FEM simulation of sheet piles type LZ250-12-A/B

Consulting project A18090100178 on behalf of SteelWall ISH GmbH

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Short description

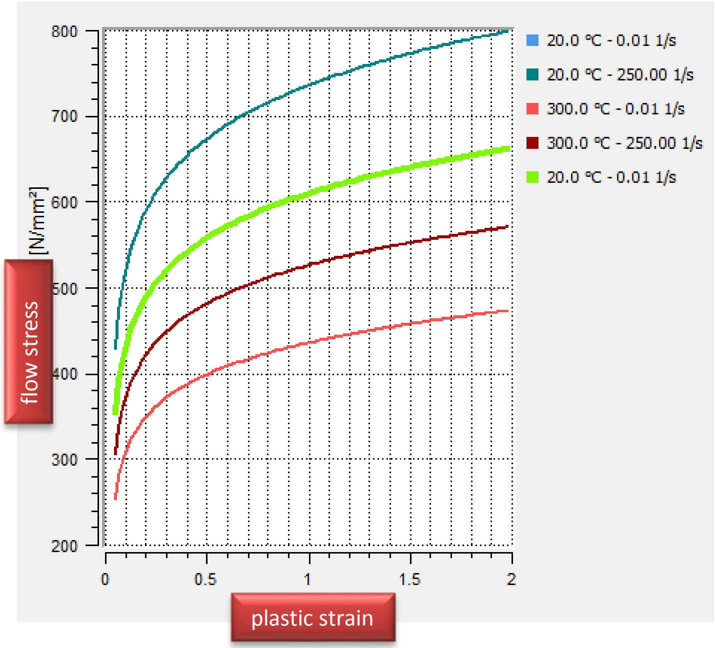
- A simulation of tensile and compressive loading of sheet piles is conducted for SteelWall ISH GmbH.
- This is done for the profiles LZ250-12-A and LZ250-12-B and two different materials.
- The simulations are set up as 2D planar calculations, assuming a plane strain state and a die velocity of 1mm/s.
- Different variations of initial positioning, friction values as well as material tensile strength and strain rates will be evaluated.
- Main focus of the post processing lies on the evolution of forces over stroke as well as the distribution of the maximum principal stresses.

Material data

- Sheet piles are made from S355GP or S430GP
- Assumed/researched characteristics:

Mechanical properties			Chemical Distribution				
Material	Min. yield stress	Min. tensile strength	C	Si	Mn	P	S
	MPa	MPa	%	%	%	%	%
S355GP	355	480	0,27	0,6	1,7	0,055	0,055
S430GP	430	510	0,27	0,6	1,7	0,055	0,055

Source: http://www.spundbohlen.com/steel-grade.html (26.09.2018)

