Journal of
Materials & Metallurgical Engineering
https://journals.stmjournals.com/jomme/

ISSN: 2231-3818 (Online)
ISSN: 2321-4236 (Print)
Volume 14, Issue 2, 2024
May–August
DOI (Journal): 10.37591/JoMME

Review JoMME

Effect of Multiwalled Carbon Nanotubes on Compressive Strength of Concrete

Sushmita Kumari*

Abstract

The objective of the suggested study was to examine the possible application of multi-walled carbon nanotubes (MWCNTs) as nano reinforcement to improve concrete's compressive strength. Single-walled carbon tubes (SWCNTs) and multi-walled carbon tubes (MWCNTs) are two groups of cylindrical-shaped carbon allotropes known as carbon nanotubes (CNTs). Tests are carried out 7, 14, and 28 days after the MWCNTs are reinforced in M20 grade concrete at 0.02% and 0.025% (by weight of cement). MWCNTs are dispersed using the dry mix technique, which involves adding the MWCNTs to cement and mixing by hand for five minutes. Test results indicate that after 7, 14, and 28 days of curing on reinforcement of 0.02% of MWCNTs, compressive strength increased by 4.6%, 6.7%, and 8.7%, and 5.3%, 10.6%, and 14.63% after 7, 14, and 28 days of curing on reinforcement of 0.025% of MWCNTs.

Keywords: Concrete, Multi walled carbon nanotubes, Compressive strength of concrete

INTRODUCTION

The most often used artificial substance in the world is concrete. As the resource that is consumed the most on Earth, it is surpassed only by water. The majority of the growth from the 1990s forward was attributed to Asia and China. About 2.2 billion tons of CO2 were produced worldwide in 2016 from the manufacturing of cement, or 8% of the total. That was derived from the calcination process to the more than half. Research on using nanotechnology to change the way cement is processed in order to lower CO2 emissions from the cement industry is being driven by the current push to do so. Utilizing CNTs increases the amount of fly ash used, which increases the amount of industrial waste used and improves environmental safety. Numerous issues with concrete use have been documented in the literature, including poor tensile strength and quasi-brittle nature, erosion, building flaws, cracking, disintegration, scaling, spalling, and efflorescence. Thus, scientists have worked to find a way to enhance concrete's quality and address the issues it causes. Lately, the usage of fibers—both natural and synthetic—at different scales—from macro to nano—has garnered a lot of interest. The high mechanical performance of cement-based composites enhanced by CNTs is attributed to their nucleation effects, crack bridging properties, and superior adherence to hydration products. CNTs enhance cementitious materials' resilience to freeze-thaw as well as their shrinkage and water-loss properties. CNT-reinforced cement has a strong defense against abrasion, chemical attack, and weathering. greater concentrations of CNTs were shown to boost the flexural strength of cement-based composites when the CNTs had a greater aspect ratio. The steel may slip due to inadequate or poor adhesion, which could result in severe deformation, cracking, or even the collapse of the entire structure. The characteristics of CNT-reinforced concrete are influenced by the following factors: volume, orientation, aspect ratio, and relative stiffness of the fiber matrix [1-5] Figure 1

***Author for Correspondence**
Sushmita Kumari
E-mail: sushmitakumari426@gmail.com

Student, Department of Chemistry, Bansal Institute of Engineering & Technology, Lucknow, India

Received Date: July 19, 2024
Accepted Date: July 23, 2024
Published Date: August 10, 2024

Citation: Sushmita Kumari. Effect of Multiwalled Carbon Nanotubes on Compressive Strength of Concrete. Journal of Materials & Metallurgical Engineering. 2024; 14(2): 1–8p.

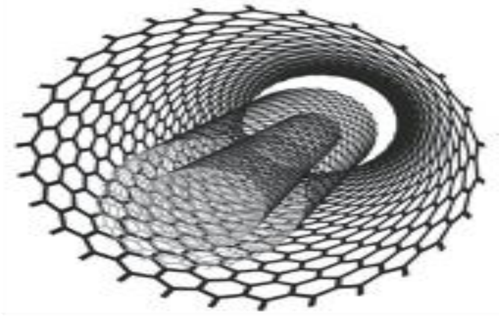

Figure1. MWCNTs.

