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Reviewing the effect of nano materials on strength of concrete

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Abstract

The study investigates review on nano cementitious composites' effects on concrete. It addresses corrosion resistance and bond strength of concrete, Nano pozalonic materials reduce concrete permeability and enhance morphology, It evaluates strength and durability characteristics of concrete, The study focuses on improving concrete strength using MWCNTs, Strength increased by with varying MWCNT percentages, The review compares concrete with and without CNT additives, Multiwalled carbon nanotubes (MWCNT) enhance epoxy binder properties, Natural fibers are considered to address environmental issues, MWCNT and SWCNT improves tensile and fracture properties of composites, Hybrid FRP systems show significant load-carrying capacity improvements, Hybrid FRP systems show significant load-carrying capacity improvements.

Keywords: Carbon Nanotube; Compressive Strength; Concrete Durability; Nanotechnology

1. Introduction

The study focuses on corrosion resistance in concrete. Nano pozalonic materials enhance concrete's morphological characteristics. The research evaluates pull-out behavior of steel reinforcement. Concrete is the most used material globally. Cement production contributes significantly to CO2 emissions. Environmental pollution from cement production needs minimization. Rapid infrastructure expansion increases cement demand in developing countries. The study focuses on enhancing concrete strength using carbon nanotubes. Multiwalled carbon nanotubes (MWCNTs) are the primary additive investigated. The research evaluates mechanical and durability properties of concrete mixtures Incorporation of carbon nanomaterials improves concrete's compressive and flexural strength. The findings suggest promising applications for construction materials. Conventional concrete is widely used for building structures. It is cost-effective and has long-lasting performance. Conventional concrete has low tensile strength and cracks easily. Innovative concretes are being designed as alternatives; The research focuses on concrete's compressive strength with CNTs. It utilizes gene expression programming and random forest techniques. Nanomaterials enhance concrete's mechanical and durability performance. The study addresses environmental impacts of concrete production. Machine learning models predict strength of CNTs-based composites. Fiber-reinforced polymer (FRP) sheets strengthen concrete structures. Interfacial debonding failure is a major issue. Premature failure reduces the effectiveness of FRP sheets. The demand for high-rise and large-scale buildings is increasing. Research aims to reduce cross-section and enable long spans. High strength and ductility are essential for concrete. Various studies focus on overcoming concrete limitations. Fiber reinforced concrete (FRC) has been traditionally used. The building industry consumes natural resources and emits carbon. Waste materials are used in construction composites for sustainability. This review focuses on waste plastics and coal fly ash. Properties of waste-derived composites are evaluated for construction applicability.

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Carbon nanotubes enhance mechanical strength in composites. Focuses on water absorption and chloride penetration. Highlights various nanomaterials like nano-SiO2 and graphene oxide. Discusses improvements in mechanical and durability properties. Aims to reduce greenhouse gas emissions from cement production. Repairing damaged structures is crucial for infrastructure development. Demolition and rebuilding are often not viable options. Strengthening techniques are needed for safety and serviceability. Concrete confinement enhances load capacity, energy absorption, and ductility.

2. Summarized Review analysis

Table 1 Summarised Study of literature review

No.	Paper Title	Year of publication	Author name	Waste material added	Method used	Findingand conclusion	Gaps Finding
1	Effect of nano cementitious composites on corrosion resistance and residual bond strength of concrete	2023	Tattukolla Kiran	Low calcium fly ash from Salem district, Tamil Nadu, India was used.	Verification of non-porous mix through experimental investigations	NC and NFA improve compressive strength over normal concrete, Suitable for repair and rehabilitation to improve durability.	The influence of nanomaterials on bond strength is limited. Need for developing concrete to reduce permeability and chloride retention.
2	Impact of Nano-silica on the hydration, strength, durability, and microstructural properties of concrete	2023	Fadi Althoey	Waste pozzolanic materials include slag, wheat straw ash, rice husk ash	Experimental Testing. MicrostructuraAnalysis, Durability Testing, Comparison with Control Samples. Statistical Analysis	Nano-silica enhances concrete's compression strength significantly, Optimal nano-silica proportion relates to reactivity and flocculation.	The paper does not specify gaps in research. It focuses on Nano-silica's effects on concrete properties.
3	Study on strength and durability characteristics of nano-silica based blended concrete	2023	Subhashish Dey	Ground granulated blast furnace slag (GGBS) from iron and steel industry	Mix Design, Material Proportions, Specimen Preparation, Testing Procedures Durability Assessment	Blended concrete shows substantial strength improvement with SCMs, Workability increases with mineral admixtures compared to control mix, Acid durability factor better in blended concrete than control mix.	No specific gaps identified in the provided contexts.

