ductile failure for enhanced concrete durability and serviceability.Abhishek Kumar’s 2023 study demonstrates that incorporating nano-silica up to 3% improves both mechanical and durability properties of concrete, with increased compressive strength, significant pozzolanic activity, refined pore structure, and potential for reducing environmental pollution by lowering CO2 emissions during hydration.In 2022, Rajkumar’s study highlights the effectiveness of colloidal nanosilica, with up to 3% substitution for cement, enhancing mechanical and durability properties, while also improving microstructure and acting as a catalyst for pozzolanic activity in high-performance concrete.In 2021, Kanta Rao’s research explores the utilization of fly ash as a cost-effective alternative to cement in concrete, revealing that a 30% replacement enhances compressive, split tensile, and flexural strengths by 13%, 9%, and 13%, respectively, with finer particles and pozzolanic action contributing to increased strength even after optimal replacement.In 2021, Abhilash’s review emphasizes the environmental impact of concrete, highlighting the potential for enhanced durability by incorporating small amounts of nano-silica, which modifies the nano-structure of cementitious materials, leading to improved mechanical properties and durability parameters.In 2021, B. Ashwini and Vidiveli’s research demonstrated enhanced durability properties in concrete through partial cement replacement with fly ash (20%) and incorporation of Multi-Walled Carbon Nanotubes (0.025%, 0.05%, 0.075%), analyzed via acid, chloride, and sulphate resistance tests.In 2020, B. Ashwini and Vidiveli conducted research on incorporating Multi-Walled Carbon Nanotubes (0.025%, 0.050%, 0.075%) and partial cement replacement with fly ash (20%) in concrete, assessing mechanical properties through compression, split tensile, and flexural tests.In 2020, B. Ashwini and Vidiveli investigated the combined effects of Multiwalled Carbon Nanotube incorporation (0.025%, 0.05%, 0.075%) and 20% cement replacement with Class-F fly ash in concrete, emphasizing the importance of dispersion for enhanced mechanical properties, specifically focusing on the elastic modulus after 28 days of curing.Sridhar's 2019 study reveals that incorporating 3% nano silica by weight in high-performance concrete accelerates early-stage hydration, improves water permeability resistance, enhances microstructure, and acts as a filler material, promoting pozzolanic activity for superior concrete quality. In 2019, Mohana Sundari's project investigates the impact of Nano-silica on reinforced beams, assessing its influence on compressive and flexural strength, workability, and comparing results with a conventional beam, aiming to optimize the material's performance in the presence of supplementary cementitious materials.The study suggests that using activated fly ash as a partial replacement for cement in concrete can be a viable option for improving the strength and sustainability of concrete structures by B.Tipraj at 2019.Jaishankar's 2018 research demonstrates that adding nano silica to M70 high-performance concrete not only improves mechanical strength but also enhances durability, as indicated by positive trends in alkalinity and water absorption tests, particularly with higher proportions of nano silica replacing cement.In a 2017 study by OM. Suganya, Nano silica in colloidal form enhanced concrete properties, with fly ash substitution at varying levels, showcasing increased mechanical strength and sustainability.In 2017, Prasath's study investigates the pozzolanic nature of nano silica and silica fume, examining their impact on improving mechanical properties in M30 and M40 concrete while addressing corrosion issues through accelerated corrosion tests on columns with varying percentages of silica fume and nano silica substitutions for cement.In 2017, C. Karthikeyan's study explores advancements in concrete technology, incorporating silica fume and nano silica as partial replacements for cement in M30 and M40 grades, demonstrating improved mechanical and durability properties, and addressing corrosion concerns through optimized usage of nano silica and silica fume.In his 2017 review paper, Rishab Joshi investigated the impact of partial cement replacement with fly ash (0%, 10%, 20%, and 30%) on M20 grade concrete, finding that while workability and durability increased with fly ash content, there was a corresponding reduction in compressive strength, with the optimal replacement identified as 30%.This research by R.D. Padhye (2016) investigated the optimal use of fly ash as a partial cement replacement in high-grade concrete. They tested various percentages of fly ash in different concrete grades and curing periods, finding the best balance between strength, cost, and applicability for each grade.In 2016, Jayanta Chakraborty's research extensively analyzes the effects of Fly Ash as a partial replacement for cement in high-grade concrete, investigating compressive strength variations at different Fly Ash percentages and curing periods to determine optimum, acceptable, and economical usage.In 2016, Mohd Mufasshir Alam Shah's study highlights the revolutionary use of nano materials, particularly nano-silica, in concrete to enhance mechanical properties, including compressive strength, split tensile strength, flexural strength, impact test, and modulus of elasticity for M50 grade concrete, offering a sustainable alternative to traditional methods.In 2015, M. Bala Vinayag's review explores the utilization of fly ash, a major waste material from thermal power plants, as a binding material in geopolymer concrete, incorporating nanosilica and silica fume to enhance properties, performance, and real-world applications, providing an effective solution to reduce environmental impact by repurposing fly ash waste.In 2003, Rafat Siddique's study reveals that incorporating high volumes of Class F fly ash (40%, 45%, and 50% replacement) in concrete initially reduces short-term strength but exhibits significant improvement in compressive, tensile, and flexural strengths, modulus of elasticity, and abrasion resistance after 91 and 365 days, suggesting suitability for up to 50% cement replacement in precast elements and reinforced concrete construction.

