Adjustable Support Simulations

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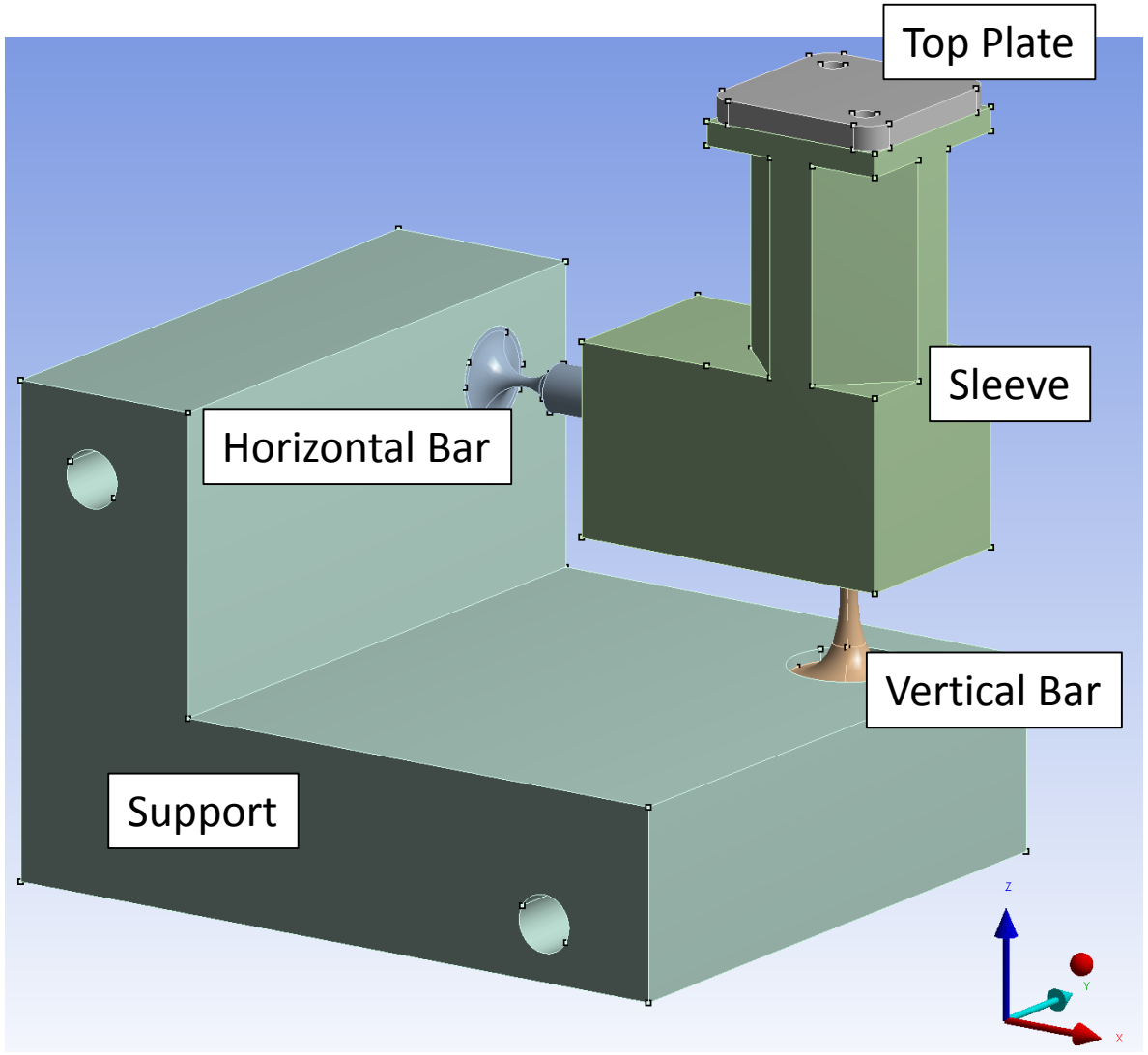
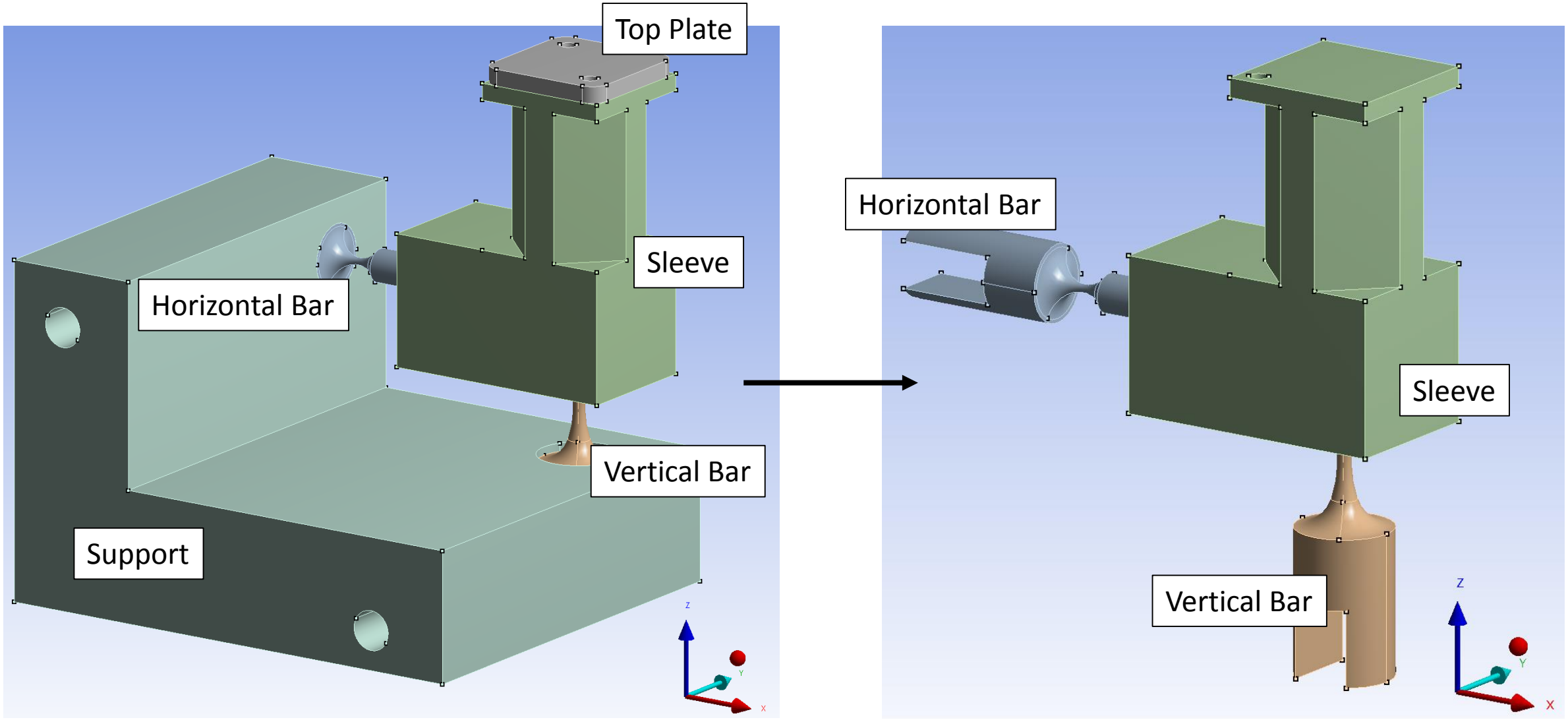
Goals

- Determine the range of adjustment before reaching yield strength
- Investigate the effect of the thickness of the bars on the range of adjustment

