Single Edge Notched Shear Test (SENS) [16]

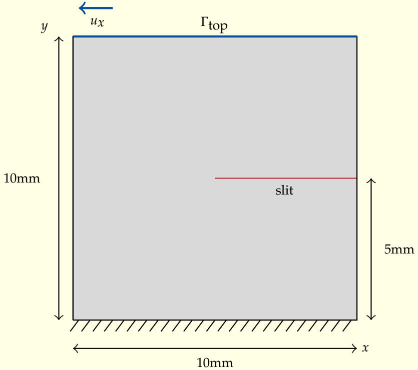

Figure: Geometry and boundary conditions of the single edge notched shear test.

Parameter	Value
λ	121.15kN/mm^2
μ	80.77kN/mm^2
ν	0.3
G_c	2.7N/mm
h	0.044mm
ϵ	0.044mm
δt	10^{-4}s
$\mathcal{I}$	0.036s
κ	10^{-10}

Table: Settings of the material and numerical parameters for the single edge notched shear test.

[16] C. Miehe, M. Hofacker and F. Welschinger, *A phase field model for rate-independent crack propagation: Robust algorithmic implementation based on operator splits*, Computer Methods in Applied Mechanics and Engineering, Elsevier 199/45-48 (2010): 2765-2778.

$\nu \to 0.5$ SENS

ν	μ	λ
0.3	$80.77 \cdot 10^3$	$121.15 \cdot 10^3$
0.49	$80.77 \cdot 10^3$	$395.77 \cdot 10^4$
0.499	$80.77 \cdot 10^3$	$403.04 \cdot 10^5$

Table: Tests with different Poisson's ratios.

ν	min. #DoF	max. #DoF
0.3	$11,829$	$158,759$
0.49	$46,181$	$192,573$
0.499	$46,181$	$189,554$

Table: The minimal and maximal number of degrees of freedom on the adaptive meshes.

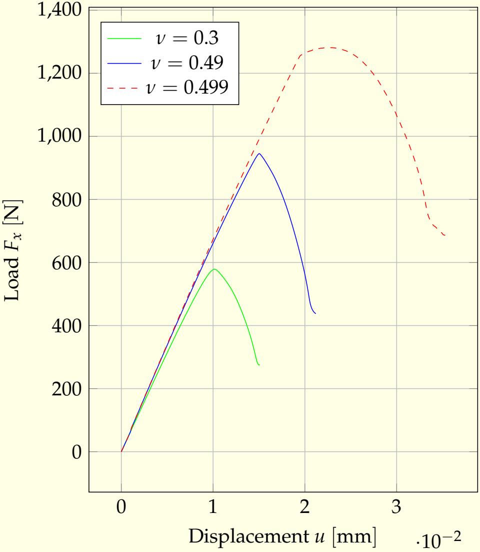

Figure: Load-displacement curves.

L-Shaped Panel Test[17]

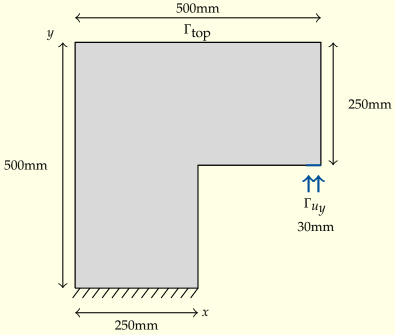

Figure: Geometry and boundary conditions of the L-shaped panel test.

Parameter	Value
λ	$6.16\text{kN}/\text{mm}^2$
μ	$10.95\text{kN}/\text{mm}^2$
ν	0.18
G_c	$8.9 \times 10^{-5}\text{kN}/\text{mm}$
h	7.289mm
ϵ	14.0mm
δt	10^{-3}s
$\mathcal{I}$	0.4s
κ	10^{-10}

Table: Standard settings of the material and numerical parameters for the L-shaped panel test.

[17] B. J. Winkler, *Traglastuntersuchungen von unbewehrten und bewehrten Betonstrukturen auf der Grundlage eines objektiven Werkstoffgesetzes für Beton*, Innsbruck University Press (2001).