3. CONCLUSION

In conclusion, this research project focused on evaluating the mechanical characteristics of concrete through the synergistic use of nano silica and partial substitution of fly ash in cementitious materials. The investigation contributed to the identification of key parameters for optimizing concrete performance. The optimal dosage of nano silica particles was determined to be 1.75%, leveraging its potential as a supplementary cementitious material. The use of OPC 53 grade cement was found to yield the best strength in the concrete mixture. Additionally, the partial replacement of cement with 35% fly ash demonstrated positive effects on the mechanical properties of the concrete. In terms of material selection, the study endorsed the use of M-sand for its favorable mechanical properties and economic advantages. Furthermore, for effective dispersion of nano silica, the combination of a Poly-carboxylic Ether solution and magnetic stirring was identified as the most suitable method. The research outcomes provide valuable insights for advancing the mechanical performance of concrete by incorporating innovative materials and techniques. The identified optimal dosages, material selections, and dispersion methods can serve as a practical guide for the concrete industry, offering a pathway to enhanced strength and durability in construction applications. This study contributes to the ongoing efforts to optimize concrete compositions for sustainable and high-performance infrastructure development.

4. REFERENCE

1) Abhishek Kumar, Vipin Pal, Chand Husain, Aditya Vatshvanshi, Anurag Shahi, Khushaboo, "An Experiment Study on Tensile & Compressive Strength of Concrete Using Nano Silica", International Research Journal of Modernization in Engineering Technology and Science, 2023, volume 5.

2) MCK Jamenraja, K Ravichandran, "Experimental Investigation of Mechanical and Durability Properties of Concrete Containing Nano Silica, Alccofine and Polypropylene Fibers", Indian Journal of Science and Technology, 2023.

3) AnjezaAlaj,VisarKrelani, Tatsuya Numao, "Effect of Class F Fly Ash on Strength Properties of Concrete", Civil Engineering Journal, 2023, volume 9.

4) Raj Kumar, Suganya Natarajan, Rahul Singh, Vinod Singh Rajput, Ganesh Babu Loganathan, Sanjeev Kumar, T. Sakthi and Akter Meem Mahseena, "Investigation on Mechanical Durability Properties of High-Performance Concrete with Nanosilica and Copper Slag", Hindawi Journal of Nanomaterials, 2022.

5) B. Ashwini and B. Vidivelli, "Durability Analysis of Concrete with Partial Cement Replacement withFlyashandMwcnt Incorporation", ARPN Journal of Engineering and Applied Sciences, 2021, volume 16.