Simplification

- Top plate
  - Always bonded to the sleeve
  - -> suppress
- Support
  - Additional mesh elements
  - Additional contact conditions (assumptions and convergence issues)
  - Test simulations reveal only very little deformation (1E-8 m)
  - -> suppress




Top Plate
Sleeve
Horizontal Bar
Vertical Bar
Support
Z
Y
X
Horizontal Bar
Sleeve
Vertical Bar
Z
Y
X

Contact Definition and Solution Method

- Two contacts
  - Contact definition: no separation
  - Frictionless sliding allowed
  - But no gaps allowed between the surfaces
- Algorithm
  - Augmented Lagrange
  - Penalty based -> require a good contact stiffness factor
  - Normal contact stiffness factor = 1 chosen after a sensitivity study

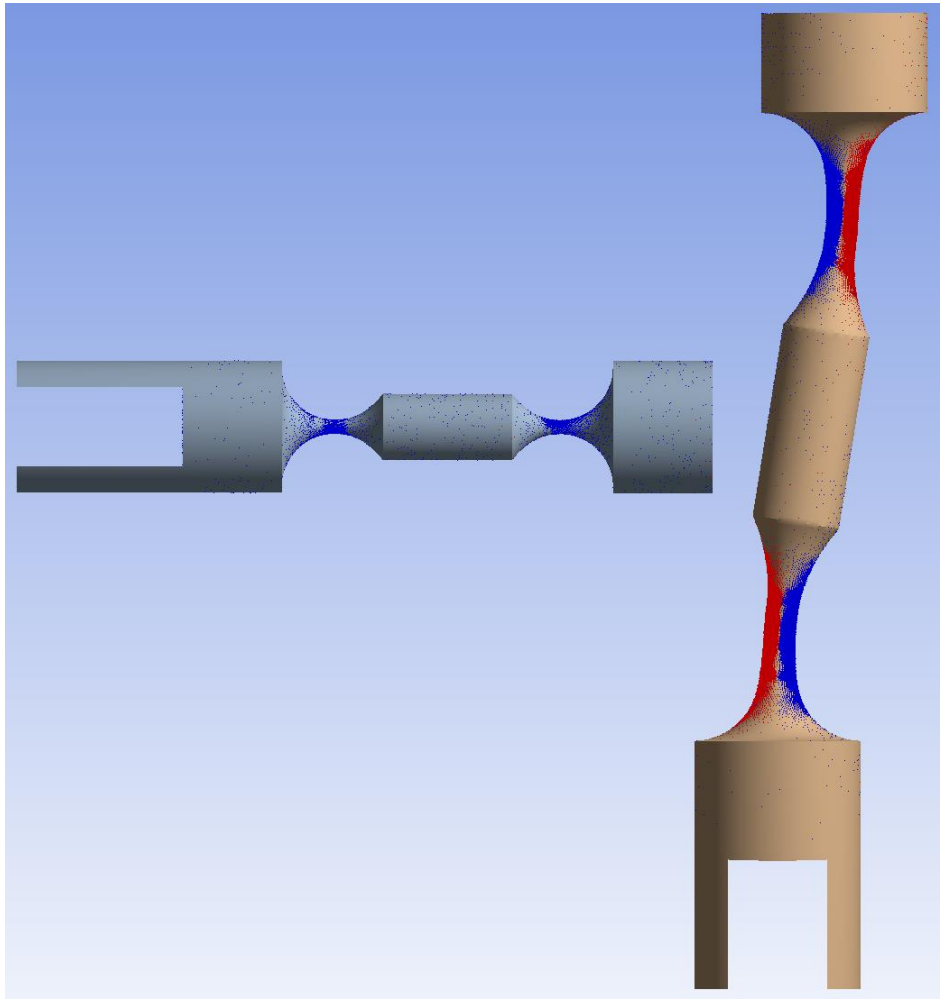
Mesh and Convergence

- Mesh
  - ~ 400’000 elements initially for the two bars and the sleeve
  - Adaptive mesh refinement enabled
  - ANSYS automatically refines the mesh where necessary after a run until the preset convergence criteria are reached
- Convergence requirements
  - < 1% change in monitored values between two successive runs
  - Monitored values
    - Maximum equivalent stress in the two bars
    - Safety factor of the system and of the two bars
- Time until convergence: ~ 20 minutes per case

Cases Considered

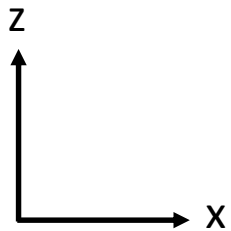
- For vertical bars of 4 different thickness
  - Only Load (228.69 N – 3 supports for the weight)
  - Load + Displacement of the horizontal bar or vertical bar
    - 0.5 mm, 0.75 mm; 1 mm; 1.25 mm; 1.5 mm
  - Load + Simultaneous displacement of the horizontal and vertical bars
    - 0.25 mm; 0.5 mm; 0.75 mm; 1 mm

Stresses of the Bars – Displacement of the Horizontal Bar Only



(exaggerated)

Blue: Compression
Red: Tension



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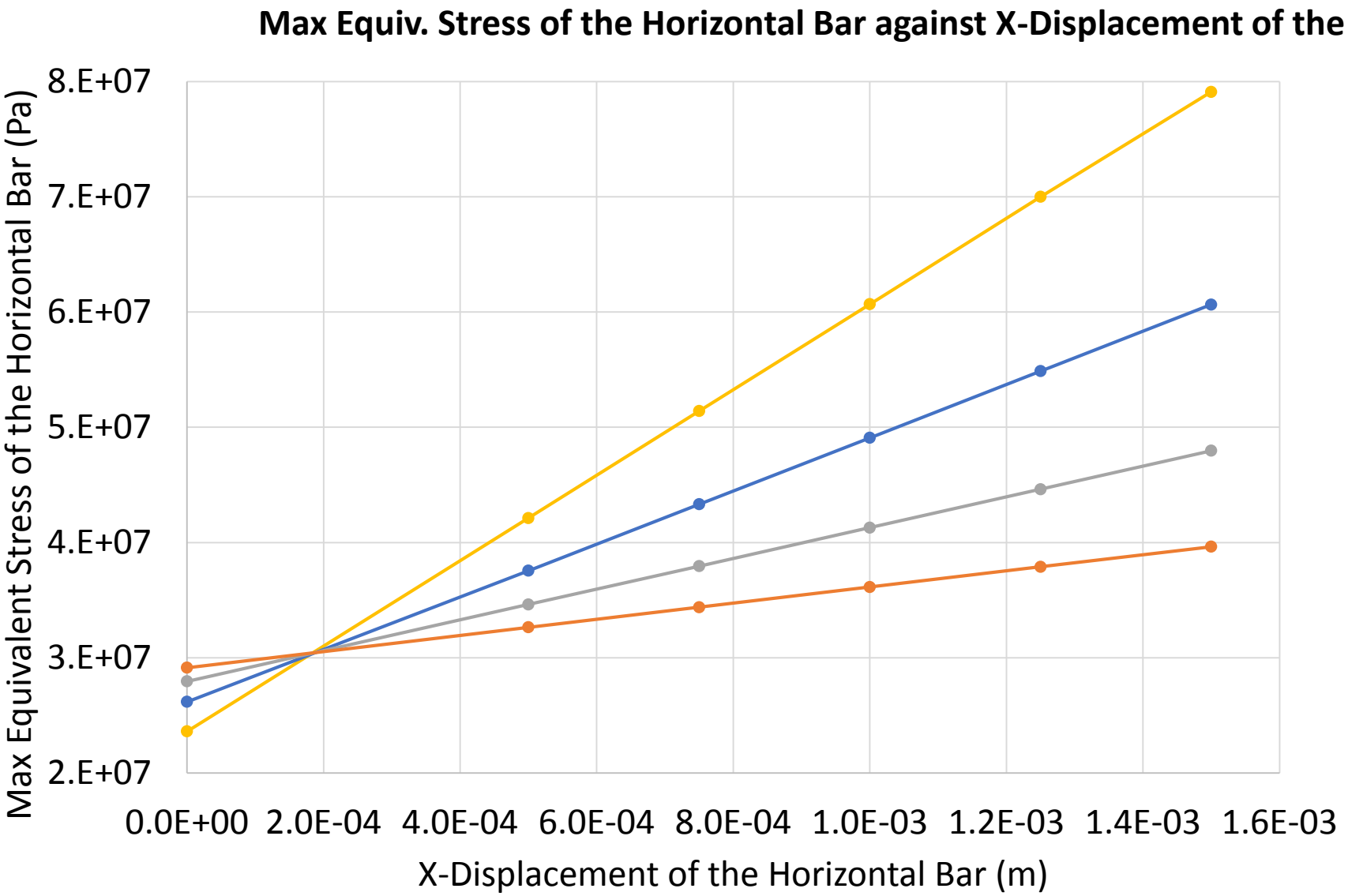

