TRUSSES WITH REDUCED THERMAL EXPANSION:
THEIR DESIGN, AND MASS AND STIFFNESS PENALTIES.

Submitted by Nunzio Maria Andrea Palumbo to the University of Exeter
as a thesis for the degree of
Doctor of Philosophy in Engineering
In March 2013

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Signature: ………………………………………………………………………
Abstract.

This thesis focused on the mechanisms involved in negative thermal expansion of 2D/3D lattice structures. The effects of varying the constituent materials and geometry were explored. The lattices had geometries similar to those found in light-weight structures in many transport applications, including aerospace and spacecraft. One specific case was to determine how to reduce the coefficient of thermal expansivity (CTE) of such structures to near zero, by using two constituent materials with contrasting CTEs, without incurring penalties in terms of other elastic and failure properties, mass and manufacturability. The lattice geometries able to exhibit altered CTE were explored, and penalties in terms of other elastic properties were quantified. The results were scale-independent and so were generic to all such lattices. Analytical prediction and generic relationships between the geometries of the lattices and their performance were proposed. Experimental validation of the model predictions was undertaken using physical samples.

The thermomechanical properties were simulated by commercial finite element method (FEM) codes (Ansys 11, Ansys, Inc.). Ansys parametric design language was adopted to generate large sets of solutions to be evaluated against chosen criteria. Results show small or, in some cases, no penalties to be paid in terms of stiffness and mass for implementing dual-material lattices with near-zero CTE. Such lattices may compete favourably with high-cost and high-density materials (e.g. Invar) and the manufacture of dual-material lattices can be by standard processes or alternative new process such as Additive Layer Manufacturing (ALM).
An example of truss core sandwich application for aerospace application was modelled by FEM. Applications as cores in sandwich panels might be the first route by which the ALM manufacturing process is required to develop dual-material capability.
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