LITERATURE REVIEW

Valentin et al. (2004) [19] Carbon nanotubes are special tubular structures with a significant length-to-diameter ratio and a nanometer-scale diameter. The quasi-one-dimensional (1D) structure of the nanotubes and the arrangement of the carbon atoms in the shells, which resembles graphite, are the sources of their remarkable mechanical and electrical capabilities. Because of their high tensile strength and Young's modulus, the nanotubes are therefore preferred for composite materials with improved mechanical properties.

Gogotsi., Nanomaterials handbook Taylor & Francis Group (2006) discovered that the 20% increase in Young's modulus observed for the nanocomposite films with an only 0.2% loading of SWNTs was attributed to the contribution of nanotubes. According to a 2012 analysis by Saurav et al., nanotechnology is being applied to building materials for a range of civil engineering projects. Utilizing nanotechnology allowed for the control of matter at the atomic level; as a result, strength, durability, and other material qualities were significantly impacted below the nanometer scale (10-9 m). Concrete that has been treated with nanotechnology is more resilient, easier to lay, and stronger.

Jayshree et al (2013) reviewed the impact of multiwall carbon nanotubes (CNT) on the durability and strength properties of concrete. After 28 days of curing, they added MWCNT with surfactants to water and assessed the sonication process using 36 specimens in cement. The samples' compressive and splitting-tensile strengths increased with increasing MWCNT, according to the data obtained after 28 days of curing. Consequently, after 28 days of cure, there was a 17% decrease in water absorption and a reduction in crack propagation. They observed that when the amount of functionalized MWCNT in the concrete increased, the concrete's water absorption decreased more significantly, making the concrete stronger and more water resistant.

Abhinayaa (2014) studied and found that the compressive strength of concrete rises with the amount of functionalized MWCNT present. In actuality, the addition of 0.045% functionalized MWCNT to concrete boosts its compressive strength by 26.69%. For 0.045% of MWCNT, the split tensile strength rose by 36.3%. The rate at which the tensile strength increases with an increase in MWCNT is higher than the rate at which the compressive strength increases.

Ramzitaha, Nasser AL Nuaimi, Mohamed O. Mohsen, Mohamed S. AL Ansari, and Ala Abu Taqa, October 2019. The author of this study came to the conclusion that concrete with high CNT contents—between 0.15 and 0.25 weight percent—would have greater flexural strength and more ductility. The addition of CNTs to concrete resulted in a minimum 45% drop in the permeability coefficient. When compared to plain concrete, the addition of CNTs to concrete produced a denser composite with higher flexural strengths and strain capacity as well as lower permeability.

Heba A. Gamal (2021) examines the CNTs' efficiency. They added 15% of nano clay to the mixture, along with 0.01%, 0.02%, and 0.04% of CNTs by weight. Various tests are conducted, including workability, air content, tests for compressive strength, tensile strength, flexural strength, resistance to corrosion, chloride penetration, and scanning electron microscopy (SEM). Based on the test results, it was determined that hybrid nanoparticles improve durability qualities and corrosion resistance while also showing an increasing trend in chloride penetration and bond strength [6-10].

METHODOLOGY

Materials

The experiment uses natural sand, pozzolana Portland cement, and aggregate with a 20 mm size. Table 1 lists the MWCNT specifications used in the project.

Mixes Preparation

In M20 grade concrete, two distinct amounts of MWCNTs—0.02% and 0.025 percent—are added by weight of cement. The water-to-cement ratio (0.5) is maintained constant. Six samples (one sample = three cubes) were made, three for 0.02% and three for 0.025% of MWCNTs.[11-14].

Experimental Procedure

A 15 x 15 x 15 cm cube specimen is created using MWCNT concentrations of 0.02% and 0.025% by weight of cement. Prior to adding aggregate and water and mixing for a further two minutes, MWCNTs are first combined with cement while it is still dry. After that, use a tamping rod to compact each of the five layers of concrte into a cube using 25 strokes. The test specimens are labeled, taken out of the molds, and preserved in clear freshwater for 7, 14, and 28 days after being kept in moist air for 24 hours. [15-19]

Table 1. Specification of MWCNTs.

