Structural Performance of Polymeric Composite Members in a Transmission Line Tower

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Abstract

On Mexican transmission lines, theft of redundant steel elements from the transmission towers has increased markedly in recent years, as shown in Figure 1. Fig. 1a presents the tower with its all metallic elements; Fig. 1b illustrates the tower when some metallic elements are stolen. The removal of these elements from the tower has resulted in the collapse of the tower (Fig. 2), causing the suspension of electric service and great economic losses. Currently, to avoid this problem, the towers are periodically inspected in order to immediately replace the missing elements. However, the latter requires a constant investment, since metallic elements are stolen again, and thus the risk of failure of the tower follows being latent.
An alternative to solve this problematic is to replace the steel components by polymeric composite elements. The above is based on that the recycling economic value for a polymer element is too low compared with the steel price. Thus, it is hoped that the theft of an unprofitable material will be discouraged; thereby the integrity of the transmission structure could be conserved.

To check the feasibility of this alternative, the resistance of the polymer elements to the mechanical stresses that occur along the structure due to the own weight of the structure and all the components installed inside the structure and due to the wind striking the structure is evaluated. The evaluation is carried out using the finite element program COMSOL Multiphysics®. In COMSOL, a linear buckling analysis of different sections of a typical transmission tower is simulated. The simulation is performed with the Solid Mechanics interface of Structural Mechanics Module. The models created are shown in Fig. 3 for 3 sections of a transmission tower. Horizontal and vertical point loads on the top of each analyzing section are applied. These loads represent the mechanical stresses that can occur in the tower section that is being studied. The polymeric material elements are represented according to their corresponding Young´s modulus. The performance of the tower sections is determined based on the critical load factor. This was made considering tower sections with all steel elements, tower sections without redundant elements, and tower sections with redundant elements of polymeric materials. The obtained results, as a function of the critical load factor, were:
a) Model no.1: with steel redundant elements, 7.17; without redundant elements, 1.05; with polymeric material redundant elements, 2.13.
b) Model no. 2: with steel redundant elements, 2.51; without redundant elements, 0.73; with polymeric material redundant elements, 1.03.

c) Model no. 3: with steel redundant elements, 2.27; without redundant elements, 0.80; with polymeric material redundant elements, 1.03.

The results show than a tower can collapse if its redundant elements are stolen. Fig. 4 shows the total displacements for the different cases simulated of the model no. 1. The substitution of these steel elements by polymeric material elements may be a good option for keeping the reliability of a transmission tower, if latter are not unprofitable for the thieves, although they are not as good as the steel redundant elements.

Reference

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