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Experimental Test On Carbon Nano Powder On The Properties Of Concrete

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ABSTRACT

Cement concrete is one of the most versatile building materials ever created. More and more often, microfibers and polymer or carbon nano fibers are added to concrete mix, causing beneficial changes in material properties. Nanotechnology, has only recently found its way into practical building applications and building materials, including concrete. The outstanding mechanical properties of Carbon nano powder have generated great interest for their potential as reinforcements in high performance cementitious composites. The main challenge in research is the proper dispersion of carbon nano powder in the cement matrix. The results revealed that inclusion of Carbon nano powder in the design mix improves both the tensile fracture characteristics and compressive strength when not mixed with a surfactant compound. The improvement in the mechanical properties specimens with the addition of nano powder are observed more clearly with increasing curing age. The mixing process to achieve uniformly dispersed and properly mixed mortar however requires specialized equipment, such as ultrasonic mixers. It is assumed that carbon nano powder are distributed uniformly in the cement and there is perfect bonding in the interface of cement and nano powder. In our Project We Are Choosing M20 Grade of Concrete and addition of 3g carbon nano powder with weight of cement

Keywords: Experimental, Carbon Nano Powder, Properties, Concrete

1.INTRODUCTION

Cement is a construction material commonly used due to its low cost and high compressive strength. An improvement in basic mechanical properties and durability of materials based on cement is of high important these days. Remarkable improvements in the electrical and mechanical properties of cement composite materials, when carbon nano powder are used as fillers instead of other conventional materials, have been demonstrated by various research groups. Water-cement ratio, porosity, bonding between cement and aggregates are some of the major factors that govern the strength of cement concrete. Carbon nano powder showing outstanding mechanical properties have been the subject of many investigations as reinforcement for several composite applications. They are also highly flexible and capable of bending in circles and forming knots. Different research groups have focused their studies on the effect of carbon nano powder on the mechanical properties of these composites. However, dispersion of carbon nano powder in the cement matrix possesses the major problem when dealing with high performance cementitious composites. The strong vander Waals forces make it difficult to achieve desired level of dispersion as carbon nano powder tend to agglomerate and form bundles. Experimental approach for determining properties of composites containing fibers especially carbon nano powder, needs using of complex experimental methods and expensive laboratorial equipments. Nanotechnology could be characterised as: the creation of nano materials, nanomodification of common building materials, study of the properties of nanostructure and identification and characterization of nano scale structures. Almost all building materials can be modified with nano particles. Scientists use: nano-titanium dioxide, nano-silica nano-silver, nano-aluminium oxide, nano-zinc oxide, nano-iron oxide and nano-clay to improve building material properties. Observing the use of nanotechnology in cement composites and describing the effect of hydrated cement phases, makes it easy to understand the relationship between structure and macro scale properties of materials.For the last decade, nanotechnology has been successfully applied to cement materials. It can enhance some of the traditional properties or introduce new capabilities of the material. An addition of a CNT additive to cement leads to an increase in amount of crystal hydrates formed in the cement paste and to change in their morphological structure. The positive effect of carbon nano powder on the elastic properties of cement stone is clearly visible at the macroscopic scale by using an ultrasonic device. Previous research shows that the addition of carbon nano powder can enhance the strength of cement matrix materials. It was found that small amount of effectively dispersed carbon nano powder can significantly increase the flexural strength.

2.METHODOLOGY

Figure.1. shows methodology adopted in this study.

