

Marcel Isandro R. de Oliveira

moliveira@labdas.eng.uerj.br
Universidade do Estado do Rio de Janeiro - UERJ
Programa de Pós-Graduação em Engenharia Civil

José Guilherme S. da Silva

Member, ABCM
jgs@perqnet.br

Pedro Colmar G. da S. Velasco

Member, ABCM
velasco@perqnet.br
Universidade do Estado do Rio de Janeiro - UERJ
Departamento de Engenharia Mecânica
20550-900 Rio de Janeiro, RJ, Brazil

Sebastião Arthur L. de Andrade

sandrade@div.puc-rio.br
Departamento de Engenharia Civil, PUC-RJ
22452-900 Rio de Janeiro, RJ, Brazil

Luciano R. O. de Lima

luciano@perqnet.br
Universidade do Estado do Rio de Janeiro - UERJ
Departamento de Estruturas e Fundações

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 (Policansi 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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Table of Contents Structural Analysis Of Guyed Steel Telecommunication Towers

1. Understanding the eBook Structural Analysis Of Guyed Steel Telecommunication Towers
 - The Rise of Digital Reading Structural Analysis Of Guyed Steel Telecommunication Towers
 - Advantages of eBooks Over Traditional Books
2. Identifying Structural Analysis Of Guyed Steel Telecommunication Towers
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Structural Analysis Of Guyed Steel Telecommunication Towers
 - User-Friendly Interface
4. Exploring eBook Recommendations from Structural Analysis Of Guyed Steel Telecommunication Towers
 - Personalized Recommendations

- Structural Analysis Of Guyed Steel Telecommunication Towers User Reviews and Ratings
- Structural Analysis Of Guyed Steel Telecommunication Towers and Bestseller Lists
- 5. Accessing Structural Analysis Of Guyed Steel Telecommunication Towers Free and Paid eBooks
 - Structural Analysis Of Guyed Steel Telecommunication Towers Public Domain eBooks
 - Structural Analysis Of Guyed Steel Telecommunication Towers eBook Subscription Services
 - Structural Analysis Of Guyed Steel Telecommunication Towers Budget-Friendly Options
- 6. Navigating Structural Analysis Of Guyed Steel Telecommunication Towers eBook Formats
 - ePub, PDF, MOBI, and More
 - Structural Analysis Of Guyed Steel Telecommunication Towers Compatibility with Devices
 - Structural Analysis Of Guyed Steel Telecommunication Towers Enhanced eBook Features
- 7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Structural Analysis Of Guyed Steel Telecommunication Towers
 - Highlighting and Note-Taking Structural Analysis Of Guyed Steel Telecommunication Towers
 - Interactive Elements Structural Analysis Of Guyed Steel Telecommunication Towers
- 8. Staying Engaged with Structural Analysis Of Guyed Steel Telecommunication Towers
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Structural Analysis Of Guyed Steel Telecommunication Towers
- 9. Balancing eBooks and Physical Books Structural Analysis Of Guyed Steel Telecommunication Towers
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Structural Analysis Of Guyed Steel Telecommunication Towers
- 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
- 11. Cultivating a Reading Routine Structural Analysis Of Guyed Steel Telecommunication Towers
 - Setting Reading Goals Structural Analysis Of Guyed Steel Telecommunication Towers
 - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Structural Analysis Of Guyed Steel Telecommunication Towers
 - Fact-Checking eBook Content of Structural Analysis Of Guyed Steel Telecommunication Towers

- Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
- 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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