# Dynamic Monitoring of Mobile Telecommunication Towers Exposed to Natural Loading with a FBG Biaxial Accelerometer

Paulo Antunes*,+, Rui Travanca**, Humberto Varum**, and Paulo André*,+

* Departamento de Física da Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Tel +351 234 370 356
Fax: +351 234 378 197, Email pantunes@ua.pt, Portugal
+ Instituto de Telecomunicações, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
** Departamento de Engenharia Civil da Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro.

**Abstract (35words)**

In this work the dynamic monitoring of a self supported telecommunications tower is presented. The feasibility of an optical FBG biaxial accelerometer to obtain the structure natural frequencies is demonstrated, recurring only to natural loading.

## 1. Introduction

Structural Health Monitoring (SHM) aims to observe the in-situ structural behavior under different loading conditions during a predetermined time period to detect structural or material properties deterioration. One approach is to use natural loading, such as the wind or traffic, to act as excitation, in order to obtain the structures natural frequencies. Early identification and assessment of structural damage can be a strategy for assuring the structural integrity of existing constructions during their lifetime. This becomes particularly important in the case of tall slender structures, like mobile telecommunication towers, which are more susceptible to external vibrations, due to the combined effects of environment and lack of maintenance. . Slender structures are currently subjected to many sources of loads inducing vibrations, as: wind, machinery, blasting and construction operations, road and rail traffic, among others [1]. In the last decades there has been a significant development in the area of structural monitoring, namely in terms of new monitoring techniques and measuring equipment. In particular, fiber optic sensors, namely fiber Bragg grating (FBG) sensors, have gained a significant importance. For being durable, stable, insensitive to external influences, and usually with minimal invasion to the aesthetics, they are particularly interesting for the long-term health monitoring [2-4].

In this work the natural frequencies of a mobile telecommunication tower are obtained, using an optical FBG accelerometer.

## 2. Experimental

The studied tower, showed in Fig. 1 (left), is a self-supported 50 meters high steel tower, used for mobile telecommunications, located at the littoral center of Portugal, namely in the Aveiro region.

Fig. 1. a) Photography of the studied tower and b) indication of the directions for which the acceleration sensor is sensitive (the picture was obtained through Bing Maps on 7th March 2011).

The structure is composed by seven distinct modules with hexadecagonal cross-section linked by forced fit and its dimension is variable in height. The structure is fixed at the base to a reinforced concrete semi-deep foundation block, with dimensions in plan 3.30x3.30m and 3.60m deep. The accelerometer was fixed in the top of the tower and its axis aligned accordingly with Fig. 1.

The acceleration data was acquired during 105 seconds using an I-MON E-USB Interrogation Monitor Unit from Ibsen, at a sampling rate of 950 Hz, while the structure was exposed to random natural vibration. Fig. 2 shows acceleration data for the vibration in direction 1 and the frequencies spectra, obtained by Fast Fourier Transform from the accelerogram.

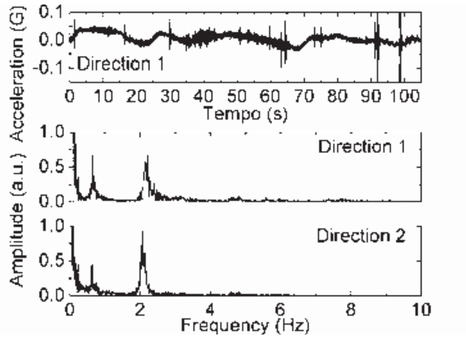

Fig. 2. Accelerogram (top) and frequencies spectra (middle and bottom) for the tower exposed to wind vibration.

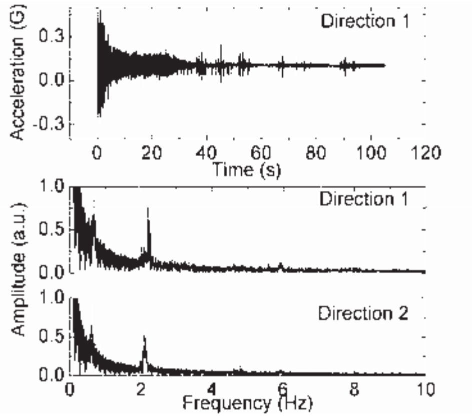

Fig. 3. Frequency spectra corresponding to the passage of a train nearby the tower.

The natural frequencies are obtained by peak picking from the frequencies spectra. Since the tower and a railway are 50 meters away from each other, vibration caused by train's passage is sensed at the tower. Fig. 3 shows the accelerogram for direction 1 obtained during a train passage and the frequencies spectra for both vibration directions obtained during a train passage in the railway near the tower.

The natural frequencies obtained for wind loading and during the train passage are represented in table 1. Being within the limits of current values for this type of structures the results are consistent for the two loading cases for both directions.

| External action | Measurement direction | 1st natural frequency | 2nd natural frequency |
|---|---|---|---|
| Wind | Direction 1 | 0.654 | 2.187 |
| | Direction 2 | 0.647 | 2.064 |
| Train | Direction 1 | 0.686 | 2.187 |
| | Direction 2 | 0.626 | 2.099 |

TABLE 1- RESONANT FREQUENCIES

## 3. Acknowledgment

P. F. C. Antunes acknowledge the financial support from Fundação para a Ciência e Tecnologia (FCT) through the Ph.D fellowship SFRH/BD/41077/2007.

## 4. Conclusions

The obtained results for the first natural eigenfrequencies in both directions have similar values, being within the limits of current values for this type of structures. This work had showed that FBG based accelerometer can be included in SHM of high slender structures successfully.

## 5. References

[1] O. Hunaidi, "Traffic Vibrations and Buildings," *Construction Technology Update,* vol. No. 39, June 2000.

[2] P. Antunes*, et al.*, "Uniaxial fiber Bragg grating accelerometer system with temperature and cross axis insensitivity," *Measurement,* vol. 44, pp. 55-59, 2011.

[3] P. F. C. Antunes*, et al.*, "Optical Fiber Accelerometer System for Structural Dynamic Monitoring," *Sensors Journal, IEEE,* vol. 9, pp. 1347-1354, 2009.

[4] P. C. Chang*, et al.*, "Review Paper: Health Monitoring of Civil Infrastructure," *Structural Health Monitoring,* vol. 2, pp. 257-267, 2003.