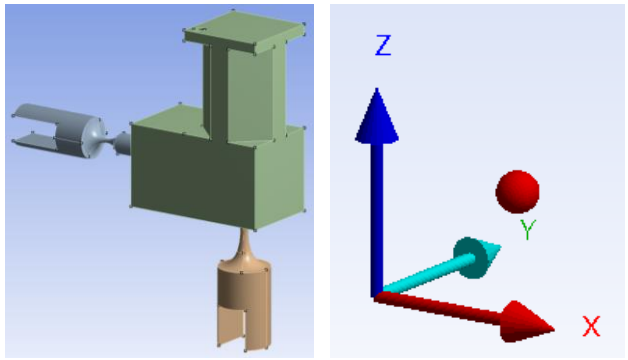

- 0.5 mm Thicker Vertical Bar
- Original Thickness
- 0.5 mm Thinner Vertical Bar
- 1 mm Thinner Vertical Bar

Material: 30CrNiMo8
Yield strength: 1.034E+09 Pa
Ultimate strength: 1.158E+09 Pa

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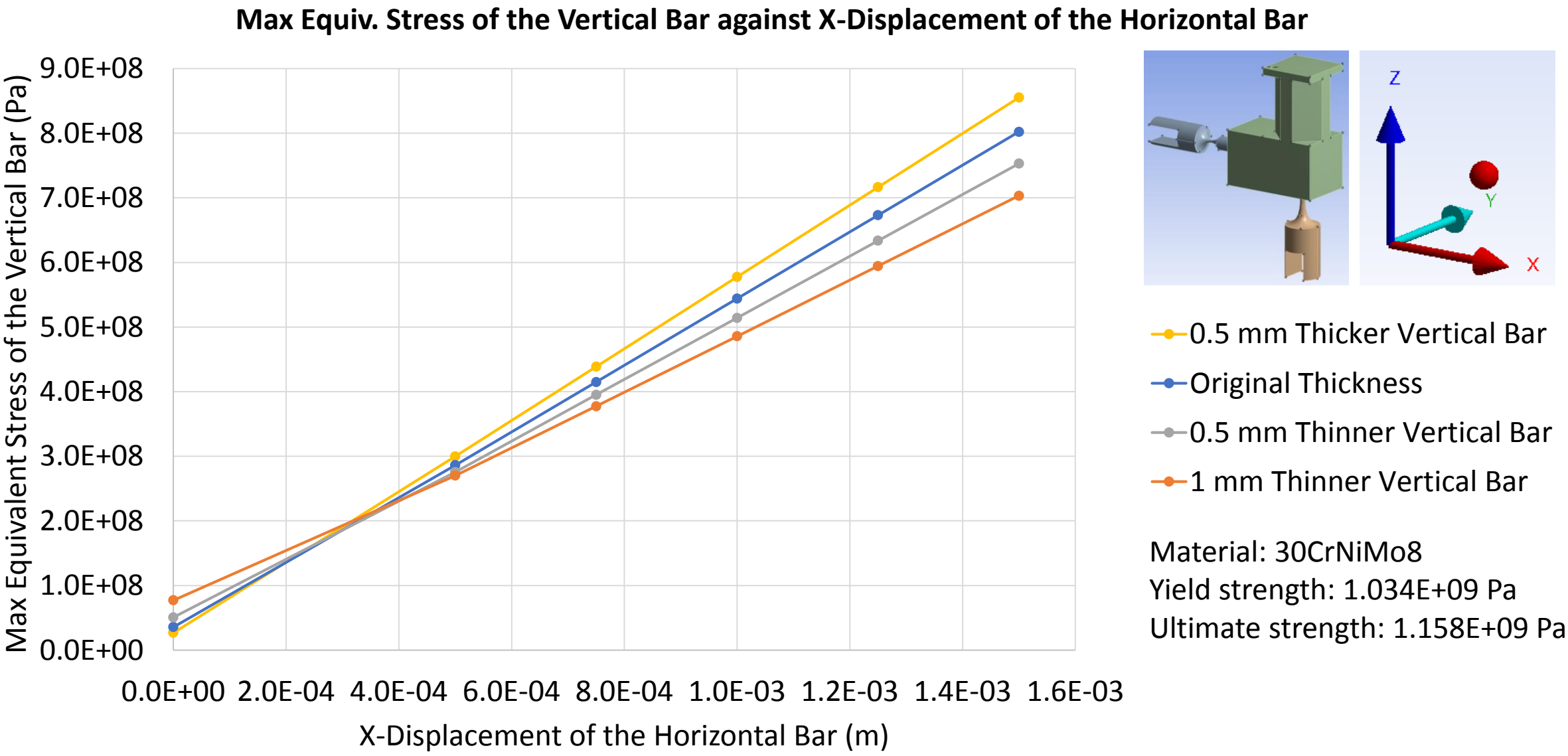

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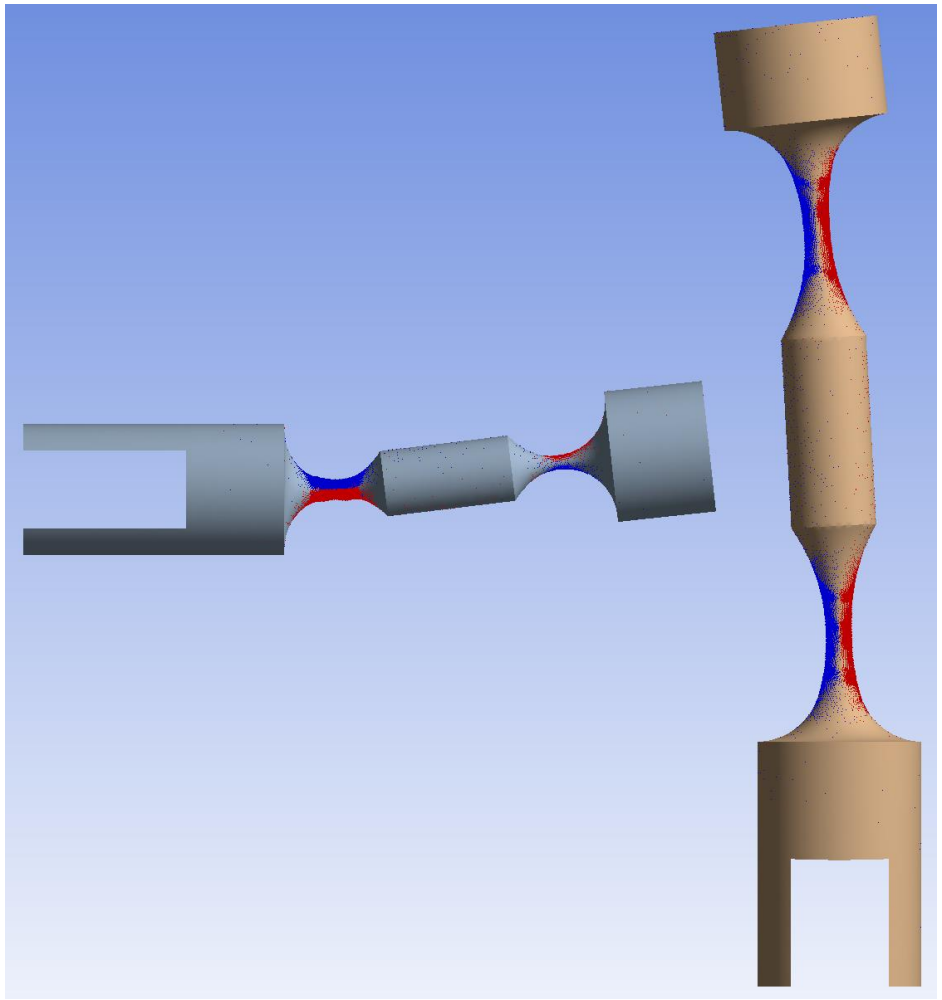

