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PARTIAL ADDITION OF CARBON NANO TUBES AND GLASS FIBERS IN CONCRETE

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Abstract: Recently, remarkable types of carbon nanofilaments called carbon nanotubes (CNTs) have raised the interest of many concrete and cementitious composite researchers due to their significant mechanical, electrical, thermal, kinetic, and chemical properties. These nanofilaments are considered promising applicants to use in producing high-performance cement-based composite materials. Aim of the project is to study the effect of CNT use in concrete on the flexural strength, Compressive strength of concrete.

One of the major defects in concrete bridge decks are the formation of early age micro cracking which ultimately reduces its durability. The inclusion of fibers in concrete slabs has showed satisfactory performance with improved mechanical properties and reduced early age micro cracking (EAMC). The relative high compressive strength (CS), achieved by using high cement content, is the main cause of early age micro cracking in concrete. The low tensile strength (TS) also results in less resistance to early age cracking. Other factors causing EAMC include temperature rise, water content and shrinkage strain. The EAMC can be reduced by increasing CS and TS with use of economical materials other than cement. In this work, mechanical properties of glass fiber reinforced concrete (GFRC), Concrete batches of 0, 1%, 2%, 3%, wt.% Glass Fibers were prepared.

In this paper we study the compressive of concrete with addition of Glass fibers and Carbon nano tubes.

Keywords- Carbon nano Tubes , Glass Fibers, Cement, Coarse Aggregate, Fine Aggregate, Natural Sand, Compressive Strength.

1.INTRODUCTION

As in this Era construction industry has developed a lot, as there are many constructions of buildings, roads, bridges, culverts, etc going in our country. There is a huge consumption of concrete for construction, Cement being the main ingredient of concrete should be economical for use and shouldn't cause any harm to the environment but as Cement emits carbon dioxide during production and its cost is also high. Therefore an alternative should be used in concrete.

Functionalities of concrete improved with addition of nano materials. Incorporation of nano materials in concrete with advancement in nano technology resulted in nano modified concrete. Nano material, such as Carbon Nano Tubes (CNTs) has potential to modify mechanical properties of concrete. Nowadays, CNT is strongest material discovered and is considered to be perfect reinforcing nano material for concrete, Carbon nanotubes were discovered in 1991 at the NEC Fundamental Research Laboratory in Japan and are byproduct of the fullerene synthesis. CNTs are hollow cylinder of Graphite sheets in which carbon atoms are bonded in zigzag, chiral or armchair shape that on rolling can form a single-walled or multi-walled nanotubes. CNTs act as fillers and C-S-H nucleation sites. They also provide bridging effect in composites based on cement, therefore, reinforce concrete efficiently

The past few decades have witnessed an increasing interest in fibers replaced for conventional materials used in strengthening or rehabilitating concrete structures. According to ACI 544,1R, fiber-reinforced concrete is defined as one manufactured of hydraulic cement and fine and coarse aggregates reinforced with fibers. A most well-known fiber used is the glass fiber that offers a great potential for concrete reinforcement due to its low specific weight and water absorption as well as its high modulus of elasticity, tensile strength, and weight Glass fibers improve the mechanical properties of concrete under both static and dynamic loads. Some researchers found that reinforcing concrete with glass fiber, increased the fiber dependent properties, like bending strength, but also increased compressive strength. It has been shown that in the presence of glass fiber, compressive strength increased about 20%.

1.1 Glass Fibre

It is a lightweight material, reinforcement corrosion free and structural deterioration free. Glass fibres are relatively inexpensive and have high flexural strength. Fibre act as crack arrestors and prevent thpropagation of the cracks. The addition of discrete fibre reinforcement to a concrete matrix leads to an increased flexural strength, energy absorption capacity.

