הטכניון מכון טכנולוגי לישראל TECHNION Israel Institute of Technology

Faculty of Mechanical Engineering הפקולטה להנדסת מכונות

MECHANICAL ENGINEERING SEMINAR

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A systematic study of the mechanical properties of lattice structures in finite element simulations

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Additively manufactured lattice structures are porous light-weight structures with mechanical properties that are dictated both from the topology and the parent material properties. These light-weight structures are attracting attention in various application in various field of engineering, and among their intriguing properties, they demonstrate superior mechanical properties with respect to the weight and excellent energy absorption capabilities. Despite, there are still challenges in modeling mechanical properties of these structures, especially in large deformations. In this work, we studied the mechanical properties of metallic lattice structures in finite element simulations. We firstly focus on body centered cubic (BCC) lattice structures under uniaxial compression up to large deformation strains. We perform a systematic study using finite element modelling (FEM) to find how both material properties and lattice topology are affecting the effective mechanical properties of BCC lattice structures under compression. We propose scaling laws between the slenderness ratio of struts and the Young's modulus, yield strength, hardening rate of the structure and the densification strain. We also discuss how rounding the connections between the struts using fillets affects the scaling laws. We demonstrate the scaling laws in the analysis of experimental results, showing the accuracy and limitations of the scaling laws in predicting the mechanical properties, with an emphasis on large deformations. We then extend the discussion on the yield surface to multi-axial loadings. We consider BCC and Octet lattice structures and explore yield criteria for a homogenized model. We use FEM, to simulate various loading conditions and define the yield states based on the principle of equivalent plastic work. We explored various yield criteria, and we find that an anisotropic model with a linear dependence on the mean stress, is the best candidate to describe the multi-axial plastic behaviour of lattice structures. In the third part of the talk, we extend the discussion to inhomogeneous trusses, with different distribution of unit cells. Using 2D lattices, we demonstrate the effect of hardening mechanisms on the level of the lattice structure. We then discuss 3D lattices, with mixing of unit cells inspired by alloys. By studying various combinations of lattice structures and comparing them with experiments, we aim to understand the origins of these inhomogeneous deformations, which expands new horizons in designing new lattice structure with tailored mechanical properties.

Seminars Coordinator: Assoc. Prof. Shmuel Gal.