Modeling yarn reorientation in woven composites under off-axis tensile loading with cohesive zone based conformal meshing

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ABSTRACT

The understanding of the mechanical response of woven composites under off-axis tensile loading requires a full description of the yarn-yarn and yarn-matrix interfaces. After the decohesion of the yarn contact interfaces and partial degradation of the matrix, the yarns will be allowed to reorient towards the loading direction, thereby leading to a rather ductile behavior. To capture this mechanical response, a degradation model should be used together with finite strain effects.

To achieve this, based on previous work [1, 2], a novel meshing methodology is proposed to extract the geometry of contacting surfaces from an implicit geometry description that is subsequently used for the conformal meshing of woven representative volume elements (RVEs) with cohesive zone elements (CZE). This allows simulating the decohesion of yarn-yarn and yarn-matrix interfaces and avoiding the distortion in elements during geometrically simulations.

With the benefit of such a meshing methodology, numerical simulations in ABAQUS are performed for a satin weave reinforced composite RVE with CZE damage under 45° tension with respect to the yarns directions. The yarns are modelled with transversely-isotropic material and the matrix is modelled with perfect plasticity. The CZE uses a linear softening traction separation law to describe the mechanical behaviour of the yarn-yarn and yarn-matrix interface. The plastic strain in the matrix and the von mises stress distribution in the yarn element is presented in Figure 1. The damage state in the CZE is also presented in Figure 1 where the element in red represent completely damaged interface. A substantial amount of decohesion is observed in the simulations which allows the reorientation of yarns as observed experimentally.

REFERENCES

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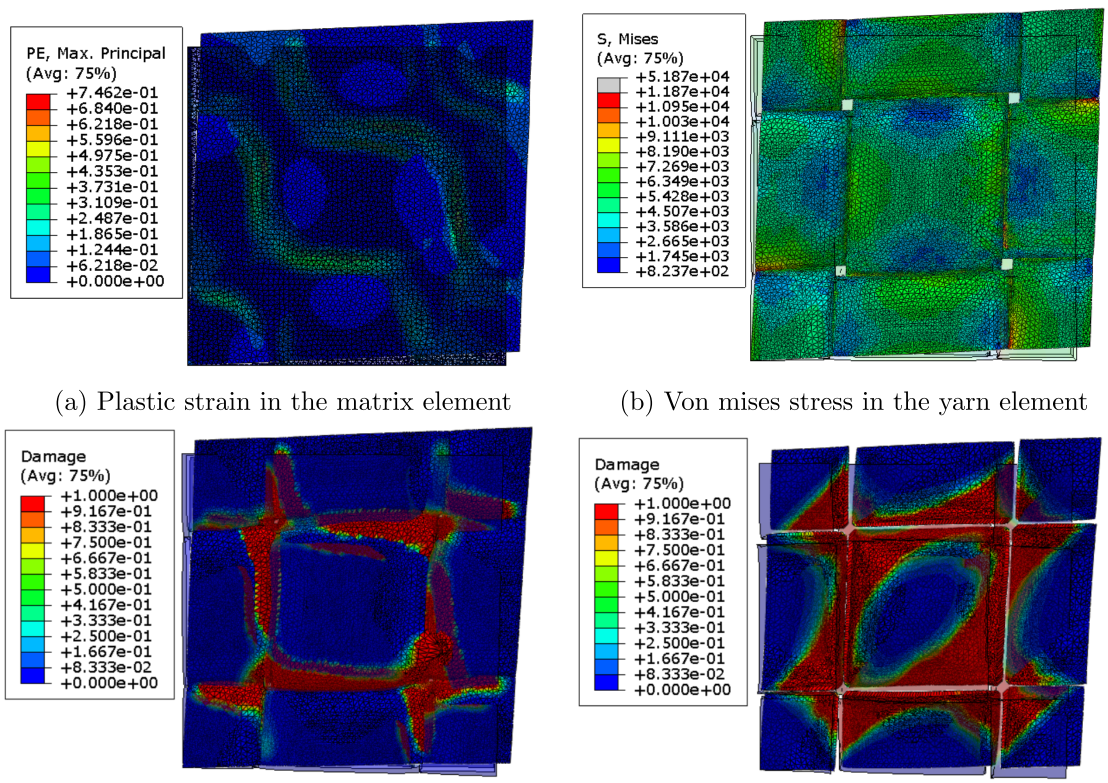

(a) Plastic strain in the matrix element

(b) Von mises stress in the yarn element

(c) Damage in the yarn-matrix CZE

(d) Damage in the yarn-yarn CZE

Figure 1: ABAQUS simulation of the plain weave RVE loaded 45° tension