

# DEVELOPMENT AND APPLICATION OF CARBON NANOTUBE REINFORCED CEMENT-BASED COMPOSITES AS FUNCTIONAL BUILDING MATERIALS

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## ABSTRACT

Concrete is the second most used material on earth (after water), and is the most common and widely used construction material in the world. However, cementitious materials in general are very brittle and characterized by a very low tensile strength and a very low strain to failure. Macroscopic steel reinforcing bars have been added to concrete since the late 1850's to provide tensile strength and ductility. Within the last few decades, researchers started testing discrete meso and micro fibers as a means to control crack growth in cementitious materials (e.g. cement paste, cement grout, concrete). The idea behind this transition to fiber reinforced cement (FRC) is that the tensile strength is developed from many individual fibers rather than a few pieces of steel. Therefore, the use of discrete fibers results in a more uniform distribution of stress within cementitious materials. Recently, exceptional types of carbon nanofilaments have raised the interest of some concrete researchers due to their remarkable mechanical, chemical, electrical, and thermal properties, and excellent performance in reinforcing polymer-based materials. Micro-fibers may delay the nucleation and growth of cracks at the micro-scale; however, nano reinforcements can further delay the nucleation and growth of cracks at the nano-scale. If cracks are successfully controlled at the nano scale, their propagation to the micro level can be prevented. These nano-filaments, both carbon nanotubes (CNTs) and carbon nanofibers (CNFs), may prove to be superior alternatives or compliments to traditional fibers, and promising candidates for the next-generation of high-performance and multi-functional cement-based materials and structures.

**Keywords:** Cement, Flexural Strength, sodium hydroxide solution Strength Parameters, Workability.

## 1. INTRODUCTION

Modifications of construction materials have an important bearing on the building sector. Several attempts have been therefore made in the building material industry to put to use waste material products, e.g., worn-out tires, into useful and cost effective items. Success in this regard will contribute to the reduction of waste material dumping problems by utilizing the waste materials as raw material for other products. The waste problem considered as one of the most crucial problems facing the world as a source of the environmental pollution. It is contributing as a direct form in pollution that includes the negative effects on the health by increasing the diseases, diseases vector, percentage of mortality and lowering the standard of living. The waste usually defined as the materials and things resulted from production, transfer and uses processes, and in general all transmitted things and resources that the owner or the producer wants to dispose or must dispose to prevent the risk on the health of the human and save the environment in general.

Following are the objectives of this work-

- To conduct test for Consistency, Initial setting time, Final setting time to obtain the properties of OPC admixed with MWCN.
- To Study workability of concrete with Carbon Nanotube fibre in different proportion.
- To Study properties of hardened Mortar and concrete on variation Carbon Nanotube and Nanofiber in various proportion.
- To Study properties of hardened concrete by non-destructive Ultrasonic Pulse Velocity Test method.
- To Study Durability Properties of concrete by Rapid Chloride Penetration Test, Acid resistance test and Sulphate resistance test.

### 1 Material Used

The following materials are used during the research work-

- Cement
- Fine aggregates (Sand)
- Coarse Aggregates(20mm)
- Coarse Aggregates(10 mm)
- CNT and Fibres

- Water

## 2. METHODOLOGY

Utilising the aforementioned test results and the IS 10262 - 2019 code. The concrete grade M30 was used in the mix design production. A trail mix for M30 grade concretewas created using the concrete mix design and the M30 grade concrete's mix proportion.