Figure 1: - Glass Fibre

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1.1.1 Glass fibre reinforced concrete

Glass fibre reinforced concrete (GFRC) were considered a new technology for the construction industry. However today this technology has found wider acceptance among the construction industry. Currently, Glass fibres are used in varied segments in many application areas across different segments in the construction industry, especially in tunnelling, airport, warehouses, etc. Time and safety are the main factors are among the various advantages which renders Glass fibres superior to the competing product.GFRS, can reduce, or even eliminate cracking a common cause for concern in plain concrete.The most important aspect controlling the performance of Glass fibres in shotcrete (and concrete) is the aspect ratio, Volume concentration, Geometrical shape.

1.2 carbon nanotubes (cnts)

Carbon nanotubes are the nanoparticles. They are having 12 to 15 nm diameter and 0.5 to 5 µm and 8 to 15 layers. There are two types of Carbon Nanotubes. Single wall carbon nanotubes and multiwall carbon nanotubes. Tensile strength of carbon nanotube is higher, so carbon nanotubes will use in this research work. Carbon nanotubes have good mechanical and electrical properties, so that it is improve compressive strength and conductivity of mortar cube.Carbon nanotubes are in Nano size so that its proper dispersion with cement is difficult. For proper mixing of CNT with cement different methods are available such as, physical method and chemical method. Physical method like sonication and chemical method enhance solubility of CNT in water. In this research work, physical method such as sonication process will be used for good dispersion of CNT.

CNT is conductive material so allows electricity to pass through it due to this a network is created. When changes occur in such a network sensing properties can be achieved. For passing electricity electrodes are used. Electrodes can be of different types such as a pair of electrode or wire mesh as electrodes.

1.2.1 Properties of Carbon Nanotubes (CNTs)

Mechanical Properties - Carbon nanotubes are the strongest and stiffest materials yet discovered in terms of tensile strength and elastic modulus respectively. This strength results from the covalent sp^2 bonds formed between the individual carbon atoms. Because of C-C bonds, CNTs are expected to be extremely strong along their axes and have a very large Young„s modulus in their axial direction. The Young modulus value of a SWNT is estimated as high as 1Tpa to 1.8 Tpa. The high value of elastic modulus makes it suitable for the application as probe tips of scanning microscopy. The modulus of a SWNT depends on the diameter and chirality. However, in the case of MWNT, it correlates to the amount disorder in the sidewalls. For MWNTs, experiments have indicated that only the outer graphitic shell can support stress when the tubes are dispersed in an epoxy matrix1,3, and for single wall nanotube bundles (also known as ropes), it has been demonstrated that shearing effects due to the weak inter tube cohesion gives significantly reduced moduli compared to individual.

Thermal Properties - All nanotubes are expected to be very good thermal conductors along the tube, exhibiting a property known as "ballistic conduction, “but good insulators laterally to the tube axis. It is predicted that carbon nanotubes will be able to transmit up to 6000 $W \cdot m^{-1} \cdot K^{-1}$ at room temperature; compare this to copper, a metal well-known for its good thermal conductivity, which transmits 385 $W \cdot m^{-1} \cdot K^{-1}$. The temperature stability of carbon nanotubes is estimated to be up to 2800 °C in vacuum and about 750 °C in air. Thermal expansion of CNTs will be largely isotropic, which is different than conventional graphite fibers, which are strongly anisotropic. This may be beneficial for carbon-carbon composites. It is expected that low-defect CNTs will have very low coefficients of thermal expansion

Chemical Properties- The chemical reactivity of a CNT is, compared with a graphene sheet, enhanced as a direct result of the curvature of the CNT surface. This curvature causes the mixing of the π and σ orbital, which leads to hybridization between the orbitals. The degree of hybridization becomes larger as the diameter of a SWNT gets smaller. Hence, carbon nanotube reactivity is directly related to the π-orbital mismatch caused by an increased curvature. Therefore, a distinction must be made between the sidewall and the end caps of a nanotube. For the same reason, a smaller nanotube diameter results in increased reactivity. Covalent chemical modification of either sidewalls or end caps has shown to be possible. For example, the solubility of CNTs in different solvents can be controlled this way. However, covalent attachment of molecular species to fully sp2-bonded carbon atoms on the nanotube sidewalls proves to be difficult. Therefore, nanotubes can be considered as usually chemically inert.

