FH Bielefeld
University of
Applied Sciences

SCHÜCO

COMSOL
CONFERENCE
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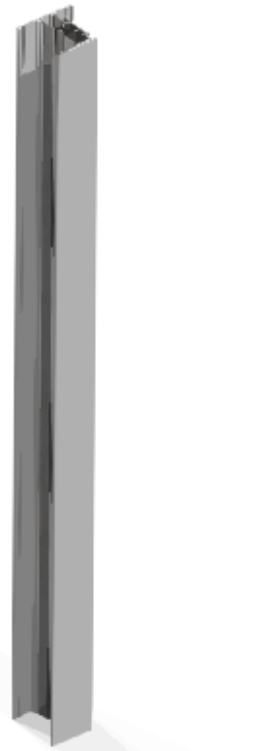


Influence of Notches in Corners of Casement Windows under Thermal Load

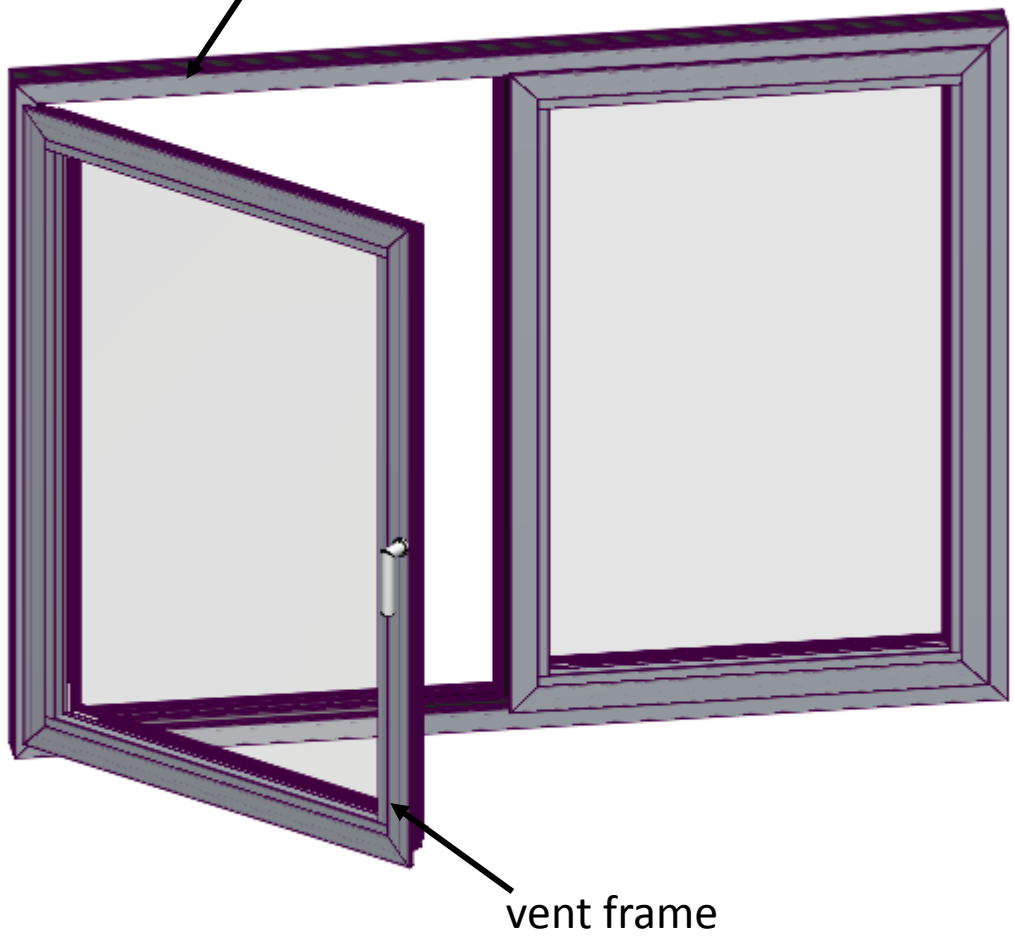
Outline

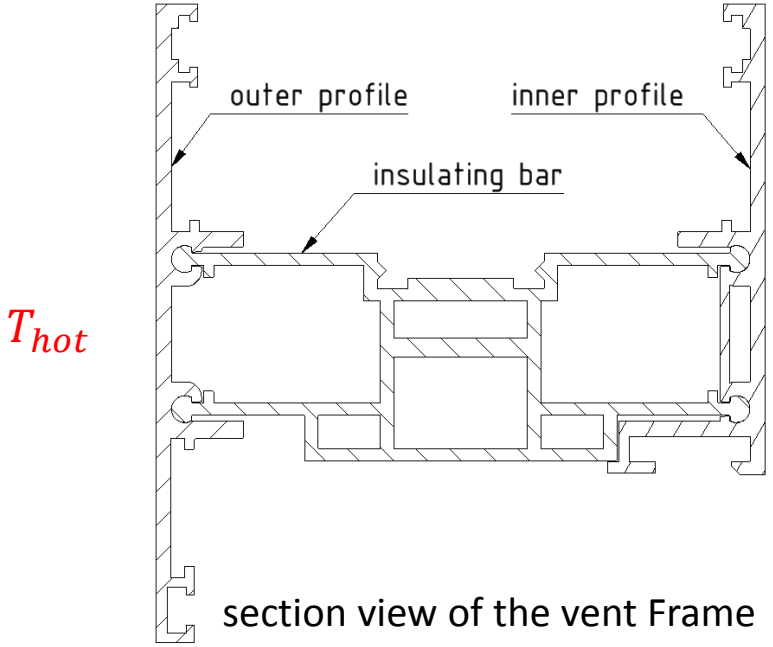
1. Introduction
2. Task 1: Pre-Investigation
3. Task 2: Main-Investigation
4. Conclusion

