PARAMETRIC STUDY OF DURABILITY PROPERTIES OF CONCRETE PREPARED USING MULTI-WALLED CARBON NANOTUBES

Devendra N Gohel[1], Dr. Jayeshkumar L. Pitroda[2], Jugal Mistry[3]

[1]P.G. Student, Sardar Patel College of engineering, Bakrol, Gujarat, India
[2]Associate Proffesor, B.V.M. Engineering College, Vallabh Vidyanagar, Gujarat, India
[3]Assistant Proffesor, Sardar Patel college of engineering, Bakrol, Gujarat, India

ABSTRACT

Nanotechnology and Nano materials have much more advantages compare to conventional materials and are also helpful to overcome certain limitations of conventional materials. Among some of the nano materials Carbon Nanotubes are found to be useful in Construction industries along with construction materials thereby increasing and improving concrete properties. This experiment is based on usage of Multi-walled carbon nanotubes (MWCNT) in (0.025%) proportions by weight of cement in preparation of M25 grade Concrete. For effectively using MWCNT in concrete Polycarboxyl ether Super plasticizer was used in (0.4) % proportion as a surfactant in water with MWCNT to disperse them. Sorptivity Test was conducted at 90 days. Cubes of (150 x 150 x 150) mm were used for testing. Cost comparison for 1m^3 of concrete was calculated for normal design mix concrete and for MWCNT containing concrete. Applications of MWCNT were discuss.

Keyword: - *Nanomaterials, Multi-walled Carbon Nanotubes, Polycarboxyl ether, Super plasticizers*

1. INTRODUCTION

The extraordinary Physical and chemical properties of materials at the nanometer scale enable new applications ranging from structural strength enhancement to self-cleaning properties. Consequently, various nanomaterials have been used in the concrete to make it a real “smart” material. CNT also have tremendous range of applications in concrete structures depending upon the size and morphology of the fibrous carbons. As the size of CNT particles is finer than cement particles, so these can be used in concrete as void filler. CNTs are effectively used in various research works which effectively improves the mechanical properties of concrete and mortar, when single-walled CNTs or multi-walled CNTs are added into concrete mixtures, the reduction in cracks generation or elimination of cracks can be done. If a crack that is generated and started propagating inside nano composite concrete material, it will encounter carbon nanotubes, and the propagation of crack will stop, and it will not propagate due to all other carbon nanotubes surrounded. In this sector of construction industry there are chances of making new cementitious material by using carbon nanotubes.

2. MATERIALS

The materials used in this research are commercially available and brought from local dealers and shops. They are used as per different IS code criteria and IS code methods. The descriptions of the all materials use in the preparation of concrete are describe as follows:

Fig - 1 Materials

2.1 Cement

The cement used in this experimental investigation was OPC 53 grade cement, manufactured by Sanghi Cements company, Conforming to I S:8112-1989 having density 1440 kg/m3.

2.2 Coarse Aggregate

The coarse aggregates used in this experiment were 20 mm and 10 mm. The Coarse Aggregates from crushed basalt rock, conforming to IS: 383 were used. The Flakiness and Elongation Indices were maintained well below 15% .

Table - 1: Specifications of Materials

Sr. No	Properties	Fine Aggregate (Sand)	Coarse Aggregate (20 mm)	Coarse Aggregate (10mm)
1	Specific Gravity	2.9	3.2	2.6
2	Bulk Density	1656	1472	1362
3	Water Absorption	0.8	0.6	2.25

2.3 Fine Aggregate

The fine aggregates used in this experiment were fraction from 4.74 mm to 150 micron. The river sand used conforming to IS: 383-1970, zone-II. The sand was screened before use and having density of sand is 1656 kg/m3.

2.4 Fly ash

Fly ash used here is Class C, and was industrially manufactured in grey powder form Fly ash. Fly ash used here is Class C, and was industrially manufactured in grey powder form.

2.5 Polycarboxyl Ether Super plasticizer

The Polycarboxyl Ether was used as a surfactant in this project. It is brownish colour liquid having density 1.02Kg/L. It is a water reducing agent.

