Simulation of the mechanical and thermal behaviour of sandwich plates with different aluminum cores

Achilleas Milios
Department of Mechanical Engineering and Aeronautics
Division of Applied Mechanics, Technology of Materials and Biomechanics
University of Patras

Introduction

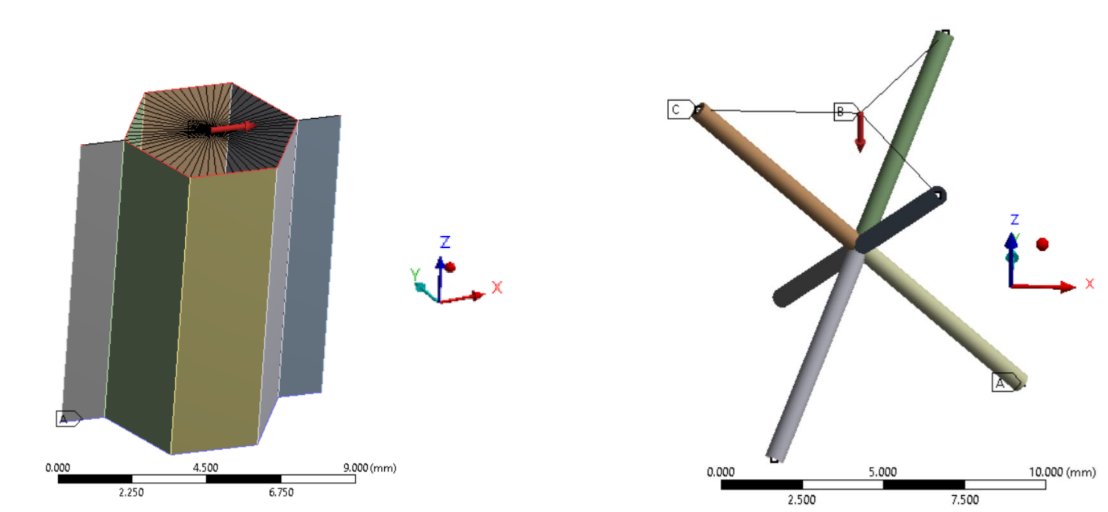
Sandwich structures made from composite materials and low-density cores offer high lightweight potential and they are being widely used as load-bearing components in spacecraft structures. Additionally, their mechanical and thermal properties can be tailored to support specific mechanical and environmental loads. A revolutionary technological field is additive manufacturing because a part is printed layer by layer according to a 3D model. Additively manufactured structures can have complex shapes which normally cannot be produced with conventional manufacturing techniques. This technology allows replacing of conventional honeycomb cores with lightweight printed aluminum truss or lattice structures. The freedom of design can be exploited to create core structures which are not only optimized from a structural-mechanical point of view, but also enable the realization of additional functions by design.

Motivation

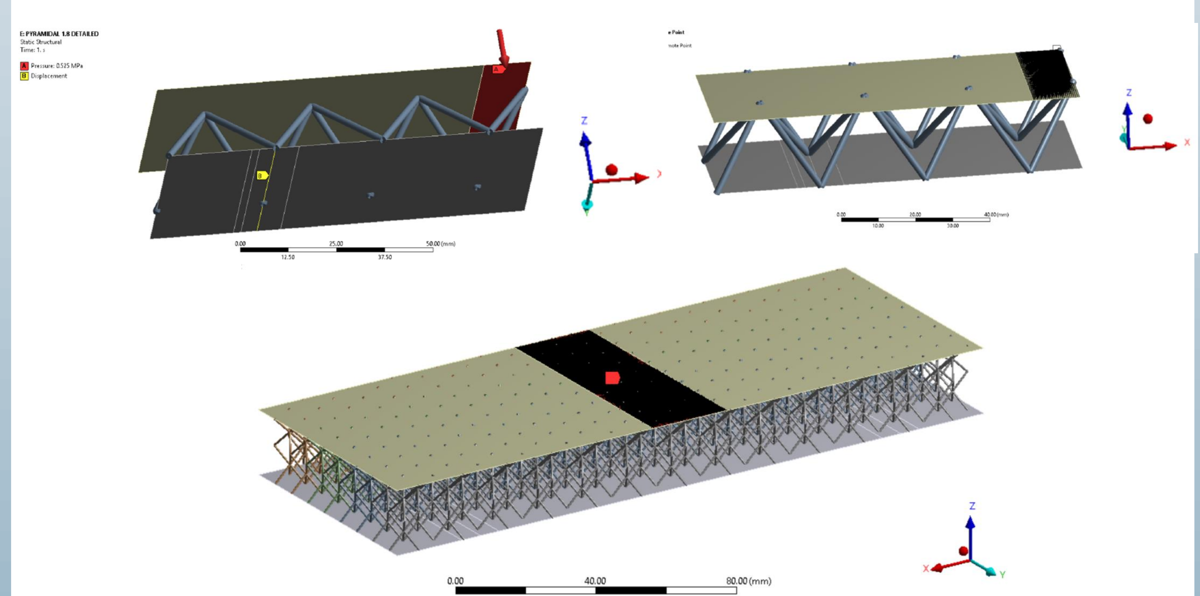
With the motivation of driving forward the development of multifunctional sandwich structures, the mechanical and thermal behaviour of different aluminum core structures is analysed with help of the finite element method. Computation of mechanical properties and numerical modelling of cellular core materials and sandwich structures is reviewed. Conventional honeycomb and foam cores and novel printed lattice truss cores are examinated. Afterwards, beginning with unit cells and continuing with sandwich plates, numerical models are created to compare the behaviour of these structures under mechanical loads. Furthermore, the difference between detailed and homogenized modelling of sandwich cores is investigated and evaluated. Special focus is put on the modelling of load introduction points and boundary conditions. Thereafter, a first assessment of the core heat exchange performance is conducted again through simulation of the former panel models. On the one hand, this thesis shall provide as final result a guideline for the numerical modelling of the different sandwich core structures. On the other hand, a comparison of the stiffness and heat transfer performance between sandwich plates with different aluminum cores is to be drawn.