Schüco

- Leading suppliers of high-quality window, door and facade systems made from aluminium, PVC-U and steel
- Head office is in Bielefeld (Germany)
- International presence in more than 80 countries
- 4,630 employees worldwide

The Casement Window





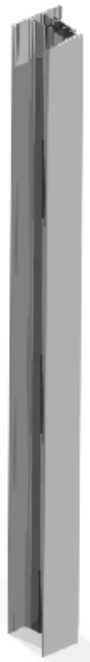
section view of the vent Frame

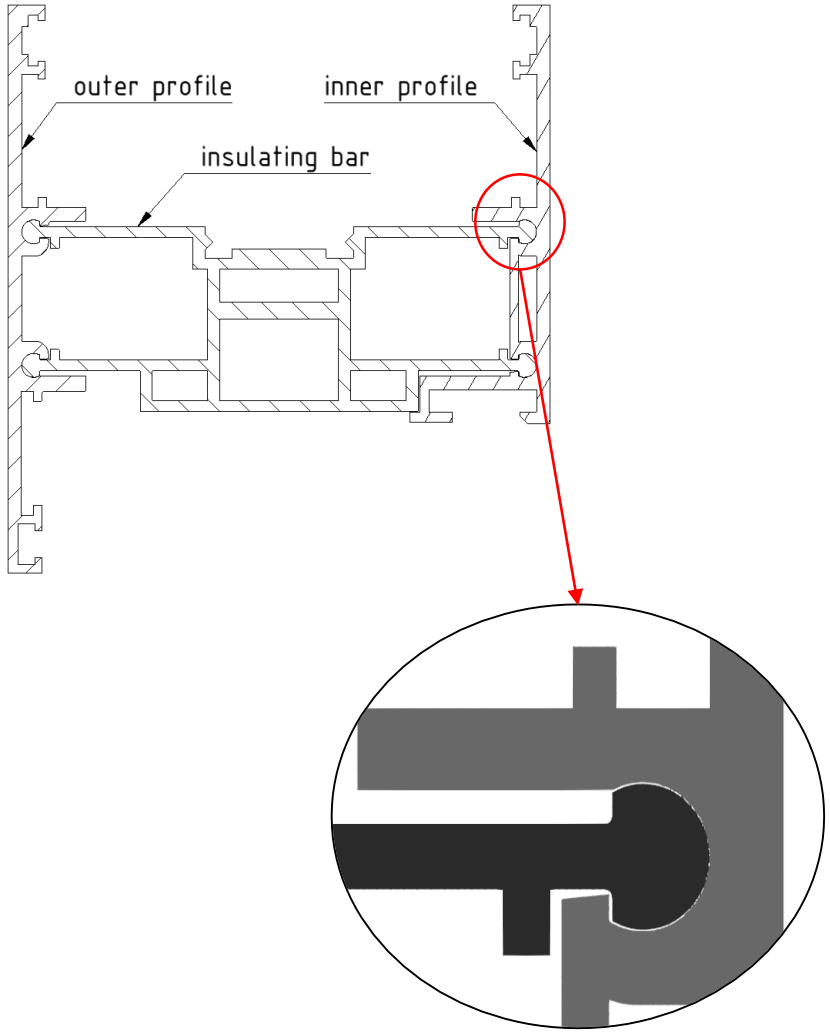
Problem: The difference in temperature causes a deflection in the corner of the profile

Task 1: Pre-Investigation

Deflection of an extruded one-meter profile

- $\Delta T = 60\ K$
- Glued connection between the insulating bar and the profiles
- Linear-elastic material model
- Analytical result (comparison)

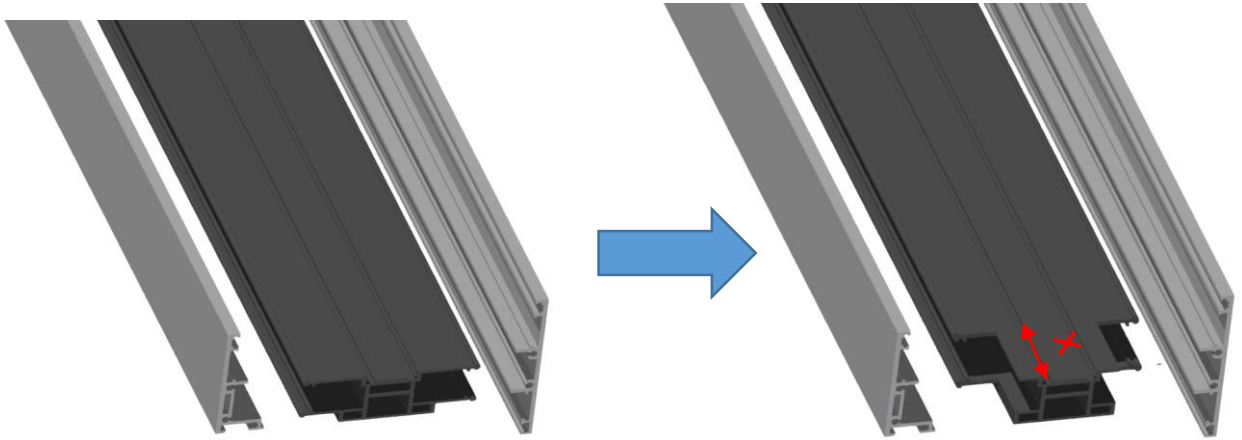




Task 2: Main-Investigation

Deflection of a profile in a corner

- $\Delta T = 60\ K$
- Notches on the insulating bar for the following lengths (x)
  - 60 mm
  - 100 mm
  - 150 mm
  - 200 mm
- Aluminum profiles deform elastic-plastic
- Comparison: Glued and contact case

