Mechanical Properties of Carbon Nanotubes Reinforced Rubberized Blended Cement Concrete

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ABSTRACT

Tyre disposal is a significant global environmental issue that poses environmental risks. Tyre rubber waste material, often known as crumb rubber, is a waste product that works well in concrete applications. It is possible to have more flexible concrete while using the waste tire rubber. The purpose concerning this study be able produce Carbon Nanotube Reinforced Rubberized Blended Cement Concrete utilizing waste tyre rubber and fly ash as a prejudiced substitute for fine aggregate and cement. In rubberized concrete, replacement of soil accompanying morsel elastic shows decreases in the substance of hardened. To improve the strength of hardened, use carbon nanotubes as support in rubberized concrete. Crumb rubber is treated with cement coating which significantly shows improvement in chloride permeability. Combined effect of crumb rubber and carbon nanotube shows good performance in chloride permeability. The findings of this study show the mechanical properties of reinforced rubberized blended cement concrete containing carbon nanotubes.

Keywords: Crumb rubber, Carbon nanotube, Chloride permeability

1 Introduction

The most popular building material worldwide with excellent compressive strength and ecological adaptability is concrete. But they have some disadvantages in the application of complex structures. In some cases, to rectify such problems in concrete add nanomaterials. The primary benefits of Portland cement include the ease of building, low cost, room temperature setting, availability of raw materials for manufacture anywhere in the world, and easy access to performance and property data for design and construction. However, the large amounts of carbon dioxide gas released during cement production into the atmosphere make it necessary to either search for another material or partially replace it with another material. Fly Ash, silica fumes, rice husk ash etc. are materials that shows pozzolanic feature which maybe second-hand in concrete as prejudiced substitute of cement [7]. Addition of fly ash to the actual have few advantages like extreme practicability, strength, durability etc [4, 6]. In this actual, fine aggregate is replaced accompanying crumb rubber for get inconsequential concrete. Crumb rubber is naturally occurring polymer which is treated with cement for obtaining low permeable concrete [1]. It is also a waste material which can be easily utilized. By the usage of crumb rubber in concrete, it becomes lightweight concrete [3].

Nanomaterials are being used to strengthen the depiction of factual accompanying the rapid growth of nanotechnology. Nano- silica can enhance workability, durability, and mechanical properties. Nano-alumina can enhance compressive strength of concrete. These materials are expensive and not easily available materials. Carbon nanotubes are one of the nanomaterials in which small doses enhances the mechanical properties of concrete. Single-walled carbon nanotubes has only one layer of graphene sheet wall. Multi-walled carbon nanotubes have number of layers of graphene cylindrical sheet wall [5].

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2 Materials And Methodology

2.1 Material Used

Cement, fly ash, fine aggregate, crumb rubber, coarse aggregate, and reinforced with carbon nanotubes are the materials used for producing carbon nanotubes reinforced rubberized blended cement concrete.

2.1.1 Cement

In this study, Ordinary Portland Cement from Chettinad in 53 grades according to IS 12269:1987 was used. Cement has 5% fineness and specific gravity of 3.16.

2.1.2 Fine Aggregate

M-sand as per IS 383:1970 was used. It has specific gravity of 2.6 and zone II. In order to produce m-sand, which is a type of artificial sands, hard massive stones, primarily rocks or granite, are crushed into fine particles. These particles are then washed and finely graded.

2.1.3 Coarse aggregate

Aggregate content of 20 mm of specific gravity 2.83 and bulk density 1523 kg/m^3 were second-hand.

2.1.4 Fly Ash

The usage of fly ash was confirmed by IS 3812:2013. It was Class C Fly Ash. It is used to partially substitute of cement. The specific gravity of fly ash is 2.5 and it has 10% fineness. Figure 1 indicates the class C fly ash

Figure 1: *Class C Fly Ash*

2.1.5 Crumb Rubber

Specific gravity 1.15 and appearance was black and rough. Crumb rubber shown in figure 2.