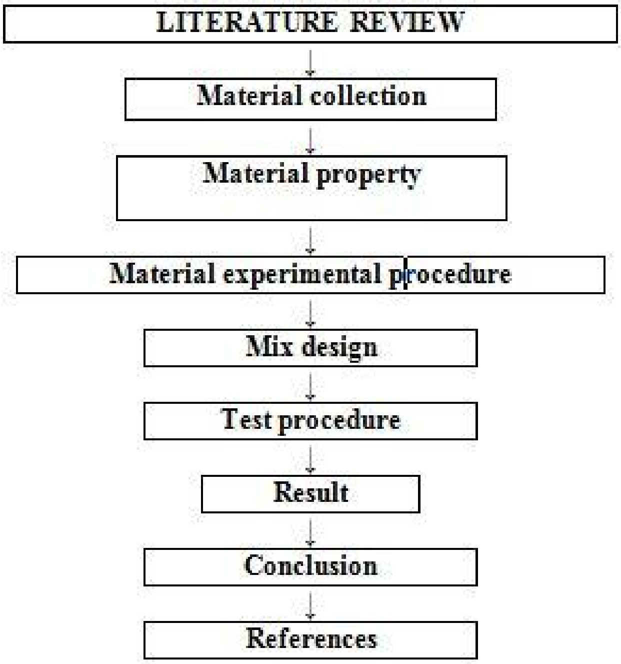

Figure.1.Methodology.

3.MATERIALS USED

3.1 Cement
The cement used in all mixtures was commercially available Ordinary Portland cement (OPC) of 43 grade manufactured by Ultratech company confirming to IS: 8112- 1989 was used in this study.

3.2 Coarse Aggregate:
The coarse aggregate is used from a local crushing unit having 20mm normal size. 20mm well-graded aggregate according to IS-383-1980 is used in this investigation. The coarse aggregate procured from quarry was sieved through all the sieves (i.e. 16mm, 12.5mm, 10mm and 4.75mm), the material retained on each sieve was filled in bags and stacked separately.

3.3 Fine Aggregate
The fine aggregate (zone-1) was used to obtain from a nearby river course. The sand obtained from quarry was sieved through all the sieves (i.e. 2.36mm, 1.18mm, 600, 300, 150). Sand retained on each sieve was filled in different bags and stacked separately for use. To obtain zone-I sand correctly, sand retained on each sieve is mixed in appropriate proportion. Fine aggregate" is defined as material that will pass a No. 4 sieve and will, for the most part, be retained on a No. 200 sieve. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

3.4 Water
The water used for experiments was potable water. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. It should be free from organic matter and the pH value should be between 6 to 7.

3.5 Carbon NanoPowder
The dispersion of carbon nano powder in the matrix is complex given the widespread specific surface area of the nano particles and due to Vander Waals forces which tend to favor the formation of agglomerates. Different techniques for

dispersing said materials in solvents (acetone, ethanol…) in addition to ultrasounds, mechanical shaking or a combination of the two techniques, have already been tried out. Moreover, as such carbon nano powder are hydrophobic. Commercial single walled carbon nano powder dispersed by sonication in isoproponal with ordinary Portland cement (0.02 by weight CNT/cement ratio) for four hours led to cement particles coated with bundles of carbon nano powder after alcohol evaporation. After hydration (with a 0.4 water to cement ratio (w/c) and use of 10 g/L of a superplasticizer), CNT bundles were smaller in apparent diameter and more widely distributed with respect to unhydrated cement. However, the carbon nano powder directly affected the early hydration process, producing higher hydration rates than those experienced by control samples, as evidenced from hardness tests and SEM observations. Carbon nano powder with specific strength of up to 48,000 kN·m·kg−1 which is infact the best of known materials, compared to high-carbon steel's 154 kN·m·kg−1. Some properties of MW carbon nano powder: Carbon Purity of above 90%, diameter in a range of 20-40 nm, length ranging from 1-10 µm, no. of walls: 3-15, density: 0.15-0.35 g/cm3 & surface area: 350 m^2/g. Carbon nano powder are made by rolling up of sheet of graphene into a cylinder. These nanostructures are constructed with length-to-diameter ratio of up to (1.32 × 108):1 (Wang 2009) that is significantly larger than any other material. As their name suggests, the diameter of nanotube is in the order of few nano meters, while they can be up to 18 centimeters in length. Ccarbon nano powder are most promising candidates in the field of nano electronics, especially for interconnect applications.

4.CARBON NANOPOWDER

To understand the crystal structure of carbon nano powder, it is necessary to understand their atomic structure. Both carbon nano powder and GNRs (graphene nanoribbons) can be understood as structures derived from a graphene sheet, shown. A graphene sheet is a single layer of carbon atoms packed into 2D honeycomb lattice structure. CNT, considered as rolled-up graphene sheet, have the edges of the sheet joint together to form a seamless cylinder.

