Development and Characterization of PRSS for Hurricane Applications

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Abstract: Higher sensitivity and sensing of small loads and stresses are essential requirements for the sensors used in hurricane applications as the wind forces acting on the structures during a hurricane are very small. In this study, the sensitivities of circular disk piezoresistive structural sensors (PRSS) were investigated and characterized under bending loading. The sensitivities of circular disk PRSS with different thicknesses were compared. The sensitivity of the circular disk PRSS increased when the thickness of the sensor was reduced. Specimen with a thickness of 0.25 in. had an average piezoresistive coefficient of 0.084 psi^{-1} during bending loading.

1. Introduction

During a hurricane many onshore, coastal and offshore civil infrastructures gets 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. Self monitoring ability of PRSS is used as an innovative solution to the maintenance and rehabilitation of civil infrastructures. In this study, circular disk PRSS with different thicknesses were developed to improve the sensitivity of the sensor and enhance the ability to sense small stresses. The sensitivity of the PRSS was characterized under bending loading condition.

2. Objectives

The overall objective of this study was to characterize and compare the sensitivities of the circular disk PRSS with different thicknesses.

3. Preparation of PRSS Specimens

In the preparation of the PRSS specimens, polymer resin, methyl ethyl ketone peroxide (MEKPO) and cobalt napthanate (CN) were used as the binder, initiator, and promoter, respectively. Carbon fiber was used as the conductive filler and the sand used was well graded. Based on the workability and performance, in this study, polymer resin content was chosen to be 20% by weight of sand and carbon fiber content was chosen as 6% by weight of sand and polymer resin. Circular disk specimens were prepared with different thicknesses. Specimens were cured at room temperature for 24 hours followed by at 80°C for 24 hours in an oven. Conductor wires were embedded into the specimens during the preparation for resistance measurement.

4. Piezoresistivity Coefficient

In this study, piezoresistivity coefficient (Π) was used to quantify the sensitivity of the PRSS and it indicates the percentile change in specific resistivity ($\Delta\rho/\rho_o$) of PRSS when it is subjected to a unit pressure change ($\Delta\sigma$).

$$\left(\frac{\Delta\rho}{\rho_0}\right) = \Pi.\Delta\sigma \quad (1)$$

5. Results and Discussions

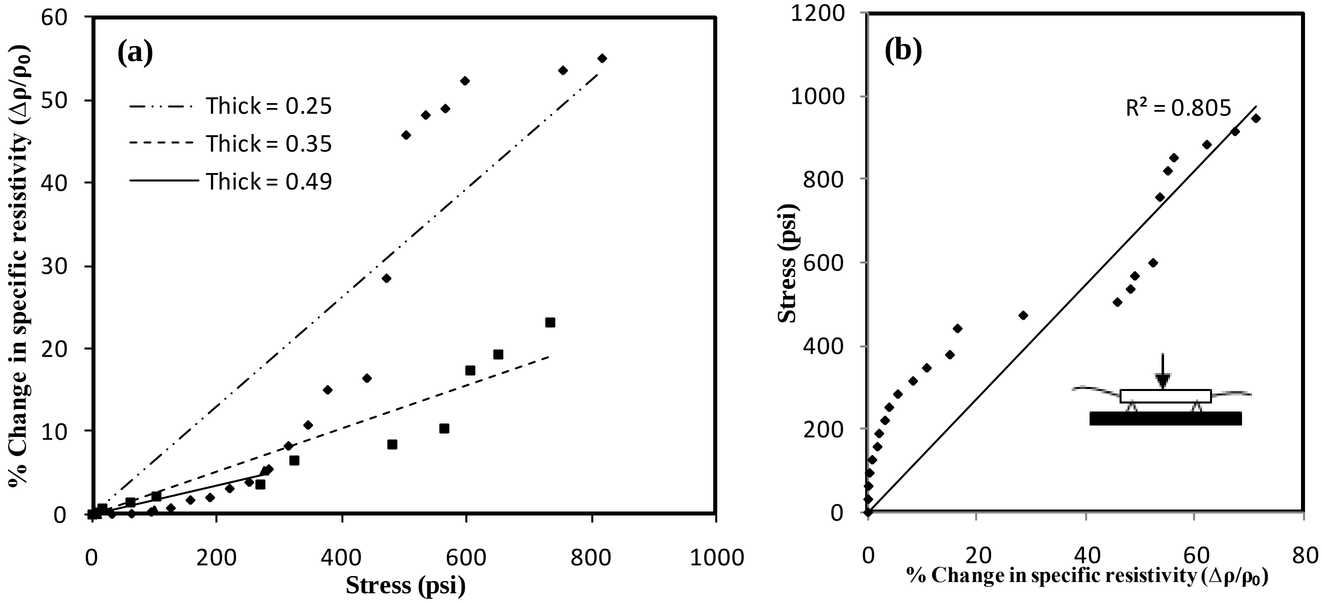

Figure 1 (a) Comparison of the sensitivities of circular disk PRSS with different thicknesses (b) variation of change in specific resistivity with stress for circular disk PRSS with 0.25 in. thickness

During the bending loading tests, the electrical resistances corresponding to each applied load were measured between the ends of the diameter of the circular disk PRSS. Tests were performed by loading up to a fraction of the failure stress. The sensing ability of the PRSS showed repeatability characteristics. From Figure 1(a) the average piezoresistivity coefficients of circular disk PRSS specimens with 0.49 in., 0.35 in. and 0.25 in. thicknesses were obtained as 0.015 psi^{-1}, 0.045 psi^{-1} and 0.084 psi^{-1}, respectively.

6. Conclusions

The sensitivity of the PRSS increased when the thickness of the specimen reduced. Because of its higher sensitivity circular disk PRSS with smaller thicknesses could be used to sense the loads and stresses applied on the civil infrastructures by the wind forces and waves during a hurricane.

7. Acknowledgement

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8. References

1. Vipulanandan C and Sett, Kallol, 2004. "Development and Characterization of Piezoresistive Smart structural Materials", *Engineering, Construction, and Operations in Challenging Environments: Earth & Space 2004*, 656-663

2. CIGMAT PC 1-02 (2002), "Standard Practice for Making and Curing Polymer Concrete Test Specimens in Laboratory", *Center of Innovative Grouting Materials and Technology (CIGMAT), University of Houston, Texas*