4	On the effect of carbon nanotubes in Ultra-High Performance Fibers Reinforced Concrete.	2023	Luciano Feo	The contexts do not mention any waste materials used	The method involves a meso-mechanical model for UHPFRC.	The model predicts bending behavior of UHPFRC with nanofiller, Modifying fracture energy parameters accounts for nanofiller bridging effect.	The research does not address gaps finding. Further experimental results are needed for calibration.
5	Compressive strength prediction of concrete blended with carbon nanotubes using gene expression programming and random forest: hyper-tuning and optimization	2023	Dawei Yang	The contexts do not mention any waste materials used	Random forest segments data into multiple sub-models for accuracy	Nanomaterials, especially CNTs, enhance concrete's compressive strength and durability, Curing time and water-to-binder ratio significantly impact concrete strength.	Flexural strength and durability characteristics were not considered . Fresh data on higher temperatures and environmental factors is suggested.
6	Improving bonding behavior between basalt fiber-reinforced polymer sheets and concrete using multi-wall carbon nanotubes modified epoxy composites	2023	Changchn Shi	The contexts do not mention any waste materials used.	The study used single-shear tests for evaluation Digital image correlation (DIC) technique monitored strains and displacements.	MWCNTs modified epoxy enhances BFRP-concrete bonding properties significantly, Bond strength and ductility improved with MWCNTs addition, Effective bond lengths increased with MWCNTs modified epoxy.	The study lacks direct measurement methods for bond shear stress. Limited research on MWCNTs in epoxy for FRP-concrete bonding exists. No detailed SEM observations of debonding interface mechanisms provided
7	Mechanical properties of mortar and concrete incorporated with nanomaterials	2023	Dong-Hee Son	The contexts do not mention any waste materials used	Mixing methods for nanomaterials were utilized, mix nanomaterials with total mixing water, prepare concentrated aqueous solution with part mixing water.	Mechanical properties of concrete improved with nanomaterials, Triple nanomaterials enhanced dispersion	Limited industrial application of nanomaterial mixing methods. Small specimen sizes hinder practical

						without special pretreatment.	building applications.
8	The title is "Plastic-fly ash waste composites reinforced	2022	Boitumelo Makgabutlane	Waste plastics are used in	Mechanical mixing improves CNT dispersibility in composites,	Nanomaterials enhance waste materials for sustainable construction products	Challenges in CNT dispersion within composite matrices remain significant.
	with carbon nanotubes			construction composites	Ultrasonication aids temporary dispersion of CNTs, Chemical treatment improves hydrophilicity and reduces agglomeration of CNT	High mechanical and thermal properties are achieved with CNTs. Further research is needed on waste and nanomaterial interactions.	Limited research on sustainable applications of waste-derived composites exists. Need for improved interfacial interactions between nanomaterials and construction materials.
9	Effect of zirconium oxide nanofiber on concrete	2022	Yaser Zarea	Zirconium oxide nanofibers were used as a cement replacement	Coarse and fine aggregates were used per ASTM standards, Various tests measured compressive, tensile, and flexural strengths	the incorporation of zirconium oxide nanofibers into concrete not only enhances its mechanical properties but also improves its durability against environmental factors, making it a promising material for future construction applications	No specific gaps were identified in the provided contexts. Further research may be needed on higher nanofiber dosages. Limited studies on zirconium oxide nanofibers' long-term effects
10	Durability performance and microstructure analysis of nano engineered blended concrete	2022	D.Praseeda	Vetrified tiles powder was used as a waste materia.	Rapid Chloride Penetration test was conducted for water penetration measurement, Water absorption and sorptivity tests were performed on concrete mixes	The mix with 0.05% CNT showed highest compressive strength. It exhibited 80% lower water absorption than unreinforced concrete.	The research does not address gaps finding. Focus is on durability performance and microstructure analysis.

