PAPER REF: 4100

DYNAMIC STRUCTURAL HEALTH MONITORING OF A CIVIL ENGINEERING STRUCTURE WITH A POF ACCELEROMETER

Paulo Antunes[1,2], João Dias[2], Humberto Varum[3], Paulo André[1,2(*)]

[1]Instituto de Telecomunicações, Aveiro, Portugal
[2]Departamento de Física da Universidade de Aveiro, Universidade de Aveiro, Portugal
[3]Departamento de Engenharia Civil da Universidade de Aveiro, Universidade de Aveiro, Portugal
[(*)]*Email:* pandre@av.it.pt

ABSTRACT

In this work we demonstrate the feasibility of POF based accelerometers for the structural health monitoring of civil engineering structures based on measurements of their dynamic response, namely to estimate natural frequencies. These sensors use plastic optical fiber, combining the advantages of the optical technology with the robustness of this particular kind of fiber. The POF sensor output is directly compared with the signal from an electrical sensor, demonstrating the potential use of such sensors in structural monitoring applications.

Keywords: plastic optical fiber, accelerometer, structural health monitoring.

INTRODUCTION

Structural Health Monitoring (SHM) main goal is to observe the structural behavior *in-situ* under different loading conditions. The measurements can be done during a programmed time period, or during the structure lifetime to detect structural or material properties deterioration (Antunes, 2011). The identification of the structures damage and the monitoring of its evolution are imperative, this imposes the development and optimization of SHM techniques, which are supported by data collected by a sensors network (Sohn, 2004). Based on the collected data, it is possible to evaluate the structural integrity and durability or to identify prematurely eventual problems, allowing pointing guidelines for the definition of the solution and optimize maintenance costs.

The optical fiber based sensors take advantage of the fibers properties, namely, immunity to electromagnetic interference, electrical isolation and reduced weight. Such characteristics make them attractive for use in hostile environments, such as submerse environments or flammable atmospheres where electrical currents might pose a hazard, dams, and nuclear plants, among others. Moreover, the advantages of POF (Plastic Optical Fiber) itself should be also considered, like resistance to hash environments, robustness, flexibility, low cost interrogation units, lower attenuation in the visible spectral region and high numeric aperture (facilitating the alignment process and allowing the use of lower cost components). The POFs are becoming a simple and low cost solution for a large variety of applications, such as in short-distance communication systems, illumination and sensors (Koike, 2009; André, 2012; Bilro, 2012).

Accelerometers are among the utmost relevant sensors used in SHM strategies, aiming the estimation of the structures natural frequencies, which can be related to the structure integrity. Following the natural frequency value along time, a decrease may be related with loss of stiffness of the structure, which can be associated to structural degradation.

EXPERIMENTAL IMPLEMENTATION

The acceleration sensor developed and tested is based on the misalignment, and consequent optical power loss modulation, between two large core plastic optical fibers. The sensor structure consists of an inertial mass, supported by an L-shaped cantilever beam, connected to the support through a steel leaf spring (Antunes, (in press)). The sensitivity of the POF accelerometer system, showed in Fig.1, was estimated to be 33.5±0.1 mV/g with a resonant frequency of 51.44±0.1 Hz.

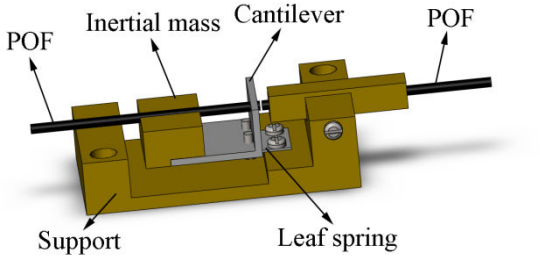

Fig. 1 - POF accelerometer schematics

The POF acceleration sensor was used to monitor a civil engineering structure (metallic bridge) at the University of Aveiro Campus, allowing estimating the structure natural frequencies with a low relative error, when compared to a calibrated electronic triaxial accelerometer (34201A, Summit).

CONCLUSIONS

A low cost POF based accelerometer was used in the characterization of a civil engineering structure, located at the University of Aveiro Campus, being used to estimate its natural frequencies.

ACKNOWLEDGMENTS

Paulo Antunes gratefully acknowledge the financial support from Fundação para a Ciência e a Tecnologia (FCT), through the Postdoctoral fellowship SFRH/BPD/76735/2011.

REFERENCES

[1]-André P, Varum H, Antunes P, Ferreira L, Sousa MG. Monitoring of the concrete curing process using plastic optical fibers. Measurement, 2012, 45, p. 556-560.

[2]-Antunes P, Lima H, Alberto N, Bilro L, Pinto P, Costa A, Rodrigues H, Pinto JL, Nogueira R, Varum H, et al. Optical Sensors Based on Fiber Bragg Gratings for Structural Health Monitoring. in New Developments in Sensing Technology for Structural Health Monitoring. S. C. Mukhopadhyay. Springer Berlin Heidelberg, 2011. 96, p. 253-295.

[3]-Antunes PFC, Varum H, André PS. Intensity Encoded Polymer Optical Fiber Accelerometer. IEEE Sensors Journal, (in press).

[4]-Bilro L, Alberto N, Pinto JL, Nogueira R. Optical Sensors Based on Plastic Fibers. Sensors, 2012, 12, p. 12184-12207.

[5]-Koike Y, Asai M. The future of plastic optical fiber. NPG Asia Mater, 2009, 1, p. 22-28.

[6]-Sohn H, Farrar CR, Hemez FM, Shunk DD, Stinemates DW, Nadler BR, Czarnecki JJ.A Review of Structural Health Monitoring Literature form 1996-2001. Los Alamos National Laboratory, 2004.