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Multiscale sectional homogenisation for the assessment of the structural plastic behaviour of corrugated board

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Corrugated board displays a complex non-linear mechanical response, arising from the interaction between its anisotropic constituents, interfaces, and characteristic corrugated geometry. An accurate modelling of its plastic behaviour is essential for the design of components subjected to severe loading scenarios. This work introduces a two-step sectional homogenisation procedure [1,2], that focuses specifically on the representation of plastic phenomena. In the first step, a detailed 3D Representative Volume Element (RVE) is developed to capture the onset of yielding, the evolution of plastic strains, and the associated stiffness degradation under uniaxial and multiaxial loading paths. The RVE explicitly accounts for the layered structure of the material, the non-linear response, and local interactions between the liners and fluting. Through sectional homogenisation, the non-linear mechanisms are condensed into equivalent elasto-plastic parameters [3], that form the basis for a computationally efficient 2D shell model. In the second step, during full structural simulations of board panels, the homogenised model provides global strain fields that are back-analysed into the 3D RVE to recover detailed stress states. Numerical investigations demonstrate that the proposed methodology accurately reproduces experimental load-displacement curves, residual strain accumulation, and post-yield stiffness reductions observed under various loading conditions. The framework maintains high computational efficiency while preserving the essential non-linear characteristics of corrugated board, offering a powerful predictive tool for the structural analysis and design of corrugated board structural components, such as packaging elements, also subjected to plastic loading regimes.

Keywords: corrugated board, sectional homogenisation, plasticity, composite materials and structures.

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