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INTRINSICALLY SMART CONCRETE FOR STRUCTURAL HEALTH MONITORING

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Abstract

Structural health monitoring and damage identification are most important to assess serviceability and safety in Civil Engineering Structures. Strain gauge or fibre-optic techniques often used for structural health monitoring but continuous monitoring and external equipment installation makes it complicated. Intrinsically Smart Concrete (ISC) is fabricated by adding functional fillers into conventional concrete which improves self-sensing ability without compromising its mechanical properties. The ISC has the potential to achieve sensing as well as a strengthening of structures along with design flexibility. There is a number of methods available to measure the resistivity but predominantly four probe method was used to measure electrical resistivity of ISC. This work is focused on the durability and strength - based quality control of concrete by considering the electrical resistivity.

Keywords:Smart Concrete, Electrical resistivity, Four probe method, Functional fillers

I. INTRODUCTION

Self-diagnosing or intrinsically smart concrete is the property by which a material can sense its own conditions such as stress, strain, damage, temperature, and so on. A self- diagnosing composite has the ability to sense its own deformation and damage and this ability makes them an excellent material for health monitoring of civil engineering structures. Strain and damage sensing in a composite material is usually achieved through detecting change in their electrical resistivity, i.e. Intrinsically Smart Concrete composite works based on piezo resistivity principle. One major advantage with the Intrinsically Smart Concrete composites is the possibility to achieve sensing as well as strengthening of civil structures simultaneously. To achieve piezo-resistivity in a composite material, it should contain a conducting element. Different types of conducting components have been used in the existing Intrinsically Smart Concrete composite materials. The conducting network and resulting change in resistivity are highly dependent on the type of conducting component, their amount as well as their distribution. One of the biggest advantages of Intrinsically Smart Concrete composites is their design flexibility. The type of response can be tailored easily through proper designing of the composite structure. As mentioned earlier, in civil infrastructures, composites are already in use as strengthening material. Therefore, these composites can also be designed as Intrinsically Smart Concrete so that they can perform both strengthening and health monitoring functions. This eliminates the need for incorporating sensors.

II. PROBLEM STATEMENT

Intrinsically smart concrete composites have found applications in the structural health monitoring because of its high sensing property. Conventional concrete has high mechanical property based on its grade; however, its sensing property is lower which limits its applications in SHM. To overcome this problem, Carbon black and Steel fibre is added as functional fillers to enhance the sensing property and as well the mechanical properties of conventional concrete.

III. OBJECTIVE

The main objective is to compare the electrical resistance property of conventional concrete and intrinsically smart concrete. To increase its strain, stress, and crack or damage sensing ability without reducing its mechanical properties.

IV. MATERIALS

In the present investigation, concrete of M40 grade with 53 grade ordinary Portland cement were designed using IS 13920 codes has arrived. For the study of electrical resistivity, with various percentage addition of fillers such as carbon black (1% and 3%) and Hybrid Materials (Carbon Black (1% and 3%) and Crimped Steel Fibres 0.4%), Super plasticizer (Polycarboxylate Polymer) has been used to make smart concrete.

V. EXPERIMENTAL WORK

A. Casting and curing

Cement mortar cylinders were cast to characterize the effect of carbon black, crimpled steel fiber and its combinations with mortar. Mortar with carbon black and crimpled steel fiber (The steel fibers used were of nominal length of 35mm, diameter 0.46mm and weighing 0.5% and 2% by volume of cement and the Hybrid fillers (carbon black and steel fiber) used were weighing 0.5% and 2% by volume of cement). The specimen cylinders were demolded after one day and allowed to cure at room temperature for 3 days and 7 days.