Models of Simulation

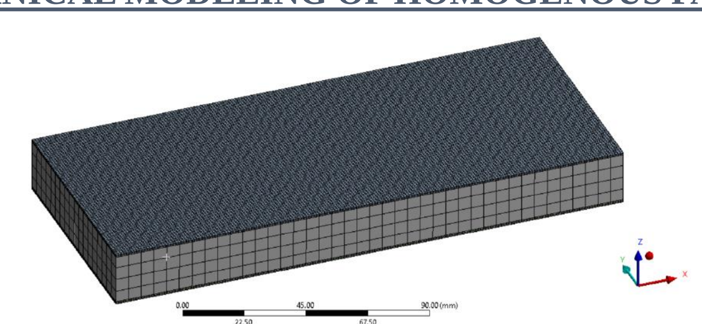
MECHANICAL MODELING OF UNIT CELLS



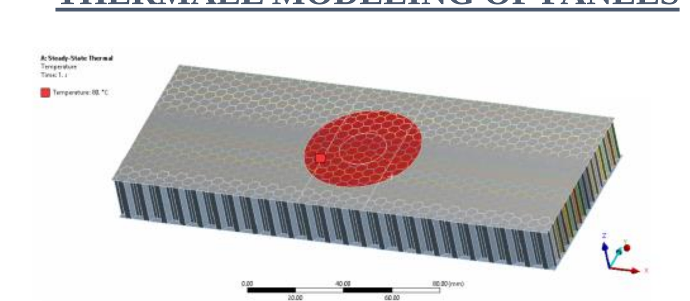
MECHANICAL MODELING OF DETAILED PANELS



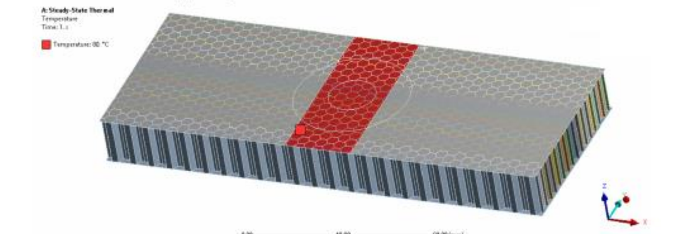
MECHANICAL MODELING OF HOMOGENOUS PANELS



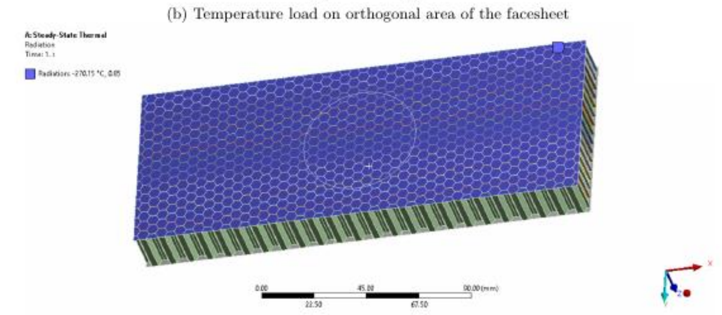
