Homogenization of corrugated boards through inverse analysis

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ABSTRACT

Homogenization of corrugated paperboards is an important issue in a packaging industry. These days the cardboard's boxes do not limit their functionality to just protect a cargo during transportation. They need to meet the requirements of optimal shape and visual design. From the practical point of view the boxes should be easily and controllably openable by tearing off the upper part and fit directly with the cargo to the shelves in the shops. Therefore a perforation on the side panels of a box is introduced, which helps in easier opening but also significantly reduces the compressive bearing capacity of the box. This implies to incorporate the sophisticated numerical tools into the design process of cardboard's structures.

Corrugated board consists of few layers of formed and connected paperboards. The typical cardboard has three layers: (1) a printable superior liner, (2) a sinus-shaped fluting and (3) interior liner. Each constituent of cardboard itself is an orthotropic material, having significantly higher stiffness in machine direction (MD) then in cross direction (CD), which together with non-isotropic plasticity of paper, interlayer debounding and local buckling of paperboard plies makes a numerical design complicated and time consuming task. To speed up the computations the effective elasto-plastic parameters can be computed and used in the homogenized model of corrugated board.

This work deals with a homogenization procedure which takes into account all above mentioned nonlinear effects in cardboard. In the literature a few proposals of homogenization, limited to elastic properties of corrugated board only, can be found (see e.g. [1],[2],[3]). Here the elasto-plastic effective parameters (embedded in an orthotropic elasticity combined with the generalized Hill's model) are computed through mixed numerical-experimental method (see e.g. [4]). The set of experiments of paperboard: short compression test (SCT) and cardboard: edge crash test (ECT), and box compression test (BCT) are enhanced here by a non-contact measurement with laser profilometer and a digital image correlation (DIC) in order to improve identifiability of sought parameters in an inverse procedure. The validation of the homogenized model is also performed. The results show the good agreement with the experimental data both in elastic and inelastic region.

References

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