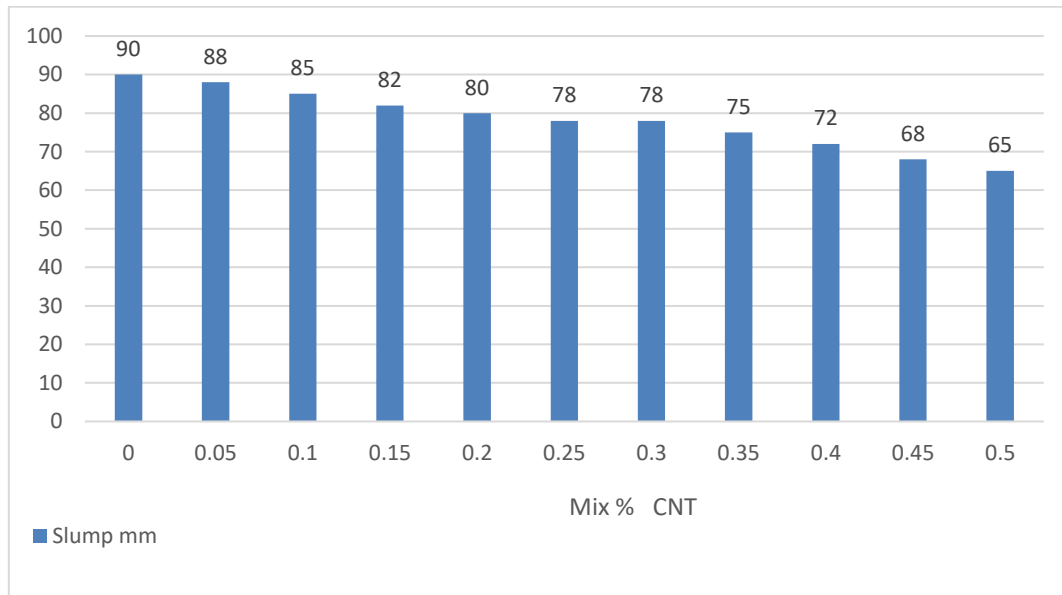
S.No.	Parameters	Data
1	Characteristic Compressive Strength	30 MPa
2	Type of cement	OPC Grade-53 (Ultra tech)
3	Specific gravity of cement	3.15
4	Nominal maximum size of Coarse aggregate	10 mm & 20 mm
5	Type of Coarse aggregate	Crushed natural stone aggregate
6	Type of fine aggregate	Natural River Sand
7	Water cement ratio	0.45(max.)
8	Exposure condition	Moderate
10	Admixture used	Super Plasticizer
11	Slump value	80 mm

## 3. RESULTS

**Table – 1** Slump Cone Test Results

Mix	Slump mm
MWCN-0	90
MWCN-0.05	88
MWCN-0.10	85
MWCN-0.15	82
MWCN-0.2	80
MWCN-0.25	78
MWCN-0.30	78
MWCN-0.35	75
MWCN-0.40	72
MWCN-0.45	68
MWCN-0.5	65

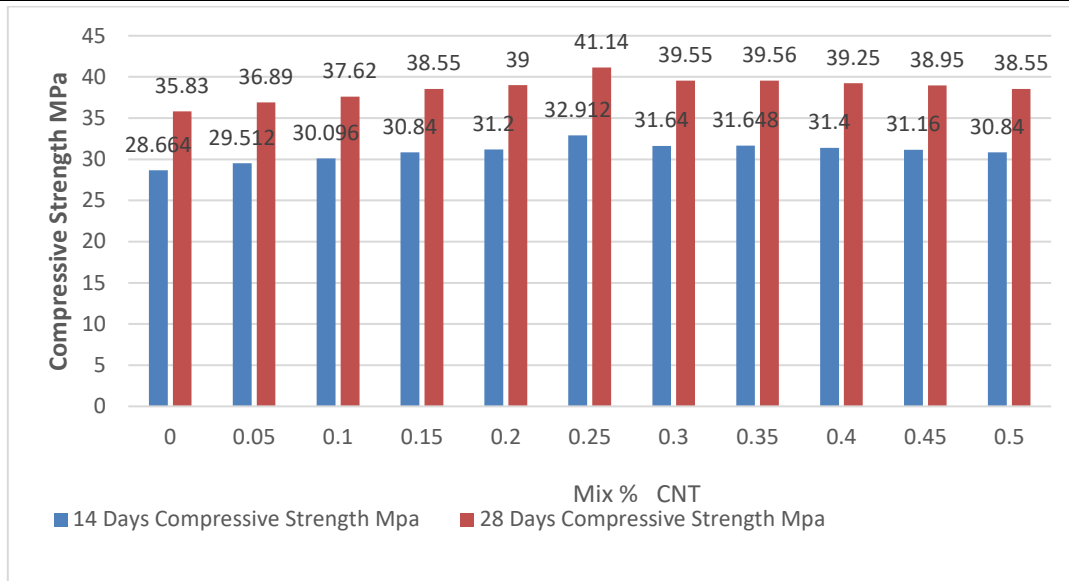
Collins et al. (Makar et al. 2005) and Konsta et al. (Abu Al-Rub et al. 2012) observed behavior in the cement pastes, attributed to strong MWCN dispersion effectiveness. The workability increment of MWCN reinforced concrete found in this study was probably caused by the extra effect of the incorporated in the remaining fine components of the mixture, which also contributes to the reduction of consistency. In addition, increasing the number of interfaces in the mix leads to a reduction in workability. It has been reported by Makar et al. (Chen et al. 2011) and Al-Rub et al. (Collins et al. 2012), the incorporation of MWCN tends to decrease in the workability of cement pastes, because of the MWCN surface area promotes significant surface interactions with the mix (Kumar et al. 2012).