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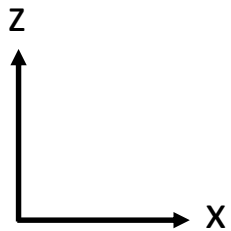

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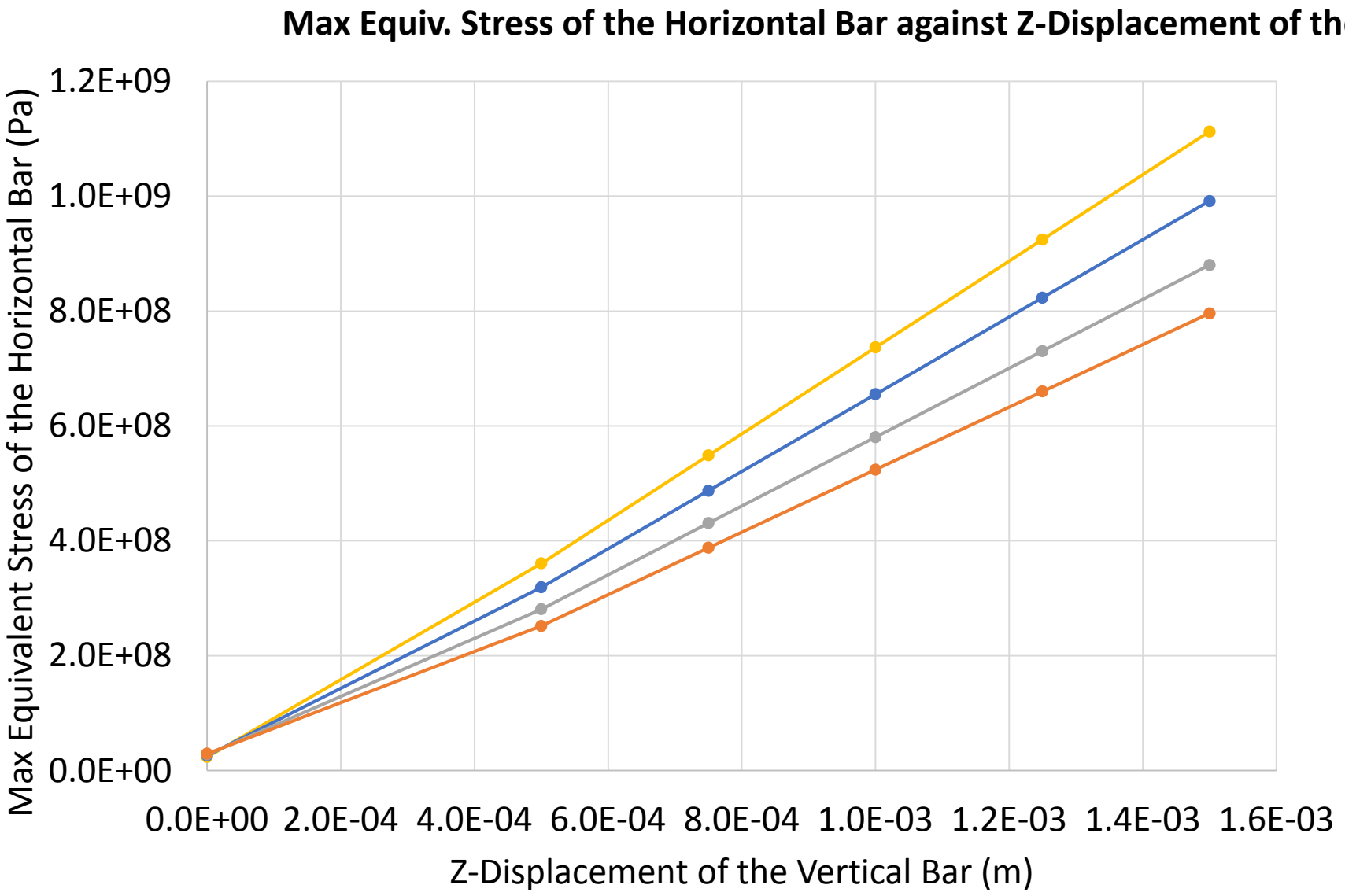

