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Study the Effect of Carbon Nanotube on Mechanical Properties of Concrete

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ABSTRACT:Carbon nanotubes (CNT) are potential candidates for use as nano reinforcement in cement-based materials. Different dosage rates of surface treated Multi-Walled Nanotubes (MWNT),water/cement ratios and plasticizers amounts (as surfactant for the MWNT) will be investigated through compressive and flexural strength determinations. Nowadays, carbon nanotubes is the most prospective advanced materials for application in cement-based products, for the construction industry, due to their excellent material properties. According to the reported results, carbon nanotubes are insoluble in organic solvents and water, so surfactants should be normally added upon classic combination of ultra sonication and vigorous agitation, in order to disperse carbon nanotubes. These are other well-known less common specific methods for carbon nanotubes dissolution in liquid media.

I. INTRODUCTION

Creating quality concrete in the present climate does not depend solely on achieving a high strength property. It also depends on improving the durability of the concrete to sustain a longer life span and producing a greener concrete. By using industrial by- products such as carbon nanotubes as a mineral admixture and partially replacing Ordinary Portland Cement (OPC) in the concrete, the amount of greenhouse gas produced in making the concrete and the energy required to produce the concrete are reduced.

Concrete is the solid composite material and made up of suitable proportion of binding material, fine aggregate, Coarse aggregate and Water. And also it is mainly used to make driveways, patios, roads, bridges, and even entire buildings. The artificial stone called concrete is the most widely used building material. It is created by mixing aggregate, cement and water. In modern construction, we need advanced admixtures to be enhancing their properties of concrete. Which means to be mostly avoid the cracks, shrinkage, and also creep in the structures. The recent researches on nanomaterial's and nanotechnologies have highlighted the potential use of these materials in various fields such as medicine, construction, automobile industry, energy, telecommunications and informatics. This is due to the special characteristics of materials at the nano scale. Building materials domain can be one of the main beneficiaries of these researches, with applications that will improve the characteristics of concrete, steel, glass and insulating materials. Improving the materials resistances and the increasing of their durability will reduce environmental pollution by reducing the carbon footprint of the building.

Carbon nanotubes, when added to concrete, will increase compression strength beyond 200 MPa, thus allowing the construction of mile-high skyscrapers. Nowadays, carbon nanotubes is the most prospective advanced materials for application in cement- based products, for the construction industry, due to their excellent material properties.

II. LITERATURE REVIEW

R. Sundharam, et. Al. Experimental Investigation of Carbon Nanotube Concrete (March 2019)
Carbon nanotubes can be used as a source in replacing partially with cement. Adding 0.25% and 0.5% of CNT by the weight of cement to determine the properties like self.

Author investigates to improve the strength and durability using carbon nanotubes concrete. Thus compressive strength and tensile strength of concrete increases on comparing with conventional concrete. As result author mentioned that the carbon nanotubes enhanced the properties and reinforcement including tensile properties.

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The load carrying capacity is improved by adding 0.25% of dispersing MWCN by the weight ofcement..Mechanical properties of concrete are enhanced. Adding carbon nanotubes with cement, the compressive strength of concrete is increased by 32% and where tensile strength is increased by 42%.Life structure of concrete structure is increased because of using CNT.

Dr. B.Vidivelli1, et.al. A Study on Carbon Nanotube (CNT) in Cement Mortar

(Feb 2019) –

Author has studied the behavior of cement to use it with carbon nanotubes. As the increase mechanical properties of the cementitious composites such as the Flexural capacity, Ductility, reduction in the porosity and resistance for the micro-crack formation.

The author analyze the MWCNTs have a nano-scale hollow structure at a high aspect ratio, with excellent mechanical properties. As results the mechanical and durability properties increases and enhanced with using of carbon nanotubes.

Some of the following conclusions were made by the author on studying the research. The mechanical properties and durability properties increases with the carbon nanotubes in cement. The carbon nanotubes in cement increases the compressive strength by 13%. The crack formation and porosity gets reduced due to 0.1% addition if carbon nanotubes. The mechanical and durability property also increased due to increase dispersion method. The Surface treated CNTS addition up to 0.75% increase the strength by 36%.

III. METHODOLOGY

Materials used include ordinary Portland cement (53 grade, conforming to IS 269-2015), coarse
Aggregate of crushed rock (max.size, 20mm), fine aggregate of clean river sand (zone II of is: 383-2016) and portable water. A mix Will be designed as per is 10262-2019 to achieve a concrete grade of M30. A sieve analysis conforming
To IS 383-2016 was carried out for both fine and coarse aggregates.. The concrete mix was designed so as to achieve cube strength of 30 MPa (28 days). Carbon Nanotubes of volume 0.01%, 0.03% ,0.07% 0.09% and 0.1%percent of concrete was mixed in concrete homogeneously The dust of short particle size was chosen.

3.4.2. Mixing and casting:

Hand mixing was used for convenient handling of the concerete. Sand and cement were mixed dry and kept separately. Then coarse aggregates, Carbon Nanotubes and dry mix of cement and sand were kept in three layers and approximate amount of water was sprinkled on each layer and mixed thoroughly. Mixing procedure was felt to be extremely tedious due to formation of small lumps .In order to avoid the formation of lumps the particles were randomly oriented in the mix. The cubes (150mmX 150mm X 150mm), flexure beams (100mm X 100mm X 500mm) of both conventional and Carbon Nanotubes reinforced concrete specimens were casted. Each layer was compacted with 25 blows with 16 mm diameter steel rod.

3.4.3 Mix proportion of M30 grade concrete:

M30 grade of concrete has been designed as per IS 10262-2019 and the mixproportions is given as follows:

Mix design for M30 concrete

Mix design for M30 grade concrete and concrete exposed to moderate exposure conditions.

