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Modelling of local buckling in corrugated board via a two-step sectional homogenization framework

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Local instability, including flute buckling, liner wrinkling, and localised collapse, is a governing factor in the overall mechanical performance of corrugated board structures. These instability phenomena often occur at local scales, yet strongly influencing global load-carrying capacity and deformation behaviour [1]. This study presents a dedicated two-step sectional homogenisation strategy, for accurately embedding local instability effects into computationally efficient structural models [2,3]. Firstly, a 3D Representative Volume Element (RVE) is constructed to reproduce the principal instability modes triggered under compression, bending, and shear. Such RVE captures geometric non-linearities, localised stiffness loss, out-of-plane wrinkling, and progressive softening of the paper layers as buckling develops. Then, through a sectional homogenisation process, pre-buckling stiffness and post-buckling degradation characteristics are extracted and incorporated into a 2D shell model, fostering and increased computational efficiency. During structural simulations, the 2D model provides strain states that are applied as boundary conditions to the 3D RVE sections, enabling the reproduction of local instability modes and their influence on global response without resolving the full corrugated geometry. Validations against numerical tests show that the proposed method reliably predicts local buckling phenomena. The framework turns out particularly effective in identifying weak zones and collapse patterns in corrugated board packaging designs, practically offering an advanced simulation tool for performance evaluation and optimisation of corrugated board structures.

Keywords: corrugated board, sectional homogenisation, buckling, non-linear material modelling.

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