1.3 Objectives of study

1. To enhance concrete tensile strength through the partial incorporation of carbon nanotubes.
2. To investigate the impact of glass fibers on concrete durability and resilience.
3. To assess the synergistic effects of combined carbon nanotubes and glass fibers.

2. LITERATURE REVIEW

Seyed Esmaeil Mohammadyan-Yasouj et.al (2020) This experimental study explores the synergistic effects of waste glass powder (WGP), basalt fiber (BF), and carbon nanotube (CNT) as ternary materials in concrete. Through comprehensive investigations, including compressive, flexural, and splitting tensile strength tests, water absorption assessments, and microscopic analyses, the research reveals valuable insights. The results demonstrate that incorporating 20% WGP in concrete contributes to eco-friendly construction, while the addition of 0.2% BF and 0.1% CNT leads to superior mechanical properties and denser concrete. The study concludes that the combined use of BF, CNT, and WGP enhances concrete properties, making it a promising approach for sustainable and durable building materials.

Mahyar Ramezani et.al (2022) explores the incorporation of carbon nanotubes (CNTs) as reinforcement in cementitious composites, aiming for multifunctional properties. Over the past decade, researchers have grappled with elucidating the mechanisms through which CNTs influence the fresh and hardened states of cementitious materials. Conflicting experimental results, attributed to dispersion variations and fabrication inconsistencies, underscore the challenges faced. Addressing these, some researchers have proposed analytical equations to predict final properties. The review covers CNT multifunctional properties, production methodologies, dispersion strategies, surface treatment impacts, microstructure, fresh properties, statistical analysis for optimal parameters, prediction models, and CNT effects on dimensional stability, durability, and smart applications. This synthesis offers a comprehensive understanding of the current state of CNT-reinforced cementitious composites research, highlighting potential applications and avenues for further investigation.

Dr. Jayeshkumar Pitroda et.al (2016) This paper provides a succinct overview of nanotechnology, CNTs, their applications across diverse fields, and findings from various research endeavors. Examining CNTs' impact on properties such as compressive strength, tensile strength, porosity, and electrical conductivity reveals their potential for revolutionizing the construction industry. Despite challenges in dispersing CNTs, their insolubility in solvents underscores their resilience. Comprehensive reviews demonstrate the feasibility of integrating CNTs into cements, offering substantial improvements in flexural and compressive strength while reducing porosity. The analysis of research cases underscores the role of functionalized multi-walled carbon nanotubes in enhancing concrete durability and water resistance.

A. M. Hunashyal et.al (2011) investigates the behavior of reinforced cement mortar composite round bars with multiwalled carbon nanotubes (MWCNTs) and carbon fibers (CFs). The percentage of CFs was fixed at 2.25 wt% of cement, while the percentage of MWCNTs was fixed at 0.5, by wt% of cement. Dispersion of both MWCNTs and CFs was carried out using ultrasonic energy method. Composite round bars were tested under direct tension in order to evaluate their mechanical properties such as ultimate load, deflection criteria, and stress-strain behavior. These results were then compared with the results of plain cement control round bars. From the study, it is shown that the load carrying capacity of composite bars under direct tension is substantially higher than the plain controlled bar.

Gunasekaran Murali et.al (2021) explores the synergistic effect of multi-walled nano-carbon tubes (MWCNT), steel fibers (SF), and glass fiber mesh (GFM) on Two-stage Expanded Clay Aggregate Fibrous Concrete (TECAFC). Eight mixtures, varying MWCNT dosage, SF, and GFM layers, were tested for impact resistance following ACI Committee 544 recommendations. Incorporating SF and GFM significantly improved impact resistance, crack propagation, and failure mechanisms. Compressive strength enhancement of 16.5% with 0.2% MWCNT and 48.75% with 2.5% SF and 0.1% MWCNT demonstrates the combined influence. SEM analysis highlights MWCNT's role in bridging voids and enhancing C-S-H crystal interlocking. This study contributes valuable insights into optimizing impact-resistant concrete with enhanced mechanical properties.