THERMALL MODELING OF PANELS



(a) Temperature load on circular area D=50 mm



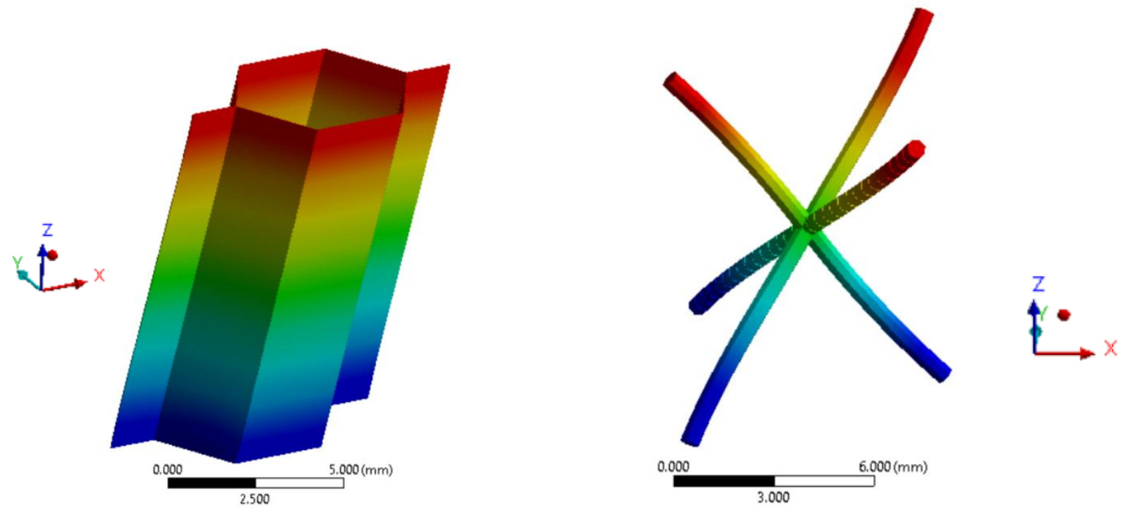
(b) Temperature load on orthogonal area of the facesheet



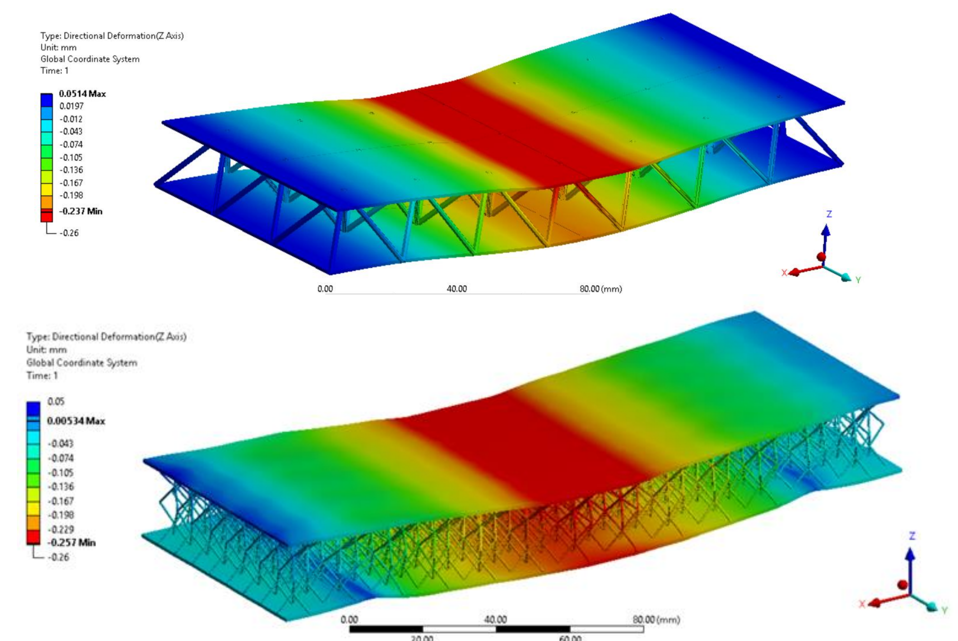
(c) Radiation condition on bottom surface of the opposite facesheet