2.6 Multi-walled Carbon Nanotubes

Table - 2: Specifications of MWCNT

Length	Diameter	Layer	Tensile Strength	Thermal Properties
0. 5- 5µm (average)	12- 15nm (average)	8-15	10-60GPa	Conductivity>3000w/mK

The MWCNT are physically in black powder form. It is produced via a modified catalytic carbon vapor deposition process. They have high purity of carbon, narrow range of outer diameter and ultra-high aspect ratio. The properties of MWCNT are as follows:

3. METHODOLOGY

In this paper Multi-walled carbon nanotubes (MWCNT) were used in proportions 0.025% by weight of cement in M25 grade concrete. They are insoluble in all organic solvents and aqueous solutions, and thus they are dispersed by using super plasticizer as surfactants in (0.4) % proportion by weight of cement.

3.1 Sorptivity Test

The sorptivity test is a simple and rapid test to determine the tendency of concrete to absorb water by capillary suction. The test was developed by Hall (1981) and is based on Darcy's law of unsaturated flow. The purpose of this test is to determine the rate of absorption of water by unsaturated concrete. Sorptivity is a function of the increased mass of a specimen resulting from absorption of water, relative to the time that one surface is exposed to water. The sides of the specimen were sealed in order to achieve unidirectional flow. Locally available wax and resin with 50:50 proportions was used as sealant. Weights of the specimen after sealing were taken as initial weight. The initial mass of the sample was taken and at time 0 it was immersed to a depth of 5-10 mm in the water. At selected times (typically 1, 2, 3, 4, 5, 8, 10, 15, 20 and 25 minutes) the sample was removed from the water and the stop watch was stopped, excess water was remove off with a paper towel or cloth and the cube sample was weighed.

The cube samples with 0.025% MWCNT were selected for this test. Also the normal mix design M25 concrete cube specimens were used for sorptivity test.

The Sorptivity (S) can be calculated from the following formula:

$I=S.t^{1/2}$

Where, $S=I/t^{1/2}$;
S= sorptivity in mm,
t= elapsed time in mint.
$I=\Delta W/Ad$
ΔW= change in weight = W2-W1
W1 = dry weight of cube specimens
W2 = Weight of cube after 30 minutes capillary suction of water in Kg.
A= surface area of the specimen through which water penetrated.
d= density of water

