

Performance Evaluation on Strength Properties of Concrete using Carbon Nanotubes

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ABSTRACT: Carbon Nanotube is a seamless cylindrical hollow fiber comprised of a single sheet of pure graphite, having a diameter of 0.7nm to 50nm with length generally in the range of 10's of microns. Carbon nanotubes are microscopic molecules that contain bonds so strong relative to their size that they are used in nanotechnology. Considerable improvement in restricting cracks in cementitious matrices was observed in addition of Carbon Nanotubes in concrete. Carbon Nanotubes are used to increase the densification and hence improve the mechanical properties & durability of cementitious materials. The service life of a structure can be doubled by using the Carbon Nanotubes. This paper presents the performance evaluation of concrete using Carbon Nanotubes in different proportions of 0.01% to 0.045% by weight of cement in concrete.

KEYWORDS: Carbon Nanotubes, Super plasticizer, Compressive strength & Split tensile strength.

I. INTRODUCTION

Nanotechnology has a significant impact in the construction sector. Several applications have been developed for this specific sector to improve the durability & enhanced performance of construction components, energy efficiency & safety of buildings, facilitating the ease of maintenance and to provide increased lining comfort. Addition of nanoparticles will lead to stronger, more durable, self-healing, fire resistance, easy to clean & quick compacting concrete. Some of the nano particles that could be used for these features are nano silica (silica fume), nano structured metal, carbon nano-tubes (CNTs) & carbon nano-fiber (CNFs).

Concrete is a mixture of cement (11%), fine aggregate (26%), Coarse aggregate (41%), water (16%) & air (6%). Concrete's versatility, durability, sustainability & economic have made it the world's most widely construction material. Concrete is considered as a chemically combined mass where the inert material act as a filler & binding material act as a binder. Concrete make a building fire safe due to its non-combustible nature. Concrete is resistant to wind & water. Therefore it is a very useful in storm shelters.

The Compressive strength of concrete with a proposing of 0.045% of functionalized MWCNTs (Multi Wall Carbon Nano Tubes) increases by 26.69% [1]. The potential of nano technology to improve the performance of concrete and to lead to development of novel, sustainable, advanced cement based composites with unique mechanical & electrical properties is really promising. Current challenges need to be solved before the full potential of nanotechnology can be exploited in concrete; in particular, proper dispersion and functionalization of MWCNTs, concrete processing, handling issue of CNTs, scale-up & material cost [2].

The ultrasonication method helps to resolve the problem uneven dispersion and tendency to aggregation of Carbon Nanotubes. Positive effect of nano-additive was found. It was almost 30% increase in strength for mortar with CNTs in amount of 0.06% by cement mass. The introduction of CNTs into cement mortar caused a decrease in 7 day

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 7, Issue 3, March 2018

compressive strength (even more than 68% for content 0.06% by weight of cement) was observed between 7th & 28th days of curing [3]. Nano materials have smallest particle size and largest surface area. Nanomaterials have great potential in improving properties of concrete. Until today, concrete has primarily been seen as a structural material but nanotechnology can help to make it as multipurpose smart functional material. They can improve the overall performance of concrete since they have high surface area to volume ratio providing the potential for tremendous chemical reactivity [4].

To develop high performance, multifunctional, ideal (high strength, ductile, crack free, durable) construction material, carbon nanotubes (CNTs) show promising rate to modify or enhance the characteristics of conventional construction material such as concrete & steel. It is also brought out that a crack free durable concrete is possible if certain issues such as uniform distribution of CNTs in composite and bond behavior of CNT modified concrete can be addressed [5]. Various chemical techniques attempt to achieve uniform and stable CNT or CNF aqueous dispersions of using surfactant, polymer, cement admixtures, functionalization combinations of various techniques. Hybrid cement nanocomposites, containing both micro fiber and nano- material are promising material which show huge enhancement in both mechanical properties and fracture toughness [6].

The author could not determine any optimum dosage of carbon nanotubes but addition in small amounts ranging from 0.05% - 0.5% by weight have shown best results; improving strength (flexural and compressive), durability and reducing porosity. The cost of production of carbon nano tubes despite decreasing continuously is still high for its use in mass construction [7].

Nano cement particles can accelerate cement hydration due to their high activity. Similarly the incorporation of nano particles and fill pores more efficiently and effectively to enhance the overall strength and durability. Nano particles can lead to the production of new generation of cement composites with enhanced strength and durability [8].

In this study, the compressive strength and split tensile strength of concrete specimen is studied which is produced by adding the carbon nano tubes with the ratio of 0.01% to 0.045% with cement by weight.