Table 1 Properties of the Carbon Nano Powder

Parameter	
External diameter (nm)	8–15
Internal diameter (nm)	4–8
Length (µm)	2 and more
Total amount of impurity (%) (after purification)	up to 5 (up to 1)
Bulk density (g/cm^3)	0.03–0.05
Specific surface (m^2/g)	300÷320 and more
Thermal stability in air (°C)	up to 600

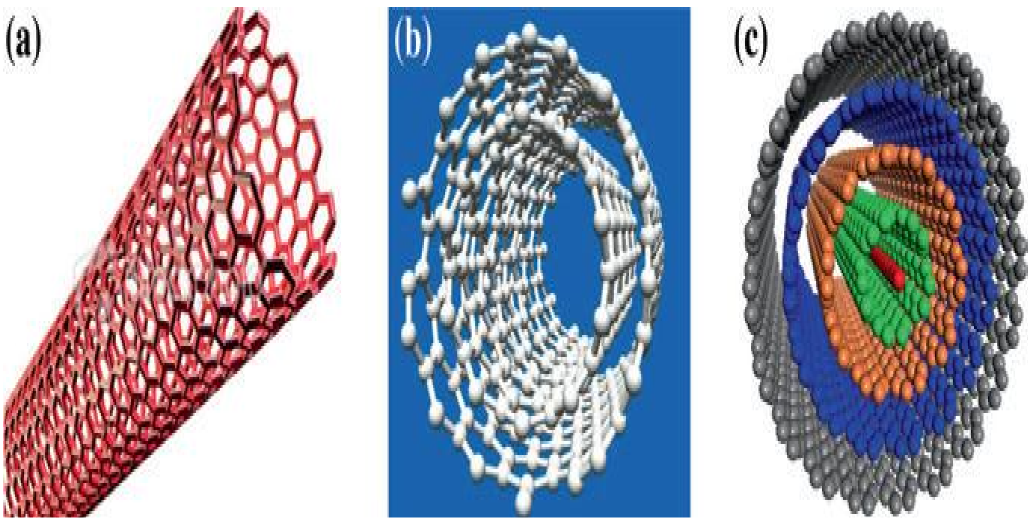

Figure.2 Basic structures of a single-walled, b double- walled and c multi-walled carbon nano powder

4.1 Types Of Nanopowder

4.1.1 Single Walled Carbon Nanotube

Single-walled nano powder (SWNT) have a diameter of close to 1 nanometer, with a tube length that can be many millions of times longer. The structure of a SWNT can be conceptualized by wrapping a one-atom-thick layer of graphite called graphene into a seamless cylinder.

4.1.2 Multi Walled Carbon Nanotube

Multi-walled nano powder (MWNT) consist of multiple rolled layers (concentric tubes) of graphene. There are two models that can be used to describe the structures of multiwalled nano powder. In the Russian Doll model, sheets of graphite are arranged in concentric cylinders. In the Parchment model, a single sheet of graphite is rolled in around itself, resembling a scroll of parchment or a rolled newspaper. The interlayer distance in multi-walled nano powder is close to the distance between graphene layers in graphite, approximately 3.4 Å. The Russian Doll structure is observed more commonly. Its individual shells can be described as SWNTs, which can be metallic or semiconducting. Because of statistical probability and restrictions on the relative diameters of the individual tubes, one of the shells, and thus the whole MWNT, is usually a zero-gap metal. Double-walled carbon nano powder (DWNT) form a special class of nano powder because their morphology and properties are similar to those of SWNT but their resistance to chemicals is significantly improved. This is especially important when grafting of chemical functions at the surface of the nano powder is required to add new properties to the CNT. In the case of SWNT, covalent functionalization will break some C=C double bonds, leaving "holes" in the structure on the nanotube and, thus, modifying both its mechanical and electrical properties. In the case of DWNT, only the outer wall is modified. DWNT synthesis on the gram-scale was first proposed in 2003 by the CCVD technique, from the selective reduction of oxide solutions in methane and hydrogen.

