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Development of Self Sensing Concrete and Its Various Possible Applications

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Abstract-This Mortar/Concrete that is non-conducting or partially conducting are transformed to electrically conductive by adding carbon fibers in confined percentage of 0.35%. The increase in electrical signal is due to the addition of carbon fibers to that of the mortar and the dispersion of the fiber in the mortar without any additional treatment is challenging. Addition of latex to that of the mortar increases its compressive strength and the silica which is the dispersing material works better in the dry mix. Change in resistivity with that of strain is plotted by means of a graph for different specimens like cube, beam, dog-bone and + specimen.

Index Terms- Electrically conductive; filler material; carbon fiber; latex; dispersion and resistivity.

1. INTRODUCTION

The Smart structure is the recent fast growing idea that makes the structure to react ideally towards various unacceptable situations like formation of cracks, overloading etc., transformation of conventional concrete into sensing concrete is not a simple job to be done. Addition of carbon fibers to that of the concrete increases the conductivity of the concrete or the mortar.

2. REVIEW OF LITERATURE

The stress and strain relationship in concrete can be identified by making the concrete sensible. Fibers are used as sensing materials in concrete. D.D.L.Chung [10] investigated “Concrete as a New Strain/Stress Sensor”. The relationship between stress, electrical resistance and strain confronted clearly. D.D.L.Chung [6] et al., studied “Theory of Piezoresistivity for Strain Sensing in Carbon Fiber Reinforced Cement under Flexure”. The theory is based on the concept that the piezoresistivity is due to the slight pull-out of crack-bridging fibers during crack opening and the consequent increase in the contact electrical resistivity of the fiber-matrix interface.

3. METHODOLOGY

Methodology of this project lies between the detailed studies of the thesis paper from which a clear knowledge on the project can be attained. Overview of self-sensing concrete is that minimum percentage addition of fibers or particulates to the concrete specimen makes it sensitive to sense stress and strain. From this carbon fiber is studied for its sensing capacity in various mortar mixes.

4. EXPERIMENTAL METHODS

4.1. *Raw Materials and Specimen details*

Raw materials like Portland cement, fine aggregate that passes completely through the 2.36mm sieve, carbon fiber of 5mm length which was replaced by 0.35% by weight of cement were used.

4.2. *Mixing and Curing Procedure*

Normal hand mixing is carried out and in which the dry mix method is followed while the silica was used and when latex was used for dispersion the fibers are entangled in the styrene butadiene rubber solution and then the mortar was prepared. Specimens are demolded after 1 day and then allowed for curing for 28 days. Table 1 represents the mix proportions of specimens prepared for the test compression test on cube specimens and + specimens, dog-bone specimens for direct tension test and specimens for flexural test. Fig.1 illustrates details of the test specimens used for this investigation.

4.3. *Electrical Set-Up*

Four probe methods are used in which input current and voltage and the output is also drawn out. A four point probe is a simple apparatus for measuring the resistivity of semiconductor samples. By passing a current through two outer probes and measuring the voltage through the inner probes allows the measurement of the substrate resistivity.

4.4. *Testing Procedure*

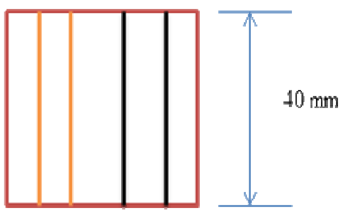
Compressive testing is carried out in universal testing machine of 40KN range in 400KN capacity UTM. Cube specimen of size 40x40x40 mm and plus shaped specimen is tested under compression. Flexural testing is carried out by three point bending for which 160x40x40 mm beam specimen is tested Tensile testing is carried out with dog-bone specimen. At same time the current and voltage is measured with the help of multi-meter from which the resistance is calculated using the formula

$$R=V/I$$

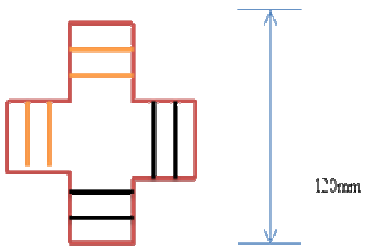
where, V denotes the voltage and I denotes the current.

Table 1. Mix proportion of test specimens.

