Development of a simplified analytical model for dynamic analysis of lattice towers with variable cross-section

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Due to their slenderness, guyed lattice towers are structures sensitive to dynamic loads. Earthquakes can excite both the structure and the cables, even if the seismic load source is located at a significant distance from the system. Ground vibrations lead to bending deformations of the tower, which in turn constitute a second source of excitation of the cables at their anchoring points, in addition to the base motion excitation at supports. The response of the guy line to the seismic loads can be an important tool used during the design process, considering maximum values of displacements and fatigue of the material. In the presented approach, a simplified analytical model of a variable-cross-section lattice tower with one or three guy lines is proposed, where the structure is simplified to a cantilever beam with an equivalent constant cross-section and mass per unit length. The earthquake is modeled as a filtered Gaussian white noise process, which is characterized by Kanai-Tajimi spectrum [1]. The Ritz method and Lagrange's equation is used to obtain the set of nonlinear differential equations of motion. A detailed discussion is given of the method for determining the equivalent characteristics of the simplified tower model based on the formulas derived from literature [2,3] and their modifications. The obtained results are compared with those obtained from numerical models of lattice towers with various geometry with one or three guy lines. The proposed approach can be used to create an application or software that allows for quick determination of basic model parameters, such as the equivalent moment of inertia and mass per unit length or the fundamental frequency of a system with one or three guy lines, without the need to create a complex computational model of the system. The obtained equivalent values for the structure can be then used to determine the cable response under stochastic seismic excitation.

References

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