II. METHODOLOGY AND MATERIALS

A. Cement

Cement is a main ingredient used in concrete as a binding material. Cement is produced from limestone by grinding, calcining the grinding to produce a fine powder which is then mixed with gypsum to retard setting time. Cement is a substance applied to the surface of solid bodies to make them cohere firmly or more specifically, a powdered substance which made plastic with water is used in a soft and pasty state to bind together bricks, stones etc in building. Portland cement is a calcined material comprising lime and silicates which is mixed with sand and stone and upon hydration forms a plastic material which sets and hardens to a rock-like material, concrete. In this study, ordinary Portland cement of 43 grade (IS 8112:1989) is used.

B. Aggregate

Aggregate is a broad category of coarse to medium grained particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to overall composite material. Aggregates are used as base material under foundations, roads and rail roads. Aggregates comprise as much as 60% to 80% of a typical concrete mix, so they must be properly selected to be durable, blended for optimum efficiency and properly controlled to produce consistent concrete strength, workability, finishability and durability.

1) Fine Aggregate: Fine aggregate is a major component of concrete and without the fine aggregate concrete will not function as intended. The properties of a specific concrete mix will be determined by proportion and type of fine aggregate used to formulate the concrete. Fine aggregate is usually a larger component of mix than cement. River sand conforming to IS 383:1987 is used as fine aggregate.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 7, Issue 3, March 2018

2) Coarse Aggregate: Good quality aggregate must be clean, hard, strong, have durable particles and be free of absorbed harmful chemicals, coatings of clay or other contaminants that can affect hydration of cement or reduce the paste aggregate bond. In this study, locally available quarry stone in good strength passing through 20mm and retained in 10mm sieve confirming to IS 383:1987 is used.

C. Water

Any natural water that is drinkable and has no pronounced taste or odor can be used as mixing water for making concrete. Some waters that are not fit for drinking may be suitable for concrete making provided that they satisfy the acceptance criteria laid by ASTM C 94. Excessive impurities in mixing water affect setting time and concrete strength and cause efflorescence, staining, corrosion of reinforcement, volume changes and reduced durability.

Potable water available in the college campus was used for preparing concrete in this study.

D. Super plasticizer

Super plasticizer also known as high range water reducers are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation and to improve flow characteristics of suspension such as in concrete applications. Their addition to concrete allows the reduction of the water to cement ratio, not affecting the workability of the mixture and enables the production of self-consolidating concrete and high performance concrete. In this study, Master Glenium SKY 8233 super plasticizer was used in concrete.

E. Mix design

Concrete mix design is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre-defined characteristics in the fresh and hardened states. The concrete mix design has been designed for M30 grade as per IS 10262:2009. Mix ratio was arrived as 1:1.269:2.57.

III. RESULTS AND DISCUSSIONS

TABLE I
COMPRESSIVE STRENGTH OF CONCRETE CUBE SPECIMEN

Sl.NO.	Compressive Strength of concrete Cube specimen	
	Amount of Carbon nanotubes by weight (%)	Compressive Strength (N/mm ²)
1.	0	30.15
2.	0.01%	32.72
3.	0.015%	32.78
4.	0.02%	33.92
5.	0.025%	35.23
6.	0.03%	35.24
7.	0.035%	35.51
8.	0.04%	35.75
9.	0.045%	36.21

Table –I shows the compressive strength of Concrete cube specimen by using Carbon nanotubes with different ratios of 0.01% to 0.045% by weight of cement.