B. *Testingprocedure*

For Split tensile testing, specimens were prepared by using 150 mmx100 mm size. Voltage input from a Regulated Power Supply (R.P.S.) was given to the cube using four probe methods and the current output and voltage output were measured using a voltmeter and an ammeter and the fractional change in resistance computed at each loading stage. Prior to the test, cylinders were painted in four layers with silver paint at an interval of 10 mm. Copper wires were wound around the layers and these were connected to the R.P.S., voltmeter and ammeter. The middle two copper wires from cylinder were connected to the two probes of the voltmeter. The positive end of ammeter was connected to positive end of R.P.S and negative end of R.P.S was connected to one end of cylinder. The negative end of ammeter was connected to another end of Cylinder. This is the four-probe method of measuring resistance. From the voltage and current values obtained at each stage of loading, the resistance is calculated. The outer two contacts give the current value in ammeter and the middle two contacts in voltmeter give the voltage. Resistance was computed using ammeter as shown in figure 1 and 2.

Electrical resistance, $R = V/I$ in ohm

Electrical resistivity, $\rho = RA/L$ in ohm m

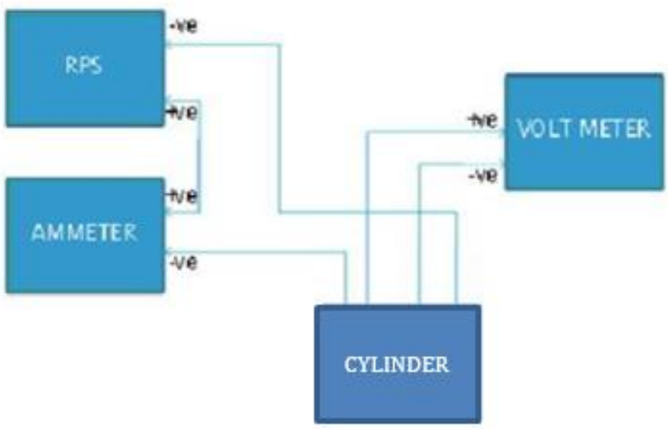

Fig. 1. Four probe method

Fig. 2. Split Tensile Test on Cylinders

Fig. 3. Split Tensile Test on Cylinder

VI. RESULT AND DISCUSSION

The results plotted are shown in Figures. 4, 5, 6, 7, 8 and 9 from Split tensile test for the cases of 1. The Eight-volt frequency for 150 mm X 100 mm cylinders. 2. Comparisons of 3 and 7 days curing. It is seen from the plots that the results in case 1. 150 mm X 100 mm cylinder is possessed better resistance to the frequency of 8 volts as shown in table 1 and 2. In case 2. 150 mm X 100 mm cylinder with 7 days curing is better than the 3 days curing. It essentially means that it is quite possible to predict the resistivity values in the field using the functional fillers combination. It is also seen that once the Split tensile strength and resistance graphs are drawn using a cylinder tensile test, Field experiments can be conducted to get actual resistivity values. Thus, health monitoring of structures can be carried by altering conventional concrete into sensible concrete.

Table 1. 3 Days Test Results for Split Tensile Test

S. No	Mix ratio	Voltage	Tension strength (N/mm^2)	Resistivity (ohm m)
1	CC	8V	2.42	19.15
2	CB 1%	8V	2.20	19.42
3	CB 3%	8V	2.92	27.27
4	CBSF 1%	8V	3.02	30.92
5	CBSF 3%	8V	3.12	37.87

