Characterization of Thin Disk Piezoresistive Smart Material for Hurricane Applications

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Abstract

In this study, the sensing ability of circular thin disk made with fiber reinforced polymer concrete (FRPC) to small loads and stresses were investigated under bending and tensile loading. FRPC circular disk specimen showed piezoresistive characteristics and the specimen with a thickness of 0.35 inches and a diameter of 3.5 inches had piezoresistive coefficient of 0.045 psi^{-1} during bending loading and 0.067 psi^{-1} during tensile loading. The smallest stresses this thin disk specimen could sense were 7.4 psi and 5.4 psi during bending and tensile loading respectively.

1. Introduction

Self monitoring ability of piezoresistive smart structural material is used as an innovative solution to the maintenance and rehabilitation of civil infrastructures. During a hurricane many onshore, coastal and offshore civil infrastructures damaged as it cannot withstand the wind and wave loading. Monitoring the loads and stresses applied to the civil structures by the wind forces and waves during a hurricane is of increasing interest. Polymers are becoming popular as alternate binders for cement because of their rapid setting, high strength to density ratio and ability to withstand corrosive environment. Polymeric composites are being used as an alternate to cementitious composites in many engineering applications.

In this study, sensitiveness and other characteristics related to the self monitoring ability of the FRPC circular disk specimens were investigated using cyclic bending and tensile loading. Specimens were tested in bending and tension to investigate its ability to sense small loads and pressures and also to verify the repeatability of the sensing ability.

2. Objectives

The overall objective of this study was to characterize the sensitiveness of the thin disk piezoresistive material to small loads and stresses.

3. Preparation of FRPC Specimens

Based on the workability and performance, in this study, polymer resin content was chosen to be 20% by weight and fiber content was chosen as 6% by weight. The sand used was well graded. In preparing the polymer concrete specimens, Cobalt Napthanate (CN) was first added to the polyester resin and the solution was mixed thoroughly and then methyl ethyl ketone peroxide (MEKP) was added. After further mixing, sand and fiber were added slowly and mixed long enough to obtain a uniform mix (CIGMAT PC 1-02). Circular thin disk specimens were prepared with different thicknesses. Specimens were cured at room temperature for 24 hours followed by 80°C for 24 hours in an oven. Wires with conductors were embedded into the specimens during the specimen preparation.

5. Piezoresistivity Coefficient

In this study, piezoresistivity coefficient (Π_{ijk}) was used to quantify the sensitiveness of the FRPC material to stress and it is defind as $(\Delta\rho/\rho_o)_i = \Pi_{ijk}.\Delta\sigma_{jk}$ where $(\Delta\rho/\rho_o)_i$ is the specific change in resistivity and $\Delta\sigma_{jk}$ is the change in stress tensor. The piezoresistivity coefficient (Π_{ijk})

indicates the percentile change in specific resistivity of FRPC specimen when it is subjected to a pressure change of 1 psi.

6. Analysis and Discussions

During the bending and tensile loading tests, the electrical resistance measurements were made between the ends of the diameter using a Hewlett Packard 34420A Nano Volt / Micro Ohm Meter. Tests were performed in multiple cycles by loading up to a fraction of the failure stress . The sensing ability of the FRPC material showed repeatability characteristics, the hysteresis effect between the loading and unloading paths was reduced with the increase in number of cycles of loading. From Figures 1(a) and (b) the piezoresistivity coefficients (Π_{ijk}) of FRPC circular thin disk specimen were obtained as 0.045 psi^{-1} during bending loading and 0.067 psi^{-1} during tensile loading respectively.

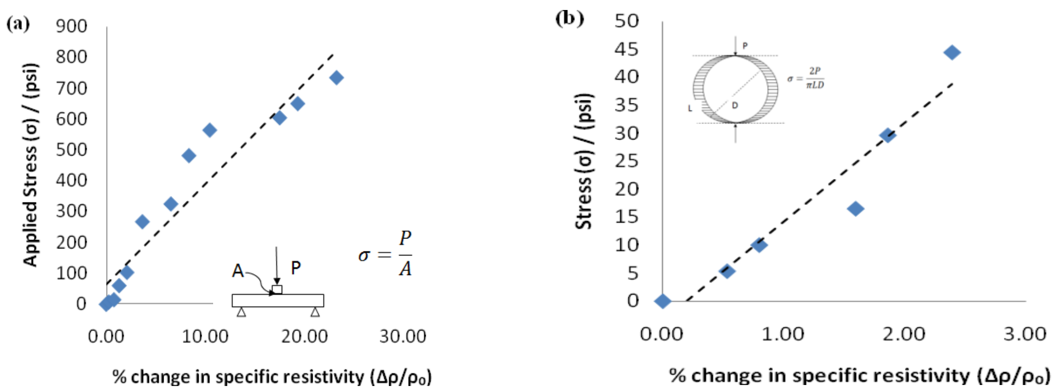

Fig. 1. Variation of Stress with Specific Resistivity during **(a)** Bending loading and **(b)** Tensile loading

7. Conclusions

The piezoresistive coefficients (Π_{ijk}) for thin FRPC disks were obtained during bending and tensile loading were 0.045 psi^{-1} and 0.067 psi^{-1} respectively and the smallest stresses it can sense were 7.4 psi and 5.4 psi during bending and tensile loading respectively. Because of its higher sensitiveness and ability to sense small loads and stresses FRPC material could be used to sense the loads and stresses applied to the civil structures by the wind forces and waves during a hurricane.

8. References

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