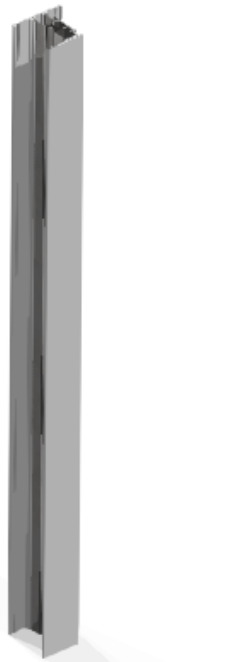


Outline

1. Introduction
2. Task 1: Pre-Investigation
   - Constraints
   - Mesh
   - Results
   - Analytical result with a simplified model

Pre-processing

Post-processing



3. Task 2: Main-Investigation
4. Conclusion

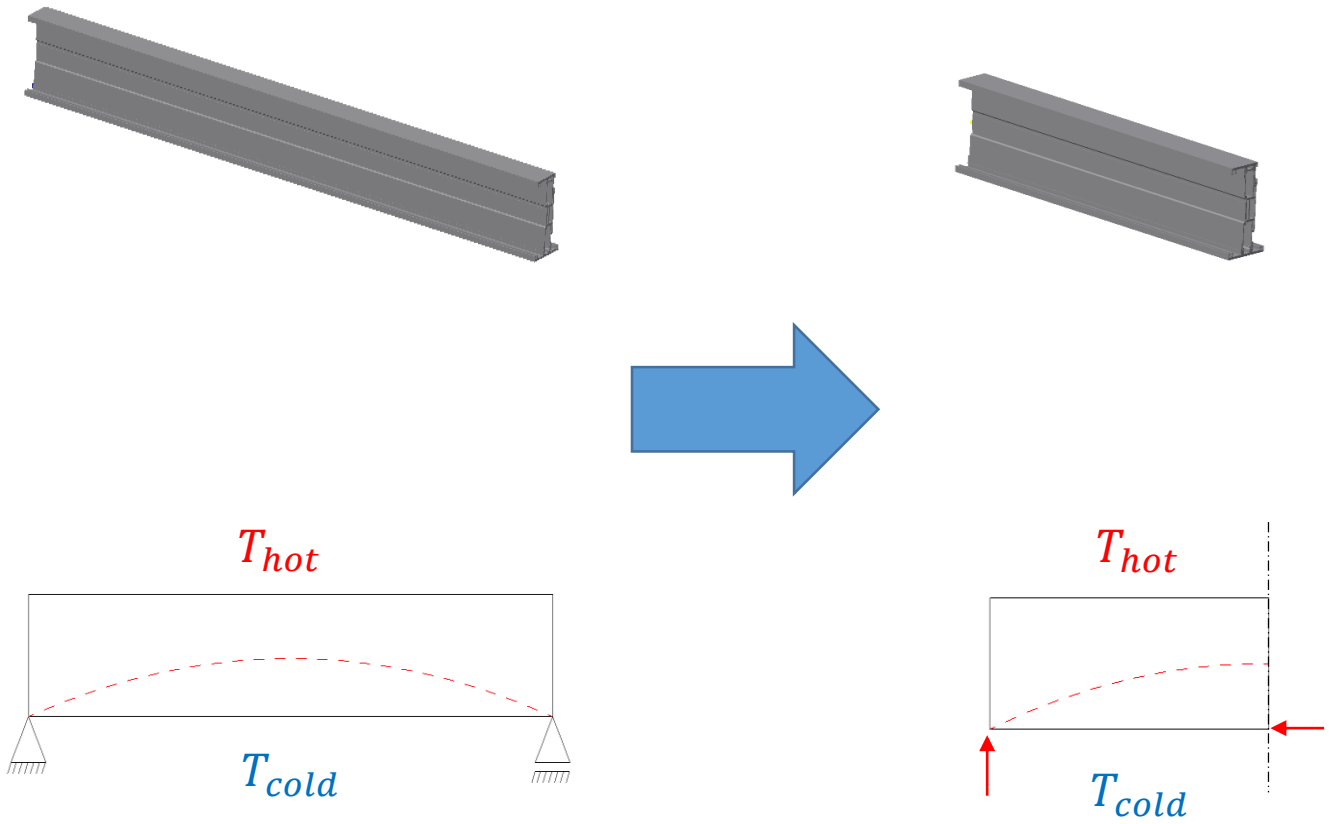
Constraints

Heat Transfer in Solids

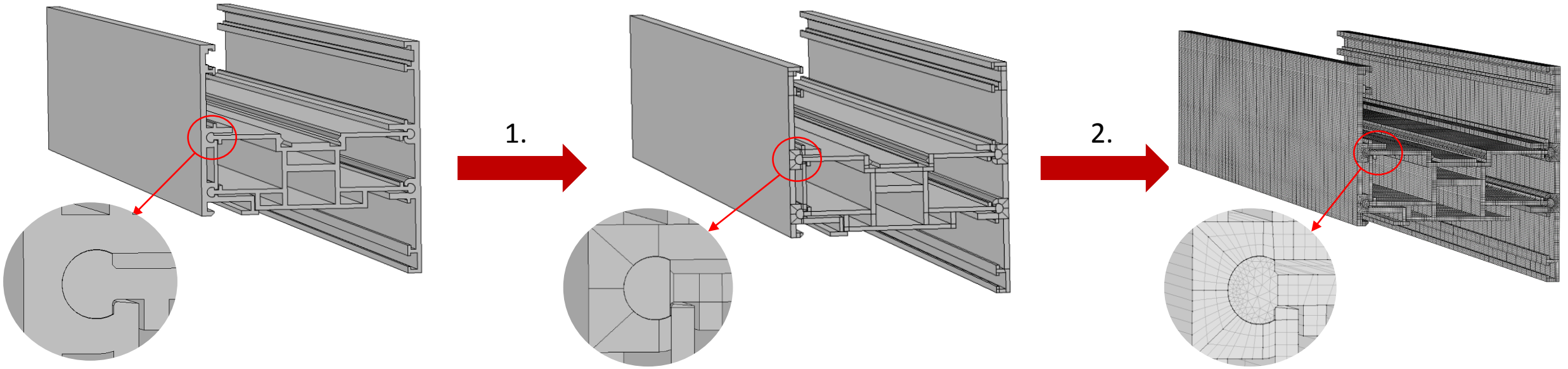
- Temperature
- Continuity

Solid Mechanics