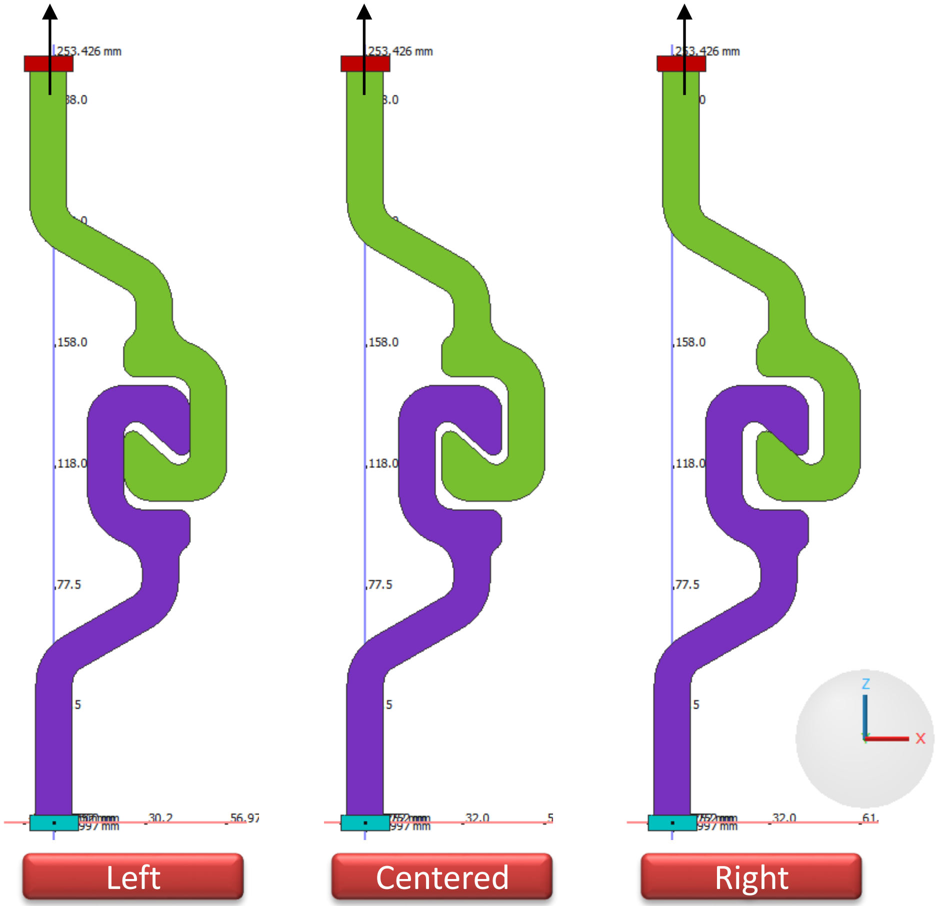


- The S355 data set from the Simufact Forming database is used and scaled to the according min. yield stress

Tensile tests

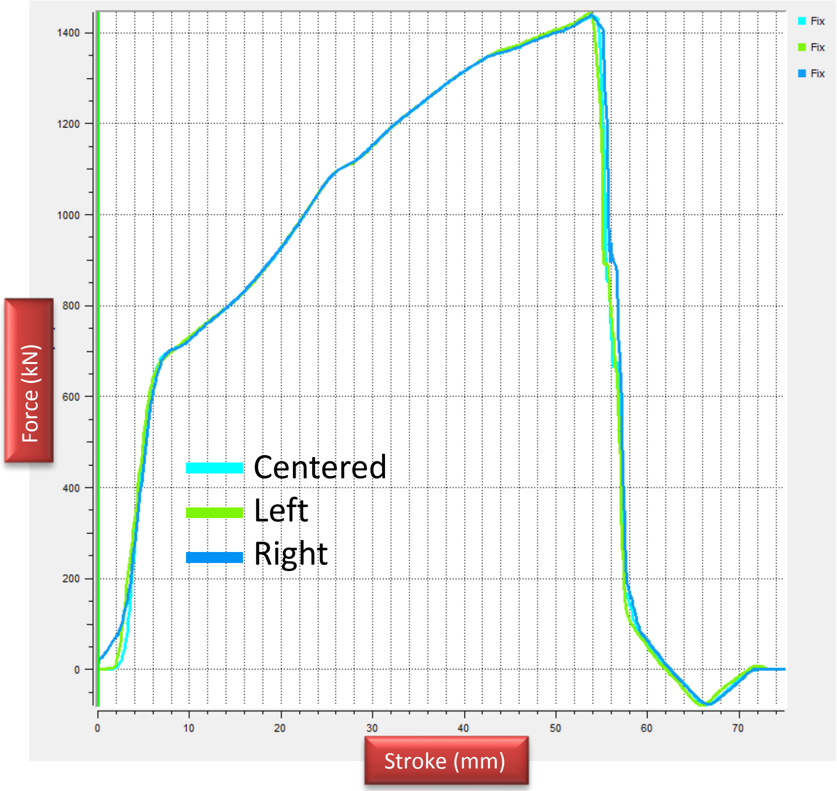
Comparison initial positioning

- Examination of the initial horizontal position:
  - Centered: profile ends centered on a common axis
  - Left: Moving profile placed as far in –X as possible
  - Right: Moving profile placed as far in +X as possible



