 ICCES, vol.13, no.4, pp.45-45

Simulation of damage in textile composites: model development and experimental validation

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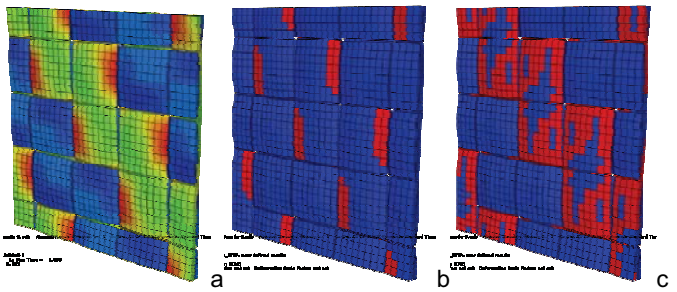
The paper will first introduce the general approach developed at the Katholieke Universiteit Leuven for modeling the internal structure of textiles and for prediction of the mechanical properties of textile based composites.

Then, the results of experimental observations of damage processes during tensile quasi-static and fatigue loading for carbon/epoxy textile composites will be presented, more specifically for (1) woven fabrics; (2) non-crimp fabrics (NCF); (3) structurally stitched NCF. The test methodology includes, apart from the "normal" tensile testing, registration of acoustic emission and full-field measurements of strains on the surface of the sample. The damage in the samples loaded to a certain characteristic level of strain or certain number of fatigue cycles, is studied using X-ray inspection and micrography of the cross-sections. Analogies between damage development in quasi-static tensile test and tension-tension fatigue are analyzed and links between the damage initiation thresholds in quasi-static tests and fatigue life are established.

Meso-level finite element modelling is performed for quasi-static tension of NCF and woven fabric composites, using a damage mechanics approach to model the progressive damage. It is shown to be a powerful tool for homogenisation of mechanical properties, study of stress-strain fields inside the unit cell, determination of damage initiation conditions and sites and simulation of damage development and associated deterioration of the homogenised mechanical properties of the composite.



FE modeling of tension (horizontal) of woven carbon-epoxy composite: (a) transverse stress in yarns, applied strain 0.29%; (b,c) damaged elements (transverse damage), applied strain 0.29% and 0.52%. Damaged elements: red.

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