Supplementary Information

Humidity Influence on Mechanics and Failure of Paper Materials: Joint Numerical and Experimental Study on Fiber and Fiber Network Scale

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Mesh Convergence study

In the following, we provide the details on how the mesh has been chosen: Generally, we used the commercial software Geodict to create the fiber network structure. The fiber network was generated based on the voxel geometry and a surface mesh was afterwards created based on that. Upon on initialization, voxel size of one micron was chosen. Then as the surface mesh was being created, coarsening procedure was performed with 25, 50, 75 and 100 percent of the initial surface mesh size. The surface mesh was then meshed to volume mesh using the open source meshing software Gmsh. We demonstrate how the mesh size was determined based on separation of a fiber/fiber cross sample (similar as in [1]), in order to determine the number of planar cohesive zone elements and element number needed to ensure the result. The four different degree of discretization are shown including their contact area with planar cohesive zone elements in figure S1. FE-simulation were then performed and their corresponding force-displacement curve plotted in figure S2. Table S1 shows the corresponding number of planar and volume element as well the mechanical properties considered with their relative error in comparison with the highest mesh density. The highlighted rows show the mesh results with relative errors smaller than 1 percent for all properties. This degree of mesh density and the corresponding element numbers needed were then chosen for all fiber networks.

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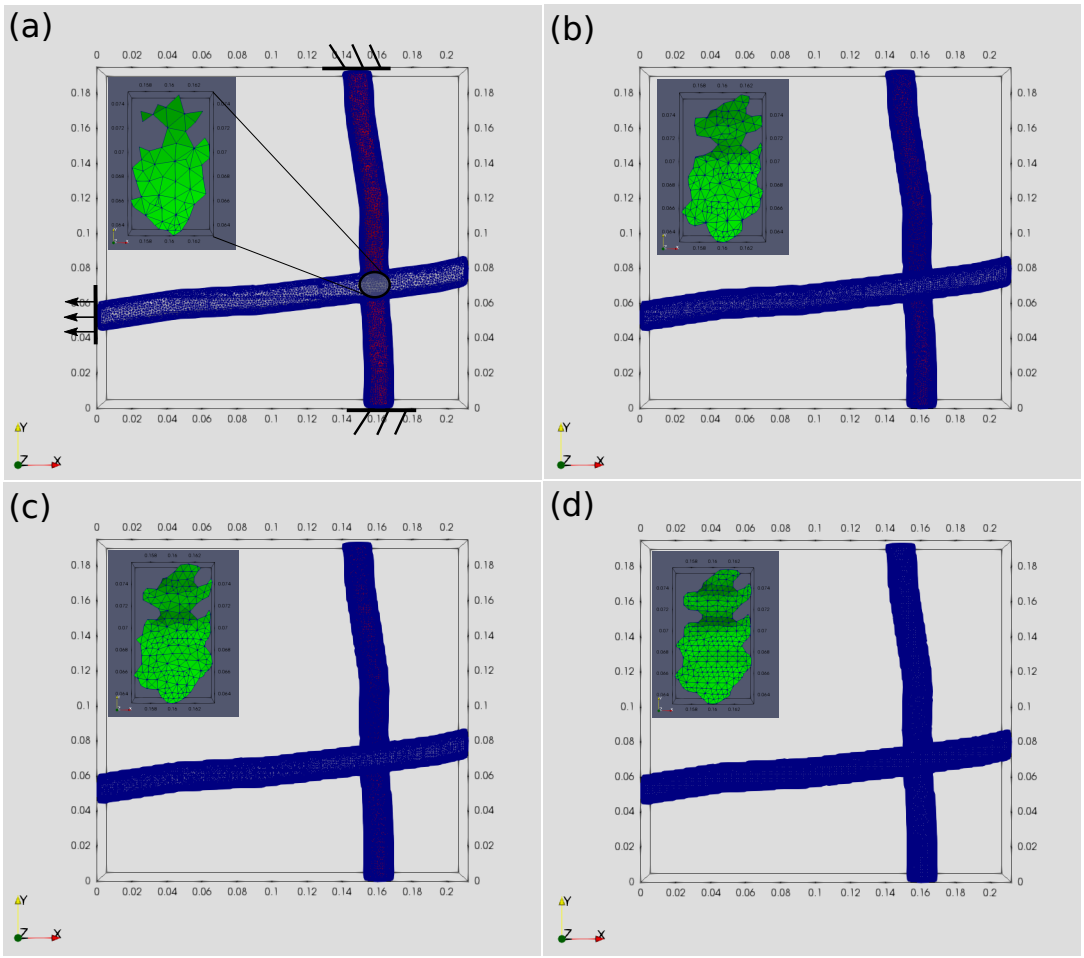

Fig. S1. Mesh discritization

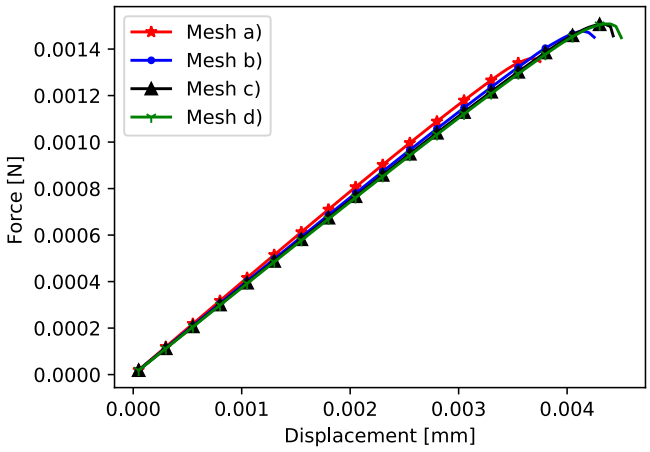

Fig. S2. F-D curve of the considered mesh sizes

Table S1. Result mesh convergence study

Mesh	Nr. of CZM-elements for the fiber cross sample	Nr. of 3D volume elements for the fiber cross sample	True area per CZM-element [μm^2]	3D volume element per fiber of length [300 μm]	CZM-elements per fibernetwork with total area of approx. 0.1 mm^2	3D element per fibernetwork with approx. 40 fibers
a)	80	4436	0.65	3327	15385	133096
b)	266	12776	0.25	9582	40000	383300
c)	324	35022	0.21	26267	47619	1050680
d)	476	60373	0.15	45280	66666	1811200

Mesh	Force at rupture [N]	rel. error [%]	Displacement to force at rupture [mm]	rel. error [%]	Stiffness [N/mm]	rel. error [%]
a)	0.001359	9.9	0.0037	14.94	0.3976	6.80
b)	0.001477	2.08	0.00415	4.59	0.3822	2.65
c)	0.001507	0.09	0.00435	0	0.3754	0.82
d)	0.001508	0	0.00435	0	0.3722	0

References

[1] Kulachenko, A. & Uesaka, T. Direct simulations of fiber network deformation and failure. *Mechanics of Materials* **51**, 1–14 (2012).