Supplementary Information for: *Stretching and Debonding of Adhesive Fibril*

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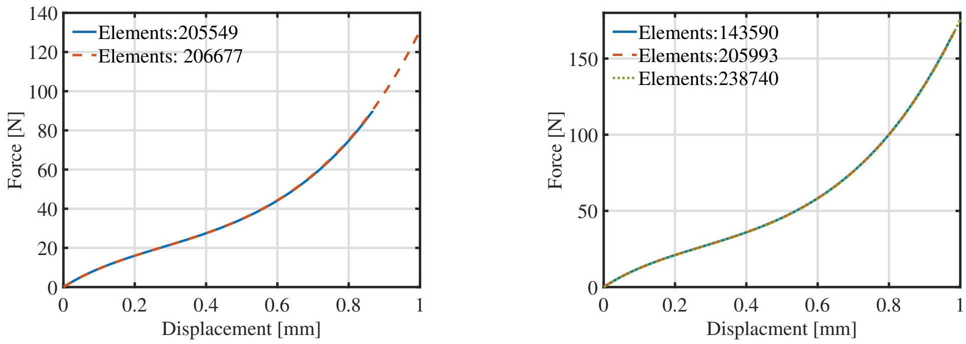
Contents

1 Mesh Invariance

(a) No. of finite elements= 219545 (b) No. of finite elements= 329682

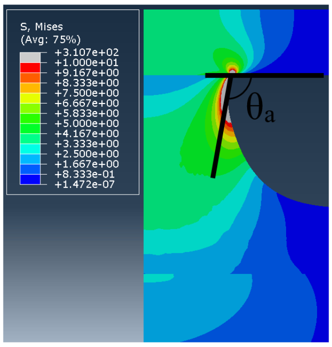
Figure S1: Fibril simulations for a/t=1.1, Arruda-Boyce, μ_{rigid}/μ_{soft} = 1000, λ_L=2, $\lambda = 3$: Mesh invariance: von Mises stress distribution



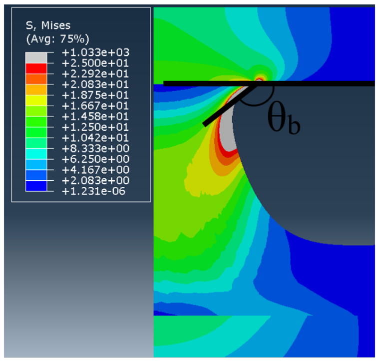
(a) a/t=2.0 (b) a/t=2.2

Figure S2: Mesh invariance: Force vs displacement, Arruda-Boyce, μ_{rigid}/μ_{soft} = 1000, λ_L=2, $\lambda = 3$: where (a) a=1 mm and t=0.5mm (b) a=1.1mm and t=0.5mm

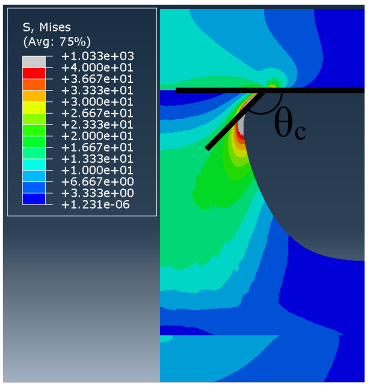
2 Effect of changing Bulk Modulus on fibril simulation