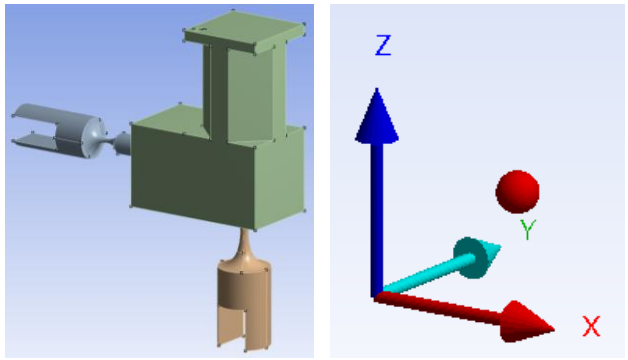

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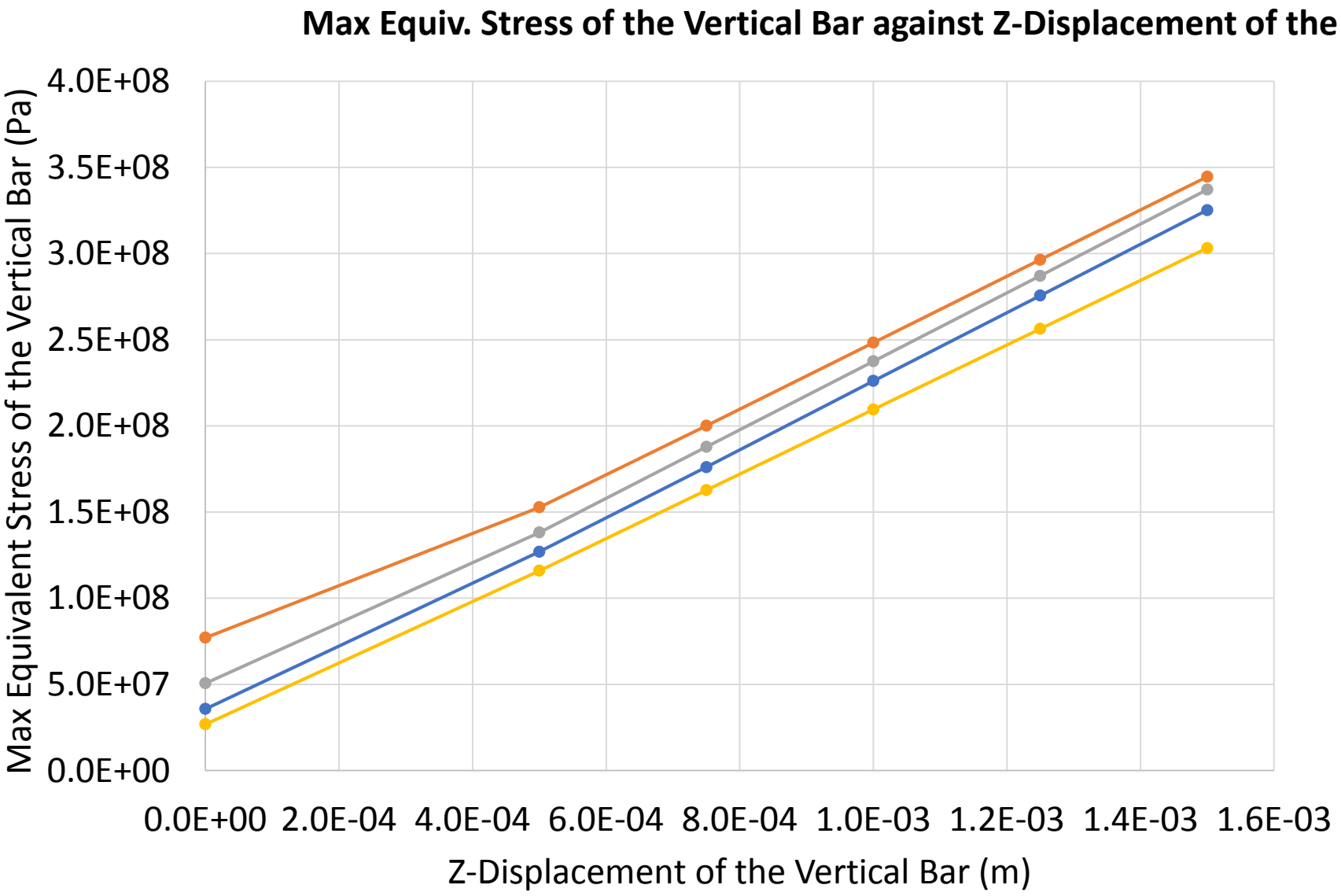

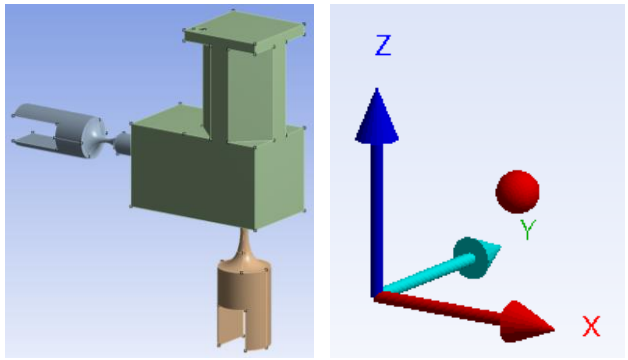

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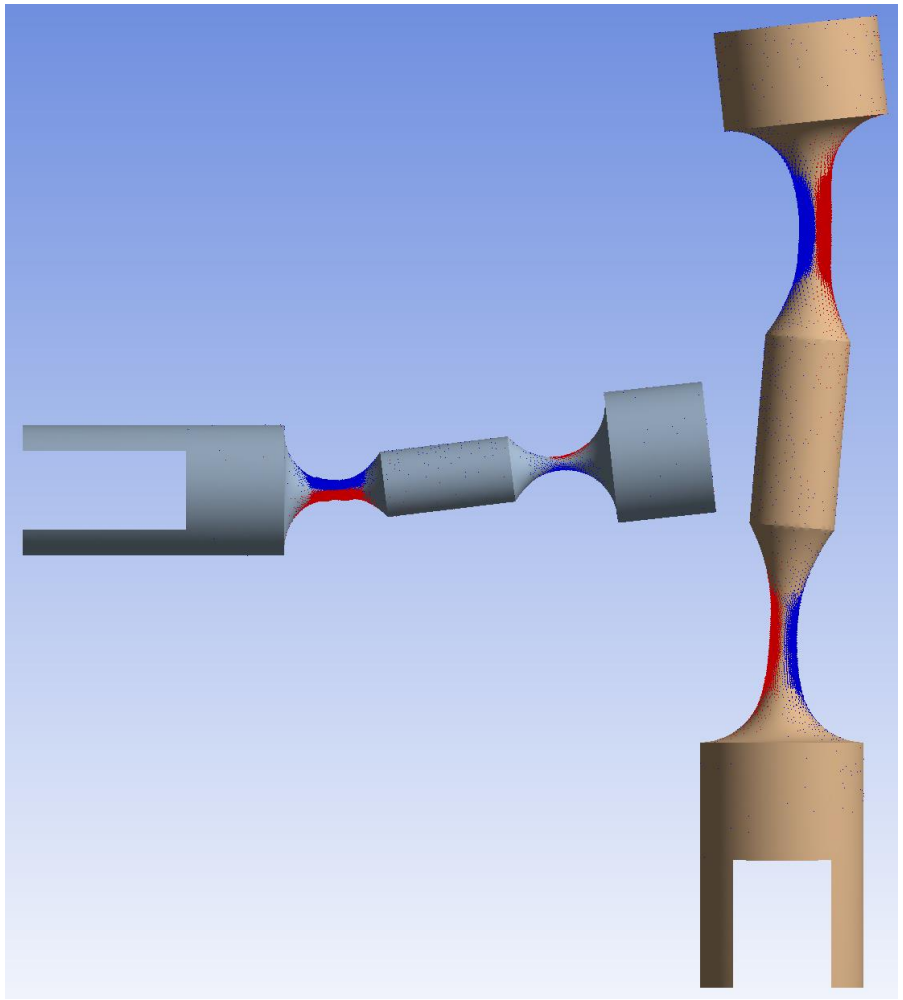
Stresses of the Bars – Simultaneous Displacement of Both Bars



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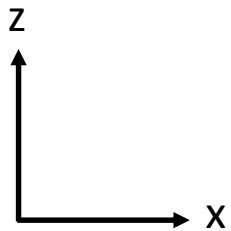