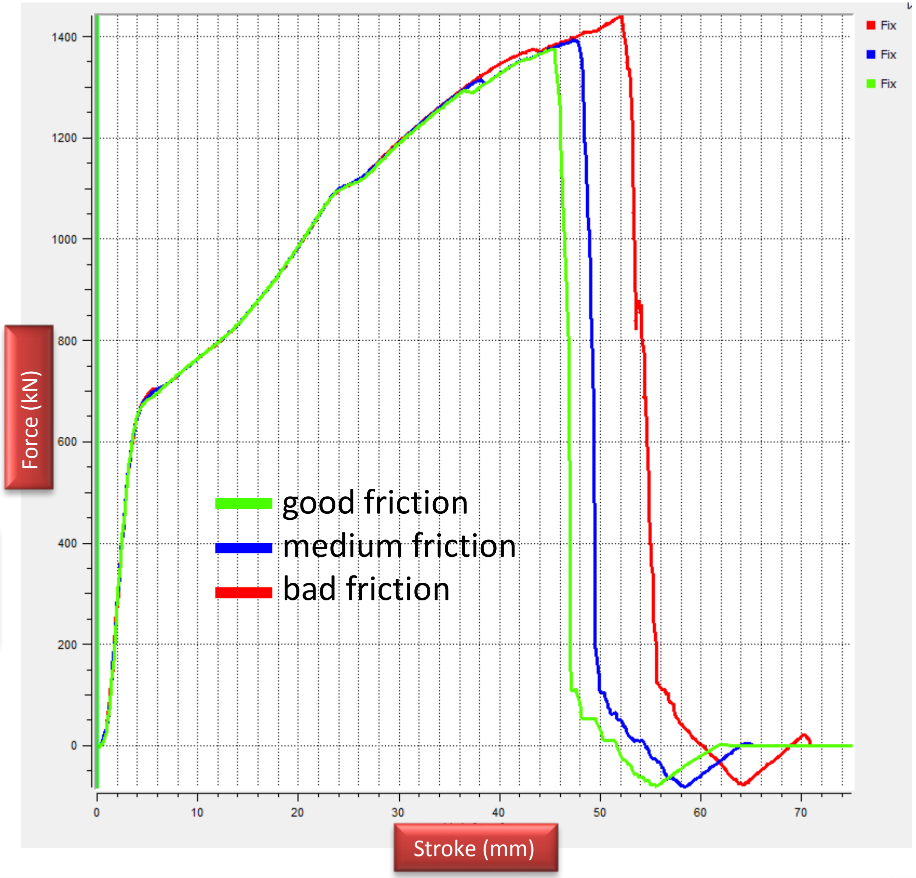
Comparison initial positioning

- Differences in achieved maximum force and stroke at failure are minimal.
- For further tensile tests the centered position will be used.



Comparison friction properties

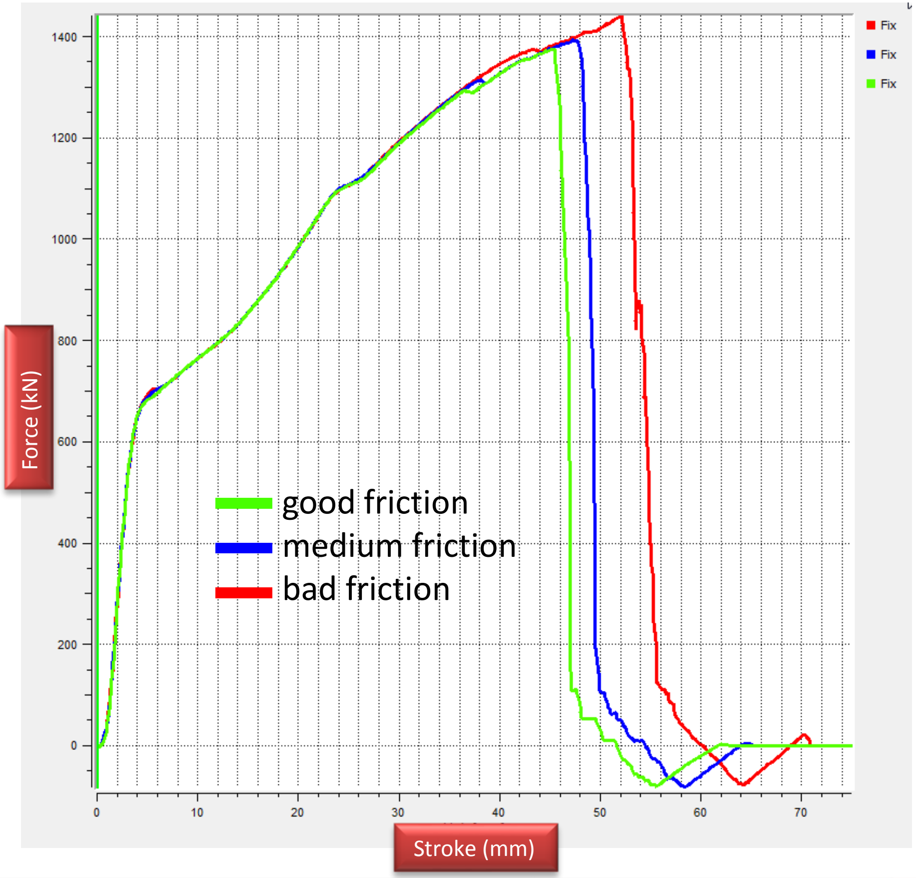
- Tensile test with three different friction conditions:
  - ‘Good’ friction: smooth surface
  - ‘Bad’ friction: rough/oxidized surface
  - ‘Medium’ friction: mixture of good and bad friction
- Note: All shown forces refer to a sheet pile length of 1m!