4.1.3 Torus

A nanotorus is a carbon nanotube bent into a torus (doughnut shape). Nanotori are predicted to have many unique properties, such as magnetic moments 1000 times larger than previously expected for certain specific radii. Properties such as magnetic moment, thermal stability, etc. vary widely depending on radius of the torus and radius of the tube.

4.1.4 Nanobud

Carbon nanobuds are a newly created material combining two previously discovered allotropes of carbon: carbon nano powder and fullerenes. In this new material, fullerene like "buds" are covalently bonded to the outer sidewalls of the underlying carbon nanotube. This hybrid material has useful properties of both fullerenes and carbon nano powder. In particular, they have been found to be exceptionally good field emitters. In composite materials, the attached fullerene molecules may function as molecular anchors preventing slipping of the nano powder, thus improving the composite’s mechanical properties.

4.1.5 Graphenated Carbon Nano Powder (G- Carbon Nano Powder)

Graphenated carbon nano powder are a relatively new hybrid that combines graphitic foliates grown along the sidewalls of multiwalled carbon nano powder. Yu et al. reported on "chemically bonded graphene leaves" growing along the sidewalls of carbon nano powder. Stoner et al. described these structures as "graphenated carbon nano powder" and reported in their use for enhanced super capacitor performance. Hsu et al. further reported on similar structures formed on carbon fibre paper, also for use in super capacitor applications. The foliate density can vary as a function of deposition conditions (e.g. temperature and time) with their structure ranging from few layers of graphene (< 10) to thicker, more graphite-like. The fundamental advantage of an integrated graphene-CNT structure is the high surface area three-dimensional framework of the carbon nano powder coupled with the high edge density of graphene.

4.1.6 Nitrogen Doped Carbon Nano Powder

Nitrogen doped carbon nano powder (N- carbon nano powder), can be produced through 5 main methods, Chemical Vapour Deposition, high-temperature and high-pressure reactions, gas-solid reaction of amorphous carbon with NH_3 at high temperature, solid reaction, and solvo thermal synthesis.

4.1.7 Peapod

A Carbon peapod is a novel hybrid carbon material which traps fullerene inside a irradiating. It can also be applied as an oscillator during theoretical investigations and predictions.

4.1.8 Cup-Stacked Carbon Nano Powder

Cup-stacked carbon nano powder (CS carbon nano powder) differ from other quasi-1D carbon structures, which normally behave as quasi-metallic conductors of electrons. CS carbon nano powder exhibit semiconducting behaviours due to the stacking microstructure of grapheme layers.

4.1.9 Extreme Carbon Nano Powder

The observation of the longest carbon nano powder (18.5 cm long) was reported in 2009.These nano powder were grown on Si substrates using an improved chemical vapour deposition (CVD) method and represent electrically uniform arrays of single-walled carbon nano powder. The thinnest freestanding single-walled carbon nanotube is about 4.3 Å in diameter. Researchers suggested that it can be either (5, 1) or (4, 2) SWCNT, but exact type of carbon nanotube remains questionable. (3, 3), (4, 3) and (5, 1) carbon nano powder (all about 4 Å in diameter) were unambiguously identified using aberration corrected high-resolution transmission electron microscopy inside double-walled carbon nano powder. The highest density of carbon nano powder was achieved in 2013, grown on a conductive titaniumcoated copper surface that was coated with co-catalysts cobalt and molybdenum at lower than typical temperatures of 450 °C.

4.2 Properties Of Carbon Nano Powder

4.2.1 Strength

Carbon nano powder are proved to be the strongest and stiffest materials due to the covalent sp2 bonds formed between the individual carbon atoms. Due to this type of bonding, the strength results are more favourable in terms of tensile strength and elastic modulus. In 2000, a test was conducted on multi-walled carbon nanotube for tensile properties and the test was succeeded to have strength of 63 GPa and in 2008, tests revealed that individual CNT shells have strengths of up to 100 GPa, which is in agreement with quantum/atomistic models. As individual CNT shells possess extremely high strength, weak shear interactions between adjacent shells and tubes lowers the strength of multi-walled carbon nano powder and carbon nanotube bundles only to few GPa's.

