International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 3.45 (SJIF-2015), e-ISSN: 2455-2585
Volume 4, Issue 4, April-2018

Self-Sensing Concrete Using Functional Fillers for Structural Health Monitoring

M. Sanjay Kumar [1], M. Rama [2] and N. Yasmin [3]

[1]*Department of civil engineering (Structures), Government college of technology, Coimbatore 641 013*

Sanjaykumarsrt10@gmail.com

[2]*Department of civil engineering, Government college of technology, Coimbatore 641 013*

mrama@gct.ac.in

[3]*Department of civil engineering (Structures), Government college of technology, Coimbatore 641 013*

yasminzoyath@gmail.com

Abstract

The self-sensing concrete is fabricated by adding functional fillers into conventional concrete. In the present investigation, the concrete of M30 grade with 53 grade ordinary Portland cement was designed using IS 13920 codes. Two types of functional fillers such as CRIMPED steel fibers (0.5% and 2%) and Graphite powder (0.5% and 2%) were added in different percentages to make various proportions on concrete in order to study their electrical resistivity property. Conventional cubes and SSC cubes are cast to examine their workability as their fresh property, strength and resistivity as their hardened property. The work is focused on a test set up of four probe method, concrete strength properties, and corresponding sensing properties by adjusting a frequency of 4 volts. The work has also relied on the determination of highly reliable sensing concrete.

Keywords:crimped steel fiber, graphite powder, electrical resistivity, four probe method

I. INTRODUCTION

In that self-sensing is a new development in concrete research in recent years. This smart material can help us develop intelligent infrastructure with elegantly integrated sensing and health monitoring abilities, thus increasing life span of concrete structures. It provides a new way for maintaining sustainable development in concrete materials and concrete structures. The self-sensing concrete is fabricated through adding functional fillers into conventional concrete is ability to sense the strain, stress, crack or damage in itself while maintaining or even improving mechanical properties. Conventional concrete serves as a structural material and it has no sensing ability. The presence of functional fillers in the concrete is necessary for the self-sensing performance to be sufficient in magnitude reproducibility.

II. RESEARCH SIGNIFICANCE

Though the earlier authors studied carbon fiber concrete as a smart material, the relative performances of steel fiber and graphite powder were not studied. Hence the present work aims at their relative performances.

III. OBJECTIVE

The main objective is to compare the electrical resistance property of conventional concrete and self-sensing concrete. To predict the electrical resistance and their corresponding strength values using the steel fiber, Graphite powder, Fosroc Conplast Sp-430

IV. EXPERIMENTAL WORK

A. Casting and curing

Cement mortar cubes were cast to characterize the effect of steel fiber, graphite powder and its combinations with mortar. Mortar with steel fiber and graphite powder. (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 graphite powder used were weighing 0.5% and 2% by volume of cement).The specimen cubes were demolded after one day and allowed to cure at room temperature for 7 days.

B. *Testingprocedure*

For Compression testing, specimens were prepared by using 100mmx100mmx100mm 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 multimeter and the fractional change in resistance computed at each loading stage. Prior to the test, cubes were painted in four layers with silver paint at an interval of 5 mm. Copper wires were wound around the layers and these were connected to the R.P.S. andmultimeter. The middle two copper wires from cube were connected to the two probes. The positive end of multimeter was connected to positive end of R.P.S and negative end of R.P.S was connected to one end of cube. The negative end of multimeter was connected to another end of Cube. 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. Testing was performed in different cycles of loading in fractions of KN, up to failure and the readings were taken at each stage as shown in Figure 1 and 2.