Purity	>96%
Colour	Black
Diameter	20 nm
Form	Powder
Length	10 micrometer

Table 2. RESULTS AND DISCUSSION: shows the Compressive Strength of concrete reinforced with different percentage of MWCNTs on the different days of the experiment
Effect of varying percentages of Multi-Walled Carbon Nanotubes (MWCNTs) on the compressive strength of concrete at different curing periods.

w/c ratio	**% of MWCNTs**	**Compressive strength of concrete (N/mm2)**		
		7 days	***14 days***	***28 days***
0.50	-	13	18	20.5
0.50	0.02	13.6	19.2	22.3
0.50	0.025	13.7	19.9	23.5

Figure 2. Multiwalled Carbon Nanotubes.

Here Figure 3 shows the Compressive Strength of concrete reinforced with 0.02% of MWCNTs on the seventh day of the experiment

(Sample1)

Here Figure 4 shows the Compressive strength of concrete reinforced with 0.02% of MWCNTs on fourteenth day of the experiment

(Sample 2)

Here Figure 5 shows the Compressive strength of concrete reinforced with 0.02% of MWCNTs on the 28th day of the experiment.

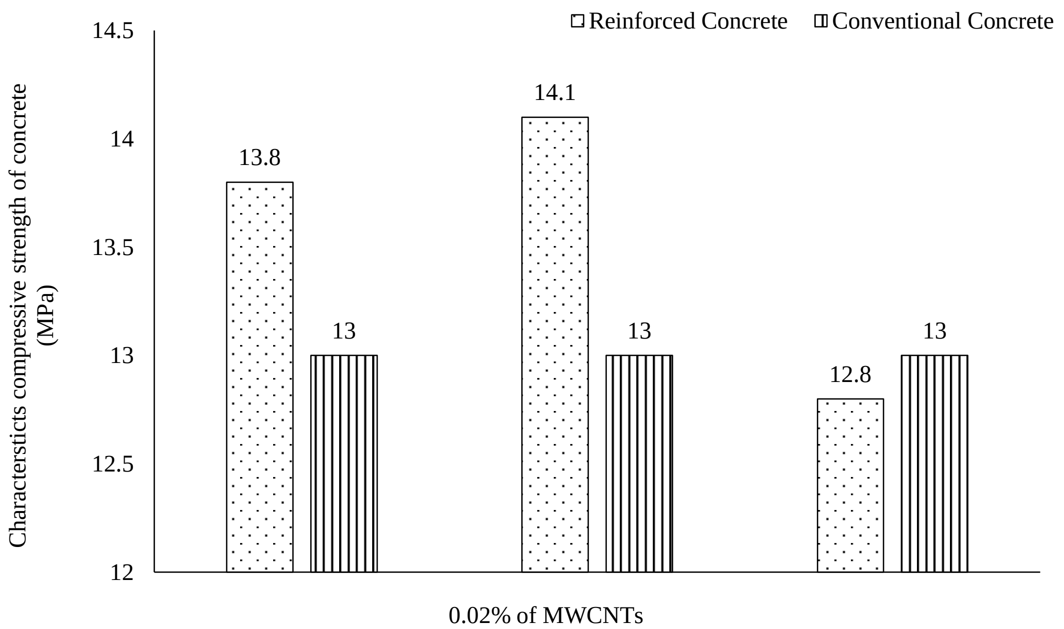

Figure 3. 7 days Compressive Strength of concrete reinforced with 0.02% of MWCNTs.