Figure 2: *Crumb Rubber*

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2.1.6 Multi-walled Carbon Nanotubes

Multi-walled Carbon Nanotube is an allotropy of carbon in which it has number of layers of graphene sheet. Multi-walled carbon nanotubes shown in figure 3.

Figure 3: *Carbon Nanotubes*

2.1.7 Water

Ordinary tap water is used. Water in concrete confirming to IS 456:2000.

2.2 Mix Proportion

In this experimental investigation, the strength properties of concrete are designated on M30 graded concrete [7]. The carbon nanotubes specimen was cast using multi-walled carbon nanotubes of length greater than 10 micrometer and 10-30 nanometer diameter. The mix design is done by the confirming to IS10262:2009. The w/c percentage and cement content were judge 0.45 and 438 kg/m^3 similarly. The fine aggregate and rude aggregate content were judge 640 kg/m^3 and 1193 kg/m^3 correspondingly. In addition to the standard concrete combination (0% crumb rubber), cement is incompletely substituted accompanying flee ruins, and three sets of crumb rubber concrete (medicated accompanying 0.4 w/c percentage of cement coat) are processed. The optimum replacement of crumb rubber and fly ash obtained is 5% and 10% respectively. From this concrete mixture, the multi-walled carbon nanotube was selected for carbon nanotube reinforced rubberized blended cement concrete production using 0.5%, 1% and 1.5% by weight of concrete. For avoiding agglomeration, it is mixed with water [2].

3 Experimental Methods

3.1 Fresh Properties of Concrete

3.1.1 Workability Test on Concrete

Workability maybe persistent utilizing the slump conoid test and the compaction determinant test similarly IS 1199-1959. Table 1 shows the workability test result of concrete.

Table 1: *Workability test result of Concrete*

Concrete Mix	Slump Value (mm)	Compaction Value
Control Mix	55	0.90
98% Sand + 2% Crumb Rubber	55	0.90
95% Sand + 5% Crumb Rubber	58	0.90

92% Sand + 8% Crumb Rubber	60	0.91
95% Cement + 5% Fly Ash	65	0.92
90% Cement + 10% Fly Ash	68	0.92
85% Cement + 15% Fly Ash	72	0.93

3.2 Hardened Properties of Concrete

3.2.1 Compressive Strength

In accordance with IS 516:1959, the cubes are 150 mm by 150 mm by 150 mm. The cubes were put to the test with a Compression Testing Machine (CTM). Results of the tests are shown in Figure 4. Figure 5 indicates comparison between compressive strength of carbon nanotubes reinforced (CNTs) rubberized blended cement concrete and normal concrete.

Figure 4: *Compressive Strength Test*

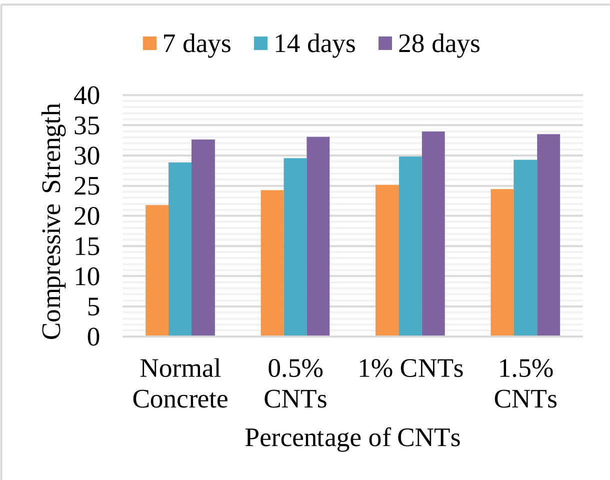

Figure 5: *Comparison between Compressive strength of Carbon Nanotubes Reinforced (CNTs) Rubberized blended cement concrete and Normal Concrete*

3.2.2 Split Tensile Strength

The split tensile strength test was attended in accordance with IS 516:1959 tests to verify the split stiffness of concrete at ages 7, 14, and 28. The cylinder is 300 mm long and 150 mm in width. Figure 6 displays the test findings. Figure 7 indicates comparison between split tensile strength of carbon nanotubes reinforced (CNTs) rubberized blended cement concrete and normal concrete.