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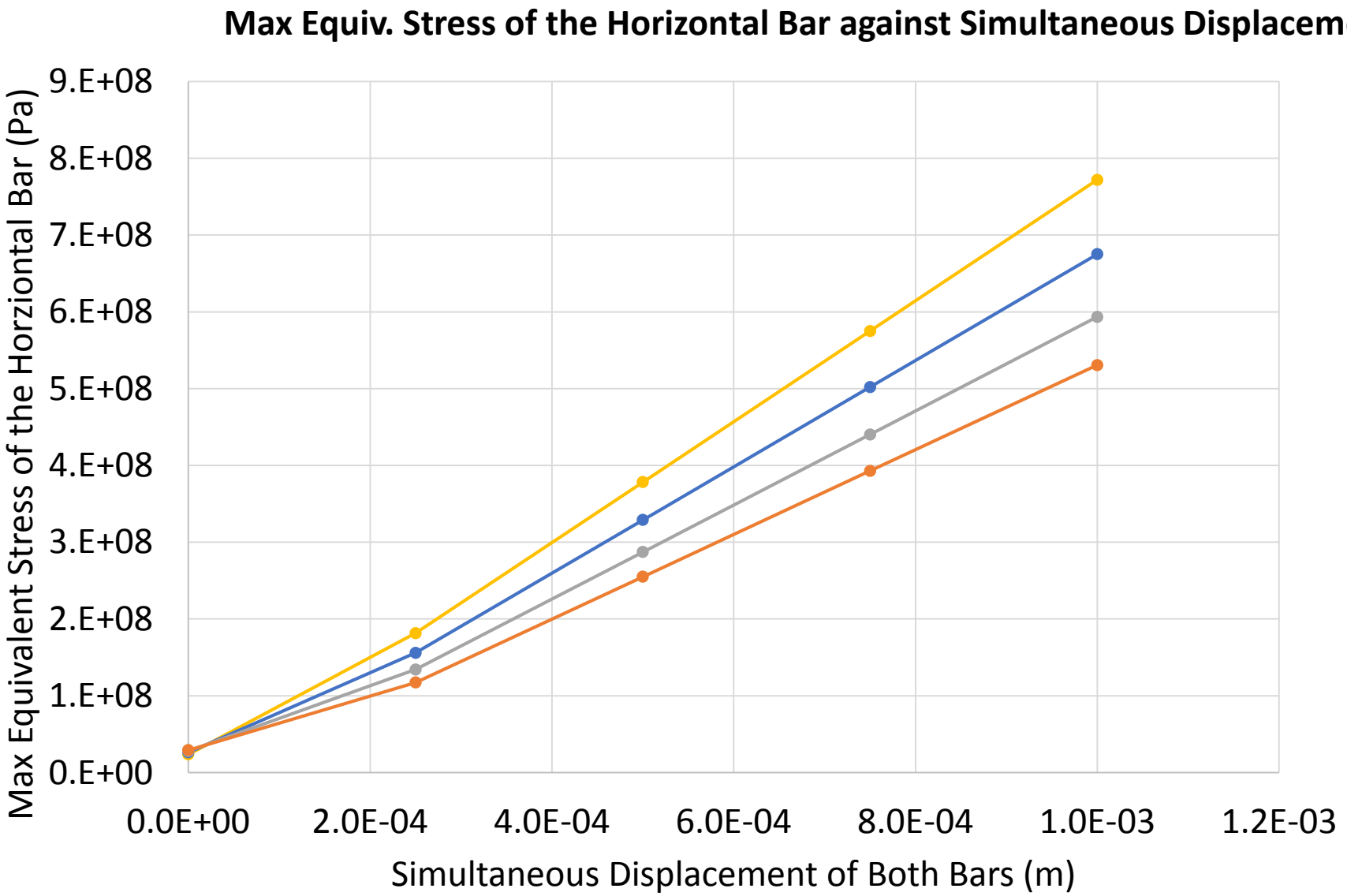

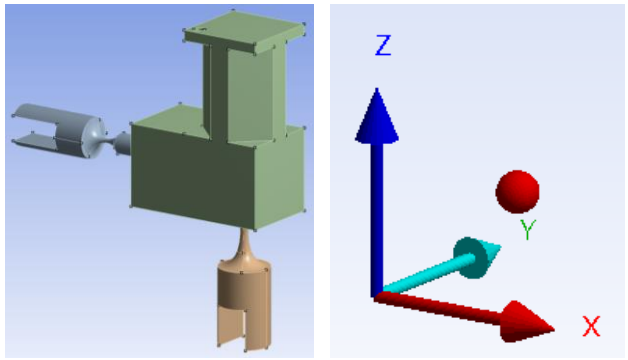

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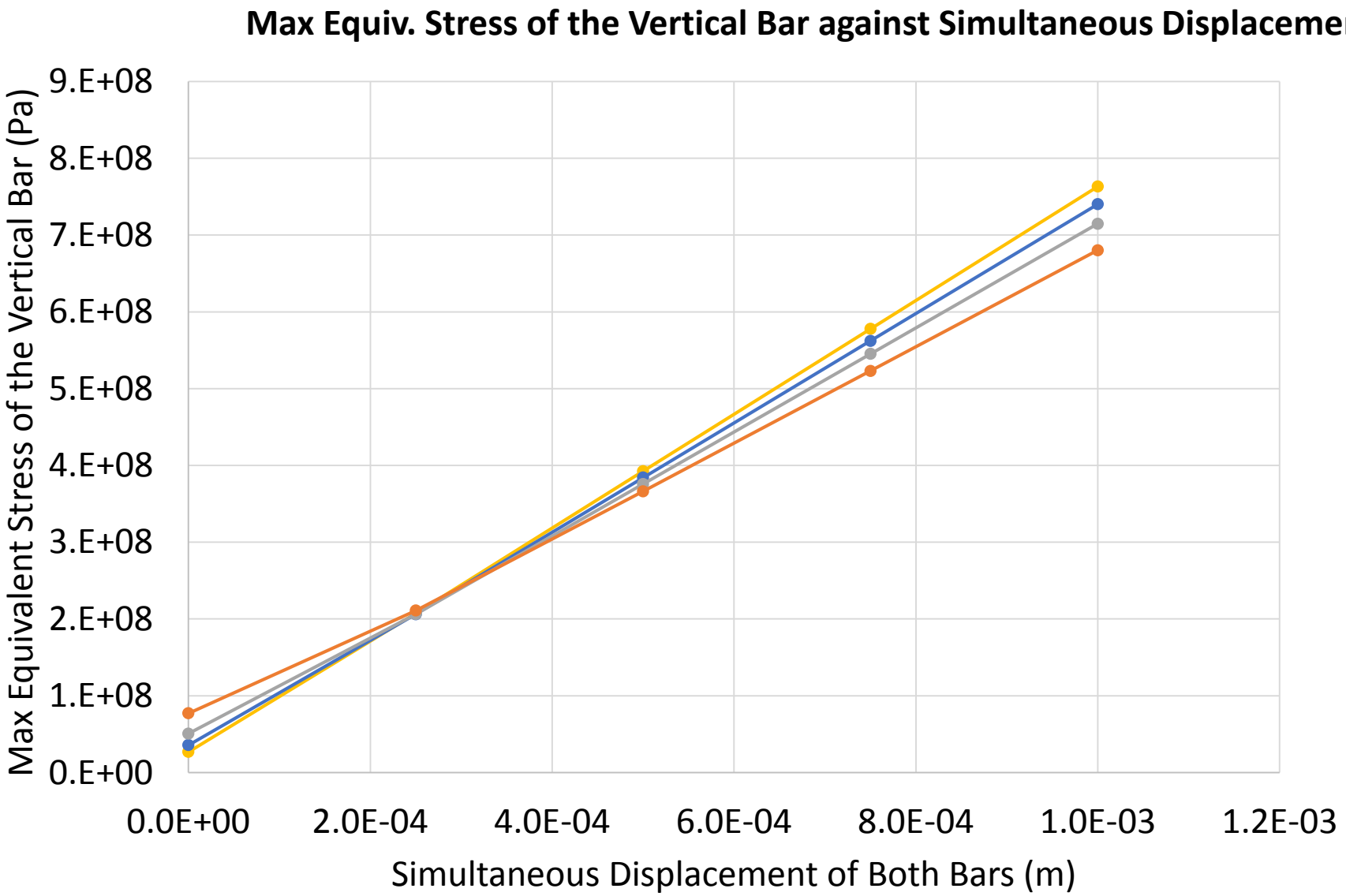