4.2.2 Kinetic Properties

Multi-walled nano powder are individual nano powder shells placed concentrically within one another. These reveal a striking telescoping property whereby an inner nanotube core may slide, almost without friction, within its outer nanotube shell, thus possessing an atomically perfect linear or rotational bearing.

4.2.3 Electrical Properties

The unique electrical properties of carbon nano powder are to a large extent derived from their 1-D character and the peculiar electronic structure of graphite. They have extremely low electrical resistance. Resistance occurs when an electron collides with some defect in the crystal structure of the material though which it is passing. The defect could be an impurity atom, a defect in the crystalline structure, or an atom vibrating about its position in the crystal. Such collisions deflect the electron from its path but the electrons inside a carbon nanotube are not so easily scattered because of their small diameter and huge ratio of length to diameter ratio that can be up in the millions or even higher.

4.2.4 Electrical Conductivity

A metallic CNT can be considered as highly conductive material. Chirality, the degree of twist of graphene sheet, determines the conductivity of CNT interconnects. Depending on the chiral indices, carbon nano powder exhibit both metallic and semiconducting properties. The electrical conductivity of MWNTs is quite complex as their inter-wall interactions non-uniformly distribute the current over individual tubes. However, an uniform distribution of current is observed across different parts of metallic SWNT (Shah et al. 2013). Electrodes are placed to measure the conductivity and resistivity of different parts of SWNT rope. The measured resistivity of the SWNT ropes is in the order of 10^{-4} Ω cm at 27 ºC, indicating SWNT ropes to be the most conductive carbon fibers. It has been reported that an individual SWNT may contain defects that allows the SWNT to behave as a transistor.

4.2.5 Strength And Elasticity

Each carbon atom in a single sheet of graphite is connected via strong chemical bond to three neighboring atoms. Thus, carbon nano powder can exhibit the strongest basal plane elastic modulus and hence are expected to be an ultimate high strength fiber. The elastic modulus of SWNTs is much higher than steel that makes them highly resistant. Although pressing on the tip of nanotube will cause it to bend, the nanotube returns to its original state as soon as the force is removed. This property makes carbon nano powder extremely useful as probe tips for high resolution scanning probe microscopy.

4.2.6 Thermal Properties

CNT have now been shown to have thermal conductivity at least twice that of diamond. CNT have the unique property of feeling cold to the touch, like metal, on the sides with the tube ends exposed, but similar to wood on the other sides. The specific heat and thermal conductivity of carbon nano powder systems are determined primarily by phonons. The measurements of the thermoelectric power (TEP) of nano powder systems give direct information for the type of carriers and conductivity mechanisms.

4.2.7 Mechanical Properties

The carbon nano powder are expected to have high stiffness and axial strength as a result of carbon-carbon sp_2 bonding. The practical application of the nano powder requires the study of the elastic response, the inelastic behaviour and buckling, yield strength and fracture. Nano powder are the stiffest known fibre, with a measured Young's modulus of 1.4 TPa and elongation to failure of 20–30%, which projects to a tensile strength of well above 100 GPa (possibly higher), by far the highest known.

4.2.8 Toxicity

The toxicity of carbon nano powder has been an important question in nanotechnology. The data are still fragmentary and subject to criticism. Preliminary results highlight the difficulties in evaluating the toxicity of this heterogeneous material. Parameters such as structure, size distribution, surface area, surface chemistry, surface charge, and agglomeration state as well as purity of the samples, have considerable impact on the reactivity of carbon nano powder.

4.2.9 Thermal Conductivity And Expansion

carbon nano powder can exhibit superconductivity below 20 K (approximately −253 ºC) due to the strong in-plane C–C bonds of graphene. The strong C-C bond provides the exceptional strength and stiffness against axial strains. Moreover, the larger interplane and zero in-plane thermal expansion of SWNTs results in high flexibility against non-axial strains. Due to their high thermal conductivity and large in-plane expansion, carbon nano powder exhibit exciting prospects in nano scale molecular electronics, sensing and actuating devices,reinforcing additive fibers in functional composite materials, etc. Recent experimental measurements suggest that the CNT embedded matrices are stronger in comparison to bare polymer matrices. Therefore, it is expected that the nanotube may also significantly improve the thermo-mechanical and the thermal properties of the composite materials.