4. RESULTS AND DISCUSSIONS

4.1 Results for Normal Concrete

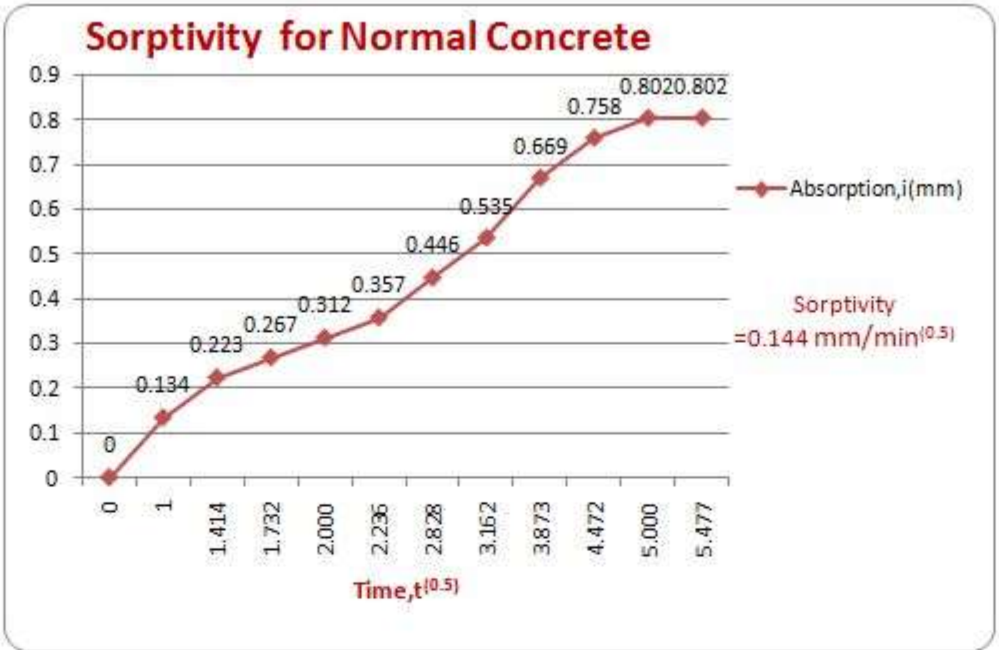

Fig - 2 Sorptivity Results at 90 days

4.2 Results for Normal Design Mix Concrete with 0.025% MWCNT

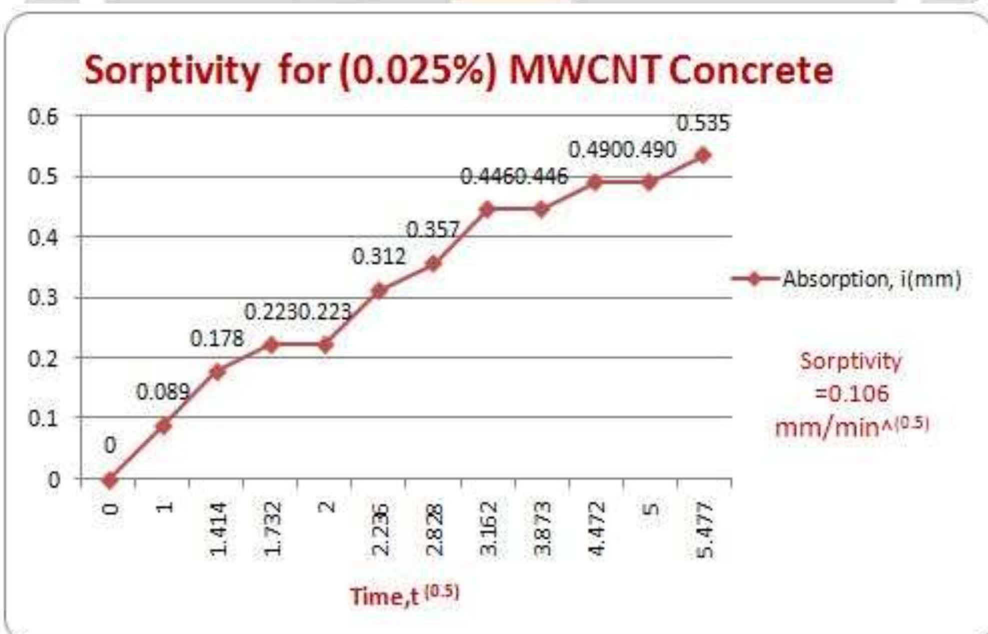

Fig - 3 Sorptivity Results at 90 days

4.3 Cost comparison for 1m^3 concrete.

The Cost is as per the materials brought from local dealers in required small quantity; these values may vary with different places, and may vary with different quantities and different dealers. The cost is as follows:

Material	Material (Kg)	Material in Bag	Cost Per Bag (Rs.)	Total Cost (Rs.)	Total Cost including MWCNT
Cement	330	6.6	320	2112	2122
Sand	796	15.92	55	875.6	875.6
Aggregate (20 mm)	289	13.78	70	964.6	964.6
Aggregate (10 mm)	416	8.32	70	582.4	582.4
Flyash	62	1.24	120	148.8	148.8
Plasticizer (Lit)	3.3	-	120	396	396
MWCNT (gm)	85	-	120	-	10200
Total Cost				5079.4	15289.4

The Cost is as per the materials brought from local dealers in required small quantity; these values may vary with different places, and may vary with different quantities and different dealers. (2018)