- Prescribed displacement
- Symmetry
- Continuity



Mesh



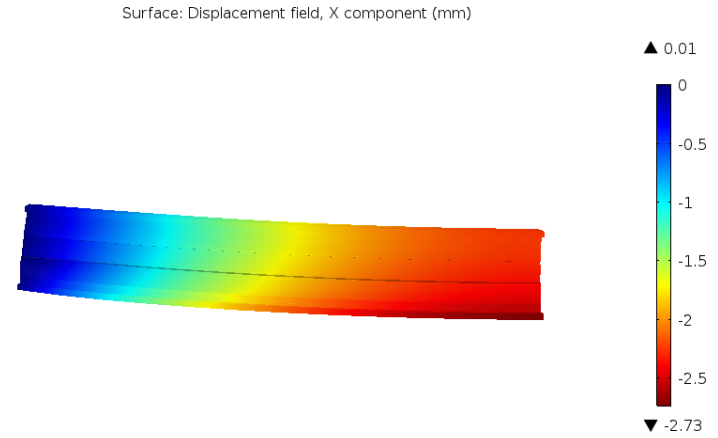
1. Step

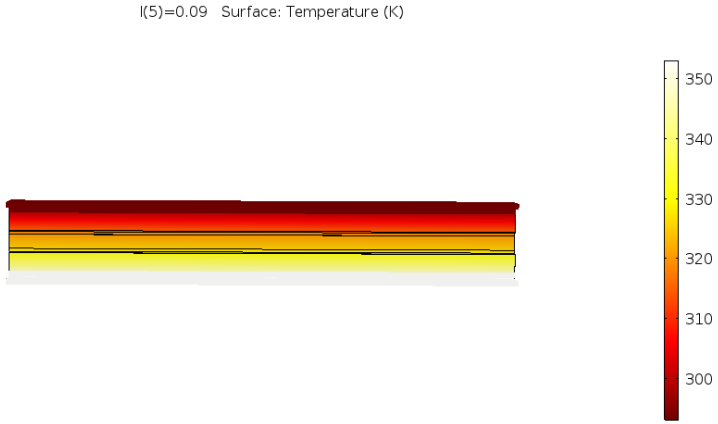
- Cut front face
  - ➢ Partition with objects or work planes
- Virtual operations (ignore edges, vertices)

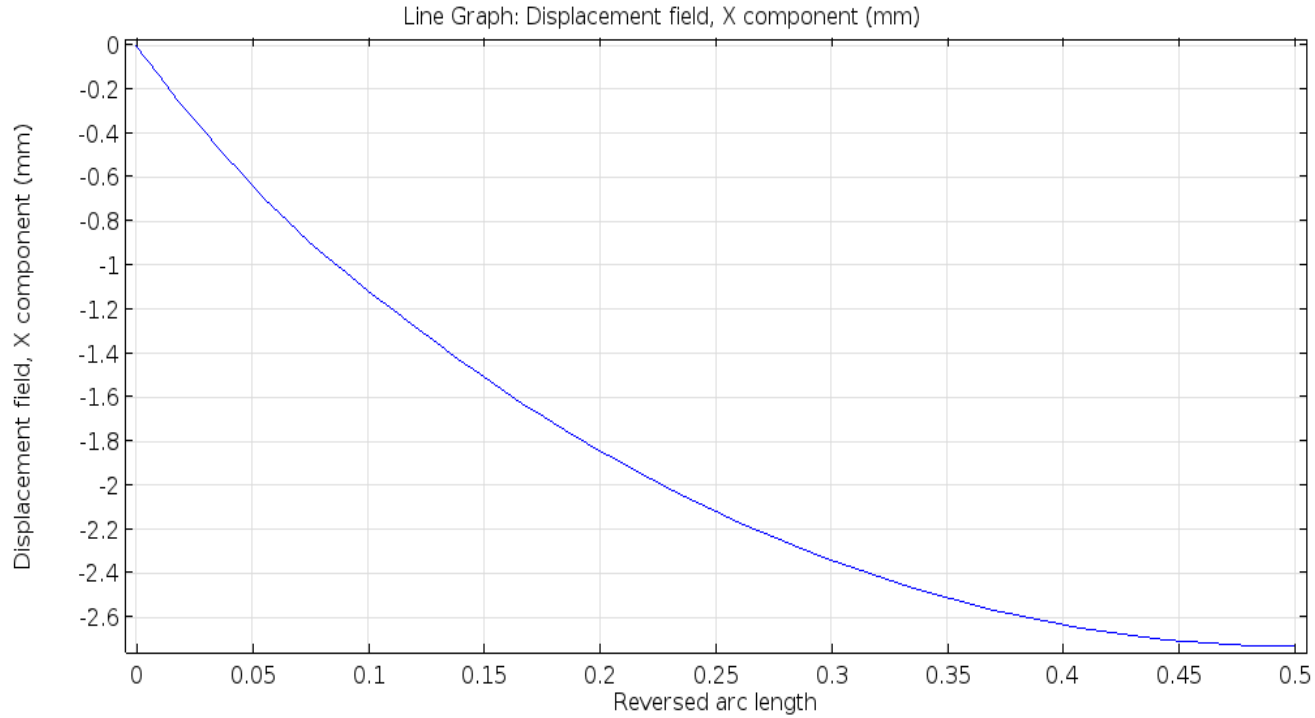
2. Step

- Mesh the front face
  - ➢ Mapped and triangular elements
- Extrude the mesh

Results (Simulation)