					SEM-EDS and XRD analyses determined microstructure and crystalline phases	MCNT4 had the lowest chloride penetration resistance.	
11	Influence of nanomaterials on water absorption and chloride penetration	2022	Jamal Abdalla	Rice husk ash (RHA) is also utilized	It analyzes water absorption and chloride penetration in cement concrete, Various nanomaterials are evaluated for their performance.	Incorporation of nano materials reduces water absorption significantly, Nano-CaCO3 reduced water absorption by 65-70%. Nano-Fe2O3 achieved a 73.77% reduction in water absorption	The paper lacks detailed experimental methodologies for nanomaterials. Limited discussion on long-term performance of nanomaterials in concrete
12	Modifying epoxy binder with MWCNT	2022	Lakshmi Joseph	Natural fibers like coir, jute, sisal, and flax were used	The study utilized MWCNT incorporated epoxy for retrofitting concrete, Various strength tests were performed on concrete cylinders	MWCNT modified epoxy enhances concrete structure strength. Hybrid confinement improves ductility and compressive strength.	The research lacks in-depth analysis of nano incorporated epoxy-based composites, Limited exploration of MWCNT effects on hybrid FRP composites exists.
13	The critical incorporation concentration (CIC) of dispersed carbon nanotubes	2022	Myungjun Jung	Silica sand acted as inert filler	Electrical DC resistance measured using four-probe method, Compressive strength tested using universal testing machine.	The critical incorporation concentration (CIC) of CNTs is 0.5 wt%. CNTs enhance multifunctional properties of UHPC.	Limited study on thermal properties of CNT-UHPC composites. Insufficient exploration of shrinkage effects with CNT addition.
					Particle size and zeta potential measured with analyzers.	Excessive CNTs above 0.5 wt% degrade mechanical properties. Autogenous shrinkage reduction is limited with	Need for comprehensive analysis of overall engineering properties

						higher CNT content.	
14	Enhancing bonding behavior between carbon fiber-reinforced polymer plates and concrete using carbon nanotube reinforced epoxy composites	2022	Pitcha Jongvivatsakul	The research does not mention any waste materials used	Single-shear tests conducted to assess bonding behavior. Evaluated bond strength, slip, and interfacial fracture energy.	Adding 0.5% SWCNTs enhances bond strength significantly. 1.0% MWCNTs also improves bond strength, but less effectively. Adequate dispersion of CNTs is crucial for bond strength.	The study does not explicitly mention gaps. Further research on high-density epoxy is needed. Effects of different CNT concentrations require more exploration.
15	Comprehensive multiscale techniques to estimate the compressive strength of concrete incorporated with carbon nanotubes at various curing times and mix proportions	2021	Shakr Nzar	-	Regression techniques were used to estimate compressive strength.	Compressive strength increases with precise carbon nanotube addition. Reliable models save time and costs in predictions. Data from 282 mixed proportions were analyzed.	No specific gaps were identified in the provided contexts. The research focuses on compressive strength prediction models

3. Conclusion

Concluding remarks from above reviews the workability of nano-reinforced mortars remains stable across varying concentrations of carbon nanotubes, indicating effective dispersion without compromising performance. The geometry and aspect ratio of CNTs play a crucial role in enhancing mechanical strength, with smaller and longer CNTs providing better reinforcement compared to larger or medium-sized ones. The application of polycarboxylate superplasticizers is essential for achieving optimal dispersion of CNTs, leading to improved mechanical properties and microstructure in cementitious composites. Ultrasonication techniques are effective in dispersing CNTs, enhancing mechanical performance, and reducing porosity, although excessive sonication can lead to fragmentation and reduced benefits.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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