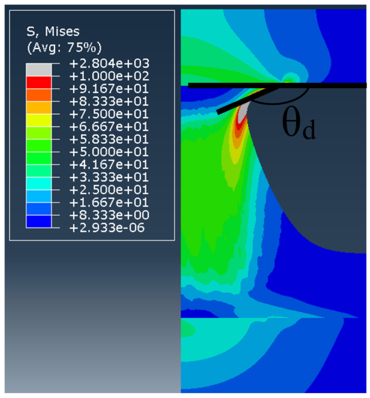
(a) D_1=1 MPa^{-1}, K_1=2 MPa



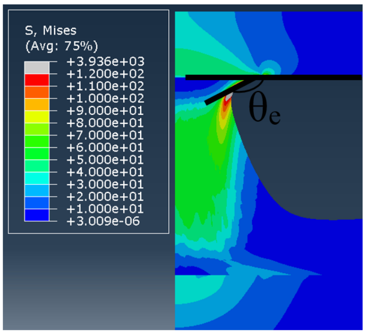
(b) D_1=0.1 MPa^{-1}, K_1=20 MPa



(c) D_1=0.01 MPa^{-1}, K_1=200 MPa

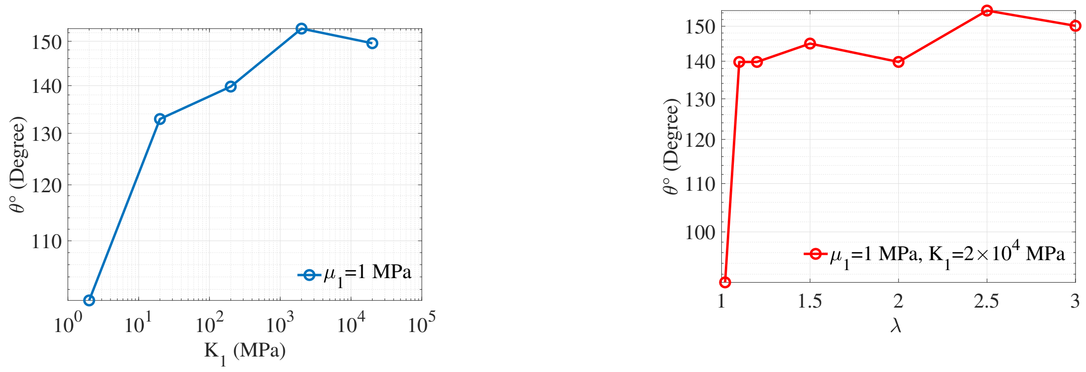


(d) D_1=0.001 MPa^{-1}, K_1=2000 MPa



(e) D_1=0.0001 MPa^{-1}, K_1=20000 MPa

Figure S3: The change in the defined interface angle of fibril due to the change in bulk modulus: a/t=1, μ_1=1 MPa, μ_{rigid}/μ_{soft} = 1000, λ_{L1}=2, λ=3

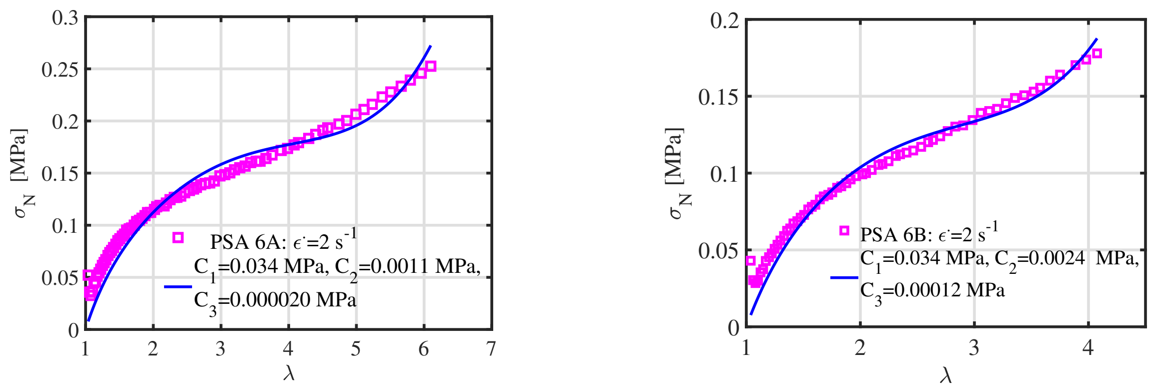


(a) Change in angle at the interface with the bulk modulus for the particular stretch: $\lambda = 3$

(b) Change in angle at the interface with the stretch for the given bulk modulus: K_I=20000 MPa

Figure S4: Change in angle at the interface: Arruda-Boyce, a/t=1, b=10 mm, μ=1 MPa, $\lambda_L = 2$

