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A Study on Strength Properties for Cement Mortar added with Carbon Nanotubes and Zeolite

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Abstract

Carbon Nanotubes (CNTs) have generated great interest for their potential as reinforcement in high performance cementitious composites. Zeolites reduce the chloride permeability and increases workability in the cement mortar. The proper dispersion of carbon nanotubes and zeolites in the cement mortar plays an important role in this study. The experimentation will be performed in 1:3 cement mortar for different water cement ratio of 0.55 to 0.7, 0.1% of multi-walled carbon nanotubes, 0.5% of Polycarboxylate Superplasticizer and 1% of zeolite. Flow on different water cement ratio of cement mortars were tested. The specimens of size 50mm x 50mm x 50mm cube and 100mm diameter, 200mm height cylinders are used. Then the specimen is to be tested on7th day,28th day 90th days. The compressive strength, split tensile strength are being determined.

Keywords - Multi-walled Carbon Nanotubes, Zeolites, Water cement ratio, Compressive strength, Split tensile strength, Micro structure

1.0 Introduction

Carbon NanoTubes (CNTs) are primarily elemental carbon consisting of curved graphene layer which consists of a single layer of carbon atoms in a honeycomb structure that may contain varying amounts of metal impurities, depending on the method of manufacture. After various years from its detailed characterization CNTs have grown from a material of dreams to a real world material that has already found its application fields. The production capability for carbon nanotubes is growing every year in an exponential degree and as a consequence the price is steeply descending. In addition to their remarkable strength, which is usually quoted as 100 times that of tensile strength of steel at one-sixth of the weight, CNTs have shown a surprising array of other properties. It has a wide range of its use in various applications like its use in energy sector, medicine sector, environmental sectors, electronics sectors, etc. In Civil Engineering applications CNTs are being effectively used in various research works which remarkably improves the mechanical properties of cement mortars, when added into it. Imagine a concrete material that has comparable compressive and tensile strengths without the need of steel reinforcements. Imagine what potential benefits that this may offer to the world infrastructure by making concrete stronger, lighter,safer, more durable and more economical.

CNTs typically come in two formulations: single- walled nanotubes, in which a single layer or sheet of carbon atoms is rolled into a tube, and multi-walled nanotubes, in which multiple sheets of carbon atoms are folded into a cylindrical tube.Single-walled or multi-walled CNTs into concrete mixtures, the construction industry could reduce or eliminate cracks. "If a crack that is starting to propagate inside nano composite concrete material, it will encounter a carbon nanotube. This crack will try to go around the carbon nanotube, but it will not be able to because other carbon nanotubes will be right nearby. So, in a sense, it will arrest the crack propagation, keep the size of the crack very, very small,"

Zeolites are highly reactive pozzolans. Pozzolans are siliceous-aluminous material which exhibit cement-like behavior when combined with Calcium Hydroxide. Experimentally, zeolites have been shown to reduce large pore content & increase smaller pores. Zeolites are thought to reduce the susceptibility of cement to corrosion . Zeolites are inherently resistive to acidic solutions. The decrease in permeability reduces the intrusion of corrosive agents and may help isolate the casing from the well bore environment. Zeolites are lighter than cement. The smaller specific gravity of zeolites will help in creating lighter cement blends. Zeolites have a higher water uptake allowing for more water in the slurry and a lighter cement.

2.0 SCOPE OF THE STUDY

The scope of this investigation is find out the behavior of multi-walled carbon nanotubes and zeolite in cement mortar, thereby optimum amount of water-cement ratio that can be used in various application in civil engineering field thus enhance the cement mortar quality. The mix proportions considered for the experimental study are given in Table 1.

The main objective of this research is to study the following properties.

- To study the workability by flow table test.
- Mechanical properties such as compressive strength, split tensile strength.

