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Application of structural topology optimization to slender telecommunication lattice towers

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Introduction

The design of lattice towers has not changed for decades, while their maintenance can be expensive and somewhat dangerous due to the number of small elements and connections that engineers have to rely on. Moreover, with the increasing demand of telecommunication systems (new equipment such as ancillary antenna support structures, cables, UHF aerials, radio and TV antenna broadcasters, telephone antenna arrays and microwave dishes which increase the solidity and surface area of the towers), new support structures are needed together with modernizing existing infrastructure to meet the design criteria.

Methods

This paper studies the application of structural topology optimization (STO) to design a new space-frame type for lattice self-supporting telecommunication towers. The present study investigates the development of lattice tower morphologis through both 2D and 3D approaches employing optimization software tools that are predominately used in other than civil engineering applications, such as mechanical, automotive, and aerospace engineering. A range of boundary and loading conditions have been applied and the analyses were performed with scope to reduced the weight and increase the stiffness off the towers. The optimized models were then translated to a practical morphology and convereted to a GSA Oasys structural model to further perform static wind and modal (linear dynamic) analyses.

Results

A new topology composed of the so-called ‘high-waisted’ bracing type was created (Fig.1) while the results make it applicable for exoskeletons of other slender tall space-frames. A lighter system in comparison to the conventional (benchmark) lattice tower has been developed while the optimized frame is characterized by its significantly low solidity and mass (i.e., fewer and larger structural elements with a less intrusive design).

Other important findings in relation to the optimization studies performed include the following:

1. The height z of the high-waisted bracing decreases with the increase of the domain height. Values of z ranged from 0.60Hp to 0.75Hp.

2. It can be argued that 20% reduction of the top width of each panel in relation to the bottom width of the domain, results in 2% reduction of height z.

3. Through the analyses, it was realised that reaching the optimal solution can be achieved by the combination of optimal layouts resulting from different analyses.

4. The application of manufacturing constraints enabled the development of a symmetrical and constructable tower topology.

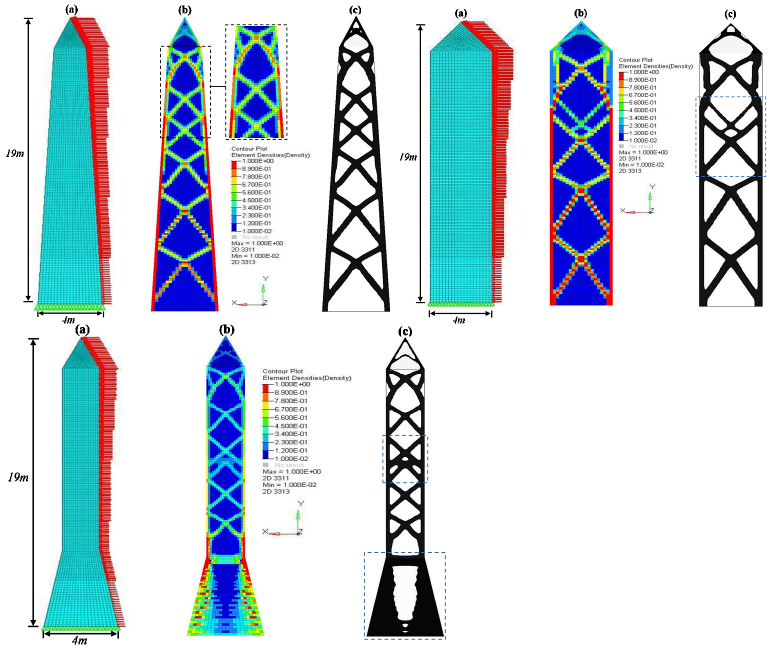

Fig.1 Optimized topologies of telecommunication lattice masts

Conclusions and Contributions (300 words)

The outcome of this paper is twofold: (a) an improved weight/stiffness ratio for the optimized space-frame, and (b) the development of a newly optimized bracing system similar to the 'high-waisted' bracing presented by Stromberg et al. [3,5] for other applications. It was also found that the material distribution is heavily dependent on stress path trajectories generated within the domain in accordance with the particular loading scenario and support conditions, thus further investigation is deemed necessary. The optimization techniques employed here indicated reasonable and consistent conceptual layouts.

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