Results

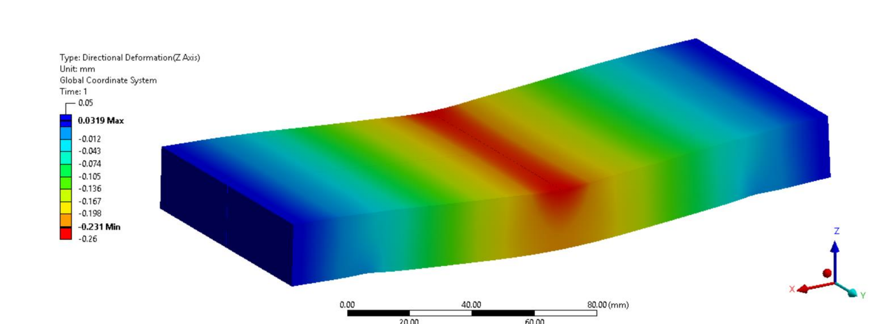
UNIT CELLS



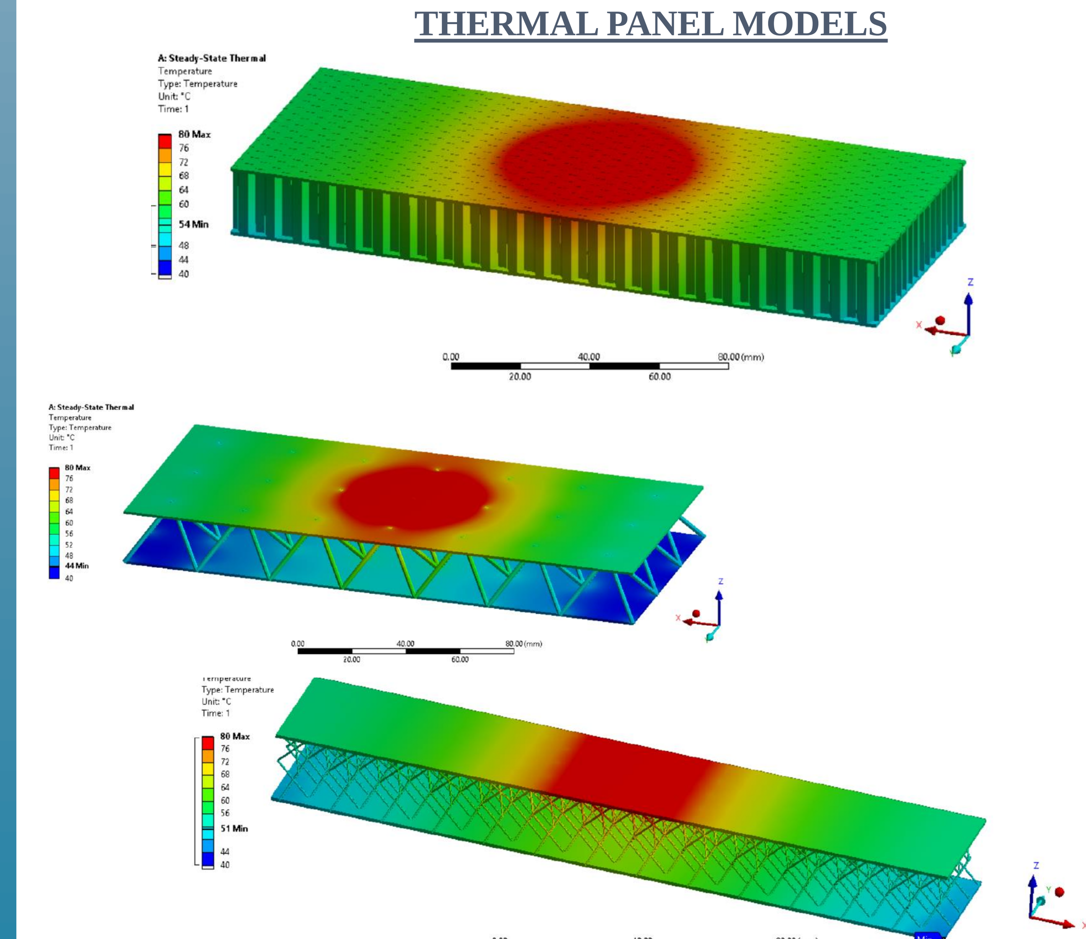
DETAILED PANEL MODELS



HOMOGENOUS PANEL MODELS



THERMAL PANEL MODELS



Conclusion

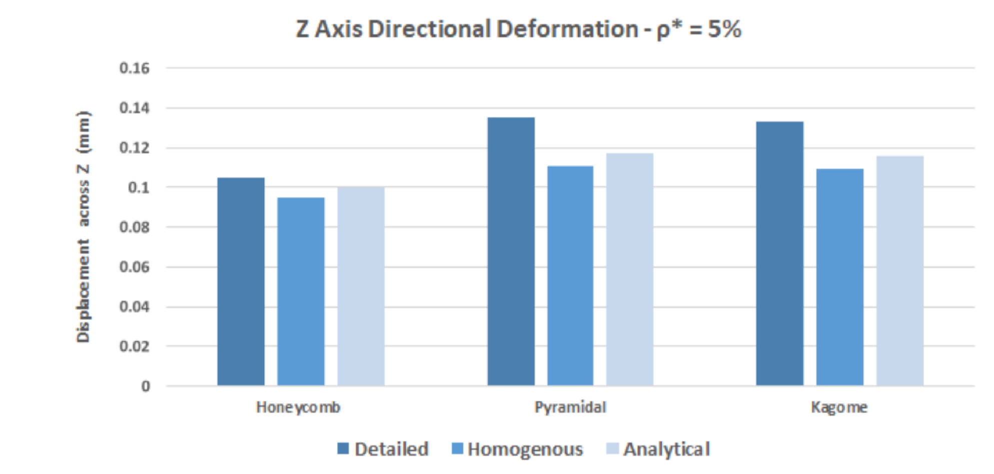


Figure 3.2.28: Displacement Results for 5% relative density

- The mechanical performance of 3D printed novel lattice truss core panels was evaluated and compared to classical core types and it was proven that lattice core panels can exhibit satisfying structural stiffness along with a wide range in relative density values.
- A comparison between different computation methods provided suggestions for a guideline of further sandwich panel modeling.