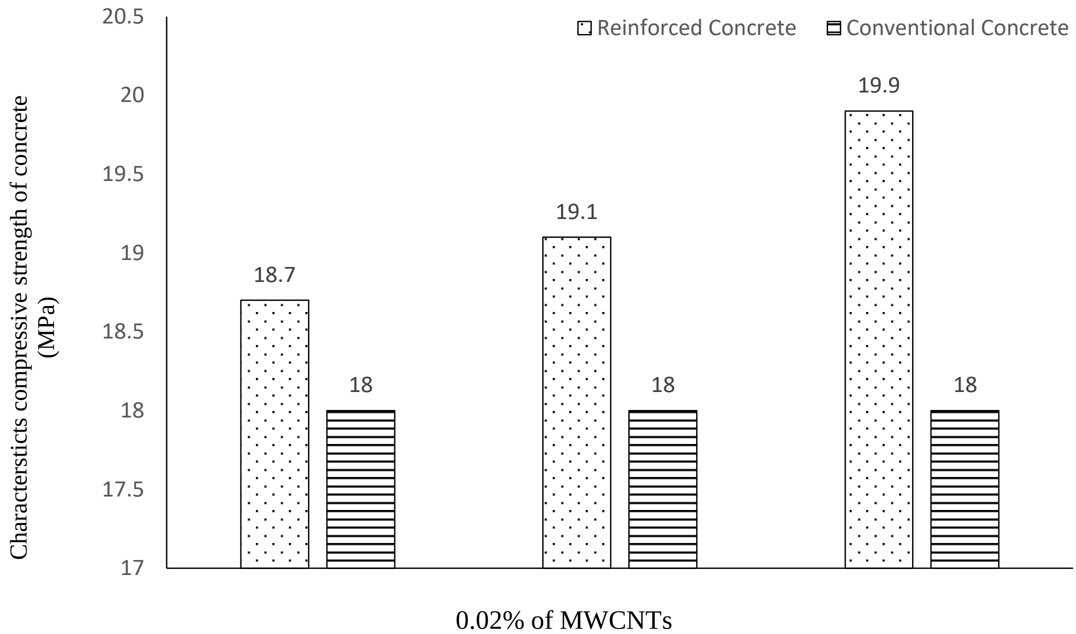

Figure 4. 14 days Compressive strength of concrete reinforced with 0.02% of MWCNTs.

(Sample 3)

Here the Figure 6 shows the Compressive Strength of concrete reinforced with 0.025% of MWCNTs on the seventh day of the experiment

(Sample4)

Here Figure 7 shows Compressive Strength of concrete reinforced with 0.025% of MWCNTs after the 14 days of the experiment

(Sample5)

Here Figure 8 shows Compressive Strength of concrete reinforced with 0.025% of MWCNTs after the 28 days of the experiment

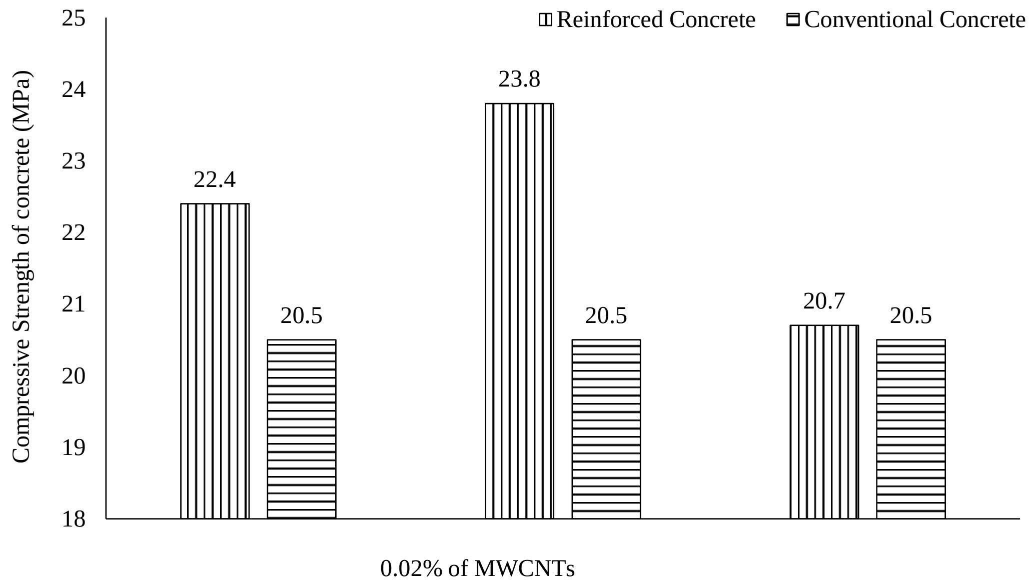

Figure 5. 28 days Compressive strength of concrete reinforced with 0.02% of MWCNTs.