Figure 6: *Split Tensile Strength Test*

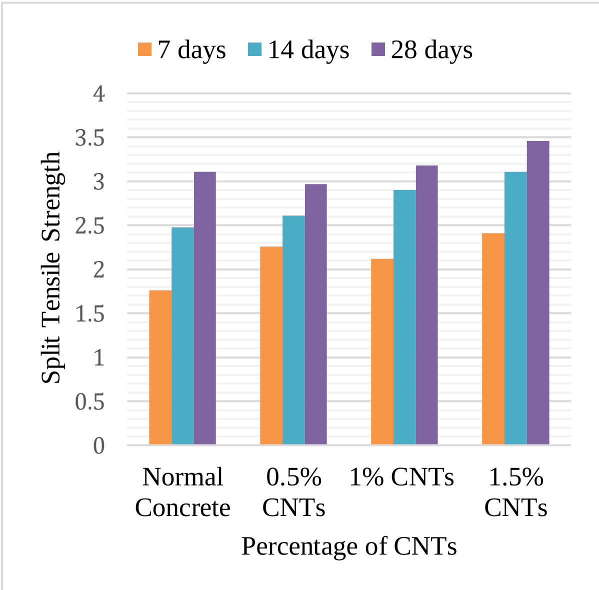

Figure 7: *Comparison between Split Tensile Strength of Carbon Nanotubes Reinforced (CNTs) Rubberized blended cement concrete and Normal Concrete*

3.2.3 Flexural Strength

The dimensions of a beam are 100 x 100 x 500 mm. The Flexural Testing Machine was used to test the beams. Figure 9 illustrates the test results. Figure 8 indicates the flexural strength test.

Figure 8: *Flexural Strength Test*

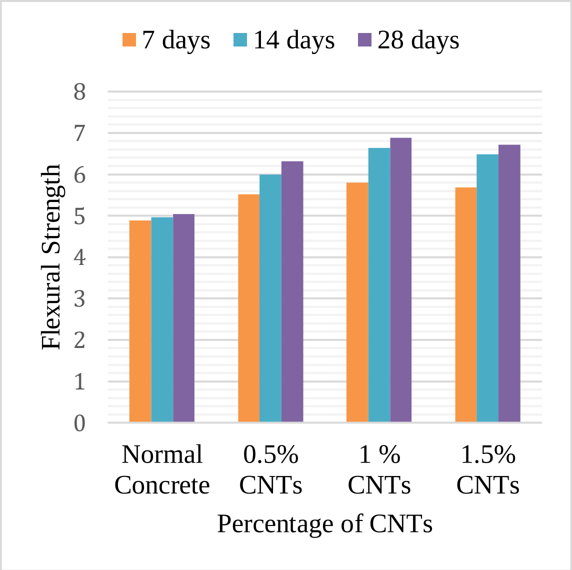

Figure 9: *Comparison between Split Tensile Strength of Carbon Nanotubes Reinforced (CNTs) Rubberized blended cement concrete and Normal Concrete*

4 Conclusion

Thus, the conclusion can be summarized as follows:

- The workability of concrete increased when slump and compaction factors increased along with the percentage of fly ash and crumb rubber.
- In comparison to the normal concrete, adding CNTs to the concrete mixture with fly ash and crumb rubber slightly increased the compressive, tensile, and flexural strengths.
- When the accumulation of CNTs was 0.5%, 1% and 1.5%, the compressive substance of 28 days cubes raised by 1.35%, 4.1% and 2.7% individually as distinguished accompanying normal concrete. The flexural strength of 28 days beams raised by 25.4%, 36.6% and 33.35%.

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- The best CNTs content to increase concrete mixture accompanying fly ash and crumb elastic is 1%; this is causing both compressive strength and flexural strength were above those of the other samples; the stiffness was kind of increased for the sample accompanying 1.5% CNTs than that obtained for the sample accompanying 1% CNTs.

5 Declarations

5.1 Acknowledgment

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