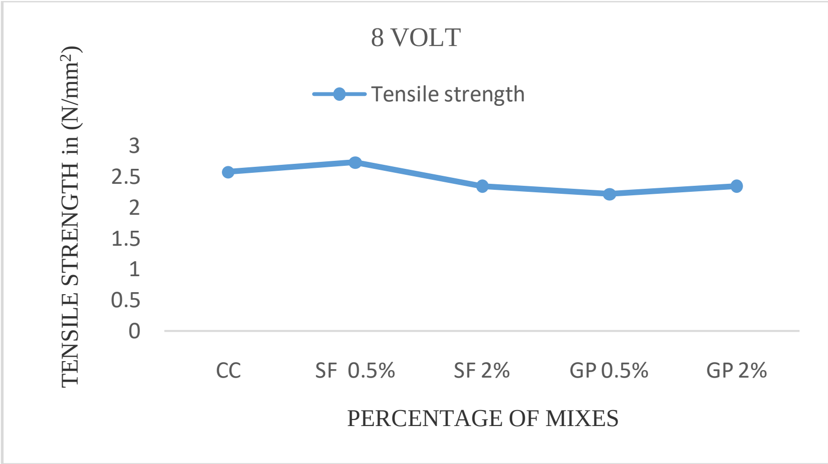

Fig. 4. Percentage of Mixes vs Tensile strength

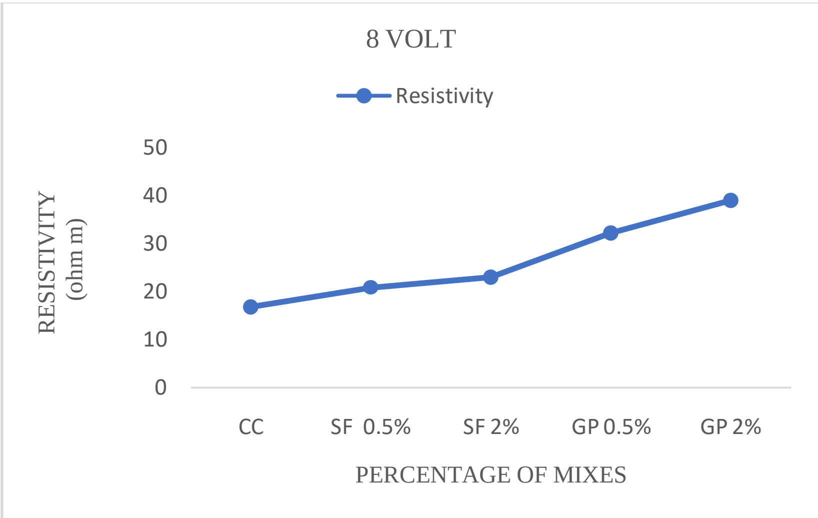

Fig. 5. Percentage of Mixes vs Resistivity

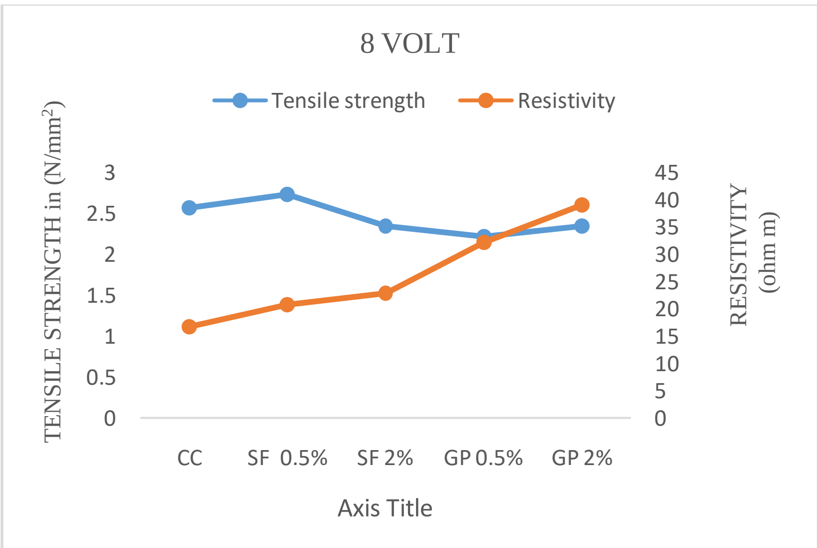

Fig. 6. Graphical representations for 3 dayson 8V test results of Cylinders

Table 2. 7 Days Test Results for Split Tensile Test

S. No	Mix ratio	voltage	Tension strength (N/mm^2)	Resistivity (ohm m)
1	CC	8V	2.92	19.15
2	CB 1%	8V	4.14	19.42
3	CB 3%	8V	2.96	27.27
4	CBSF 1%	8V	3.59	30.92
5	CBSF 3%	8V	3.28	37.87