Comparison friction properties - Results

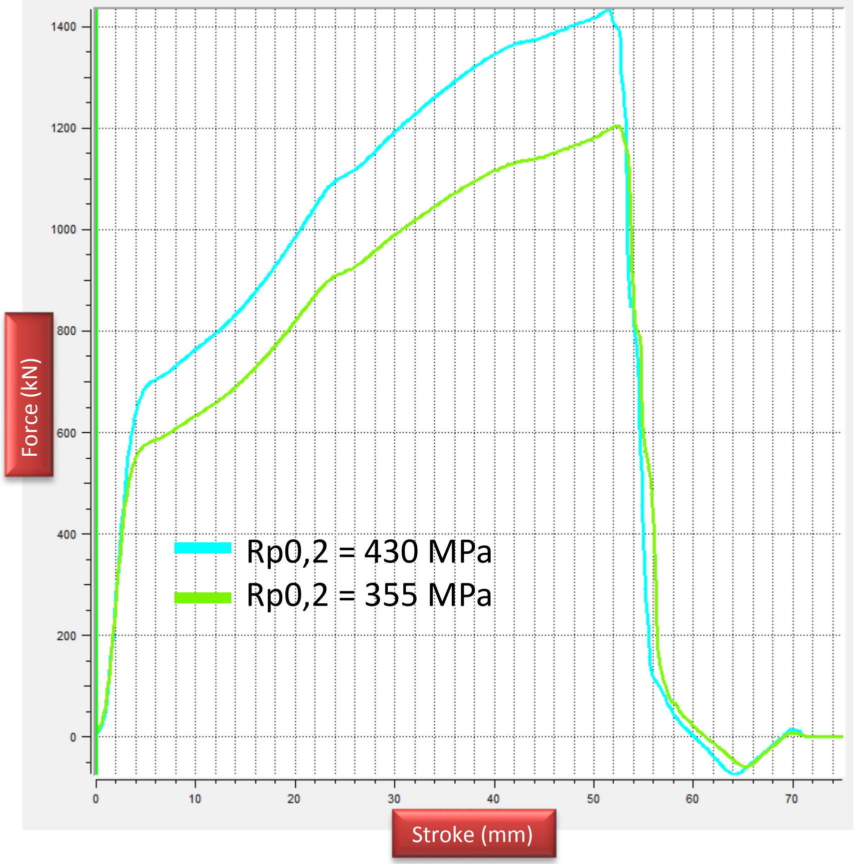
- The lock fails at:
  - good: 45,8mm/1380kN
  - medium: 48mm/1395kN
  - bad: 52,5mm/1445kN

- Difference of 6,7mm/65kN between good and bad friction.
- ‘Bad’ friction is used for further simulations as it is assumed that the sheet piles do not receive a special surface treatment and are possibly oxidized.