4.2.10 Field Emission

Under the application of strong electric field, tunneling of electrons from metal tip to vacuum results in field emission phenomenon. Field emission results from the high aspect ratio and small diameter of carbon nano powder. The field emitters are suitable for the application in flat-panel displays. For MWNTs, the field emission properties occur due to the emission of electrons and light. Without applied potential, the luminescence and light emission occurs through the electron field emission and visible part of the spectrum, respectively.

4.2.11absorbent

Carbon nano powder and CNT composites have been emerging as perspective absorbing materials due to their light weight, larger flexibility, high mechanical strength and superior electrical properties. Therefore, carbon nano powder emerge out as ideal candidate for use in gas, air and water filtration. The absorption frequency range of SWNT-polyurethane composites broaden from 6.4–8.2 (1.8 GHz) to 7.5–10.1 (2.6 GHz) and to 12.0–15.1 GHz (3.1 GHz) (Wang et al. 2013). A lot of research has already been carried out for replacing the activated charcoal with carbon nano powder for certain ultrahigh purity applications.

5.FUNCTIONALIZATION AND DISPERSION OF CARBON NANO POWDER

In order to effectively utilize carbon nano tubes and make use of their extraordinary properties, they should be well dispersed within the reinforced matrix. Dispersion of carbon nano powder means spreading the tubes individually within the matrix by separating the agglomerations and bundles. In this study, dispersion of carbon nano powder within the cement paste was a major element in controlling the mechanical properties of the cement nano composite (as discussed in the next sections). Poor dispersion of these nano filaments within the matrix will not enhance the nano composite properties; in fact, it might significantly degrade and deteriorate the matrix properties. Carbon nano powder in their dry state bundle together due to the van der Waals forces. These interfacial forces at the nano scale are strong enough to pull the nano powder back to stick together, even after being dispersed in an aqueous solution. Chemical surfactants that provide non-covalent bonds have been used to reduce the surface tension of the solution and keep the carbon nano powder suspended and unbundled within the solution after they have been dispersed (separated) by mechanical dispersion.

6.TESTING PROCEDURE

6.1 Compressive Strength Test

At the time of testing, each specimen must keep in compressive testing machine. The maximum load at the breakage of concrete block will be noted. From the noted values, the compressive strength may calculated by using below formula When a specimen of material is loaded in such a way that it extends it is said to be in tension. On the other hand if the material compresses and shortens it is said to be in compression.

6.2 Split Tensile Test

The size of cylinders 300 mm length and 150 mm diameter are placed in the machine such that load is applied on the opposite side of the cubes are casted. Align carefully and load is applied, till the specimen breaks. The formula used for calculation.

Split tensile strength = 2P/ µdl

6.3 Flexural Strength Test

During the testing, the beam specimens of size 7000mmx150mmx150mm were used. Specimens were dried in open air after 7 days of curing and subjected to flexural strength test under flexural testing assembly. Apply the load at a rate that constantly increases the maximum stress until rupture occurs. The fracture indicates in the tension surface within the middle third of span length. The flexural strength was obtained using the formula (R)

$R = Pl/bd^2$

Where,

R = Modulus of rupture (N/mm^2)
P = Maximum applied load (N/mm^2)
l = Length of specimen (mm)
b = Width of specimen (mm)\

7.TEST RESULT

7.1 Compressive Test On Concrete

Table 2 shows Compressive Test On Concrete. Figure.3 shows Compressive Strength Test Results

Table 2 Compressive Test On Concrete

Grade of concrete	% of Material	Compressive strength		
		7 days	14 days	28 days
M20	3g Added With Cement	13.5	15.65	18.5