Table 1: Mix proportions considered for experimental study

Cement Mortar Ratio 1:3										
Mix ID	Cement	Fine Aggregate	Water		Polycarboxylate Superplasticizer		Multi-Walled Carbon NanoTube		Zeolite	
	gm	gm	w/c ratio	Water in ml	Percentage	in ml	Percentage	gm	Percentage	gm
C1	6231	18693	0.55	3427	-	-	-	-	-	-
C2	6231	18693	0.6	3739	-	-	-	-	-	-
C3	6231	18693	0.65	4050	-	-	-	-	-	-
C4	6231	18693	0.7	4362	-	-	-	-	-	-
T1	6231	18693	0.55	3427	0.5%	31	0.1%	6.23	1%	62.31
T2	6231	18693	0.6	3739	0.5%	31	0.1%	6.23	1%	62.31
T3	6231	18693	0.65	4050	0.5%	31	0.1%	6.23	1%	62.31
T4	6231	18693	0.7	4362	0.5%	31	0.1%	6.23	1%	62.31

Where,

C1- Control mix Specimen 1

C2- Control mix Specimen 2

C3- Control mix Specimen 3

C4- Control mix Specimen 4

T1-Trial mix Specimen 1

T2-Trial mix Specimen 2

T3-Trial mix Specimen 3

T4-Trial mix Specimen 4

3.0 MATERIALS USED

The properties of the materials used for the preparing mortar are given below

3.1. Cement

The cement used in this experimental investigation was 43 grade OPC manufactured by Maple leaf cements.

3.2. Fine Aggregate

The sand used for experimental program was locally procured and conforming to zone II. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. The fine aggregates were tested as per Indian Standard Specification IS: 383-1970.

3.3. Polycarboxylate Superplasticizer

The super plasticizer used in this project conform the guide lines drawn by IS 9103-79, SkiaViscoCrete-20HE1205 (high-performance Polycarboxylate super plasticizer water reducing admixture) is used in this project. Physical properties of Super Plasticizer are based on manufacture's catalogue.

- Color : Brownish liquid, clear to slightly cloudy
- Type : liquid
- Density : 1.08 kg/l

3.4. Multi-walled Carbon NanoTube (MWCNT)

MWCNTs are allotropes of carbon. Tubular in shape, made of graphite and diameter in nanometers have a very broad range of electronic, thermal, and structural properties.

Outer Diameter (OD) : 30nm to 50nm

Length : 10µm to 20µm

Young Modulus (E) : 1000 to 1250 GPa

Tensile strength : 10- 60 GPa

Fig. 1 Multi-Walled CNT

3.5. Zeolite

Physical properties of Zeolite are based on manufacture's Test Certificate.

- Color : off - White
- Type : Powder
- Density : 0.4 kg/l

Fig. 2 Zeolite

4.0 METHODOLOGY

4.1. Preparation of Zeolite and MWCNT mix cement mortar

The polycarboxylate superplasticizer was firstly mixed with required quantity of water (the water to cement ratio is 0.55 – 0.7) by hand stir for about 5 minutes.

Next, MWCNT (0.1% by weight of cement) were added into this aqueous solution and by hand stir for about 5 minutes to make a uniformly dispersed suspension.

Then, dry mix the required quantity of cement, sand and zeolite by hand mix for about 5 minutes to make a uniformly mixing.

Finally, the MWCNT solution was added into the dry cement, sand and zeolite mixture and mixed for another 10 minutes.

Fig. 3 adding and mixing of polycarboxylate superplasticizer into the water

Fig. 4 adding and mixing of MWCNT into the mixture of polycarboxylate superplasticizer water solution

Fig. 5 dry cement, sand and zeolite mixture and adding of MWCNT solution into the dry cement, sand and zeolite mixture

Fig. 6 Zeolite and MWCNT mix cement mortar

4.2. Casting of specimens

The mortar is placed into moulds and the mortar is filled in the moulds by three layers in which three layers is tamped by 25 times with a tamping rod for compaction after that the moulds are placed in vibration table for obtaining sufficient compaction. Figure 7 shows the casted specimen of C3 and T3

by adding of water cement ratio 0.65

Fig.7 Specimens after casting

4.3. Curing of specimens

The specimens were carefully casted and demouled after 24 hours, without disturbing the specimens, these were cured in the curing tank for 7 days, 28 days and 90 days.

5.0 RESULTS AND DISCUSSION

5.1 General

This chapter describes the workability characteristics of fresh mortar and compression tests results of mortar cube.

5.2. Workability of mortar

The results showed that Flow Value increases when mortar is added with MWCNT and Zeolite.