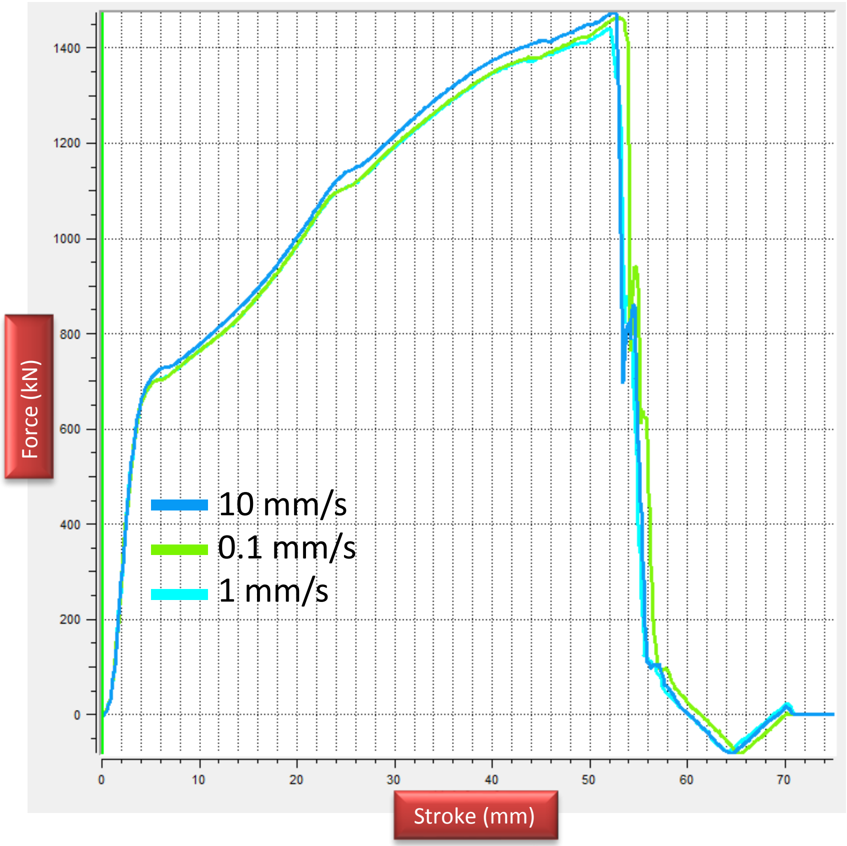
Comparison of material strength

- The same flow curve set was scaled to 355 resp. 430 MPa Rp0.2 to respect the **minimum** yield stress of the steel grades S355GP and S430GP:
  - S355GP: 53,2mm/1215kN
  - S430GP: 52,5mm/1445kN
- Difference of 0,7mm/230kN between the two materials.
- Distinctive difference in force but almost the same stroke until failure.