- A first assessment of the heat dissipation behaviour of the printed aluminum truss cores showed that they can perform well, given an according adjustment of their geometry.

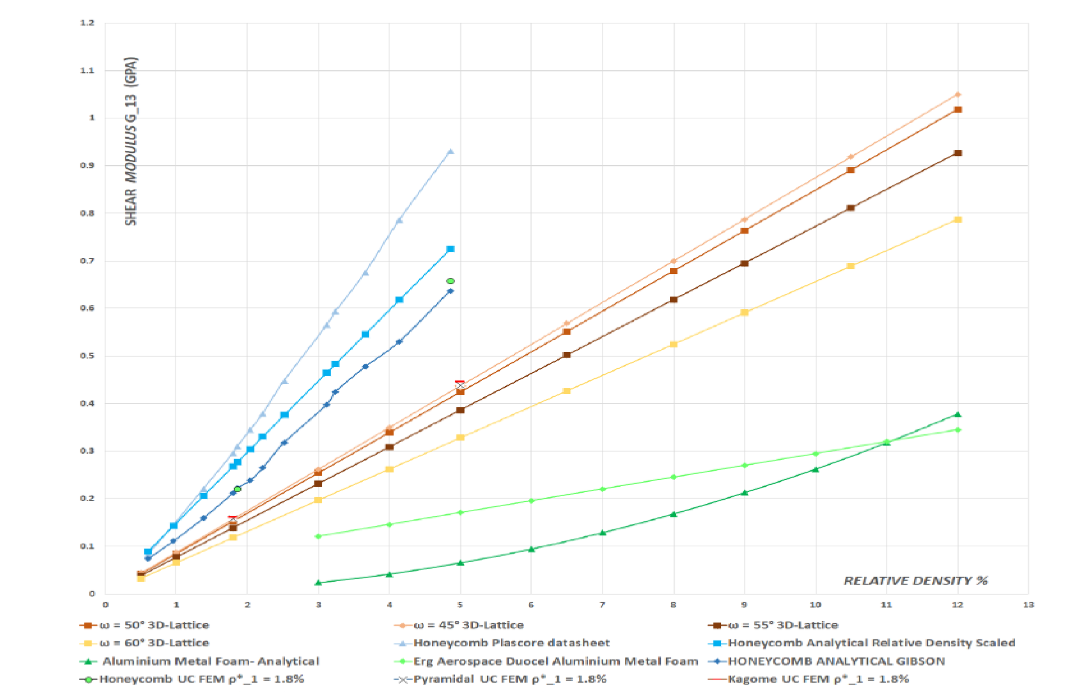


Figure 3.1.39: Shear modulus according to relative density for the aluminium core types of interest

References

- L.J.Gibson, M.F.Ashby: *Cellural Solids* – Structure and properties – Second Edition (2009)
- H.N. G. Wadley: *Multifunctional Periodic Cellular Metals*, Phil. Trans. R. Soc. A Vol. 364 (2006)
- N. Buannic, P. Cartraud, T. Quesnel: *Homogenization of corrugated core sandwich panels*, Composite Structures Vol. 59 (2003).
- Gilmore, David G.: *Satellite Thermal Control Handbook*, The Aerospace Corporation Press (2002).