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"PARAMETRIC STUDY ON PERFORMANCE OF HIGH STRENGTH CONCRETE BY USING MULTI-WALLED CARBON NANOTUBES"

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Abstract— Concrete is produced in variety of compositions, finishes, and performance characteristics to meet a wide range of needs. Concrete is used in structure to increase the strength, durability, and tensile strength. The concrete which is used had strength and durability then also High Strength Concrete (HSC) has introduced to increase the performance. Therefore for increasing more performance of High Strength Concrete (HSC) the researchers find additive material call Carbon Nano tubes (CNT's). CNT had strength and flexibility which makes them of potential use in controlling other Nano scale structures, which suggests they will have an important role in Nano technology engineering. Multi wall carbon Nano tubes (MWCNT) is one type of CNT which is part of Nano technology which is going to be used in nowadays structure. It has a highest tensile strength of 63GPa which had been tested as per past study. Increasing the strength for longer duration of time and prolonging life along with giving boost to compressive strength and contributing to the tensile strength by improving the flexural strength is reported from earlier research work, when CNT's are mixed with concrete. For effectively using MWCNT in concrete polycarboxylate ether super plasticizer is used as a surfactant in water with MWCNT to disperse them. Conducting an experiment on performance of high-strength concrete (M 65) by adding low concentration of MWCNT for finding compressive strength and durability. After using this additive material in concrete compared the relative performance of compressive strength and durability with the concrete material in which additive material (MWCNT) is not used.

Keywords— High strength concrete (HSC), Nano technology, Carbon Nano tubes (CNT), Multi wall carbon Nano tubes(MWCNT),Compressivestrength,Durability.

[1] Introduction

The 21st century considered the century of Nanotechnology which played a central role in producing innovative concrete materials. Concrete is the most used human-made material extensively applied in all of construction projects. The popularity of the material is due to its relatively low cost, high compressive strength, and relatively simple construction technology. Carbon nanotubes (CNTs) attract the researchers since their discovery, because of their higher strength and relatively low weight. These nanotubes are useful for any application where hardiness and flexibility are necessary. Carbon nanotubes (CNTs) describe a family of Nano materials made up entirely of carbon. 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. Used polyacrylic acid as different solvents (ethanol, toluene, chloroform) have been used for uniform dispersion of carbon nanostructures via sonication to ensure effective dispersion, acid treatment with a mixture of 98% H2SO4 and 66% HNO3 was also suggested. In present work the effect of dispersion of MWCNTs on compressive strength of MWCNT-Cement composite has been experimentally investigated for both MWCNT-Cement composite in powder form and MWCNT Cement composite in hydrated form so as to determine the influence of dispersion of as-grown CNT with open flame synthesis using domestic LPG as the carbon feedstock. In this sector of construction industry there are chances of making new cementitious material by using carbon nanotubes. In this family, multi-walled carbon nanotubes (MWCNTs) are of special interest for the industry and will be the subject of this paper. The structure of MWCNT consist of multiple layers of graphite superimposed and has been rolled to form a tubular shape. The diameter of CNTs is (100) thousand times smaller than the diameter of a human hair, as mentioned by Toma, in 2004.While their lengths usually reach the micrometer range, although centimeters -long. So they have very large aspect ratios (length to diameter ratio). MWCNTs have from tens to hundreds of walls, with typical adjacent walls separations of (0.34) nm as reported by Popov et al, in 2004. MWCNTs have a tensile strength of 63 GPa (about (100) times stronger than steel) with an ultimate strain capacity of more than (12%) (About 60) times higher ductility than steel) and a Young's modulus of about (950) GPa. Also CNTs have a very low mass density about (1.3) to (1.4) g/cm^3 that varies based on their purity, (about (1/6) of the density of mild steel) as mentioned by Collins et al. in 2000.MWCNTs are very flexible materials that do not suffer damages in their structure when bend or subject to high pressures, as reported by Wong et al. in 1997. The average flexural strength was reported between (14.2) ± (8.0) GPa.

[2] **Carbon nano tubes (CNT)**

Carbon nanotubes (CNTs) attract the researchers since their discovery, because of their higher strength and relatively low weight. These nanotubes are useful for any application where hardness and flexibility are necessary. Nano-tubes is stable under any extreme high temperatures ,chemical environments and moisture as well. Carbon nanotubes (CNTs) describe a family of Nano materials made up entirely of carbon. The extraordinary Physical and chemical properties of materials at the nano metre scale enable new applications ranging from structural strength enhancement to self-cleaning properties. 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. In this sector of construction industry there are chances of making new cementitious material by using carbon nanotubes.