3 Fibril debonding



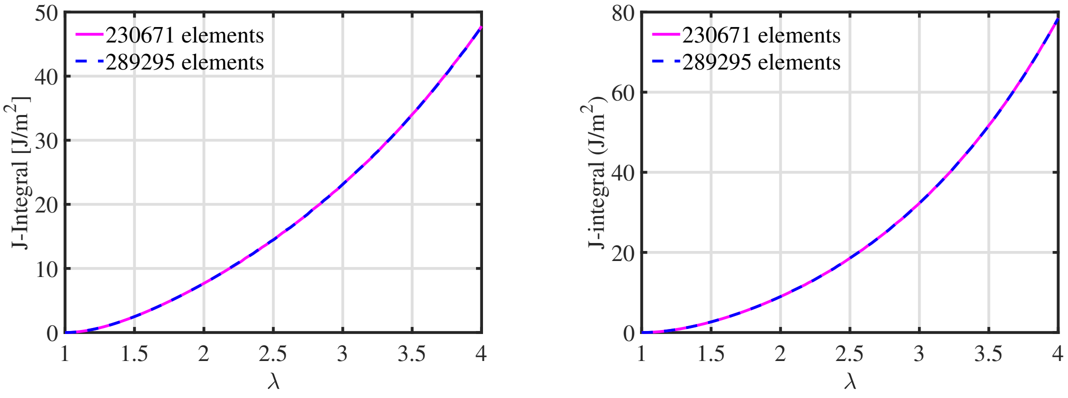
(a) PSA tape 6A

(b) PSA tape 6B

Figure S5: Yeoh model fit for the reference strain rate of 2 s^{-1}

In order to validate the ABAQUS implementation of J, we first consider the energy difference between two simulations where everything is constant except the radius of the contact patch a (which corresponds to the crack front position), letting the aspect ratio change from $a/t = 1$ to 1.1 (for fixed thickness t). More precisely we evaluate the quantity:

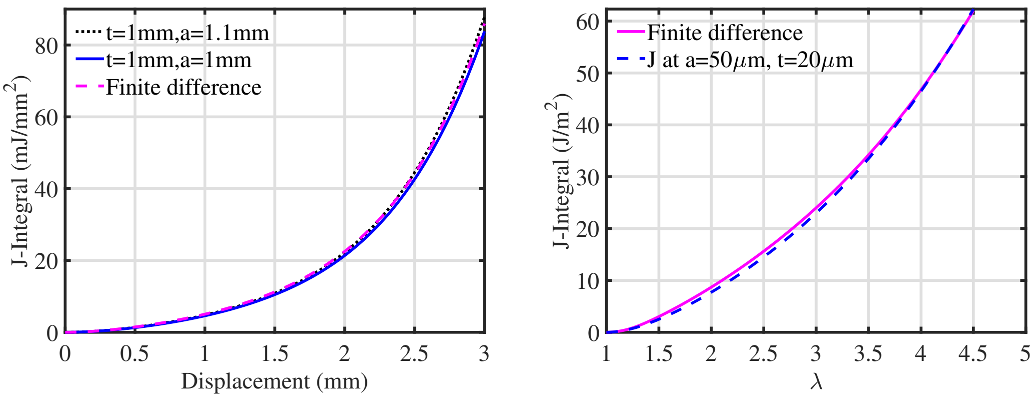
$$J = \frac{\Delta U_{el}}{\Delta A} = \frac{U_{el}(a+) - U_{el}(a-)}{2\pi a_-(a_+ - a_-)} \tag{1}$$