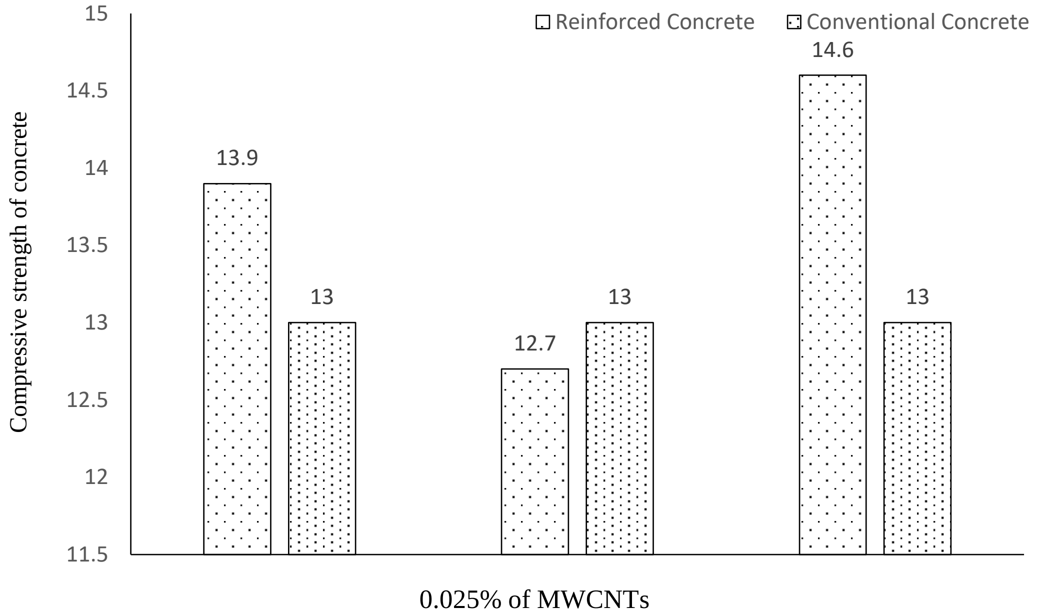

Figure 6. 7 days Compressive Strength of concrete reinforced with 0.025% of MWCNTs.

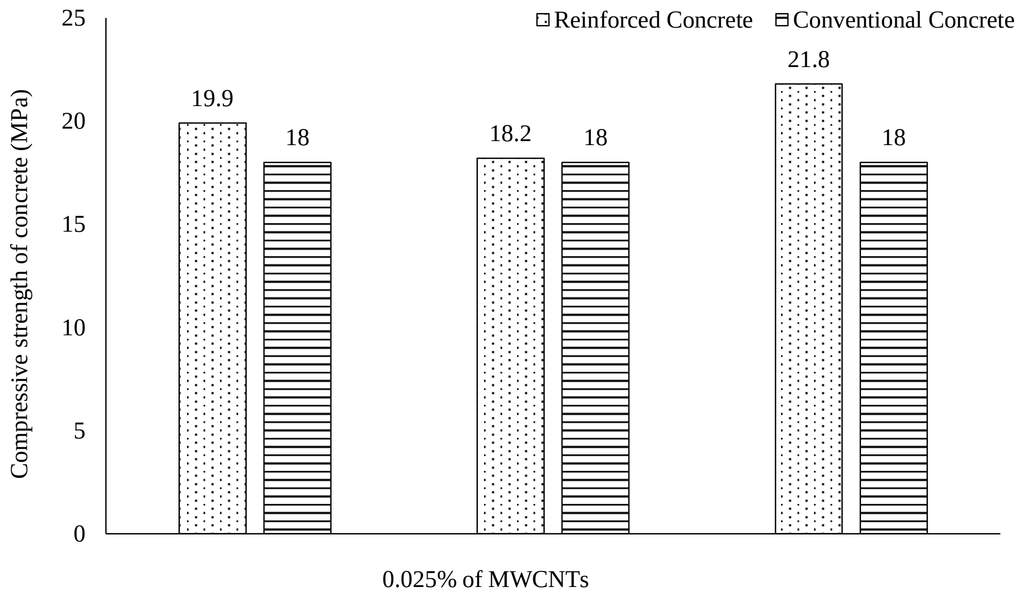

Figure 7. 14 days Compressive Strength of concrete reinforced with 0.025% of MWCNTs.