Maximum deflection = 2.73 mm

Analytical Result Of A Simplified Model (Rectangular Profile)

Elongation ε of a fibre

$$\varepsilon = \frac{h}{R}$$

Thermal expansion:

$$\varepsilon_{th} = \alpha_{th} * \Delta T$$

$$R = \frac{h}{\alpha_{th} * \Delta T}$$

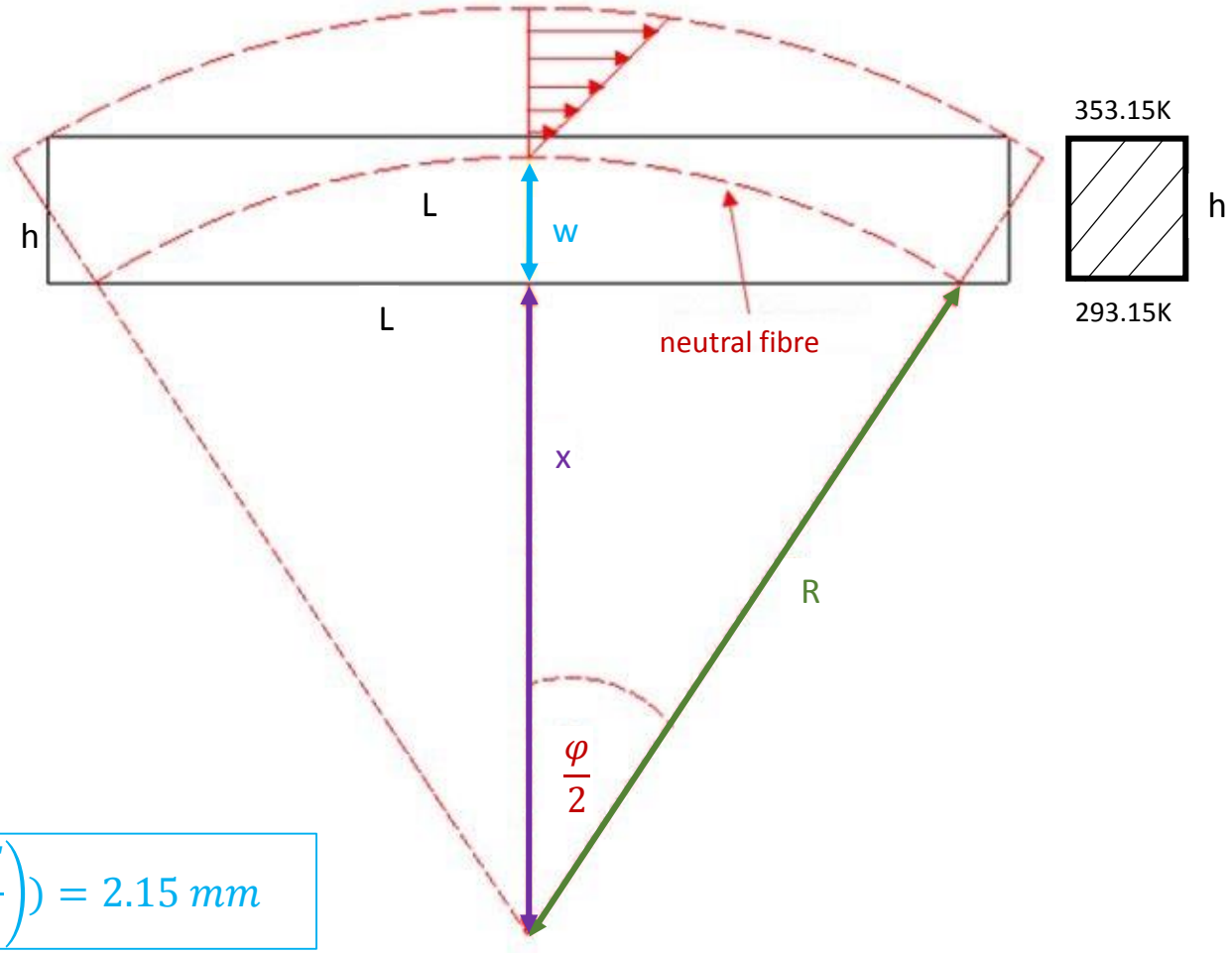
Radian measure

$$\varphi = \frac{L}{R}$$

length x

$$x = R * \cos\left(\frac{\varphi}{2}\right)$$

$$x = \frac{h}{\alpha_{th} * \Delta T} * \cos\left(\frac{L * \alpha_{th} * \Delta T}{h * 2}\right)$$



$$Deflection: w_{(\Delta T)} = R - x = \frac{h}{\alpha_{th} * \Delta T} * \left(1 - \cos\left(\frac{L * \alpha_{th} * \Delta T}{h * 2}\right)\right) = 2.15\ mm$$

Outline

1. Introduction
2. Task 1: Pre-Investigation
3. Task 2: Main-Investigation
   - Material Model
   - Constraints
   - Mesh