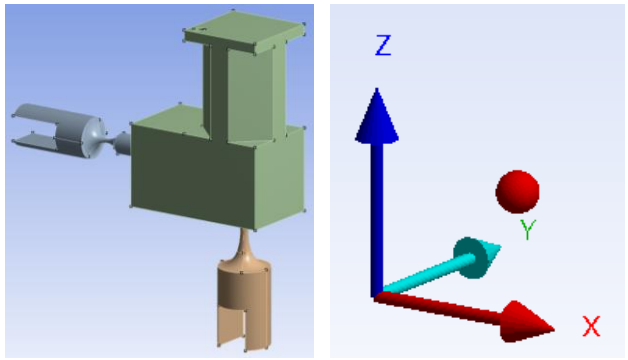

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From extrapolation up to the yield strength:

Vertical Bar	Displacement range of the horizontal bar (only horizontal adjustment)	Displacement range of the vertical bar (only vertical adjustment)	Displacement range of both bars (simultaneous adjustment)
0.5 mm thicker	Up to 1.82521 mm	Up to 1.40390 mm	Up to 1.35708 mm
Original	Up to 1.95669 mm	Up to 1.58024 mm	Up to 1.41851 mm
0.5 mm thinner	Up to 2.10496 mm	Up to 1.78631 mm	Up to 1.48287 mm
1 mm thinner	Up to 2.30213 mm	Up to 1.98169 mm	Up to 1.59089 mm

A thinner vertical bar allows a wider displacement range while staying below the yield strength of the material.
Note that the ranges reported are absolute limits. A margin should be allowed.

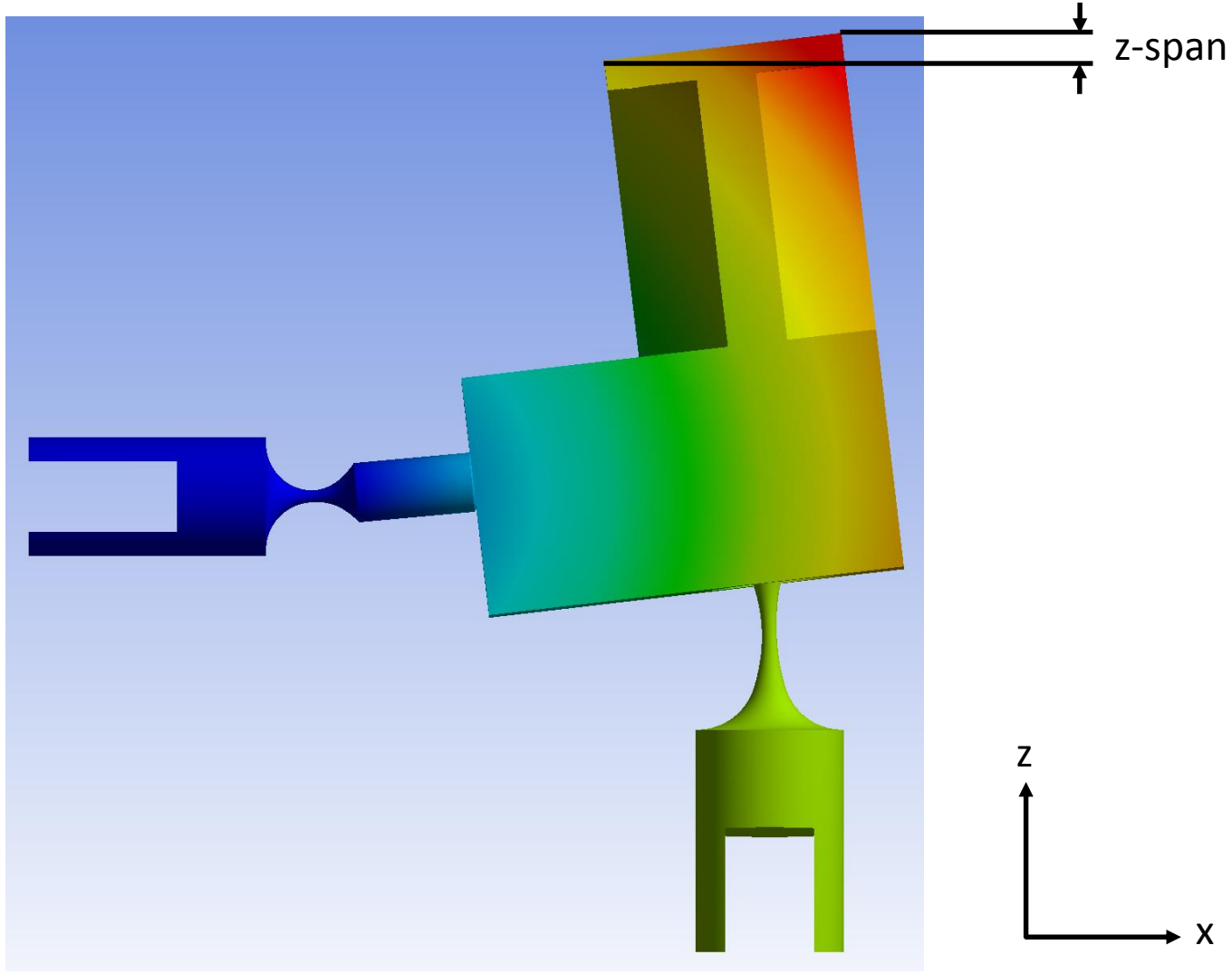
Limitations not considered in the simulation:

1. Tilting and movement of the top surface of the sleeve -> reaction moment and force from the load
2. Force required to displace the bars cannot be estimated as the friction condition between the bars and the support are not known.

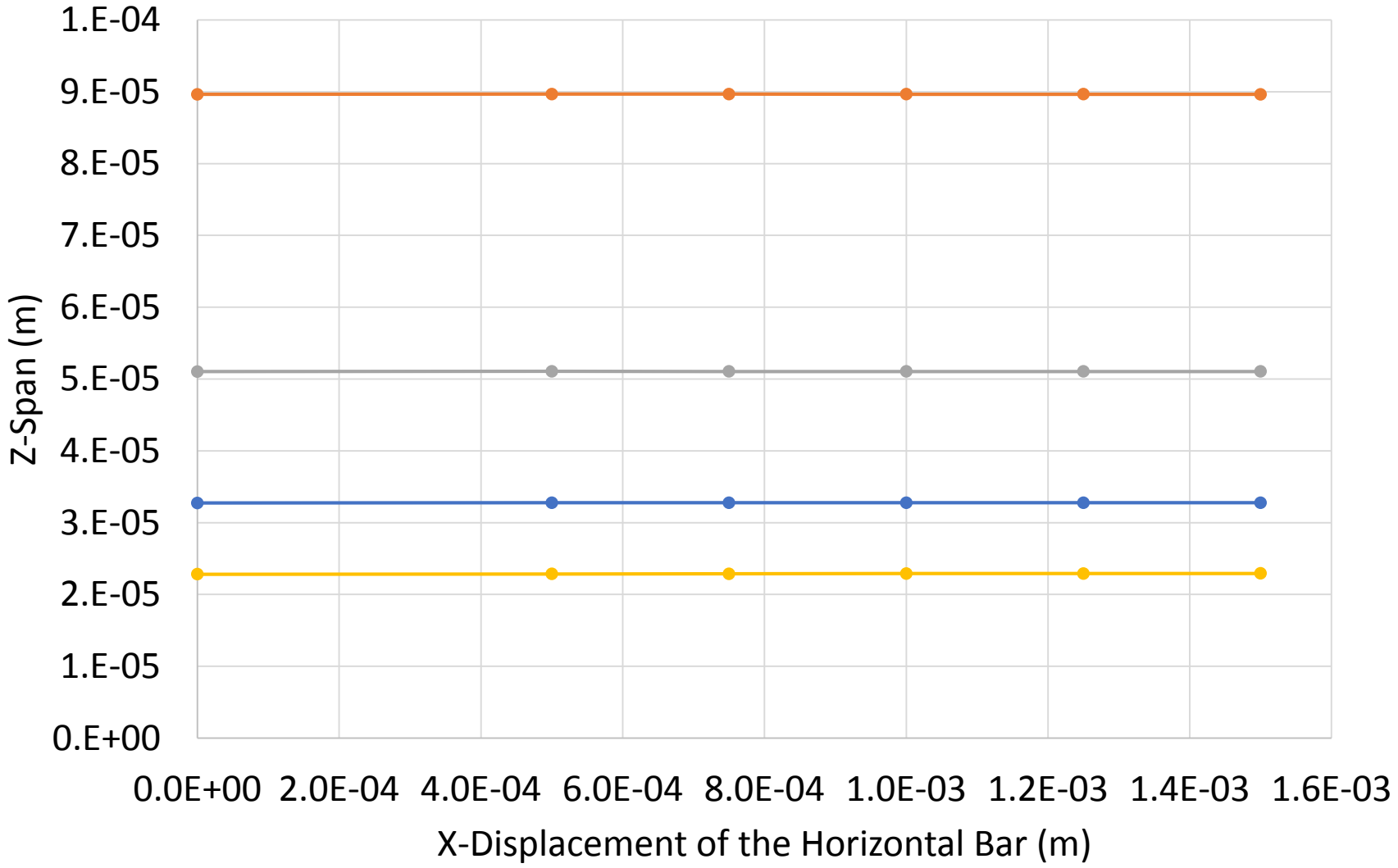
Tendency for the Sleeve to Tilt – Z-Span