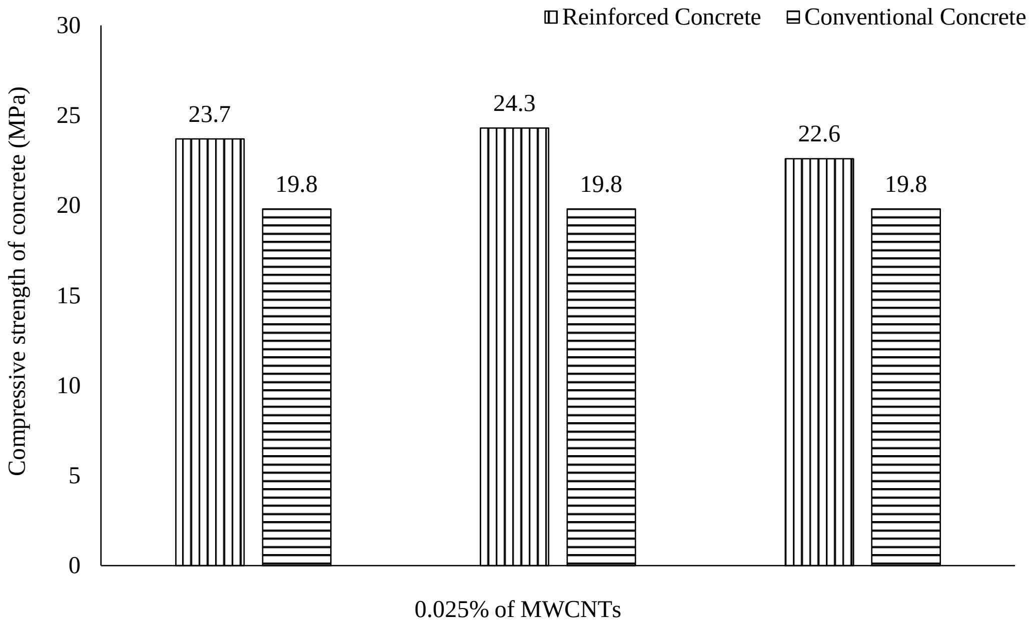

Figure 8. 28 days Compressive Strength of concrete reinforced with 0.025% of MWCNTs.

CONCLUSION

The aforementioned data indicates that, when reinforced with 0.02% of MWCNTs, the compressive strength of concrete increased by 4.6%, 6.7%, and 8.7% compared to conventional concrete on the curing duration of 7, 14, and 28 days; when reinforced with 0.025% of MWCNTs, the increases were 5.3%, 10.6%, and 14.63%. Thus, when the amount of MWCNTs increased, so did the compressive strength.

Future Scope

The following parameters also apply to research papers: the concrete's workability decreases as the concentration of MWCNTs increases, while the concrete's initial and ultimate setting times remain unaffected.

The high mechanical performance of cement-based composites enhanced by CNTs is attributed to their nucleation effects, crack bridging properties, and superior adherence to hydration products. The following parameters also apply to research papers: the concrete's workability decreases as the concentration of MWCNTs increases, while the concrete's initial and ultimate setting times remain unaffected.

The high mechanical performance of cement-based composites enhanced by CNTs is attributed to their nucleation effects, crack bridging properties, and superior adherence to hydration products. The flexural strength of cement pastes containing carbon nanotubes (CNTs) was shown to increase when compared to conventional cement paste. greater concentrations of CNTs were shown to boost the flexural strength of cement-based composites when the CNTs had a greater aspect ratio. Cementitious composites containing CNTs have superior durability performance when the water-to-cement ratio is low. The chemically treated CNTs are also very resistant to the penetration of chloride ions. Furthermore, CNTs exert a stronger influence on the long-term, time-dependent shrinkage and creep.

By decreasing the quantity of micropores and nanopores, the pore filling and nucleation action of CNTs results in the improved durability properties. As a result, adding CNTs to cementitious materials enhances both their resistance to shrinkage and water loss as well as their ability to withstand freeze-thaw cycle