(a) PSA tape 6A

(b) PSA tape 6B

Figure S6: J-integral: a=50μm, t=20μm, Φ=5%

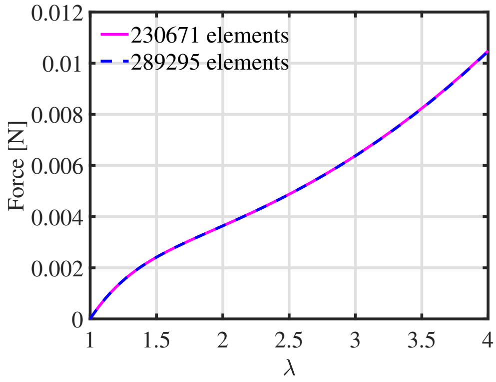


(a) Arruda-Boyce, $\lambda_L = 2$

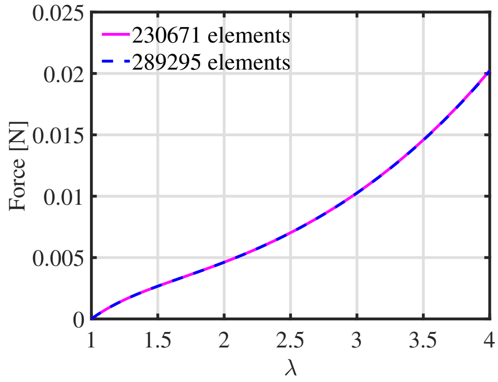
(b) Yeoh Model: PSA tape 6A

Figure S7: J-integral validation by Energy difference method

where $U_{el}(a)$ is the strain energy of the fibril simulation having initial radius a and thickness t, and $a+$ and $a-$ are two close values. The calculations were carried out for both the Arruda-Boyce model (with the parameters of table 1 and $\lambda_L = 2$) and the Yeoh model (with the parameters of tape 6A from table 3). In figs. S7a and S7b we show the good agreement between the J-integral evaluated by ABAQUS and the one determined by the energy difference method as a function of the applied stretch for the two material models.

