Dynamic Behavior of Lattice Transmission Towers

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Abstract
Transmission towers as kind of complex structures are comprehensively used in power transmission lines. Regarding the exposure of transmission towers to the wind and storm, the dynamic investigation of these structures is important. In this research, the dynamic behavior of a lattice transmission tower, including nonlinear effects i.e., geometric, material and joint slippage, is studied. For this reason, the lattice transmission tower is firstly pre-analyzed due to the weight load, incorporating nonlinear parameters in different cases, and then, the frequency analysis is performed and the natural frequencies of the lattice transmission tower are obtained. Afterwards, these natural frequencies are compared for different cases and it is observed that in contrast to the geometric and material nonlinearities which are not effective on the natural frequencies of the structure, incorporating the joint slippage can substantially decrease the natural frequencies. These natural frequencies are significant in the dynamic analysis of these structures either individually or as coupled system along with conductors. Finally, the first five mode shapes of the tower are presented.
Keywords: lattice transmission tower, nonlinear effects, joint slip effect, NASTower, natural frequency

1. INTRODUCTION

Transmission towers are kinds of complex lattice structures usually built by angle sections and bolted connections, bringing about some problems in their accurate modeling and analysis, making the prediction of their behavior as one of the structural engineering challenges. Inaccurate modeling and analysis of transmission towers increases the risk of their collapse during the service loads leading to substantial damages to the transmission line, as declared in many previous reports. Transmission towers failures are due to so many reasons such as incorrect design assumptions, improper detailing, material defects, fabrication errors, force fitting during erection, variation in bolt grade, etc. [1].

Many of researchers have devoted themselves to the study of transmission towers behavior and prediction of their failure. Al-Bermani and Kitipornchai presented a nonlinear analytical technique for simulation of the ultimate structural behavior of self-supporting transmission towers, incorporating both geometric and material nonlinearity effects. Modeling of material nonlinearity for angle members is based on the assumption of lumped plasticity coupled with the concept of a yield surface in force space. Several transmission towers were modeled and analyzed in developed AK TOWER to simulate their behavior in the full-scale experiments [2-6]. Moreover, Chan and Cho proposed a practical second-order analysis and design method for trusses composed of angle sections. Realistic modeling of semi-rigid connections associated with one- and two-bolt end connections with flexible gusset plate and member imperfections such as initial curvatures and residual stresses was made and load eccentricity was also simulated [7]. Also, Ungkurapinan studied the behavior of such joints, incorporated 36 joint tests, generated joint slip data and developed mathematical expressions to describe slip and load-deformation behavior. In this study, it was concluded that joint slip effect cannot be eliminated and incorporation of the reported joint slip data or mathematical expressions in the tower analysis software will refine their results [8]. Afterwards, Ungkurpinan joint slippage models were employed by Jiang et al. in the modeling of a transmission tower, which resulted in improvement in the displacements results which coincided with the full-scale test results [9]. In other research, the nonlinear finite element analysis program NE-NASTRAN had been used by Rao et al. to model