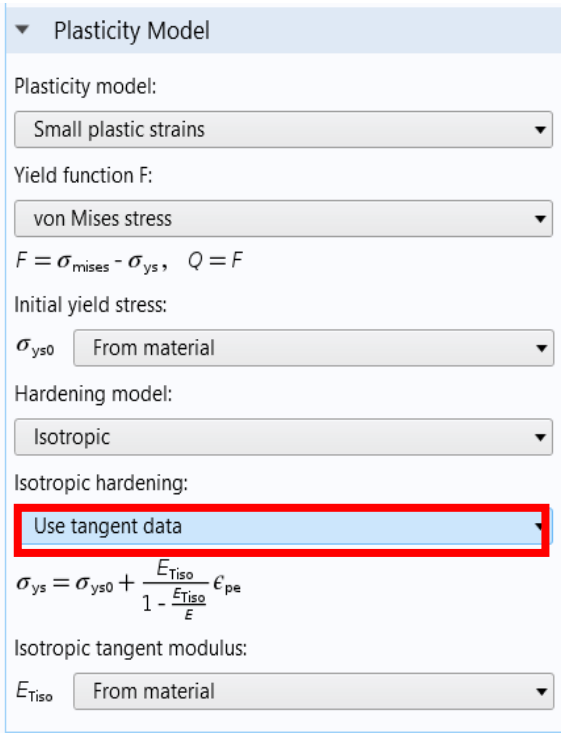
   } Pre-processing

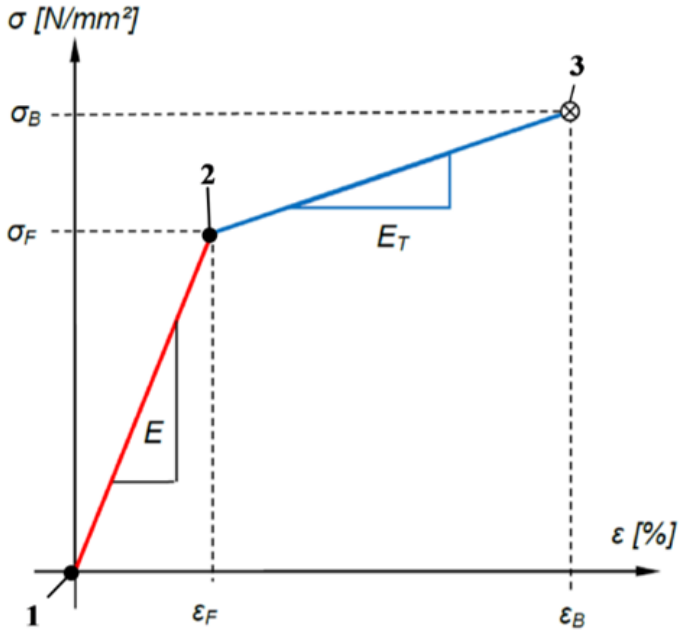
   - Solver
   - Results → Post-processing
4. Conclusion

Material Model

Aluminum: elastic-plastic

- Bilinear material





2. Yield Point
3. Breaking stress

$$E_t = \frac{R_m - R_{p0,2}}{\varepsilon_B - \frac{R_{p0,2}}{E}}$$

Constraints

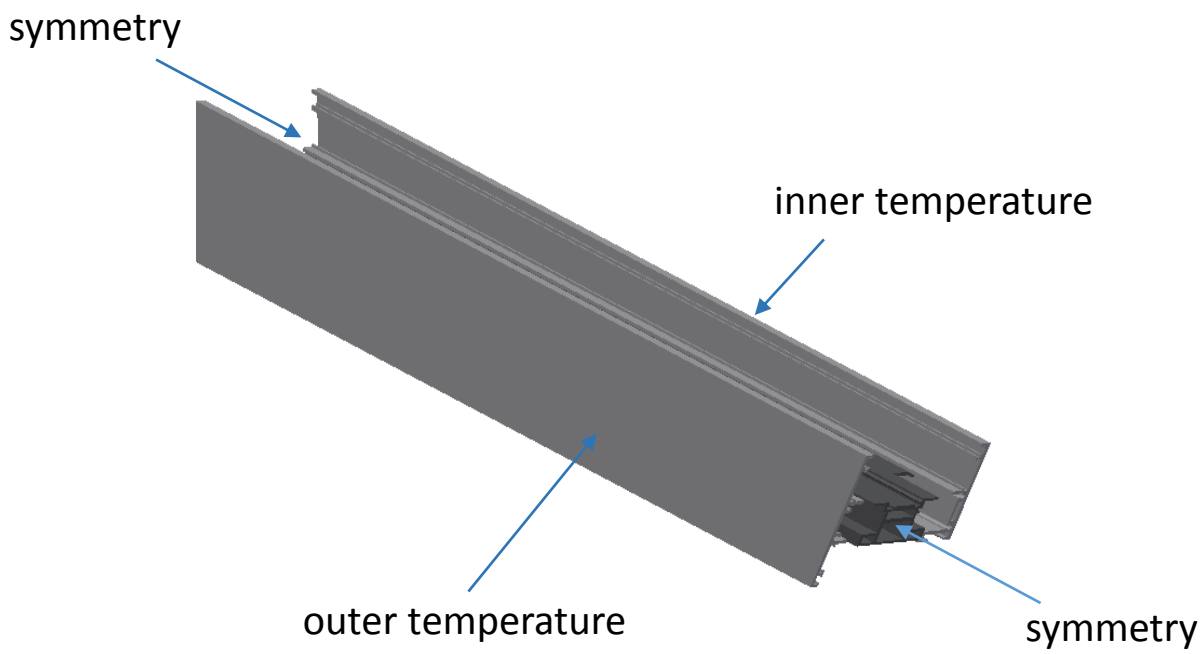
Heat Transfer in Solids

- Temperature
- Continuity

Solid Mechanics

- Prescribed displacement
- Symmetry
- Continuity (identity pair) or contact

  (contact pair)