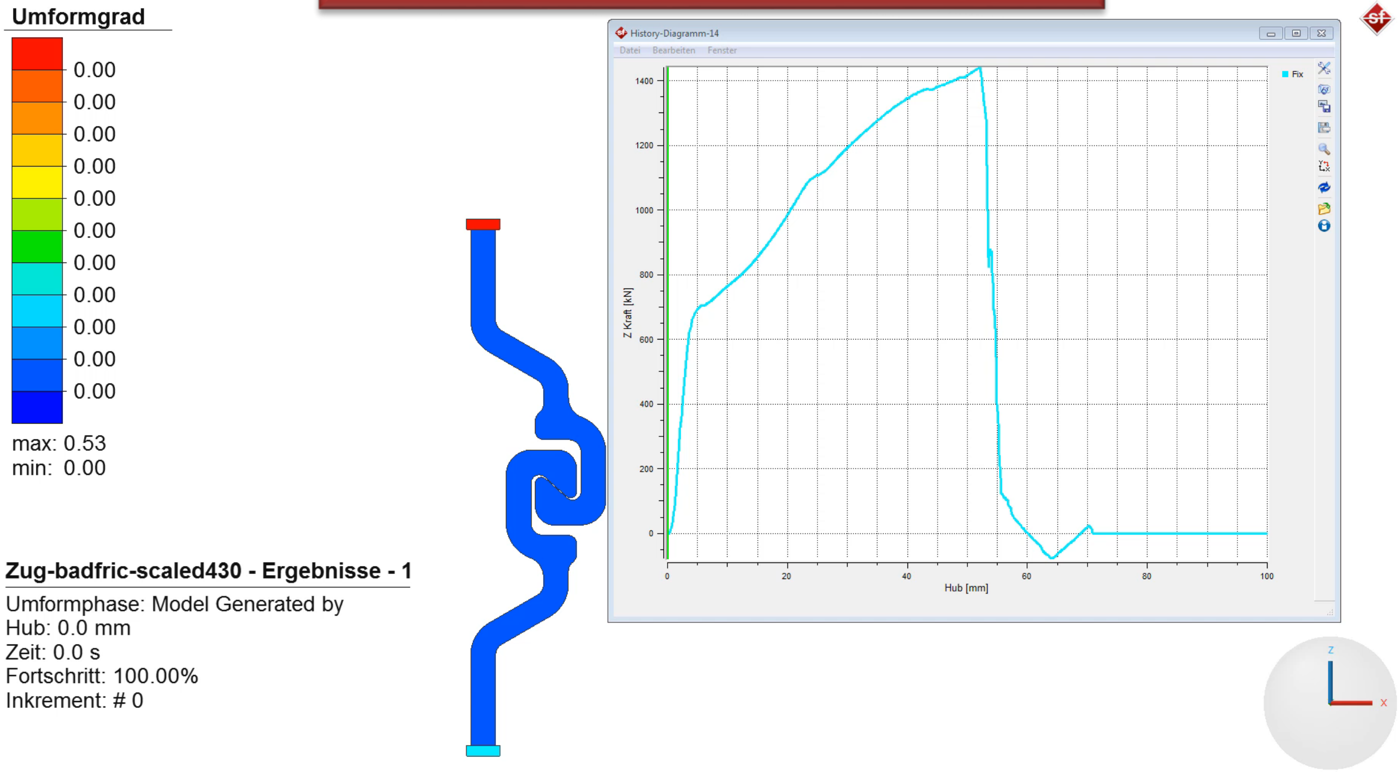
Comparison of strain rates

- The tensile test with Rp0.2 = 430MPa and ‘bad‘ friction is conducted with different strain rates.
- Therefore the tensile test is done with die velocities of 0,1mm/s, 1mm/s and 10mm/s respectively.
- The achieved forces for the two slower tensile tests are very similar. This is because the occurring strain rates are close to the low end of the material data definition.
- The fastest tensile test shows an increase in force of 2-3%.



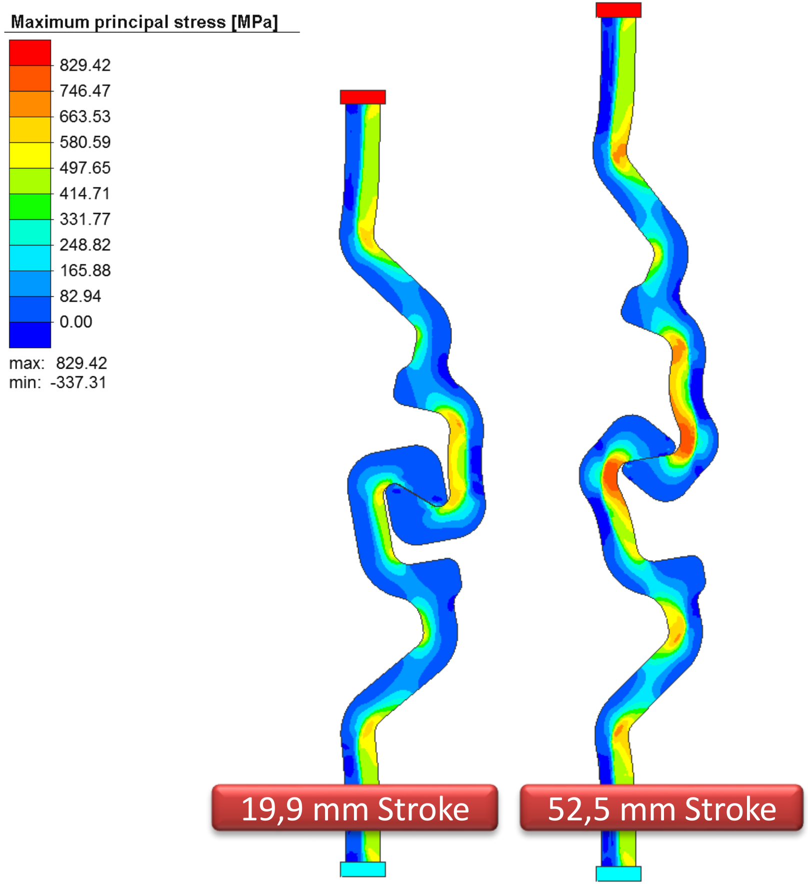
Animation tensile test Rp0.2 = 430 MPa, 1mm/s