Fig. 8 Flow Table Test

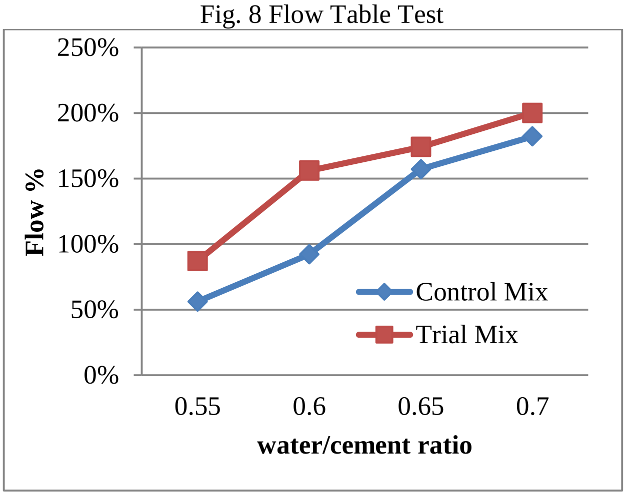

Fig. 9 Flow percentage v_s water / cement ratio

5.3 Compressive Strength

From the compressive strength results obtained for 7 days, 28 days and 90 days it was observed that the excess of water cement ratio the compressive strength was decreased in control mix but on trial mix the compressive strength increased due to the addition of Carbon nanotube and Zeolite.

Fig. 10. Compression Testing Machine

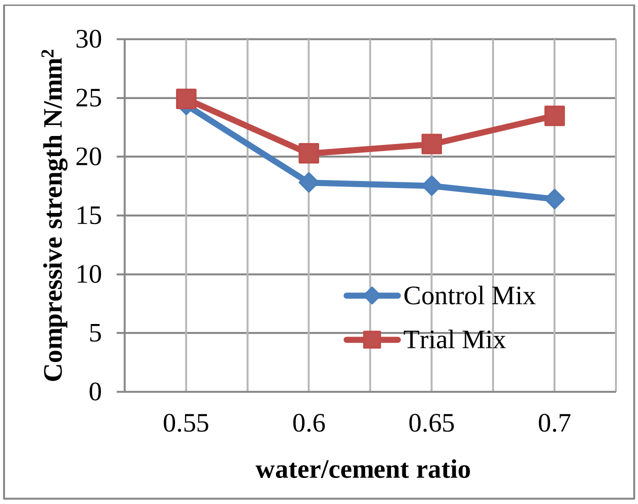

Fig. 11. 7th day Compressive strength results

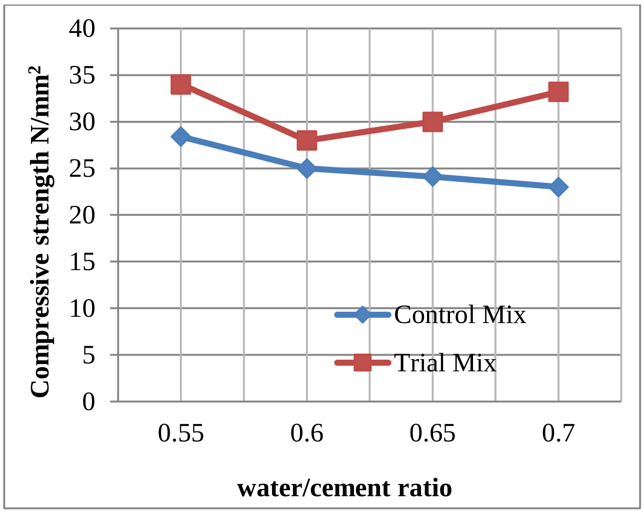

Fig.12 28th day Compressive strength results

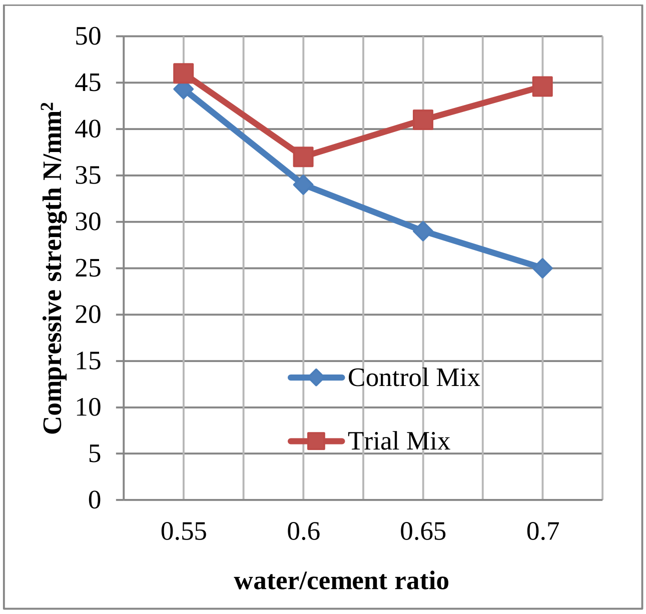

Fig.13 90th day Compressive strength results

5.4. Split Tensile Strength

From the split tensile strength results obtained for 7 days, 28 days and 90 days it was observed that the excess of water cement ratio the split tensile strength was decreased in control mix but on trial mix the split tensile strength increased due to the addition of Carbon nanotube and Zeolite.