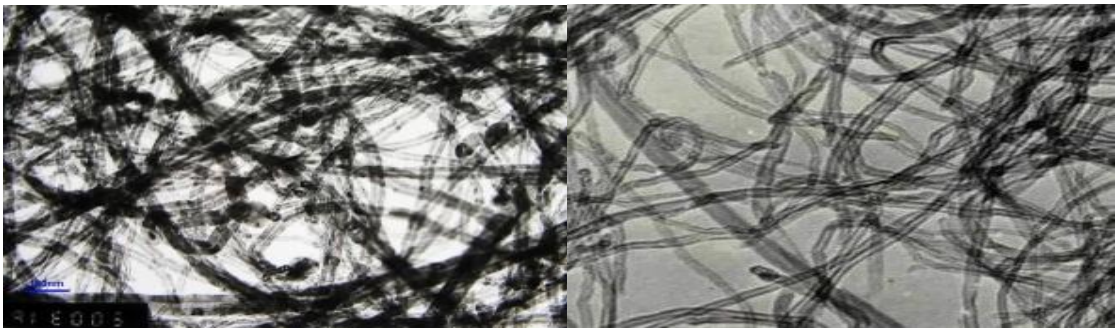


Figure-1Multiwallcarbonnanotubes10-20nm

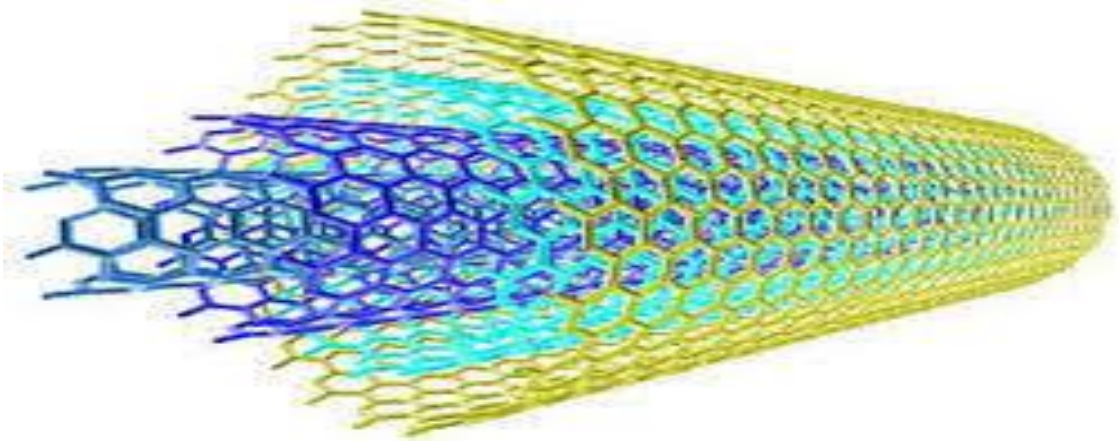


Figure-2MWCNTLayerImage

Figure-3CNTpowderform

Figure-4MWCNTPowder

[3] **Objective and scope of research**

OBJECTIVE

The objective of this parametric study on performance of high strength concrete By using multi wall carbon Nano tube (MWCNT) by weight of cement is to Compared the Compressive Strength, Durability of Normal concrete and concrete with MWCNT. To Study the effects with MWCNT, in the concrete and examine the effect on various fresh (workability) and hardened properties (compressive strength and durability) of M 65 grades of concrete.

SCOPE OF RESEARCH

- Material procurement
- Testing of Ingredients- Aggregate, sand and cement.
- Design mix for M 65 using IS method.
- Experimental Comparative Study of Concrete by varying parameter such as :-
- MWCNT: 0.025%, 0.030%, 0.035%, 0.045%, 0.050%, 0.055% by weight of cement.
- Derive conclusion based on results.