$\nu \to 0.5$ L-shaped Panel Test

ν	μ	λ
0.18	$10.95 \cdot 10^3$	$6.18 \cdot 10^3$
0.4	$10.95 \cdot 10^3$	$42.36 \cdot 10^3$
0.49	$10.95 \cdot 10^3$	$51.89 \cdot 10^4$

Table: Tests with different Poisson's ratios.

ν	min. #DoF	max. #DoF
0.18	$13,765$	$46,376$
0.4	$13,765$	$44,744$
0.49	$13,765$	$46,747$

Table: The minimal and maximal number of degrees of freedom on the adaptive meshes.

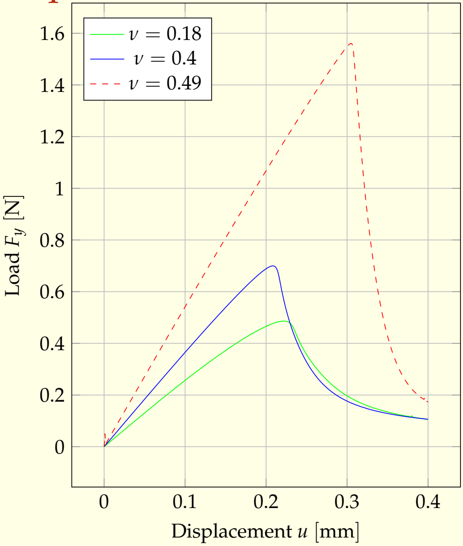

Figure: Load-displacement curves.

Phase-field Function for $\nu = 0.18$

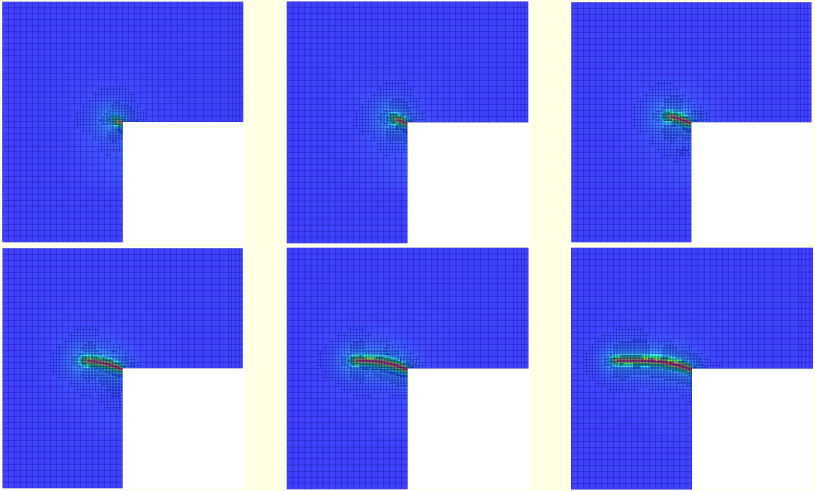

Figure: The phase-field function after three adaptive refinement steps in incremental step 0.236, 0.243, 0.255, 0.276, 0.307 and 0.4s on the current adaptive mesh.

Phase-field Function for $\nu = 0.49$

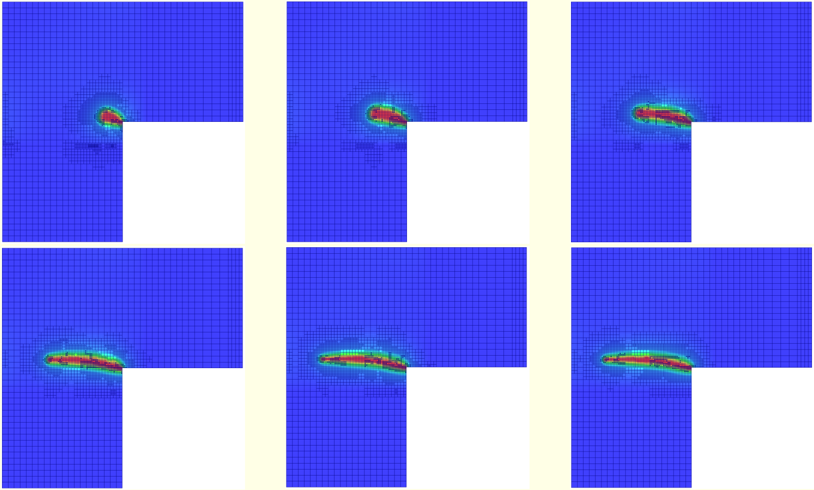

Figure: The phase-field function after three adaptive refinement steps in incremental step 0.32, 0.33, 0.336, 0.37, 0.394 and 0.4s on the current adaptive mesh.