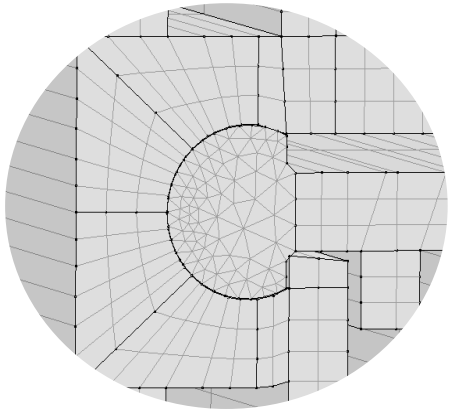
Contact Pair

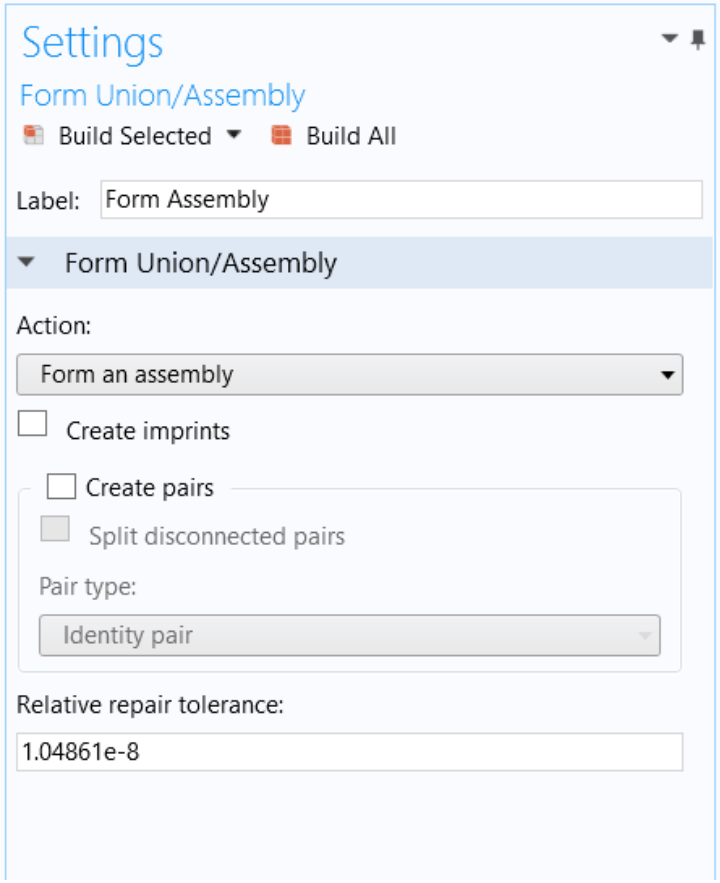
1. Form assembly:
   - Identifies the touching, adjacent, boundaries of all objects

2. Selection
   - Source boundary stiffness is higher than the destination boundary stiffness

3. Mesh
   - Source boundary has to be finer than destination boundary (twice)

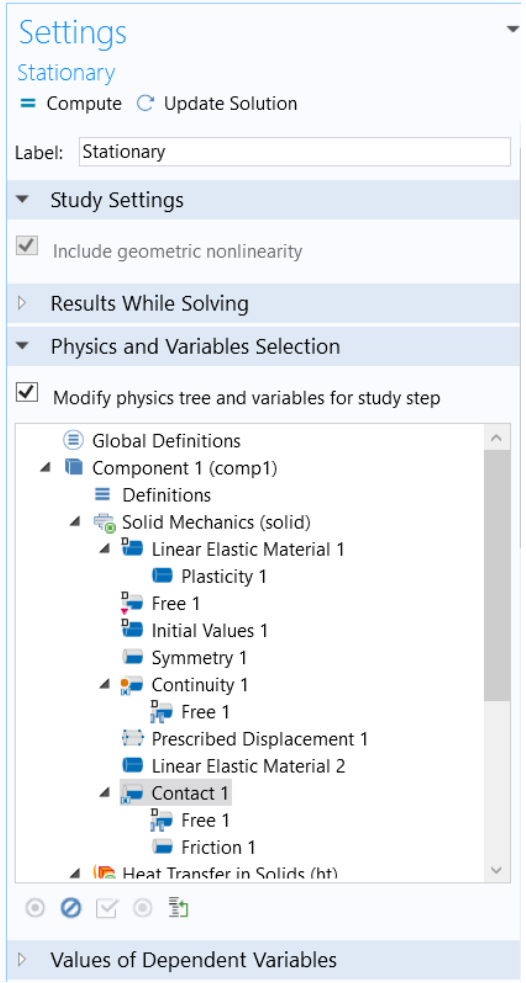
4. Friction (assumed value μ=0.2)

