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Dynamic monitoring and numerical modelling of communication towers with FBG based accelerometers

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ABSTRACT

This study presents the dynamic monitoring of two telecommunication tall slender steel towers with an optical FBG accelerometer. Numerical simulation for both towers was used recurring to finite elements modelling in order to demonstrate the feasibility of using optical technology in this type of structural monitoring. The results show a good agreement between experimental and simulated data, demonstrating that the optical accelerometer can be a very useful tool in the monitoring of tall slender structures.

1. Introduction

Towers are one of the most important physical supports for the installation of radio equipment used for the emission of electromagnetic waves that allow various services, such as radio, television and/or mobile communications. Unfortunately, the number of anomalies observed in such structures is high when compared with other structures with equal economic and social importance. A great number of the anomalies observed are due to poor design, ensuing in unsafe structures that can even conduce to its full collapse [1–5]. Particularly, for economic and functional reasons of their own nature, steel towers are lightweight structures with high slenderness and great flexibility. The increasingly strength of the materials used in its construction and, consequently, the changes verified in stiffness, mass and damping should lead to a new design approach of the wind action for these type of structures. The resonant response becomes important when these structures have the first natural frequency below 1 Hz. Therefore, dynamic analysis is needed to determine the resonance response that could be significant compared with the background response.

The dynamic analysis of tall slender towers is commonly performed in the frequency domain, based on the frequency dependent character of both the wind loads and the mechanical properties of the structure. In this approach, gust winds are characterized in a probabilistic basis, i.e., using statistically derived descriptions of the relevant properties, such as frequency content and spatial organization [2,5]. Nevertheless, more simplified procedures can be used to obtain the structural response. For example, RSA [6] prescribes a simplified static analysis that only applies if the first natural frequency is above 0.5 Hz. Within this method, the first natural frequency is used only to check the domain of application of the methodology and to validate this simplified procedure. According to the Eurocodes [7,8], simplified quasi-static design procedures can be adopted using the appropriate gust response factors. These factors depend on several parameters, including the first natural frequency of the tower, its damping and the characteristics of the wind. So, also in the design approach followed in the Eurocodes, the first natural frequency is undoubtedly a key parameter to estimate the response of the structure.

Structural Health Monitoring (SHM) is essential to access the structural integrity and guaranty the lifetime of such structures. A key parameter to be monitored is acceleration from which the natural frequencies of the structure can be obtained. The changes verified in natural frequencies can be related with degradation of the structure and this parameter is a very good indicator of the structure health, allowing taking action preventively if needed, saving money and, sometimes, lives. Occasionally, conventional electronic accelerometers can be used. However, the high level of electromagnetic radiation near the antennas can easily mislead to wrong results and can even interfere with radio operation with inevitable economic losses for the operator. Another approach is use all-optical instrumentation like the one proposed in this paper. The accelerometer used in this work is based on Fiber Bragg Gratings (FBG) technology. So, the usage of this technology presents many advantages, particularly: a) low cost, b) immunity to electromagnetic interference, c) do not

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