[4] MATERIAL TEST

4.1 Basic Materials

The materials used in this research are commercially available and brought from local dealers and shop. They are used as per different IS code methods which are mention in codes. The fundamental properties of materials used throughout the experimental work are as given below:

1. Cement
2. Coarse Aggregates
   - 20 mm
   - 10 mm
3. Fine aggregate (sand)

4.1.1 Cement

The cement used in this experiment investigation was OPC 53 grade cement, manufactured by Ultratech cements company, conforming to IS8112-1989 having density 1440 kg/m^3. Cement is gray color fine powder, chemically formed by raw materials such as calcium oxide (CaO), silica (SiO_2), alumina (Al_2O_3), and iron oxide (Fe_2O_3) heated to a temperature around 1200 – 1400 ^oC in kiln. During the process of mixing the ingredients inside the rotary kiln, the four major mineral constituents of cement are born. These are the main compounds that participate in strength gaining of concrete. The basic physical property of cement is given in the table below.

Initial setting time	60 min
Final setting time	480 min
Fineness (90 um sieve)	3.3%
Standard consistency	34%

Table 4.1 Physical properties of cement

4.1.2 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 Elongation and Flakiness Indices were maintain well below 15%. Aggregates occupied minimum three quarters of volume of concrete. Quality is specially very important. Coarse aggregate cheaperthan the cement, put into the mix as possible. Higher stability of volume and durability is better than the cement paste alone. Concrete is made up of aggregate,cement and water. In concrete, coarse and fine aggregates make up around 75 % of the total concrete material. Therefore it is significantly important to determine the various physical properties of the coarse aggregates. The physical properties of the coarse aggregate as found through laboratory test are given below.

SIEVE ANALYSIS OF COARSE AGGREGATE

Locally available 10mm and 20mm coarse aggregates were used for this experimental study. Different sieve sizes used for sieve analysis of coarse aggregates are 40 mm, 20 mm, 10 mm, 4.75 mm. Sieve analysis result is given in table:

Sieve size (mm)	Weight retain (Kg)	Cumulative weight retain (Kg)	Cumulative percentage weight retain (%)	Cumulative percentage weight passing
40	0.0	0.0	0.0	100
20	0.255	0.255	12.75	87.25
10	0.746	1.001	50.5	49.5
4.75	1	2	100	0

Table 4.2: Sieve analysis of Coarse Aggregate

PHYSICAL PROPERTIES OF COARSE AGGREGATE

Other properties of coarse aggregate we need to know are the specific gravity, Water Absorption, Aggregate Abrasion Value, Aggregate Impact value, Flakiness index and Elongation index are shown in the table below:

Aggregate Impact value	9.56%
Aggregate Crushing Value	16.71%
Specific Gravity for 20mm Aggregate	2.863
Water Absorption	0.6
Combined Flakiness Index, Elongation Index	25.17 % ,20.58 %

Table 4.3: Physical properties of Coarse Aggregate

4.1.3 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/m^3. Natural Sand– it is the aggregate resulting from the natural disintegration of gravel rock and had been deposited by streams or glacial agencies.

• Stone Sand– it is fine aggregate produced by crushing hard stone.
• Gravel Sand– it is fine aggregate produced by crushing natural gravel.

According to size the fine aggregate has been described in coarse sand, medium sand and fine sand. IS specifications classify the fine aggregate into four types according to its grading as fine aggregate of grade Zone-1 to grade Zone-4. The grading zones become progressively finer from grade Zone-1 to grade Zone-4. 90% to 100% of the fine aggregate passes 4.75 mm IS sieve and 0 to 15% passes 150 micron IS sieve depends upon its grading area of zone.

SIEVE ANALYSIS OF FINE AGGREGATE

The locally available river sand used as fine aggregate. The properties of sand was determined by conducting tests as per IS 2386. The sieve analysis is conducted to determine the particle size distribution of fine aggregate. The different sieves sizes used for sieve analysis of fine aggregate was 4.75 mm, 2.36 mm, 1.18 mm, 600 µm, 300 µm, 150 µm and 75µm. Sieve analysis result is given in table.

