

Supplemental Data

Comparison of Circular and Rectangular Cross-Section Fibers

A model with circular cross-section fibers was generated equivalent to the base model with square cross-section fibers. Due to the complex intersections between fibers, a constant contact radius between adjacent fibers could not be modelled. Instead, the natural intersection of the fibers was defined as fully bonded. With a layer spacing (Z) of 0.24 mm, the circular intersection yielded a mean radius of 0.16 mm when approximated as an ellipse. This was most comparable to the lower bound contact radius of 0.18 mm in the study.

As compared to the square fiber model, the circular fiber model had more complex geometric features and could not be meshed with hex elements in Abaqus. Tetrahedral elements (C3D10) were used instead with the same validated seed size from the square fiber model (0.075 mm). An equibiaxial condition was conducted using the circular fiber model with the same materials, boundary conditions, and analyses as the square fiber model. The full analysis with cylindrical fibers (meshing, solving, and post-processing) took more than ten times longer than the corresponding square fiber analysis.

Figure A3 shows the deformed state of both models and Table A1 compares the resultant mechanics of both models. Both models show visually similar deformation, though local stresses may vary between the two geometries. The maximum error in the calculated mechanics between the two geometries was 1.05% indicating a high level of agreement regardless of the square fiber approximation.

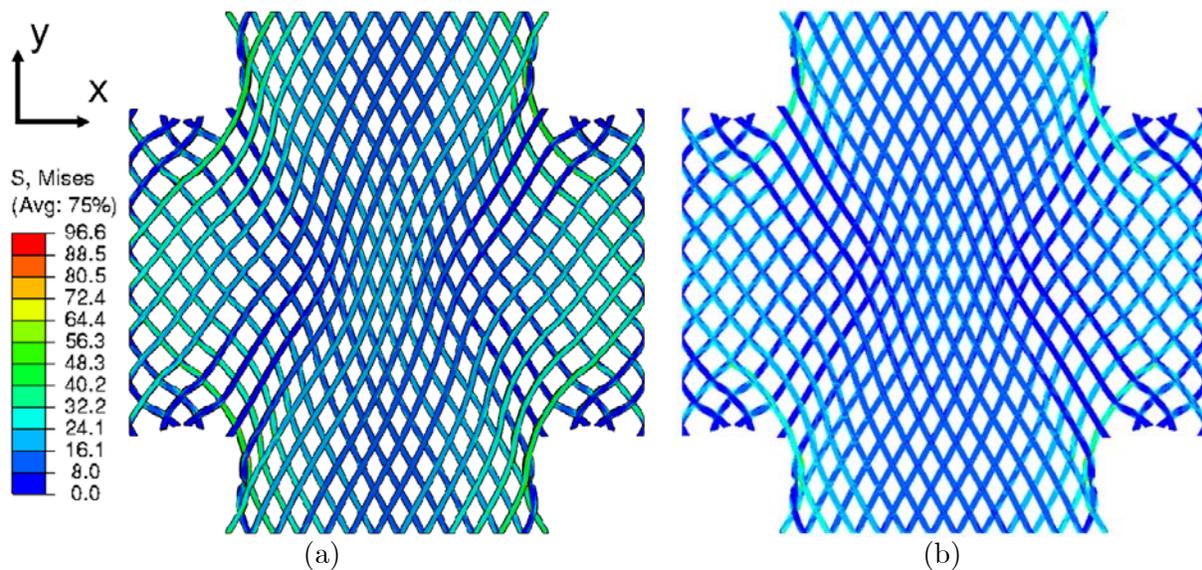


Figure A3. Comparison of (a) square cross-section fibers and (b) circular cross-section fibers subject to equibiaxial tension showing Mises equivalent stress contours (MPa).

Table A1. Resultant mechanics of square and circular cross-section fibers subject to equibiaxial tension showing error of square cross sections relative to circular cross sections.

	EE_x (MPa)	EE_y (MPa)	EE_r (MPa)
Circular Cross-Section	-9.88	32.8	-3.32
Square Cross-Section	-9.93	33.1	-3.33
% Error	0.584	1.05	0.462