REFERENCES

1. Peyvandi, A.; Soroushian, P.; Abdol, N.; Balachandra, A.M. Surface-modified graphite nanomaterials forimproved reinforcement efficiency in cementitious paste. Carbon 2013,63, 175–186.
2. Alrekabi, S.; Cundy, A.; Lampropoulos, A.; Savina, I. Experimental investigation on the effect of ultrasonicationon dispersion and mechanical performance of multi-wall carbon nanotube-cement mortar composites. Int. J. Civ. Environ. Struct. Constr. Archit. Eng. 2016,111, 268–274.
3. Xu, S.; Liu, J.; Li, Q. Mechanical properties and microstructure of multi-walled carbon nanotube-reinforced cement paste. Constr. Build. Mater. 2015,76, 16–23.
4. Ruan, Y.; Han, B.; Yu, X.; Zhang, W.; Wang, D. Carbon nanotubes reinforced reactive powder concrete.Compos. Part A Appl. Sci. Manuf. 2018,112, 371–382.
5. .Manzur, T.; Yazdani, N.; Emon, A.B. Effect of carbon nanotube size on compressive strengths of nanotubereinforced cementitious composites. J. Mater. 2014,2014, 1–8.
6. .Zou, B.; Chen, S.J.; Korayem, A.H.; Collins, F.; Wang, C.; Duan, W.H. Effect of ultrasonication energy onengineering properties of carbon nanotube reinforced cement pastes. Carbon 2015,85, 212–220.
7. Collins, F.; Lambert, J.; Duan, W.H. The influences of admixtures on the dispersion, workability, and strength of carbon nanotube–OPC paste mixtures. Cem. Concr. Compos. 2012,34, 201–207.
8. Du, M.; Jing, H.; Gao, Y.; Su, H.; Fang, H. Carbon nanomaterials enhanced cement-based composites:Advances and challenges. Nanotechnol. Rev. 2020,9, 115–135.
9. Douba, A.; Emiro˘glu, M.; Kandil, U.F.; Taha, M.M.R. Very ductile polymer concrete using carbon nanotubes.Constr. Build. Mater. 2019,196, 468–477.
10. Hawreen, A.; Bogas, J.A. Creep, shrinkage and mechanical properties of concrete reinforced with different types of carbon nanotubes. Constr. Build. Mater. 2019,198, 70–81.
11. .Carriço, A.; Bogas, J.A.; Hawreen, A.; Guedes, M. Durability of multi-walled carbon nanotube reinforcedconcrete. Constr. Build. Mater. 2018,164, 121–133.
12. A. Hawreen, J.A. Bogas, Influence of carbon nanotubes on steel concrete bond strength, Materials and Structures/Materiaux et Constructions. 51 (2018). https://doi.org/10.1617/s11527-018-1279-8.
13. M.O. Mohsen, M.S. al Ansari, R. Taha, N. al Nuaimi, A.A. Taqa, Carbon nanotube effect on the ductility, flexural strength, and permeability of concrete, Journal of Nanomaterials. 2019 (2019). https://doi.org/10.1155/2019/6490984.
14. A. Hassan, H. Elkady, I.G. Shaaban, Effect of Adding Carbon Nanotubes on Corrosion Rates and Steel-Concrete Bond, Scientific Reports. 9 (2019). https://doi.org/10.1038/s41598-019-42761-2.
15. M.S. Konsta-Gdoutos, P.A. Danoglidis, S.P. Shah, High modulus concrete: Effects of low carbon nanotube and nanofiber additions, Theoretical and Applied Fracture Mechanics. 103 (2019) 102295. https://doi.org/https://doi.org/10.1016/j.tafmec.2019.102295.
16. A. Hawreen, J.A. Bogas, R. Kurda, Mechanical Characterization of Concrete Reinforced with Different Types of Carbon Nanotubes, Arabian Journal for Science and Engineering. 44 (2019) 8361 8376. https://doi.org/10.1007/s13369-019-04096-y.
17. A. Hawreen, J.A. Bogas, Creep, shrinkage and mechanical properties of concrete reinforced with different types of carbon nanotubes, Construction and Building Materials. 198 (2019) 70 81. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2018.11.253.
18. V. Parvaneh, S.H. Khiabani, Mechanical and piezoresistive properties of self-sensing smart concretes reinforced by carbon nanotubes, Mechanics of Advanced Materials and Structures. 26 (2019) 993 1000. https://doi.org/10.1080/15376494.2018.1432789.
19. Valentin et al. (2004) Creep, shrinkage and mechanical properties of concrete reinforced CNT. Volume 198, 20 February 2019, Pages 70-81 https://www.amazon.in/Shilpent-Multi-Walled-Carbon-Nanotube.