Sieve analysis size (mm)	Wt. retain (grams)	Cumulative wt. retain (grams	Cumulative wt. retain (%)	Cumulative passing percentage weight passing
10mm	0	0	0	100
4.75mm	108	108	10.8	89.2
2.36mm	50	158	15.8	84.2
1.18mm	118	276	27.6	72.4
600µ	247	523	52.3	47.7
300µ	373	896	89.6	10.4
150µ	74	970	97	3

Table 4.4: Sieve analysis of fine aggregate

PHYSICAL PROPERTIES OF FINE AGGREGATE

The water absorption of fine aggregate is measured by increase in weight of oven dry fine aggregate when the fine aggregate is immersed in water for 24 hours. Specific gravity of fine aggregate is to be find out by Pycnometer bottle is show in the table as below:

Gradation	Fall in Zone II, (IS-383,1970,Part-4)
Moisture content	0.80%
Fine modulus	2.931
Specific Gravity	2.680
Water Absorption	0.80%

Table 4.5: Physical properties of fine aggregate

4.1.4 Polycarboxyl Ether Super Plasticizer

The Polycarboxyl Ether was used as a surfactant in this project. It is brownish colour liquid having density 1.147 Kg/L. It is a water reducing agent.

4.1.5 Multi-Walled Carbon Nanotubes (mwcnt)

Multi Walled Carbon Nanotubes are hollow, cylindrically shaped allotropes of carbon that have a high aspect ratio (length to diameter ratio). Their name is derived from their structure and the walls are formed by multiple one-atom-thick sheets of carbon. MWNT consist of multiple rolled layers of concentric nanotubes of graphene inside other nanotubes.
The MWCNT are physically in black powder form. It is produced via a modified catalytic carbon vapour 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:

MWCNT	Description	Characterization Method
Production Method	Chemical Vapour Deposition[SLV]	Proprietary Method
Diameter	Avg. Outer Diameter: 5-20nm	TEM, SEM
Length	10 μm	SEM, TEM
Nanotubes Purity	99%	TGA, RAMAN
Metal Particles	<1%	TGA
Amorphous Carbon	<1%	TGA, XRD
Specific Surface Area	330 M2/G	BET
Bulk Density	0.20-0.35 G/Cm3	Pycnometer

Table 4.6 Properties of MWCNT

APPLICATIONS OF MWCNT

1) Carbon nanotubes have been widely used for a variety of applications due to their excellent physical properties.
2) The most important application of Nano-tubes based on their mechanical Properties will be as reinforcements in composite materials.
3) 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.
4) The famous New Jubilee Church (Rome, Italy) is the first building that is made of Nano photo catalytic concrete.
5) Cables made from carbon nanotubes are strong enough to be used in building.
6) 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.
7) For load bearing applications, CNT powders mixed with polymers or precursor resins can increase stiffness strength, and toughness. These enhancements depend on Carbon nano-tubes aspect ratio, alignment,diameter, dispersion, and interfacial interaction with the matrix.
8) 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] Mix Design

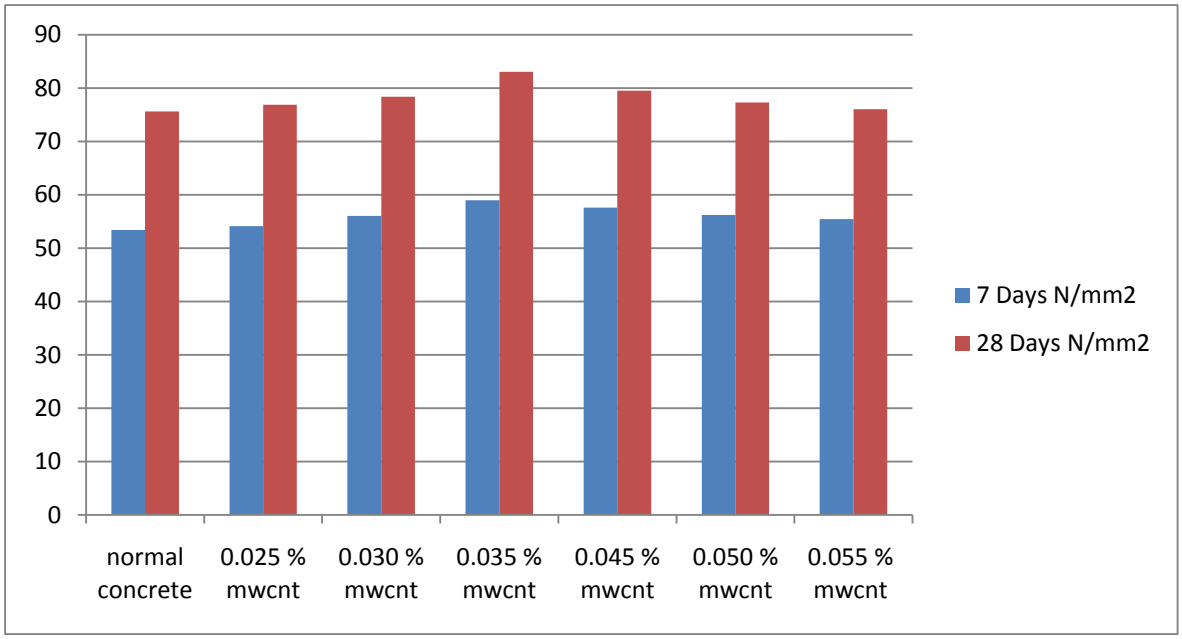
Water	Cement	Fine aggregate	Coarse aggregate
138 kg/m^3	552 kg/m^3	599 kg/m^3	1279 kg/m^3
0.25	1	1.08	2.31