Stipulation for Proportioning Concrete Ingredients-

Characteristic compressive strength required in the field at 28 days grade designation M 30

Type of Cement: OPC 53 Grade confirming to IS 12269-2015

Maximum Nominal size of aggregate: 20 mm

© Shape of CA: Angular

Workability required at site: 100 mm (slump)

€ Type of exposure the structure will be subjected to (as defined in IS: 456):

Moderate

(h) Method of concrete placing: pumpable concrete

Test data of material-

The following materials are to be tested in the laboratory and results are to be ascertained for the design mix:

Cement Used: OPC 53 Grades Confirming to IS 12269-2015

Specific Gravity of Cement: 3.1

© Chemical admixture: Super plasticizer confirming to IS 9103

Specific gravity

Specific gravity of Fine Aggregate (sand): 2.58

Specific gravity of Coarse Aggregate: 2.80

€Water Absorption

Coarse Aggregate: 0.65%

Fine Aggregate: 1.0%

(f)Free (surface) moisture

Coarse Aggregate: Nil

Fine Aggregate: Nil

Aggregate are assumed to be in saturated surface dry condition usually while preparing design mix.

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(g) Sieve Analysis
Fine aggregates: Confirming to Zone II of Table 4 IS – 383 3]
Concrete Mix Design of M30
Grade Concrete IS 10262 – 2019 Table – 2 Page No 3.
Step 1: Determining the Target Strength for Mix Proportioning F'ck = fck + 1.65 x S
Where,
F'ck = Target average compressive strength at 28 days Fck = Characteristic compressive strength at 28 days
S = Assumed standard deviation in N/mm2 = 5 (as per table -1 of IS 10262- 2009)
= 30 + 1.65 x 5.0 = 38.25 N/mm2

Step 2: Selection of Water-Cement Ratio:-
From Table 5 of IS 456, table no 3 page no 20 Maximum water-cement ratio = 0.50

Step 3: Selection of Water Content is 10262 : 2019 tabale no 4 page no 5.
Maximum water content for 20 mm aggregate = 186 Kg (for 25 to 50 slump
We are targeting a slump of 100mm, we need to increase water content by 3% for every 25mm above 50 mm i.e. increase 6% for 100mm slump
i.e. Estimated water content for 100 Slump = 186+ (6/100) X 186 = 197
litre of Water content = 197 liters
Step 4: Calculation of Cement Content Is 2000 tabale no 5 as per cl 8.2.4.2
Water-Cement Ratio = 0.50
Water content from Step 3 i.e. 197 liters
Cement Content = Water content / "w-c ratio" = (197/0.50) = 394 kgs From Table 5 of IS 456,
Minimum cement Content for moderate exposure condition = 300 kg/m3 394 kg/m3 > 300 kg/m3, hence, OK.
As per clause 8.2.4.2 of IS: 456
Maximum cement content = 450 kg/m3, hence ok too.

Step 5: Proportion of Volume of Coarse Aggregate and Fine Aggregate Content
From Table 3 of IS 10262- 2019, table no 5 page no 6 cl 3.5.1 Volume of coarse aggregate corresponding to 20 mm size and fine aggregate (Zone II) = 0.60

Step 6: Estimation of Concrete Mix Calculations
The mix calculations per unit volume of concrete shall be as follows:
Volume of concrete = 1 m3
Volume of cement = (Mass of cement / Specific gravity of cement) x (1/100) = (39/3.15) x (1/1000) = 0.125 m3
Volume of water = (Mass of water / Specific gravity of water) x (1/1000) = (197/1) x (1/1000) = 0.197 m3
Vol of CNT = 0.09% of cement = 0.0000128 m3
Total Volume of Aggregates = 1- (b+c) =1- (0.125+0.325) = 0.677 m3
Mass of coarse aggregates = d X Volume of Coarse Aggregate X Specific Gravity of Coarse Aggregate X 1000 = 0.677 X 0.54 X 2.80 X 1000 = 1020 kg/m3

Mass of fine aggregates = d X Volume of Fine Aggregate X Specific Gravity of Coarse Aggregate X 1000 = 0.677 X 0.46 X 2.58 X 1000 = 801.09 kg/m3
Step-7: Quantity of material: Cement = 394 kg/m3
Water = 197 kg/m3
Fine aggregates = 801.09 kg/m3 Coarse aggregate = 1020 kg/m3 Water-cement ratio = 0.45

3.4.4. Selection of water cement ratio:

Various parameters like type of cement, aggregate, maximum size of aggregate, surface texture of aggregate etc. are influencing the strength of concrete, when water cement ratio remain constant, hence it is desirable to establish a relation between concrete strength and free water cement ratio with materials and condition to be used actually at site. From Table 5 of IS 456, maximum water cement ratio for M30mix = 0.45From the trial mixes, water cement ratio is fixed as 0.44 0.44 <0.5, hence OK

IV. OBJECTIVE OF PROJECT

To study the physical properties concrete combined with carbon nanotubes by conducting workability tests
To conduct compression tests on carbon nanotubes mixed concrete cubes
To study the flexural behavior of carbon nanotubes mixed concrete beams by experimental investigations.
To compare the compressive and flexural performance of carbon nanotubes composite cube and beam with conventional concrete respectively.
The sample prepared by addition of CNT by weight of cement and 0.01%,0.03%,0.07%,0.09%,0.1% respectively is made.

V. RESULT

From above result it shows that compressive strength increases up to 0.09% of CNT .Above that percentage compressive strength

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does not changes. It shows 0.09% is optimal range of CNT.At the stage of 0.09% of CNT we achieve 41.36 N/mm2 compressive strength which is highest.

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