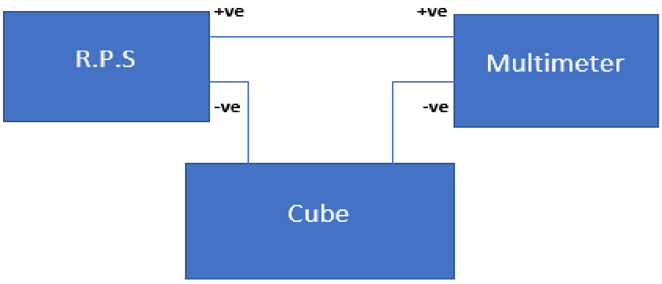

Fig. 1 Four probe method

Fig. 2 Compression Test on Cube

V. RESULT AND DISCUSSION

The results plotted are shown in Figures. 3, 4, 5, 6, 7 and 8 from compression test for the cases of 1. The four-volt frequency for 100 mmx100 mmx100 mm cubes 2. Comparisons of 3 and 7 days curing. It is seen from the plots that the results in case 1. 100mm cube is possessed better resistance to the frequency of 4 volts. In case 2. 100 mm cube 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 compressive strength and resistance graphs are drawn using a cube compression 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.

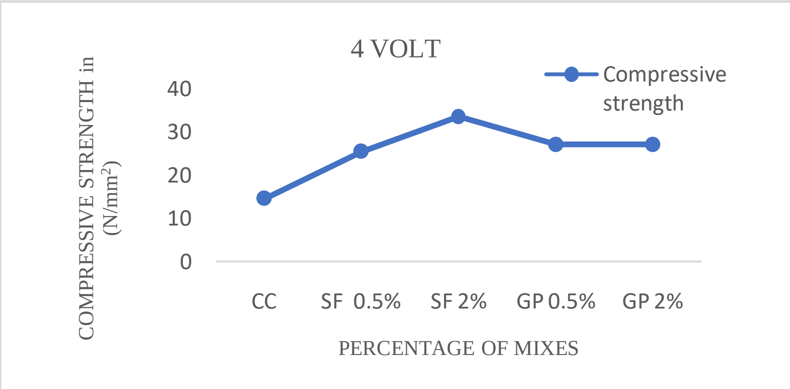

Fig. 3 Percentage of Mixes vs Compressive Strength

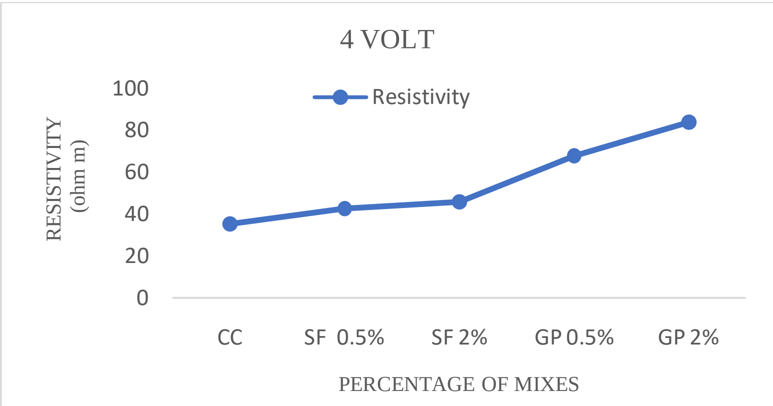

Fig. 4Percentage of Mixes vs Resistivity

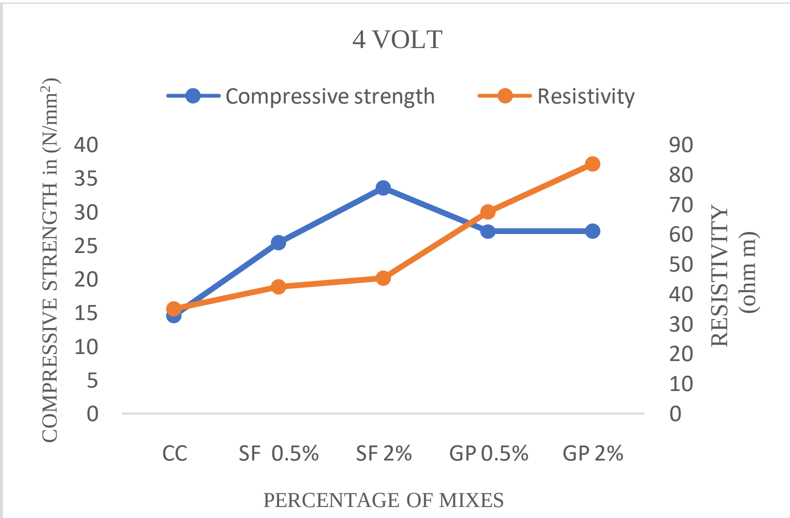

Fig. 5 Graphical representations for 3 dayson 4V test results of concrete cubes

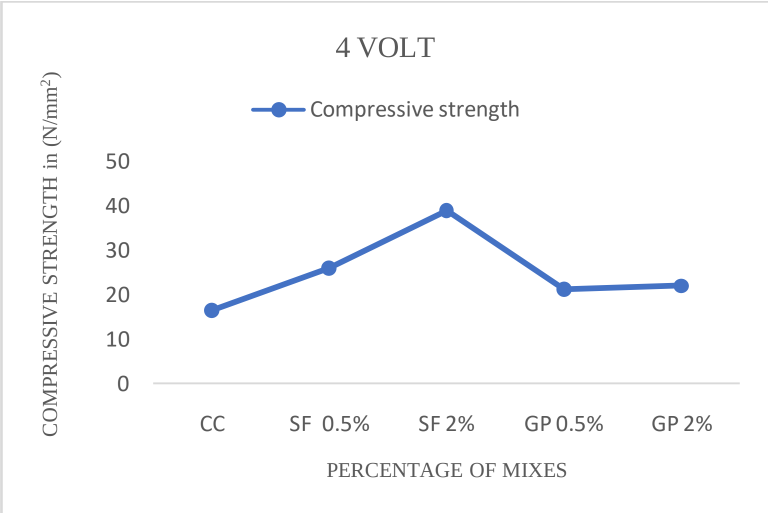

Fig. 6Percentage of Mixes vs compressive strength

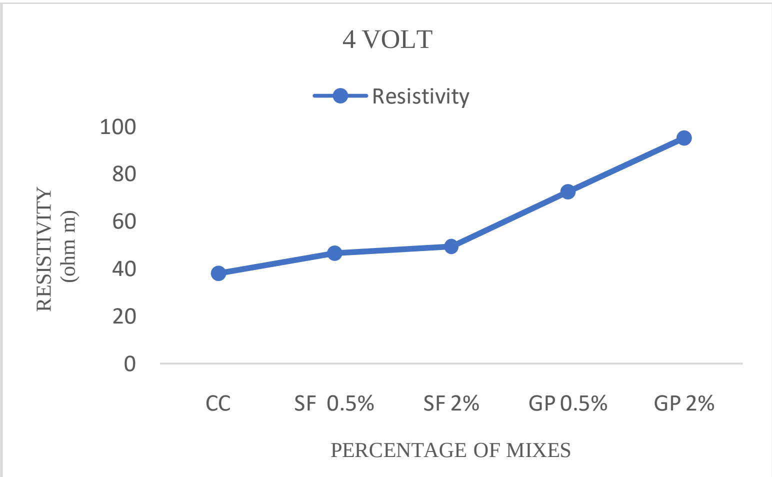

Fig. 7Percentage of Mixes vs Resistivity

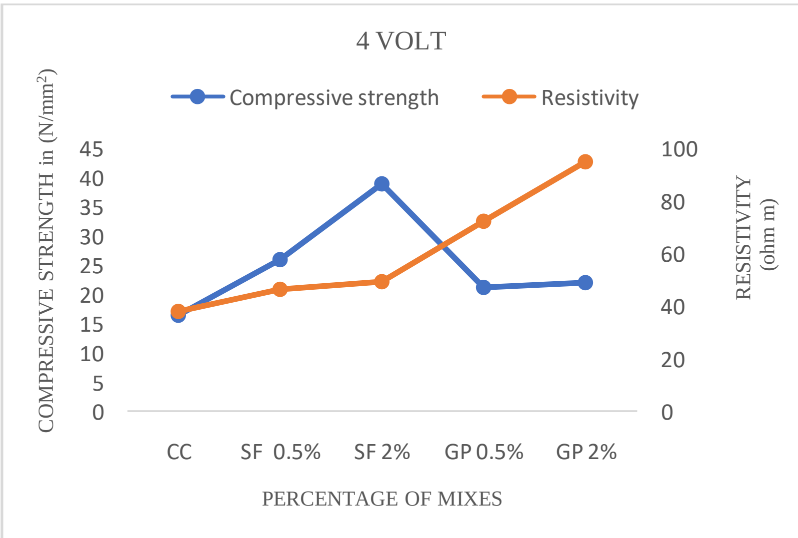

Fig. 8 Graphical representations for 7 days on 4V test results of concrete cubeS

VI. CONCLUSION

This study enables monitoring damage of the concrete cubes and cylinders by correlating the durability parameter of corrosion with their electrical resistivity. The resistivity tests were carried out for all the compositions with the