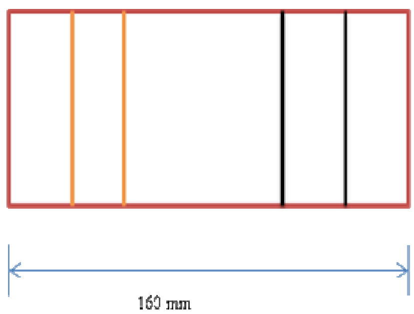
Test	**Sample**	**Fibre Vol (%)**	**W/C Ratio**	**Sand/Cement Ratio**	**Latex/Cement Ratio**	**Silica Fume /Cement**
Compression test on cube + Flexure test on Beam + Compressive test on + specimen + Direct tension test on Dog bone specimen	Normal mix	0.00	0.35	1.5	0.0	0.00
	Normal mix +silica	0.00	0.35	1.5	0.0	0.15
	Normal mix +latex	0.00	0.30	1.0	0.2	0.00
	Normal mix +silica +carbon fiber	0.35	0.35	1.5	0.0	0.15
	Normal mix +latex +carbon fiber	0.35	0.30	1.0	0.2	0.00



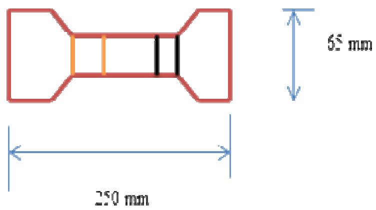
a) Cube specimen for compression test



b) + specimen for compression test



c) Beam specimen for flexure test



d) Dog bone specimen for tensile test

Fig. 2. Compression test setup for cube.

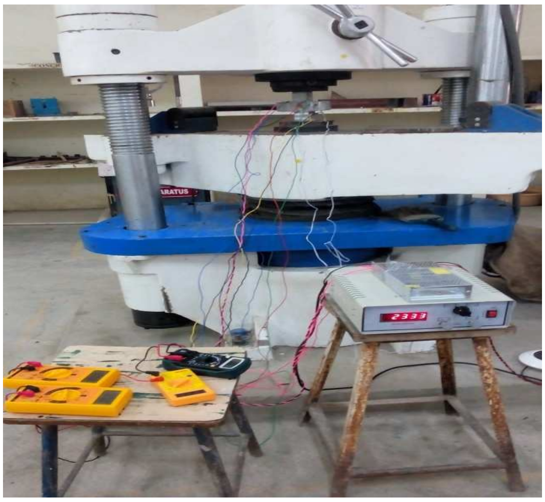


Fig. 3. Compression test setup for joint Specimen.

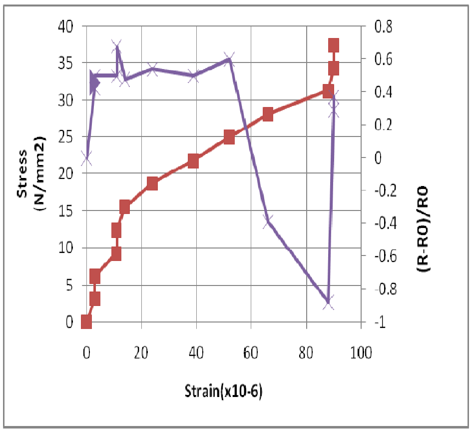
Fig. 1. Test specimens.

Fig. 4. Tensile testing Setup

Fig. 5. Flexure Testing Setup

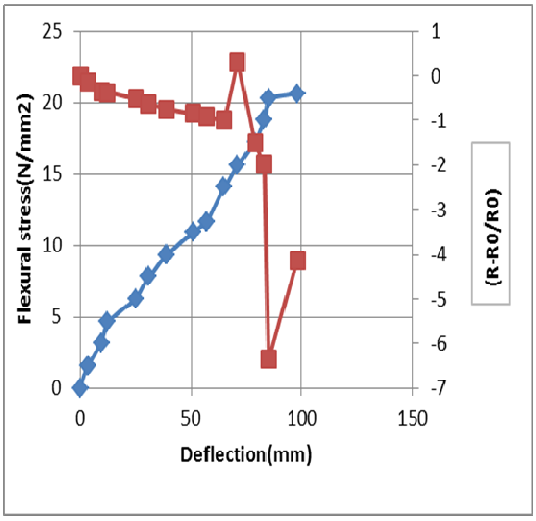
5. RESULTS AND DISCUSSION

Each specimen is tested under corresponding test procedures and the result is interpreted by means of graph with varying strain in X-axis whereas stress and change in resistivity on Y-axis.