Fig - 4 Cost for 1 meter cubic concrete

4.4 Applications of MWCNT

- Carbon nanotubes have been widely used for a variety of applications due to their excellent physical properties. The most important application of nano-tubes based on their mechanical properties will be as reinforcements in composite materials.
- CNT also have tremendous range of applications in concrete structures depending upon the size and morphology of the fibrous carbons as its size particles are finer than cement particles. So these can be used in concrete as void filler. On the other hand, we could say carbon nanotubes are used as reinforcements in cement based materials
- The famous New Jubilee Church (Rome, Italy) is the first building that is made of nano photo catalytic concrete.
- Cables made from carbon nanotubes are strong enough to be used in building.
- The small and uniform dimensions of the nanotubes can be use in wide applications. With extremely small sizes high conductivity, high mechanical strength and flexibility, nanotubes may ultimately become necessary in their use as nano probes.
- For load bearing applications, CNT powders mixed with polymers or precursor resins can increase stiffness, strength, and toughness. These enhancements depend on CNT diameter, aspect ratio, alignment, dispersion, and interfacial interaction with the matrix.
- Carbon nanotubes have high strength and high flexibility, so they can also be useful in aircraft industry which includes highly stressed components, a lightweight, low power anti-icing system.

5. CONCLUSIONS

- The capillary absorption of concrete with MWCNT is much lower than the normal concrete. Hence its capillary water absorption capacity is low and it is beneficial for different construction practices.
- The Cost comparison shows that its cost is much higher as compare to normal concrete. Hence it would be difficult to use it when cost is much higher.
- Carbon nanotubes are equipped with much high material properties, which are very close to their theoretical limits. A combination of these impressive properties will probably enables a whole new variety of useful and beneficial applications.
- Thus prior to some of its economic restrictions and its method to use in construction industries, it may be for good construction practice. And still many researches are in progress to find an easy way of using and implementing it on construction site.

6. REFERENCES

[1] Grigorij Yakolev , Jadvyga Keriene, Albinas Gailius, Ingrida Girniene , "Cement Based Foam Concrete Reinforced by Carbon Nanotubes" (2006) ISSN 1392-1320 Material Science) vol. 12, no. 2.

[2] Arnon Chaipanich, Thanongsak Nochaiya, Watcharapong Wongkeo, Pincha Torkittikul, "Compressive Strength and Microstructure of Carbon Nanotubes–Fly ash Cement Composites" (2010), Material Science and Engineering A527(2010) 1063-1067 Elsevier Ltd.

[3] Tanvir Manzur, Nur Yazdani, and Md. Abul Bashar Emon "Effect of Carbon Nanotube Size on Compressive Strengths of Nanotube Reinforced Cementitious Composites", (2013), Hindawl Publishing Corp. Journal of Materials Vol. 2014,Article ID 960984

[4] Tanvir manzur & Nuryazdani, "Importance of Flow values in Qualitative evaluation of Carbon Nanotube Reinforced Cementitious Matrix" (2013) Malaysian Journal of civil Engg. 25(1):72-81(2013)

[5] Tanvir Manzur and NurYazdani , "Optimum Mix Ratio for Carbon Nanotubes in Cement Mortar" KSCE Journal of Civil Engg. (2014) pISSN 1226-7988, eISSN 1976-3808

[6] Nur Yazdani,Vinoth Mohanam "Carbon Nano-Tube and Nano-Fiber in Cement Mortar: Effect of Dosage Rate and Water-Cement Ratio" (2014) International Journal of Material Science Vol.4 Issue 2,June 2014

[7] N. Saktheieswaran M. Suresh "A Study on Strength Properties for Cement Mortar added with Carbon Nanotubes and Zeolite" (2015) International Journal of Material Science Vol.4 Issue 6, June 2015

[8] Liulei Lu, Dong Ouyang, and Weiting Xu "Mechanical Properties and Durability of Ultra High Strength Concrete Incorporating Multi-Walled Carbon Nanotubes", (2016)

[9] Tanvir Manzur, Nur Yazdani, and Md. Abul Bashar Emon "Potential of Carbon Nanotube Reinforced Cement Composites as Concrete Repair Material" (2016), Hindawl Publishing Corp. Vol. 2016, Article ID 1421959

[10] Xiaobin Song, Junyi Zhang, Susu Shang "Mechanical properties of early-age concrete reinforced with multi-walled carbon nanotubes" (2016) Instituion of Civil Engineers publishing Paper 1600424