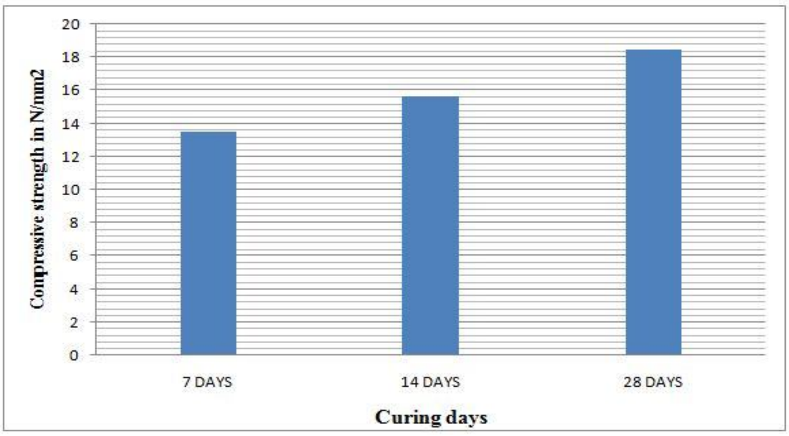

Figure.3 Compressive Strength Test Results

7.2 Split Tensile Test For Cylinder

Table 3 shows Split Tensile Test. Figure.4 shows Split Tensile Test Results

Table 3 Split Tensile Test

Grade of concrete	% of Material	Split Tensile		
		7 days	14 days	28 days
M20	3g Added With Cement	2.97	3.30	3.77

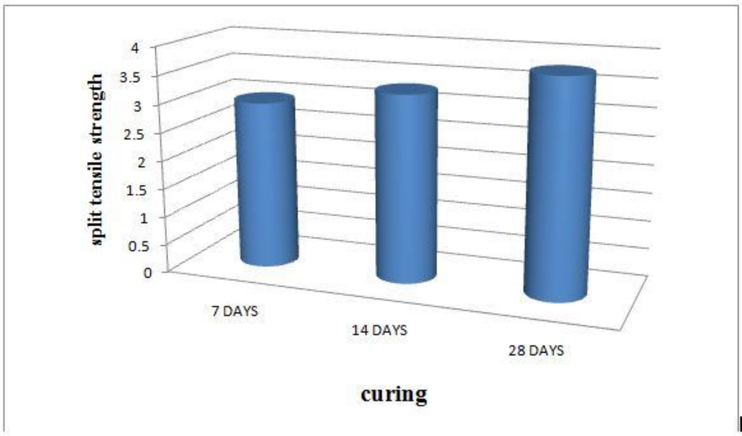

Figure.4 Split Tensile Test Results

7.3 Flexural Strength Of Beam

Table 4 shows Flexural Strength Of Beam. Figure.5 shows Flexural Strength Test Results

Table 4 Flexural Strength Of Beam

Grade of concrete	% of Material	Flexural Strength		
		7 days	14 days	28 days
M20	3g Added With Cement	1.96	2.38	3.08

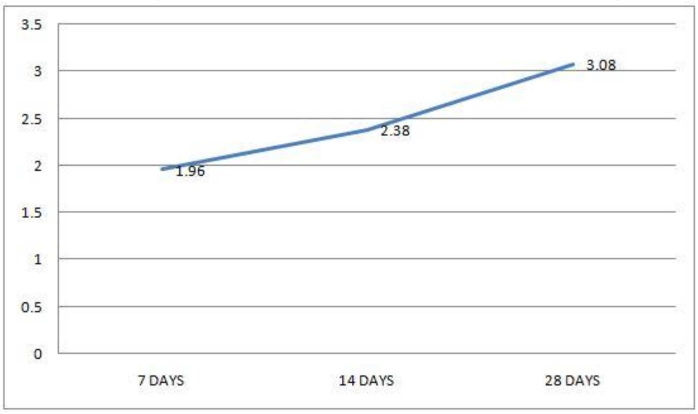

Figure.5 Flexural Strength Test Results

8. CONCLUSIONS

- Our study has shown it is possible to design and use nanomodificated concrete incorporating nano materials and nanoproducts which leads to an improvement in the materials characteristics or give new properties to the considered materials.
- From the results, it is understood that increasing the proportions of functionalized carbon nano powder into concrete increases the compressive strength. In fact the compressive strength of the concrete with a proportion of adding 3g with cement of functionalized carbon nano powder increases by 18.5 N/mm^2
- The split tensile strength increases with the increase in carbon nano powder. In fact, the split tensile strength increased by 3.77 for adding of cement.

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