curing time of 3 days and 7 days with Regulated power supplies of 4V. In that, combination of 2% of steel fiber along with 2% of possess high electrical resistivity and also high compressive strength but possess low resistivity in split tensile test. This results that the possibilities ofcorrosion but will never attain fairly like other mix composites. The resistivity has been compared with mechanical properties of concrete in order to assess its durability and also to determine the possibilities of corrosion in concrete.

ACKNOWLEDGEMENT

I express my sincere thanks to “Government College of Technology, Coimbatore” for providing all the facilities to carry out this work.

REFERENCES

1) Azhari, Faezeh, and Nemkumar Banthia. *"Cement-based sensors with carbon fibres and carbon nanotubes for piezo resistive sensing."* Cement and Concrete Composites 34.7 (2012): 866-873.
2) Chen PW, Chung DDL.*“Improving the electrical conductivity of composites comprised of short conducting fibers in a conducting matrix: The addition of a non-conducting particulate filler”*. Journal of Electronic materials. 1995; 24(1):47–51.
3) Chung DDL. *“Carbon fibre reinforced cement as a strain sensing coating. Cement and Concrete Research. 2001”;* 31:665–7.
4) Gupta, Sumit, Jesus G. Gonzalez, and Kenneth J. Loh. *"Self-sensing concrete enabled by nano-engineered cement-aggregate interfaces."* Structural Health Monitoring 16.3 (2017): 309-323.