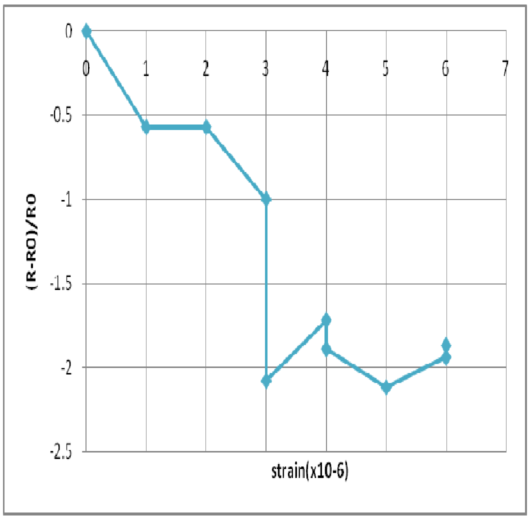


Graph 1 Test result graph of cube with normal mix + Latex + fiber

Graph 2 Test result graph of + specimen with normal



mix + Latex + fiber



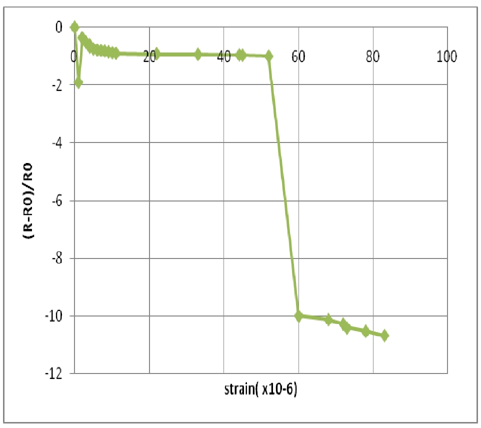
Graph 3 Test result graph of beam specimen with normal mix + Latex + fiber

Graph 4 Test result graph of Dog-bone specimen with normal mix + Latex + fiber

Table 2. Test on Compression for Cube Specimen

Specimen	**Day of test**	**Combination**	**Failure load KN**
Cube	28	Normal mix	35
		Normal mix +silica	32
		Normal mix +latex	45
		Normal mix +silica +carbon fiber	45
		Normal mix +latex +carbon fiber	60

Table 3. Test on Compression for + Specimen



Specimen	Day of test	Combination	Failure load KN
+ shape	28	Normal mix	3
		Normal mix +silica	3
		Normal mix +latex	3.2
		Normal mix +silica +carbon fiber	4.5
		Normal mix +latex +carbon fiber	5.1

Table 4. Test on Tension for Dog-Bone Specimen

Specimen	Day of test	Combination	Failure load KN
Dog Bone	28	Normal mix	45
		Normal mix +silica	61.9
		Normal mix +latex	65.6
		Normal mix +silica +carbon fiber	71.2
		Normal mix +latex +carbon fiber	90

Table 5. Test on Compression of Beam Specimen

Specimen	Day of test	Combination	Failure load KN
Beam	28	Normal mix	2.96
		Normal mix +silica	2.96
		Normal mix +latex	3.28
		Normal mix +silica +carbon fiber	4.72
		Normal mix +latex +carbon fiber	5.28

6. CONCLUDING REMARKS

Based upon the test results the following conclusion is drawn out:-

- Addition of fibers to that of the cement improves the current carrying capacity of the specimens.
- Comparing silica and latex which are used as the dispersing agent in this experimental study latex shows better performance.
- Relationship between the stress, strain and resistivity is exhibited by means of graph.
- For consecutive strain reading and resistivity reading the graph is is made which can be extended for practical application.
- Test results and graph of the specimens' shows that the mix with latex and fiber shows better performance comparing all other mixes of specimens.
- But tanglement of fibers is seen as there is no treatment method is given for the fibers so it is advisable to do some treatment for fibers.
- If the fibers are treated with ozone treatment etc., further improved graph result can be obtained.

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