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Environment-induced damage modelling of corrugated board by a sectional homogenisation methodology

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The mechanical performance of corrugated board is highly sensitive to environmental conditions, particularly temperature and relative humidity, due to the nature of its cellulose-based constituents [1,2]. This study introduces two-step sectional homogenisation methodology [3,4], aiming at incorporating temperature- and humidity-induced material damage into mechanical simulations. Consistently, a detailed 3D Representative Volume Element (RVE) is developed to characterise the temperature- and relative humidity -dependent constitutive behaviour of corrugated board structural constituent and sections, also accounting for experimental calibration data. In the first step of the computational methodology, the environment-dependent behaviours are homogenised onto a 2D shell model whose parameters evolve with the environmental state. In the second step, strains obtained from the homogenised model are applied back onto the RVE, for corresponding sectional elements, enabling the assessment of local stresses and “damage” conditions. This methodology provides a consistent representation of environment-induced damage conditions, as validated in the present investigation by numerical tests. The devised framework supports efficient computational analyses, while preserving an effective and specific description of corrugated board sensitivity. As such, it may serve as a robust tool for evaluating durability and supporting the optimisation of corrugated board structural components, intended for diverse environmental conditions.

Keywords: corrugated board, sectional homogenisation, humidity effects, temperature effects.

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