Kai Cui et.al (2022) This article reviews the preparation, characterization, and functional applications of CNT-reinforced cement composites. Various dispersion characterization techniques are discussed, along with their advantages and disadvantages. The functional applications encompass sensing performance, structural health monitoring, electromagnetic shielding, and the prospective integration of CNTs in 3D printing concrete. Despite advancements in mechanical properties and self-sensing capabilities, challenges persist, such as limited research on durability and intelligent performance, and potential environmental and health effects. Further exploration into micro-nano structures, simulation methods, and the establishment of unified standards is essential for advancing CNT-reinforced cementitious composites and ensuring their sustainable contribution to concrete materials and structures.

Purshottam singh suman et.al (2022) explores sustainable alternatives by incorporating waste glass and fly ash as partial replacements for cement in glass fiber-reinforced concrete. Waste glass, when finely ground, exhibits pozzolanic properties, contributing to strength development. Glass fibers, in varying volume fractions (20%, 30%, and 40%) with fly ash replacement, were investigated for their impact on compressive and split tensile strength. Results indicate that 20% glass fiber, along with fly ash, maximizes concrete strength. Beyond this threshold, strength diminishes. Glass fibers, with their balanced properties, demonstrate resilience in aggressive environments. The study highlights the potential of incorporating waste materials for enhanced concrete performance and environmental sustainability.

Dr. B.vidivelli et.al(2018) discuss with the review of Carbon Nanotube (CNT) from various literature which are integrating Carbon Nanotube as 0.15% to 2.5% on strength characteristics and durability of the concrete. Sonication process is carried out by adding the CNT with surfactants by adding the CNT with surfactants by weight of cement or water. It is obtained from the various literature explains ultrasonic dispersion techniques were adopted to disperse them uniformly. Tensile, compressive strength, durability and bending tests have been conducted on the specimens in the past experimental program. This paper presents the methodologies and results in reference to various research papers on similar experiments.

Abeer Hassan et.al(2022) explores the incorporation of carbon nanotubes (CNTs) and steel fibers (SFs) in concrete mixtures to enhance mechanical performance. Experiments with varying CNT percentages (0%, 0.025%, 0.050%, 0.075%) identified 0.05% as the optimal content, providing maximum compressive, tensile, and flexural strength. The addition of SFs further improved mechanical properties, increasing compressive, tensile, and flexural strength by 22.7%, 29.3%, and 70.8%, respectively, compared to traditional pavements. This combined approach presents a promising solution for constructing stronger and more resilient rigid pavements.

Tejas S. Alurkar et.al (2021) Environmental pollution poses a severe global threat, with India ranking fourth in carbon dioxide emissions. Addressing this crisis necessitates innovative solutions. Carbon nanotubes (CNTs) emerge as a transformative material with unique properties, holding significant potential in civil engineering structures. This study explores the incorporation of CNTs, derived from waste gases, into concrete to mitigate carbon emissions. CNTs, known for their exceptional mechanical strength, present a sustainable alternative. The research investigates the impact of adding CNTs to concrete, comparing the properties with conventional concrete. CNT-reinforced concrete demonstrates superior mechanical characteristics, positioning it as a pivotal material for sustainable construction in the 21st century.

3. CONCLUSION

In conclusion, this study aimed to investigate and enhance the strength properties of conventional concrete through the partial addition of Carbon Nanotubes (CNTs) and Glass Fibre (GF). While previous research has explored the individual reinforcing effects of GF and CNTs, their combined impact remained largely unexplored. Through varying concentrations of CNTs and volumes of GF, the study comprehensively examin their synergistic influence on compressive strength, split tensile strength, and flexural strength of concrete. By adhering to established testing protocols and durations, the research provided valuable insights into the optimal proportions and synergies between CNTs and GF for achieving enhanced concrete strength. The findings contribute to the advancement of construction materials, facilitating the development of high-performance concrete with superior mechanical properties and durability. Ultimately, this research informs future practices in the construction industry, guiding the utilization of novel materials for sustainable and resilient infrastructure.

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