**Fig. 2** Slump Results on Fresh Concrete COMPRESSIVE STRENGTH

**Table .2** Compressive Strength of concrete

Compressive Strength MPa		
Mix	14 Days	28 Days
MWCN-0	28.664	35.83
MWCN-0.05	29.512	36.89
MWCN-0.10	30.096	37.62
MWCN-0.15	30.84	38.55
MWCN-0.2	31.2	39
MWCN-0.25	32.912	41.14
MWCN-0.30	31.64	39.55
MWCN-0.35	31.648	39.56
MWCN-0.40	31.4	39.25
MWCN-0.45	31.16	38.95
MWCN-0.5	30.84	38.55

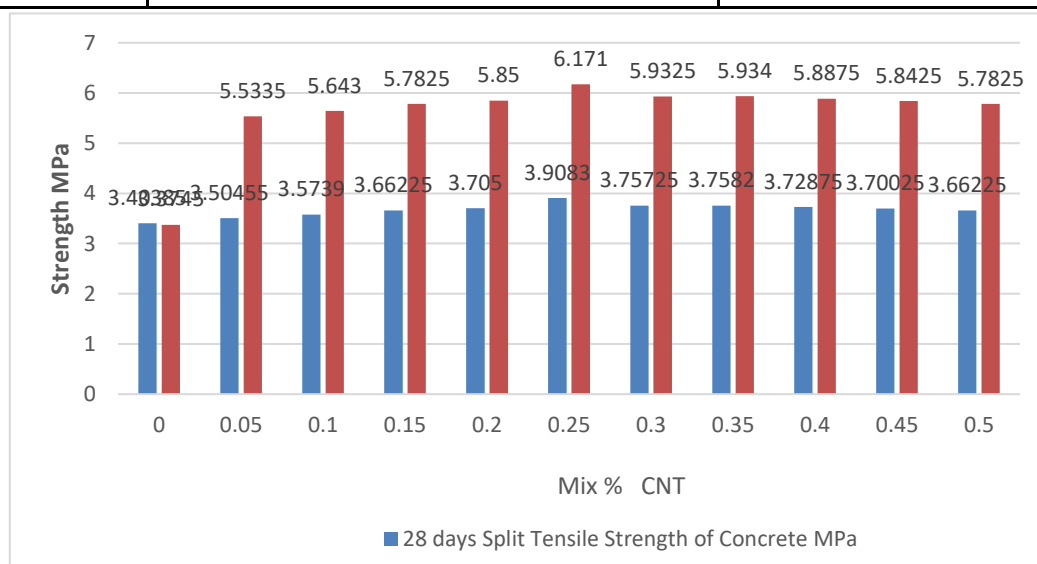


**Fig .3** Compressive Strength Results

### TENSILE STRENGTH TEST OF CONCRETE

**Table .3** Tensile Strength

Mix	28 days Split Tensile Strength of Concrete MPa	28 days Flexural Strength of Concrete MPa
MWCN-0	3.40385	3.3745
MWCN-0.05	3.50455	5.5335
MWCN-0.10	3.5739	5.643
MWCN-0.15	3.66225	5.7825
MWCN-0.2	3.705	5.85
MWCN-0.25	3.9083	6.171
MWCN-0.30	3.75725	5.9325
MWCN-0.35	3.7582	5.934
MWCN-0.40	3.72875	5.8875
MWCN-0.45	3.70025	5.8425
MWCN-0.5	3.66225	5.7825



**Fig. 4** Tensile Strength on Hardened Concrete

#### 4. CONCLUSION

- The increase in the percentage of MWCN, the consistency of the binding materials to which the MWCN are added also increases. A maximum consistency of 30% was observed for MWCN-0.5, and a minimum consistency of 24% was observed for MWCN0% (control specimen) to absorb water and MWCN higher fineness property. With an increase in the MWCN dosage, cement initial and final setting time also increases.
- The enhanced IST and FST were attributed to Multiwalled carbon nanotubes pozzolanic activity and their decreased effects on hydration and cement interactions.
- When the dosage of MWCN increases, the setting times are also slightly increased. This is mainly due to the mechanism of the MWCN effect is similar to the pozzolanic additive to a certain extent.
- The MWCN dosage would increase the compressive strength of the mix up to MWCN-0.25. The strength would decrease gradually from MWCN-0.30 to MWCN-0.5. Higher concentrations of MWCN contribute to the disintegration of the Compressive strength. With the addition of MWCN, the initiation of micro cracks was delayed, enhancing macro mechanical properties in the cement matrix, and the MWCN also acted as a fiber bridging between MWCN and the C–S–H gel.
- In addition, MWCN included the crystalline growth of the carbon matrix, increasing the compressive strength of the mortar.
- --The workability of concrete decreases with an increase in the dosage of MWCN. However, the slump value was within the allowable limit.

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