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Structural Analysis of Guyed Steel Telecommunication Towers for Radio Antennas

The usual structural analysis models for telecommunication and transmission steel tower design tend to assume a simple truss behaviour where all the steel connections are considered hinged. Despite this fact, the most commonly used tower geometries possess structural mechanisms that could compromise the assumed structural behaviour. A possible explanation for the structure stability is related to the connections semi-rigid response instead of the initially assumed pinned behaviour. This paper proposes an alternative structural analysis modelling strategy for guyed steel towers design, considering all the actual structural forces and moments, by using three-dimensional beam and truss finite elements. Comparisons of the above mentioned design models with a third alternative, that models the main structure and the bracing system with 3D beam finite elements, are made for three existing guyed steel telecommunication towers (50m, 70m and 90m high). The comparisons are initially based on the towers static and dynamic structural behaviour later to be followed by a linear buckling analysis to determine the influence of the various modelling strategies on the tower stability behaviour.
Keywords: telecommunication and transmission towers, guyed steel structures, spatial structures, structural analysis, computational modelling, modal analysis, stability analysis.

Introduction

The Brazilian telecommunication and electrical power transmission systems expansion were the main reasons for efficient and cost-effective transmission and telecommunication steel towers. Steel truss towers have been used to support transmission antennas or to enable electrical power transmission lines to be built, interconnecting the vast Brazilian territory. However, structural collapses, mainly associated with the wind action, are not uncommon to this particular structural solution (Bliesemann, 2001; Camil Júnior 2000).

Despite these facts, most of the traditional structural analysis methods for telecommunication and transmission steel towers still assume a simple truss behaviour, where all connections are considered hinged. On the other hand, structural mechanisms, that could compromise the assumed structural response, can be present in various commonly used tower geometries whenever truss type models are adopted (Policanski 2000, 2000a; Silva et al. 2000, 2002).

A usual solution to overcome this problem is the use of dummy structural bars to prevent the occurrence of the unwanted degrees of freedom. These bars, possessing a small axial stiffness, are generally employed to prevent the occurrence of structural mechanisms, enabling the use of standard finite element programs. A possible explanation for the structure stability is related to the semi-rigid, instead of the assumed hinged joint behaviour. In fact, most major steel tower constructors still rely on full-scale tests to determine which design and fabrication details can provide a good test correlation with the assumed simple truss model results.

This paper proposes an alternative structural analysis modelling strategy, based on a less conservative model combining 3D beam finite elements in the main structure and 3D truss elements in the bracing system and eliminating the use of dummy bars present in the traditional analysis.

Further comparisons of the two above mentioned methods and another design alternative only using 3D beam finite elements on three existing guyed steel telecommunication towers (50m, 70m and 90m high) are described. The comparison is focused on the tower structural response in terms of displacements, bracing moments, stresses, natural frequencies and buckling loads.

Nomenclature

- w_{max} = Maximum stress of the tower;
- w_{max} = Maximum horizontal displacements of the tower
- f_{11} = First natural frequency of the tower,
- f_{22} = Second natural frequency of the tower,
- f_{33} = Third natural frequency of the tower,
- f_{44} = Fourth natural frequency of the tower,
- f_{55} = Fifth natural frequency of the tower,
- R_{11} = First buckling load of the tower,
- R_{22} = Second buckling load of the tower,
- R_{33} = Third buckling load of the tower,
- R_{44} = Fourth buckling load of the tower,
- R_{55} = Fifth buckling load of the tower,

The Structural Modelling

Several authors have contributed with theoretical and experimental investigations to assess the best modelling strategy for steel transmission and telecommunication towers. It is fair to

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