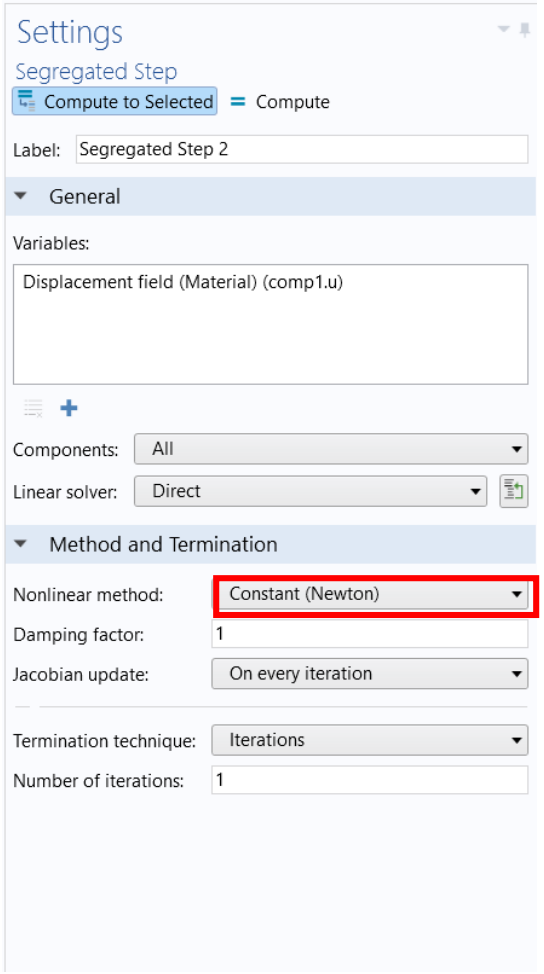




Stationary Solver

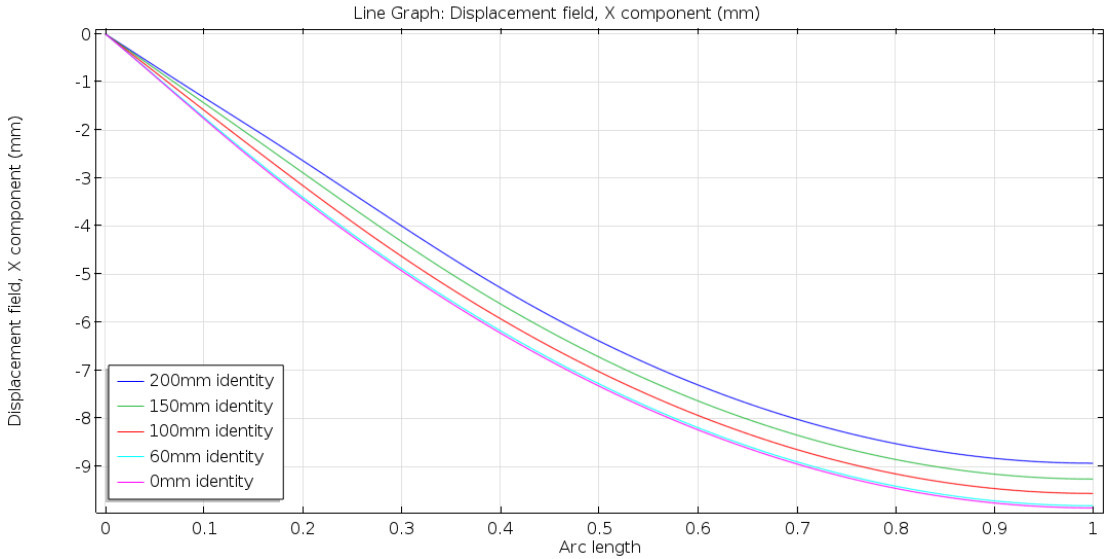
- Modify physics tree
- Segregated
    1. Temperature: Constant Newton
    2. Displacement: Constant Newton
- Continuation solver for contact pair





Results (Deflection)

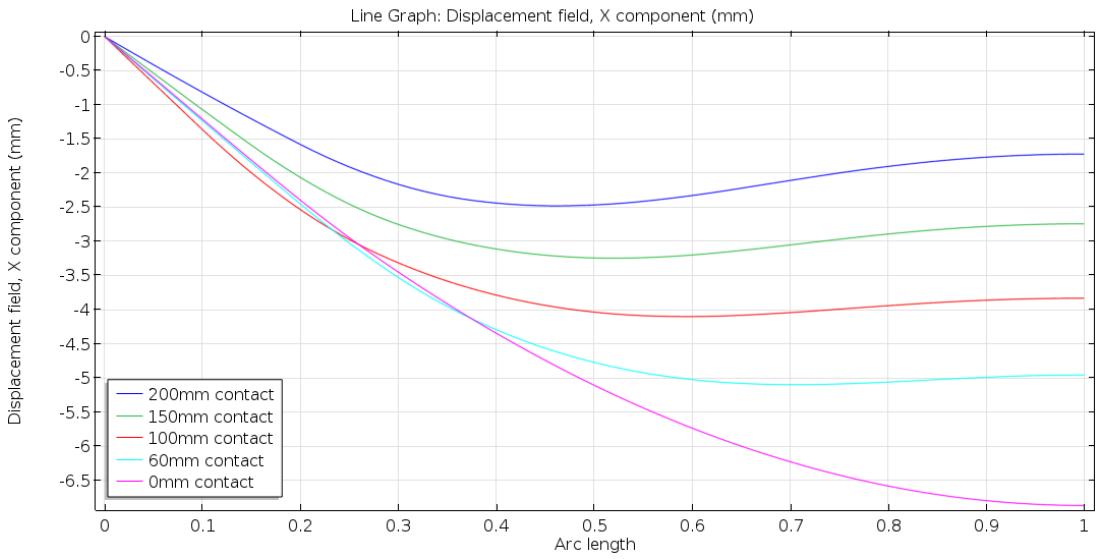
Identity pair case



Length of notches (mm)	Deflection (mm)
0	9,86
60	9,82
100	9,56
150	9,26
200	8,94

Reduced deflection ≈ 1 mm

Contact pair case



Length of notches (mm)	Deflection (mm)
0	6,86
60	4,96
100	3,83
150	2,74
200	1,72

Reduced deflection ≈ 5 mm

Outline

Conclusion

Pre-Investigation

- In spite of simplifications in the analytics there is a good approach to the simulation
- The influence of air cavities is not significant

Main-Investigation

- Confirmation that notches reduce the deflection
  - Glued pair case: Notches don´t reduce the deflection significantly
  - Contact pair case is more suitable
- The length of notches has to be limited
  - By increasing the length of notches, the stiffness reduces

→ **Next step: Comparison with a real experiment**

Contact/References

Contact

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References

1. Schüco homepage: https://www.schueco.com/web2/de-en/company/about_schueco/company_profile
2. COMSOL homepage: https://www.comsol.com/support/knowledgebase/1102/