5) Han, Baoguo, Liqing Zhang, and Jinping Ou. *"Self-Sensing Concrete."* Smart and Multifunctional Concrete Toward Sustainable Infrastructures. Springer Singapore, 2017. 81-116.
6) Han, Baoguo, Siqi Ding, and Xun Yu. *"Intrinsic self-sensing concrete and structures: A review."* Measurement 59 (2015): 110-128.
7) Howser, R. N., H. B. Dhonde, and Y. L. Mo. *"Self-sensing of carbon nanofiber concrete columns subjected to reversed cyclic loading."* Smart materials and structures 20.8 (2011): 085031.
8) Konsta-Gdoutos, Maria S., and Chrysoula A. Aza. *"Self sensing carbon nanotube (CNT) and nanofiber (CNF) cementitious composites for real time damage assessment in smart structures."* Cement and Concrete Composites 53 (2014): 162-169.
9) Li H, Ou J. *“Smart concrete sensors and self-sensing concrete structures. Key Engineering Materials. 2009; 400–2:69–80.”*
10) Nanni, F., et al. *"Self-sensing CF-GFRP rods as mechanical reinforcement and sensors of concrete beams."* Smart materials and structures 15.1 (2006): 182.
11) Nanni, F., et al. *"Self-sensing CF-GFRP rods as mechanical reinforcement and sensors of concrete columns."* Smart materials and structures 15.1 (2010): 182.
12) Wen, Sihai, and D. D. L. Chung. *"Self-sensing of flexural damage and strain in carbon fiber reinforced cement and effect of embedded steel reinforcing bars."* Carbon 44.8 (2006): 1496-1502.
13) Yu, Xun, and Eil Kwon. *"Carbon Nanotube Based Self-Sensing Concrete for Pavement Structural Health Monitoring."* Final Report, Department of Civil Engineering, University of Minnesota, Duluth (2012).