Animation shows plastic strain and the Force – Stroke evolution in the graph



Maximum principal stresses

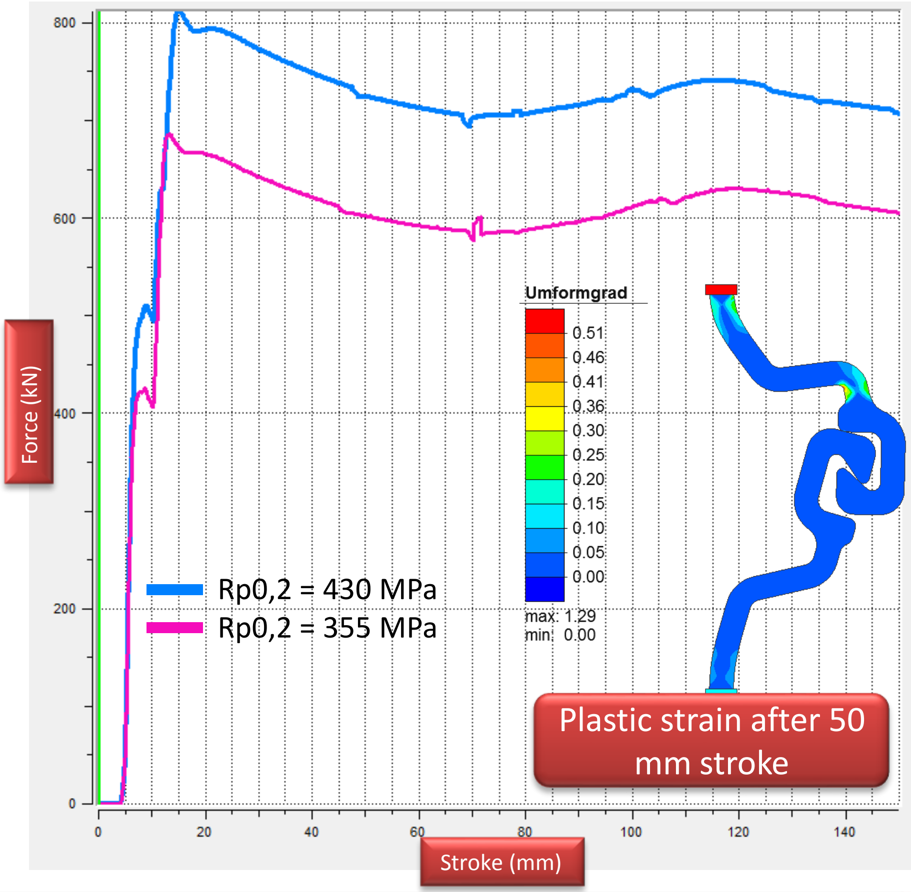
- The maximum principal stress shows the highest possibly occuring tensile stresses in the material.
- Tensile stresses are often an indicater for possible material failure (e.g. fracture).
- It shows that the occuring tensile stresses prior to the complete failure of the lock exceed the tensile strength of the material which can be an indicator for a premature fracture.
- If a fracture actually occurs is very material dependent and cannot be accurately predicted without a calibration with real experiments.



