Dynamic analysis of a guyed mast with uncertainties on the stiffness and the nominal wind velocity

Jorge S. Ballaben*,Marta B. Rosales*, Rubens Sampaio†

* Department of Engineering, Universidad Nacional del Sur
Alem 1253, 8000 Bahía Blanca, Argentina
CONICET, Bahía Blanca, Argentina
jorgeballaben@gmail.com, mrosales@criba.edu.ar

†Department of Mechanical Engineering, Pontifícia Universidade Católica
Rua Marquês de São Vicente, 225, Rio de Janeiro, Brazil
rsampaio@puc-rio.br

ABSTRACT

Nowadays the use of guyed structures as support for telecommunication antennas (radio, TV, internet, cell signals) is a practice widely adopted. The location of guyed masts is preferred in open zones, but the low cost and easy of assembly are making more and more common to find them in city areas. Nevertheless, detailed studies of the dynamic response of the structural system under natural actions, as wind or earthquake are not frequent, despite the potential of adverse impact, particularly in the quality of the transmission. The reduced order models are useful tools, since the resolution of the full formulation is computationally demanding.

In this work, the dynamic response of a guyed mast is analyzed under wind load action. The simplified structural model consists of a beam-column model accounting for the second order effect due to axial loads and one guy. The guy is represented by an extensible cable governed by nonlinear equations. The nonlinear dynamics of a similar model are studied by Gattulli and Lepidi [1]. The wind load is calculated from the wind velocity field, which is derived considering temporal and spatial correlations by means of the Spectral Representation Method [2]. The resulting governing system is discretized using finite elements and a reduced order model is afterwards developed using vibration modes as a basis. The tower stiffness can vary due the reinforcement of the structure. Since it is not easy to foresee their behavior, an uncertainty quantification study appears necessary to obtain more realistic results. Because the nonlinear structures show special sensitivity to dynamic loads, the mean value of wind velocity (used to construct the wind loads) is also considered as a stochastic parameter. The distribution of the selected stochastic parameters is adopted according the Principle of Maximum Entropy [3]. Then Monte Carlo simulations are performed. As results, first, the dynamic behavior of the structure is observed from a deterministic point of view: as expected the wind mean velocity has a higher impact on the response than the tower stiffness. Additionally, is observed that the dynamic response varies in a very nonlinear fashion even for small changes in the parameters. Next, the results are statistically processed. The probability distributions (pdf) of the results are observed accounting for each parameter separately. Furthermore both parameters were considered stochastic by means of a joint distribution. In all the cases, the tower stiffness shows a very small influence on the response, suggesting that is not a parameter of interest for reinforcement or retrofitting.

REFERENCES

[1] Gattulli V. and Lepidi M. “Nonlinear interactions in the planar dynamics of cable-stayed beam”, Computers & Structures, 40, 4726-4748 (2003).

[2] Shinozuka M. and Jan C. “Digital simulation of random processes and its applications”, Journal of Sound and Vibration, 25(1), 111–128 (1972).

[3] Shannon C. “A mathematical theory of communication”, The Bell Technical Journal, 27, 379–423 (1948).