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Vol. 7, Issue 3, March 2018

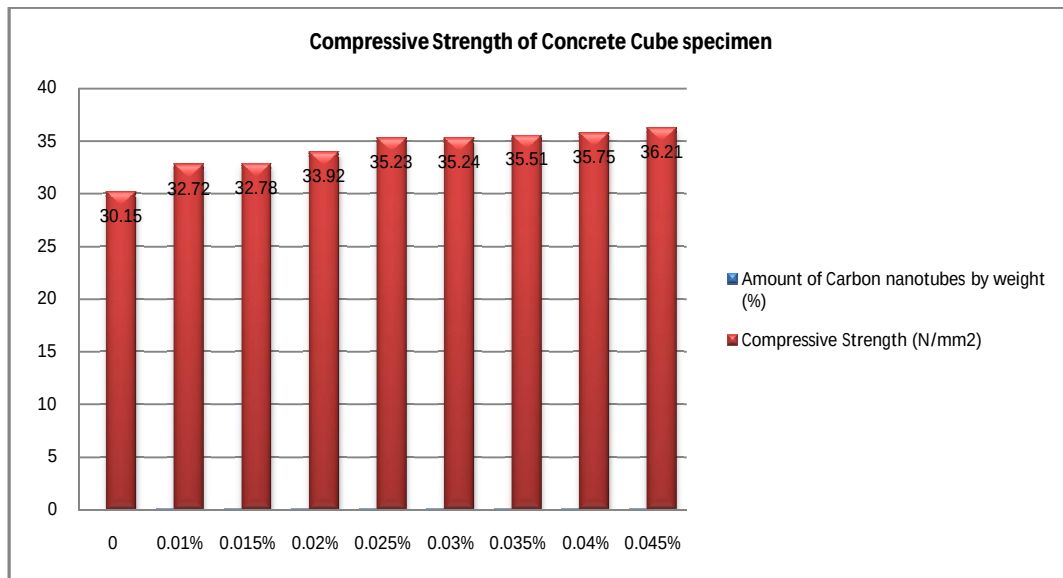


Fig. 1 Compressive Strength of Concrete Cube specimen

From the above Fig.1, the compressive strength of concrete cube specimen with carbon nanotubes (0.01%) is 32.72N/mm². The maximum possible percentage of Carbon nanotubes used in concrete is 0.045% which gave better compressive strength when compared to other ratios of carbon nanotubes.

TABLE II
SPLIT TENSILE STRENGTH OF CYLINDER SPECIMEN

Sl. No.	Split tensile strength of concrete cylinder specimen	
	Amount of Carbon nanotubes by weight (%)	Split tensile strength (N/mm ²)
1.	0	7.32
2.	0.01%	7.52
3.	0.015%	7.78
4.	0.02%	7.91
5.	0.025%	8.02
6.	0.03%	8.15
7.	0.035%	8.26
8.	0.04%	8.38
9.	0.045%	8.56

Table –II shows the Split tensile strength of Concrete cylinder specimen by using Carbon nanotubes with different ratios of 0.01% to 0.045% by weight of cement.

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Vol. 7, Issue 3, March 2018

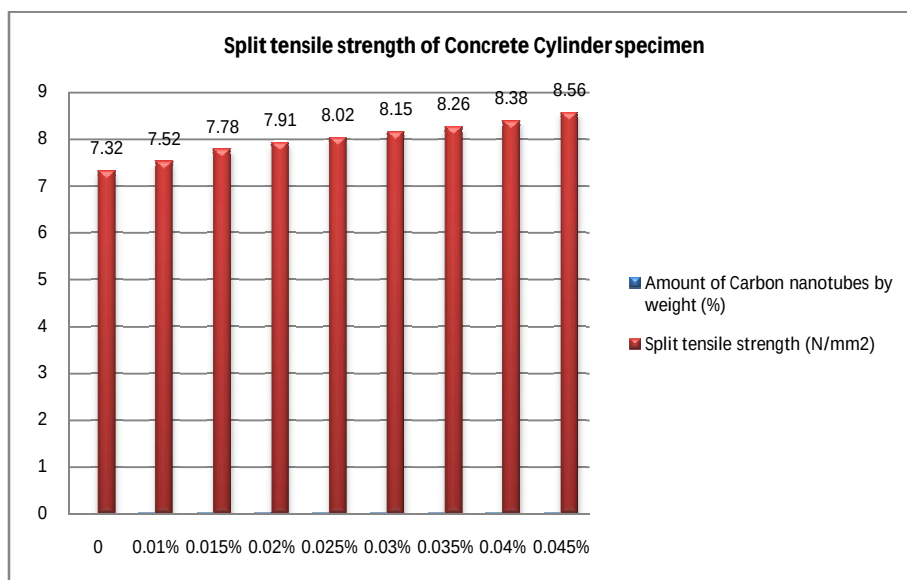


Fig. 2 Split tensile Strength of Concrete Cylinder specimen

From the above Fig.2, the Split tensile strength of concrete cylinder specimen with carbon nanotubes (0.01%) is 7.32N/mm². The maximum possible percentage of Carbon nanotubes used in concrete is 0.045% which gave better split tensile strength when compared to other ratios of carbon nanotubes.

IV. CONCLUSION

Based on the above investigations, the following conclusions can be drawn:

- From the results, it is understood that the compressive strength of concrete with proportion of 0.045% Carbon nanotubes increases when compared to other compressive strength. Up to 0.045% by weight of cement, carbon nanotubes concrete gave better result with addition of super plasticizers.
- The split tensile strength increases with increase in the proportion of Carbon nanotubes in concrete. The split tensile strength increased up to 0.045% of Carbon nanotubes by weight of cement in concrete.

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ISSN(Online): 2319-8753
ISSN (Print): 2347-6710

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

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