[6] Experiment and Result

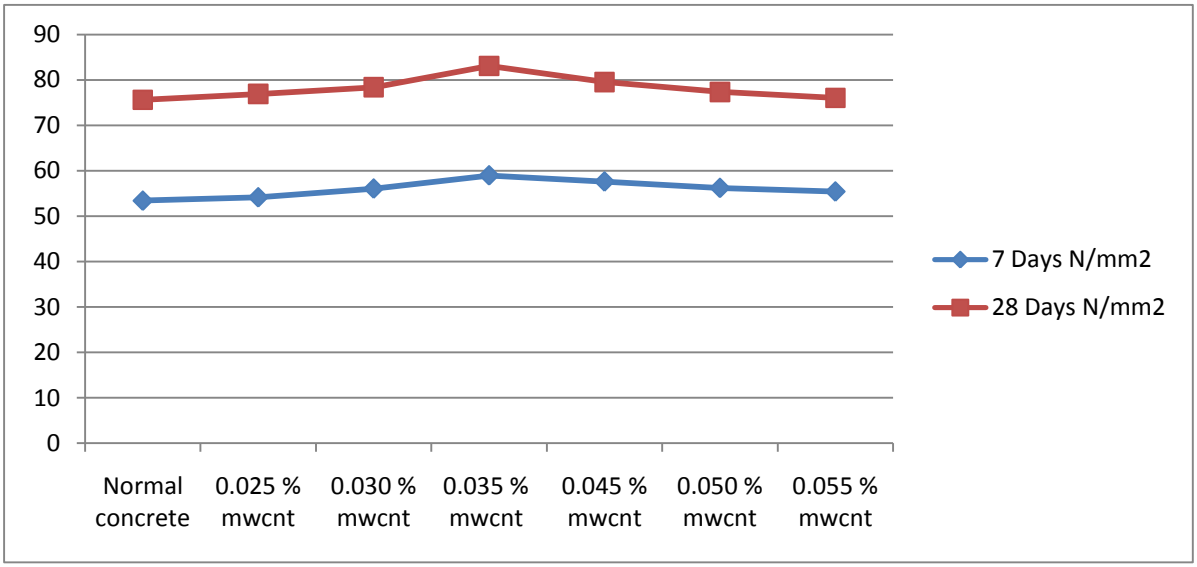
Experimental Comparative Study of Concrete by varying parameter such as:-

A. Normal Concrete
B. MWCNT: 0.025%, 0.030%, 0.035%, 0.045%, 0.050%, 0.055% by weight of cement.

BAR CHART: Compressive Strength Vs Concrete with varying Parameters.



GRAPH: Compressive strength Vs Concrete with varying Parameters.



RESULT OF EXPERIMENT

Concrete Mix	**7 Days N/mm^2**	**28 Days N/mm^2**
Normal Concrete	53.41	75.60
With 0.025 % MWCNT	54.15	76.89
With 0.030 % MWCNT	56.07	78.37
With 0.035 % MWCNT	**58.96**	**83.04**
With 0.045 % MWCNT	57.61	79.50
With 0.050 % MWCNT	56.21	77.32
With 0.055 % MWCNT	55.42	76.02

[7] Conclusion

- The slump value remains constant for various proportions of MWCNT in concrete mix.
- From the results, it is understood that increasing the proportions of MWCNT into concrete it increases the compressive strength compare to normal concrete.

- But results also shows that after optimum value at 0.035 % MWCNT in concrete the compressive strength started to gets lower down as we increases the amount of MWCNT.
- Further you can go for M70 grade of mix design for same proportion of value and find out result.

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