Remarks

- L-shaped panel test originally done with concrete
- Single edge notched shear test originally done with Poisson's ratio $\nu = 0.3$
- Assumption of our model: linear elasticity
- Contradiction: nearly incompressible materials as rubbers allow large deformations
- We just increased the Poisson's ratio, what's about the critical energy release rate and the Young's modulus?

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- **Again: we are happy to get your input and discussions!**

Collaboration with DIK[18]

⇒ Compare experimental and numerical results of crack propagation

- Sulphur crosslinked EPDM (Ethylen-Propylen-Dien-Kautschuk; Keltan 2450: type of the Kautschuk) filled with 60 phr (parts per hundred parts of rubber) carbon black $N550$
- Nearly incompressible ($\nu \approx 0.4999$)

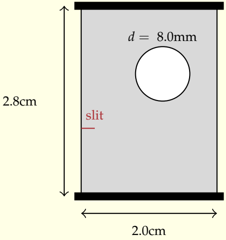
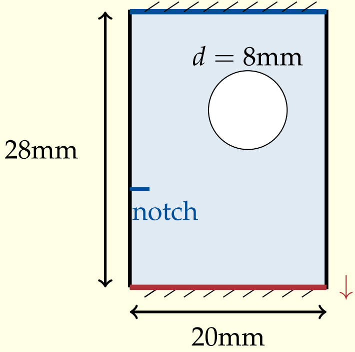


Figure: Geometry of the elastomer plate. The sample is fixed on the top boundary and we pull on the bottom boundary.

Figure: Setup of the experiment.

[18] N. H. Kröger, *Deutsches Institut für Kautschuktechnologie e.V., Hannover.*

Setup for the numerical simulations



G_c	Critical energy release rate	0.97 N/mm
λ	Lamé's first parameter	2369 N/mm^2
μ	Shear modulus	1.22 N/mm^2
ν	Poisson's ratio	0.4999

Figure: Setting of the material parameters evaluated via separated experimental tests used for running the numerical tests.

Some current results of the crack paths

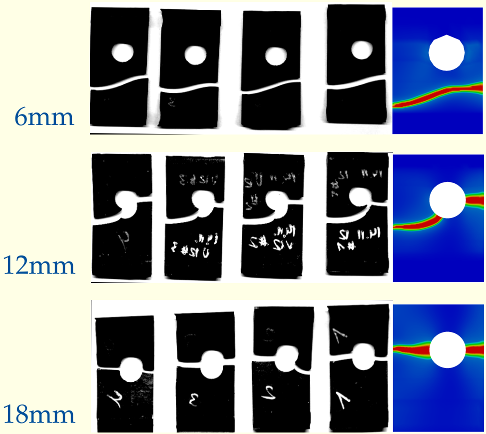


Figure: Crack paths in punctured EPDM strips compared to the FEM simulation with a given notch at $6, 12$ and 18mm measured from the bottom boundary.

- These results show that our current model seems to have some applicability for treating nearly-incompressible solids!

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- Some successes and shortcomings of our proposed variational phase-field fracture models
- A numerically stable phase-field model for nearly incompressible fracture
- Numerical advancements in deriving a posteriori error estimates used for local mesh adaptivity. In ongoing work also useful for solver control and multiple goal functional evaluations

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Key references of this talk

- T. Heister, M.F. Wheeler, T. Wick; CMAME, 2015;
- D. Wick, T. Wick, R.J. Helmig, H-J. Christ; Comput. Mater. Sci July 2015;
- T. Wick; Comp. Mech, 2016;
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Thanks for attending my talk!