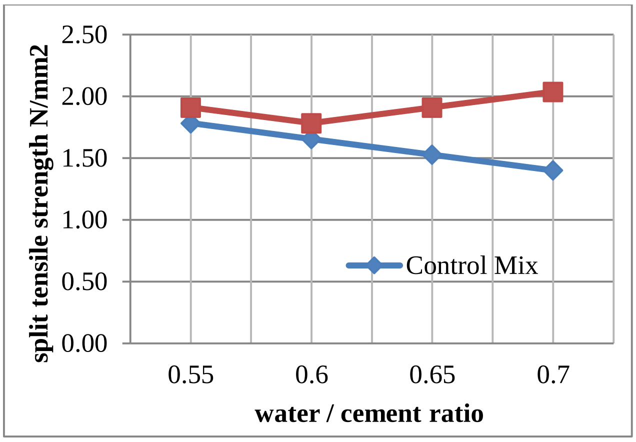

Fig.14 7th day Split Tensile Strength results

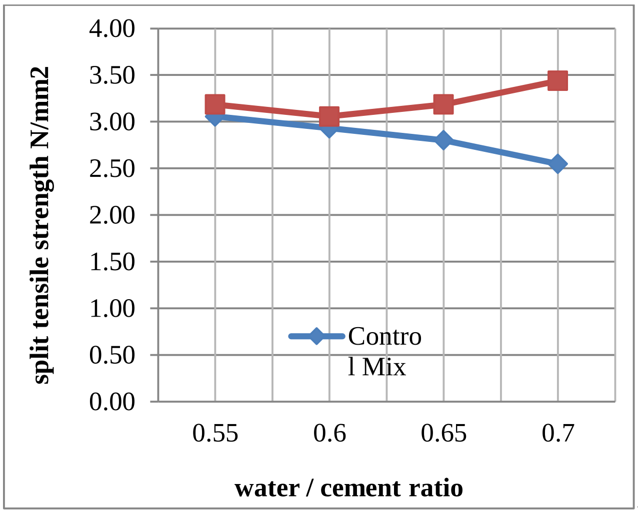

Fig.15 28th day Split Tensile Strength results

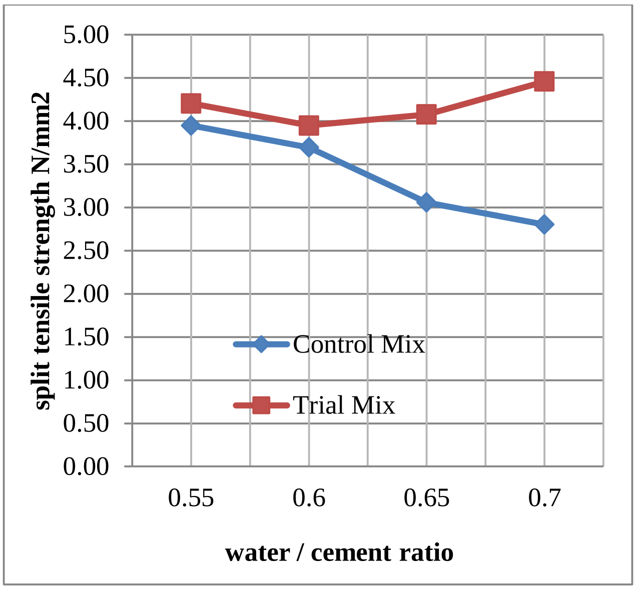

Fig.16 90th day Split Tensile Strength results

6.0 CONCLUSION

From the summary of this experimental work, the following conclusions were arrived,

- Workability – increased when it is compared with conventional mortar.
- Due to excess of water cement ratio, Compressive strength was decreased in control mix but on trial mix Compressive strength increased due to the addition of Carbon nanotube and Zeolite.
- Due to excess of water cement ratio, Split Tensile strength was decreased in control mix but on trial mix Split Tensile strength increased due to the addition of Carbon nanotube and Zeolite.

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