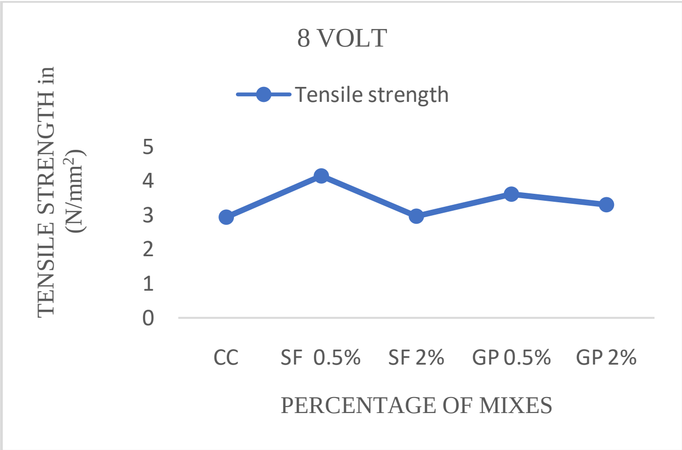

Fig.7. Percentage of Mixes vs Tensile strength

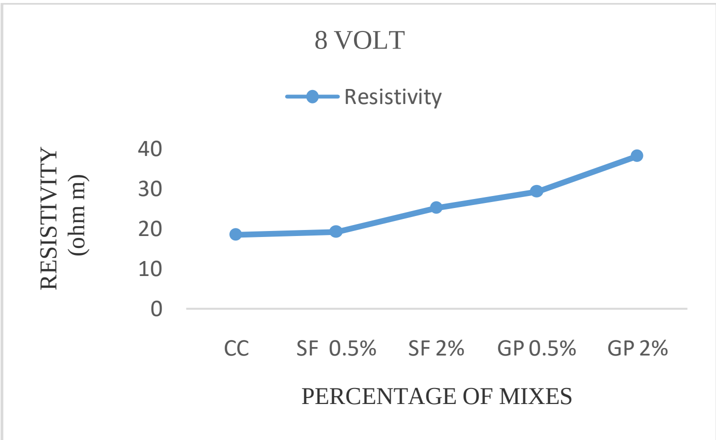

Fig. 8.Percentage of Mixes vs Resistivity

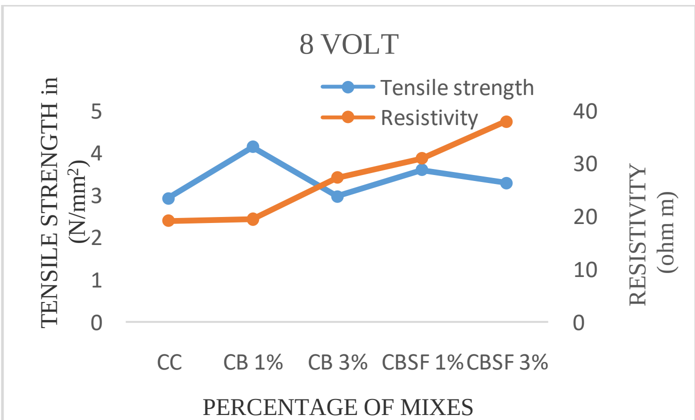

Fig. 9. Graphical representations for 7 days on 8V test results of concrete cylinders

VII. CONCLUSION

Intrinsically smart concrete is an intrinsic construction material since it is made of concrete material, and it has attracted increasing interest over the last two decades. The intrinsically smart concrete possesses many advantages including high sensitivity, good mechanical properties, natural compatibility, identical life span with concrete and easy installation and maintenance. This would be helpful for ensuring structural integrity and safety, extending the lifespan of the structures. This study was concentrated on the damage assessment of concrete cylinders by correlating the split tensile strength with their electrical resistivity. The resistivity has been compared with hardened property of concrete in order to assess its durability and also to declare strength of concrete. Future work should concentrate in increasing percentage of carbon black mass fraction through filler dispersion procedure to increase the resistivity of conventional concrete. your text on the same line.

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