Compression test

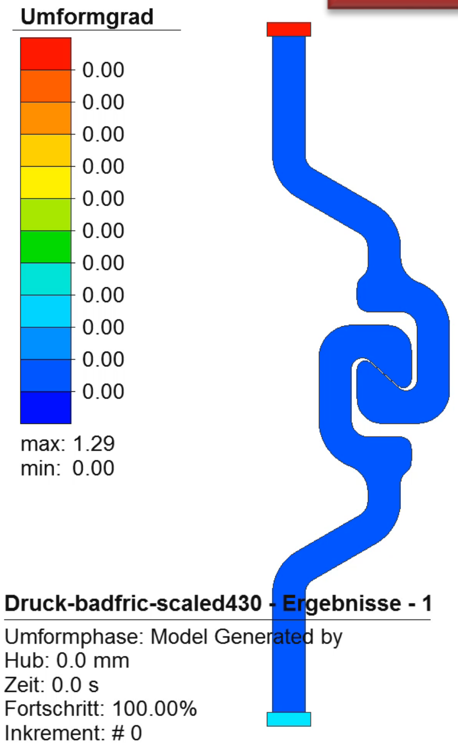
Compression test

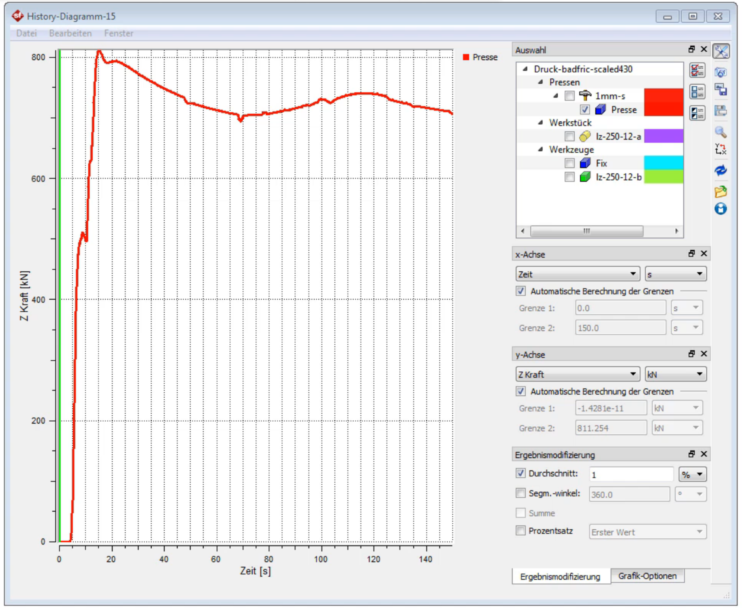
- For the compression test the die movement is reversed and the sheet pile is compressed with 1mm/s.
- The force exceeds 800 kN until it starts to deform plastically. This happens at a stroke of roughly 10 mm after the initial contact of the lock profiles.
- With increasing stroke the deformation grows.
- However the lock does not open during the compressive load.



Animation compression test Rp0.2 = 430 MPa

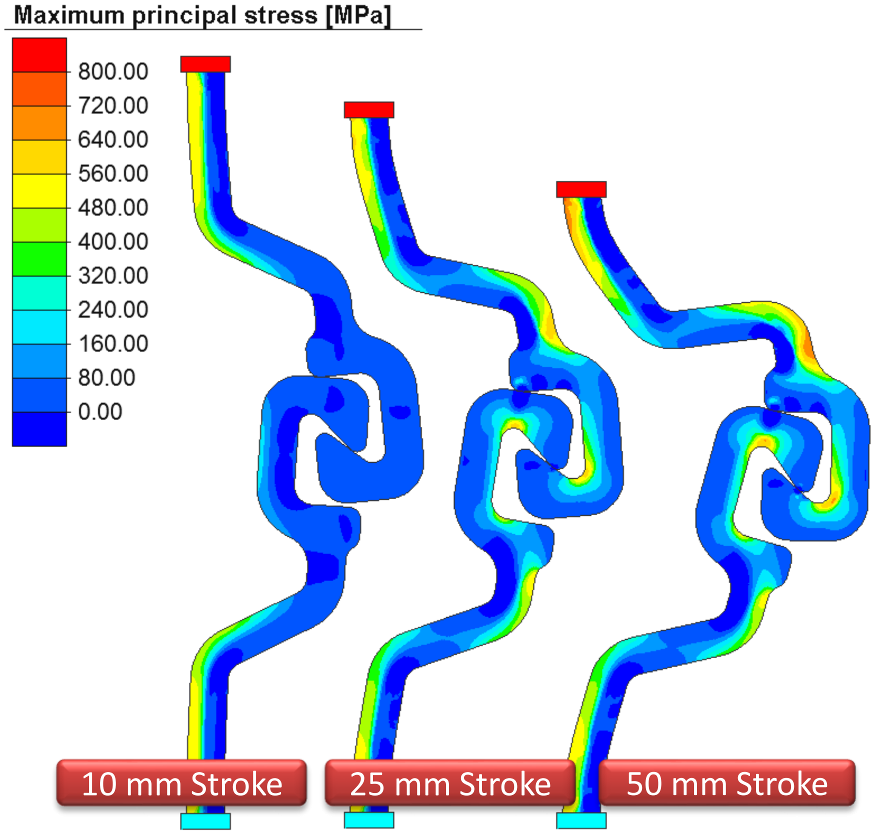
Animation shows plastic strain and the Force – Stroke evolution in the graph





Maximum principal stresses

- The highest tensile stresses (and the highest plastic strain) occure at the connection of the upper lock.
- This is the area with the (theoretically) hightes risk of fracture. If it actually breaks or keeps deforming plastically would have to be confirmed with real experiments.



Thank You Very Much

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