6) Abhilash P. P, Dheeresh Kumar Nayak, Bhaskar Sangoju, Rajesh Kumar, Veerendra Kumar, "Effect of nano-silica in concrete; a review", Construction and Building Materials, 2021.

7) Kanta Rao M, Naga Satish Kumar, "Evaluation of Strength Properties of the Concrete Prepared from Class F Fly Ash", IOP Conf. Series: Earth and Environmental Science, 2021.

8) B. Ashwini and B. Vidivelli, "Effect of multiwalled carbon nanotube Incorporation in modulus elasticity of concrete with Partial replacement of cement with flyash", IOP Conference Series: Materials Science and Engineering, 2021.

9) B. Ashwini and B. Vidivelli, "Effect of Multiwall Carbon Nanotube Incorporation on Mechanical Properties of Concrete with Partial Replacement of Cement with Fly Ash", International Journal of Engineering Research & Technology (IJERT), 2020, volume 9.

10) J. Sridhar, D. Vivek, D. Jegatheeswaran, "Mechanical and Flexural Behavior of High-Performance Concrete Containing Nano Silica", International Journal of Engineering and Advanced Technology, 2019, volume 9.

11) S. Mugil, K. Mugunthan, A. Prabhu, P. Rohind, S. MohanaSundari, "Enhancing the Performance of Concrete by Using Nano Silica", International Research Journal of Engineering and Technology, 2019, volume 6.

12) P. Jaishankar, K.T. Poovizhi, K. Saravana Raja Mohan, "Strength and Durability Behaviour of Nano Silica on High Performance Concrete", International Journal of Engineering & Technology, 2018.

13) OM. Suganya, S.K. Sekar, "Study on The Effect of Nano Silica on Mechanical Properties of Concrete", International Journal of Civil Engineering and Technology, 2017, volume 8.

14) S. Prasath, Dr. S. Senthil Selvan, E. Balaji, "Experimental Study of Nano Silica and Silica Fume Concrete Column Subjected to Corrosion", International Journal of Civil Engineering and Technology, 2017, volume 8.

15) C. Kaarthikeyan, Dr. S. Senthil Selvan, E. Balaji, "Flexural Behaviourof Nano Material Concrete Beam Subjected to Various Levels of Corrosion", International Journal of Civil Engineering and Technology, 2017, volume 8.

16) Rishabh Joshi, "Effect on Compressive Strength of Concrete by Partial Replacement of Cement with Fly ash", International Research Journal of Engineering and Technology, 2017, volume 4.

17) MohdMufasshirAlam Shah, E. Balaji, Prof. G. AugustineManiraj Pandian, "Experimental study on mechanical properties of high strength concrete using Nano-Silica", International Research Journal of Engineering and Technology, 2016, volume 3.

18) R. D. Padhye, N. S. Deo, "Cement Replacement by Fly Ash in Concrete", International Journal of Engineering Research, 2016, volume 5.

19) Jayanta Chakraborty, Sulagno Banerjee, "Replacement of Cement by Fly Ash in Concrete", SSRG International Journal of Civil Engineering, 2016, volume 3.

20) B. Tipraj, M. Guru Prasad, E. Laxmiprasanna, A. Priyanka, Prashant.K. Hugar, "Strength Charecterstics of Concrete with Partial Replacement of Cement by Fly Ash and Activated Fly Ash", SSRG International Journal of Civil Engineering, 2016, volume 3.

21) M Bala Vinayag, M I Abdul Aleem, J Thaarrini, S YaminiRoja, "Review on Strength and Durability Characteristic of Geopolymer Concrete with Macro Silica, Nano Silica", International Research Journal of Engineering and Technology, 2015, volume 2.

22) RafatSiddique, "Performance characteristics of high-volume Class F fly ash concrete", Cement and Concrete Research, 2004.