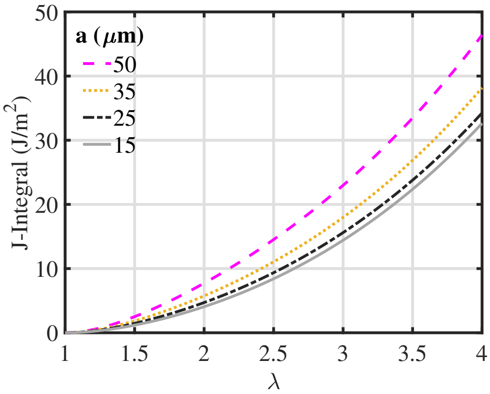


(a) PSA tape 6A

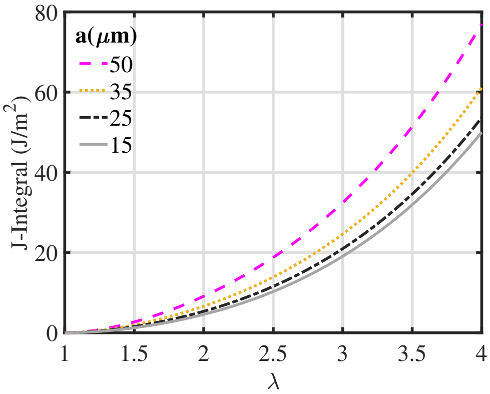


(b) PSA tape 6B

Figure S8: Force vs. stretch: a=50μm, t=20μm, Φ=5%

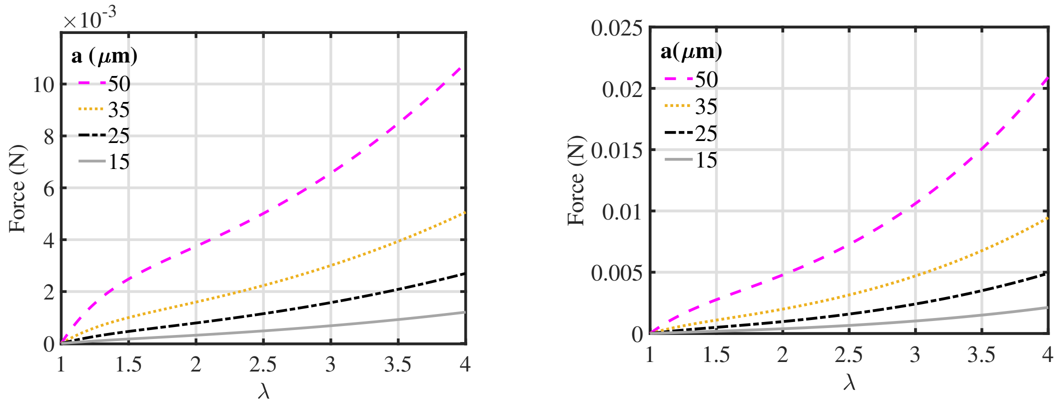


(a) PSA tape 6A



(b) PSA tape 6B

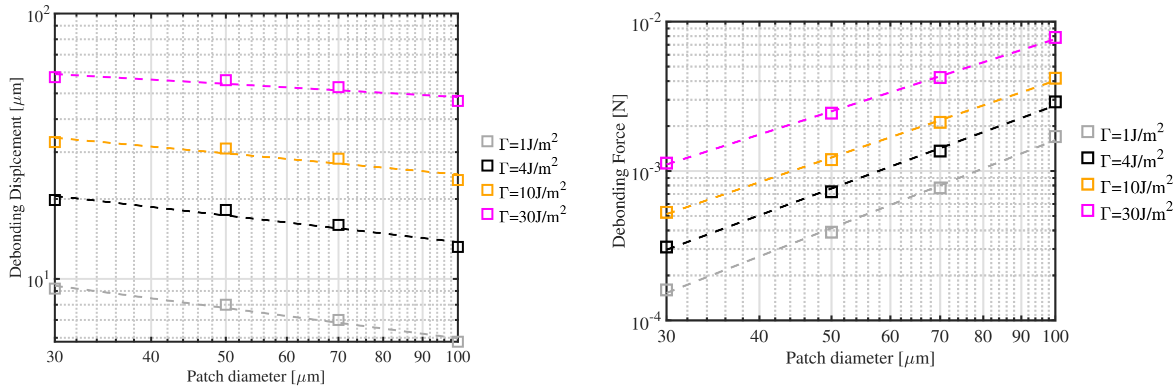
Figure S9: J-integral: t=20μm, Φ=5%



(a) PSA tape 6A

(b) PSA tape 6B

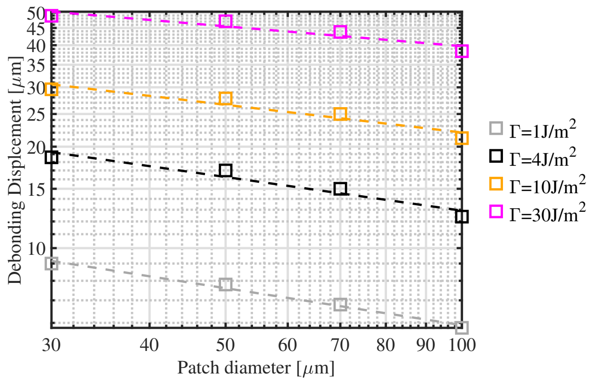
Figure S10: Force vs. stretch: t=20 μm, Φ=5%



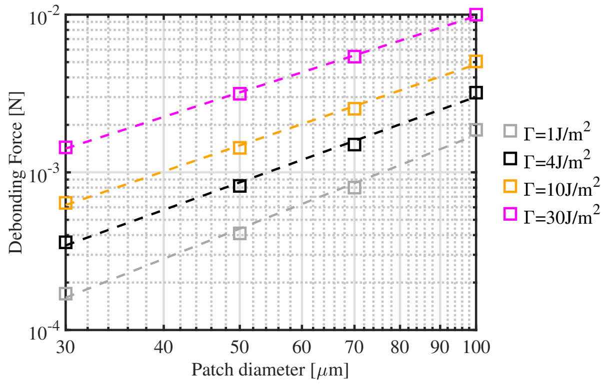
(a) Debonding Displacement

(b) Debonding Force

Figure S11: PSA tape 6A: t=20μm, Φ=5%, Square markers are the simulation data points and the dotted line represents a fit to the simulation data points



(a) Debonding Displacement



(b) Debonding Force

Figure S12: PSA tape 6B: t=20μm, Φ=5%, Square markers are the simulation data points and the dotted line represents a fit to the simulation data points

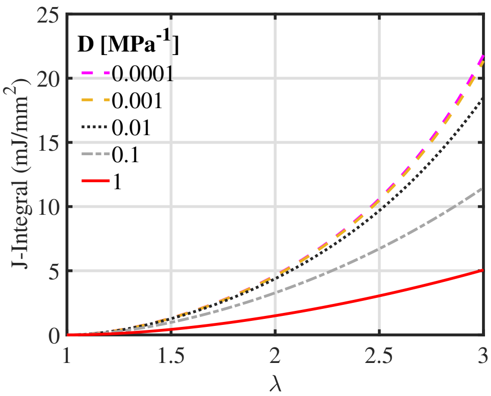


Figure S13: J-integral at different compressibility level: Arruda-Boyce, a/t=1, b=10 mm, μ=1 MPa, $\lambda_L = 2$