IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I - Development and Verification (Space Vehicles and Components) (1)

Author: Dr. Litesh Sulbhewar
University of Glasgow, United Kingdom, Litesh.Sulbhewar@glasgow.ac.uk

Prof. Colin R. McInnes
University of Glasgow, United Kingdom, colin.mcinnes@glasgow.ac.uk

EFFECT OF GEOMETRIC PARAMETERS OF CONSTITUENT MEMBERS ON THE STRUCTURAL BEHAVIOUR OF THE LATTICE TRUSS BEAM FOR SPACE APPLICATIONS

Abstract

Lattice trusses are highly efficient lightweight structures formed by the arrangement of constituent members in a repetitive pattern. Truss beams, formed by placing slender structural elements at the vertices of the lattice and connected together at the joints, are particularly useful as load-bearing members for various large-scale space applications, for example space solar power.

As a triangle requires the minimum number of vertices to form a two-dimensional lattice cross-section, the longerons running along the axis of the beam are placed at the corners of an equilateral triangle. These are joined by the repeating pattern of diagonals which forms the most preferred lattice truss beams. The longerons are responsible for the axial and flexural strength of the beam, while the diagonals add shear and torsional strength.

The structural performance of these truss beams depends not only on the strength of individual members, but also on their geometry and placement. To achieve an efficient high strength structure, an estimate of the structural behaviour of these trusses with various geometric parameters of constituent members is necessary.

In this paper, a parametric study of the mechanical response of these truss-beams with variations in cross-section, location and orientation of the constituent members is performed using Finite Element simulations. A cantilevered lattice beam made from tubular members is taken as a test example. Each constituent member is modelled with a two node Timoshenko beam element. The FE simulations are carried out for axial, bending, shear and torsional loadings. The consistent FE loads are applied at the free end of the cantilever at the respective nodes. A comparative assessment of the strength under these different loading conditions is then made.

The strength-to-mass ratio is used as the reference criterion for comparing structural effectiveness. Then, nonlinear behaviour of the strength-to-mass ratio with different geometric parameters is observed. In addition, the effect of these geometric parameters on the first natural frequency of the truss beam is estimated. The results obtained can serve as a reference to select structurally economical geometric parameters of the lattice truss beam for the specific loading environment. Finally, an example application of the analysis to ultra-large orbiting solar reflectors for energy from space (Çelik, Viale, Oderinwale, Sulbhewar, McInnes, 2022) is presented.

References: Çelik, O., Viale, A., Oderinwale, T., Sulbhewar, L., McInnes, C. (2022). Enhancing terrestrial solar power using orbiting solar reflectors. Acta Astronautica, (195) 276–286.