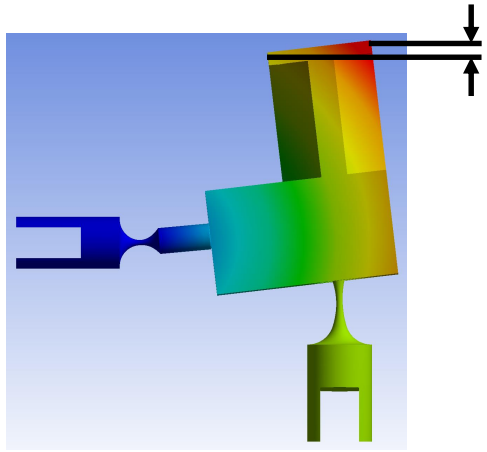
Because the reaction forces and moments from the load were not known, in the simulation no constraint was put on the surface except the weight of the load.

Nevertheless this measure gives an idea of the tendency for the sleeve to tilt when the bars are displaced.



Tendency for the Sleeve to Tilt – Displacement of the Horizontal Bar Only

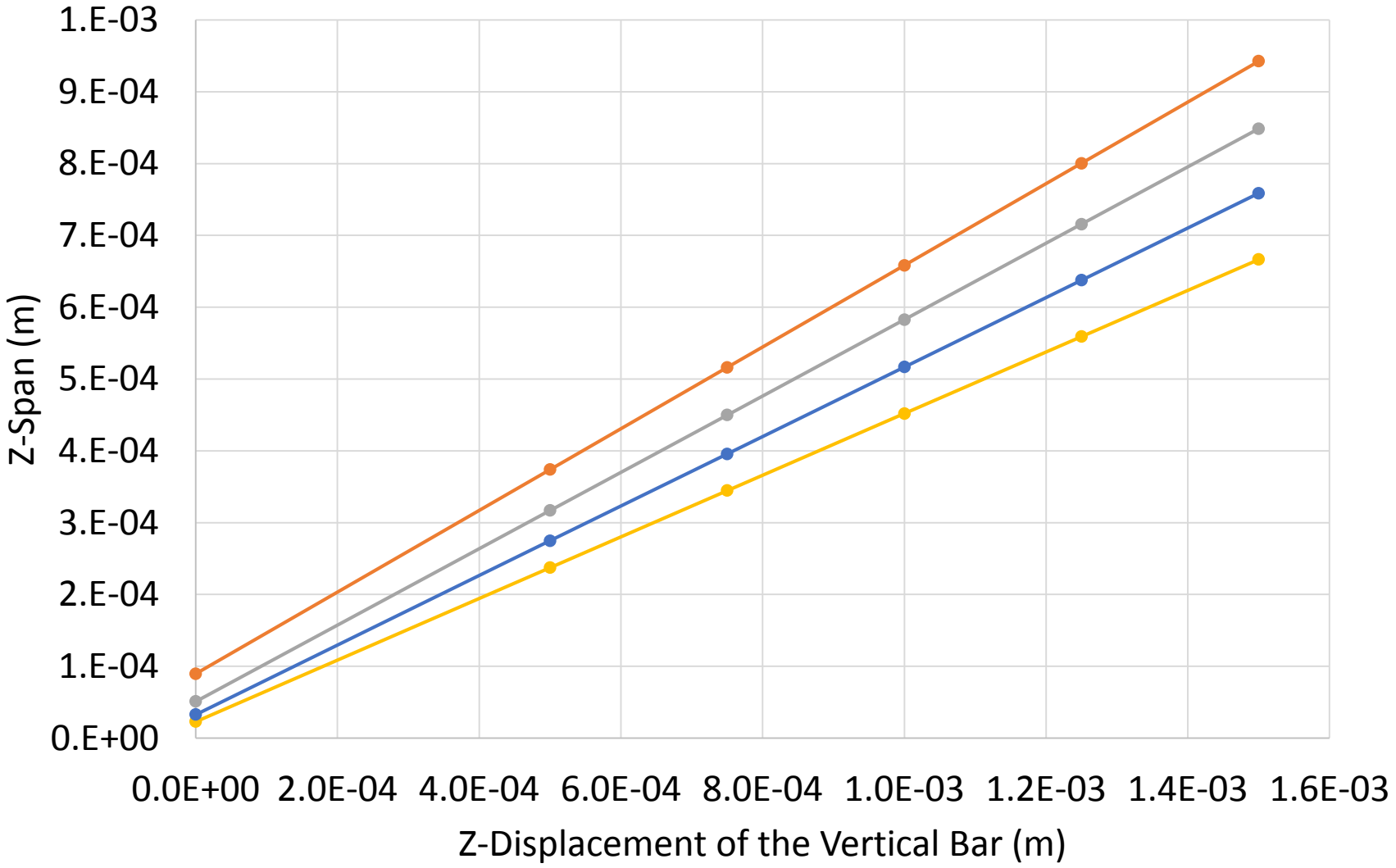


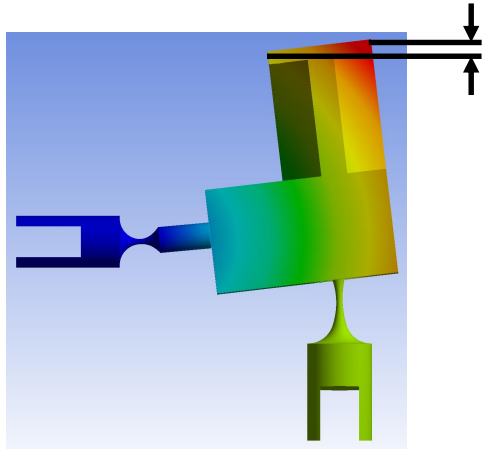


0.5 mm Thicker Vertical Bar
Original Thickness
0.5 mm Thinner Vertical Bar
1 mm Thinner Vertical Bar

The tendency to tilt does not change with displacement of the horizontal bar.

Tendency for the Sleeve to Tilt – Displacement of the Vertical Bar Only





- 0.5 mm Thicker Vertical Bar
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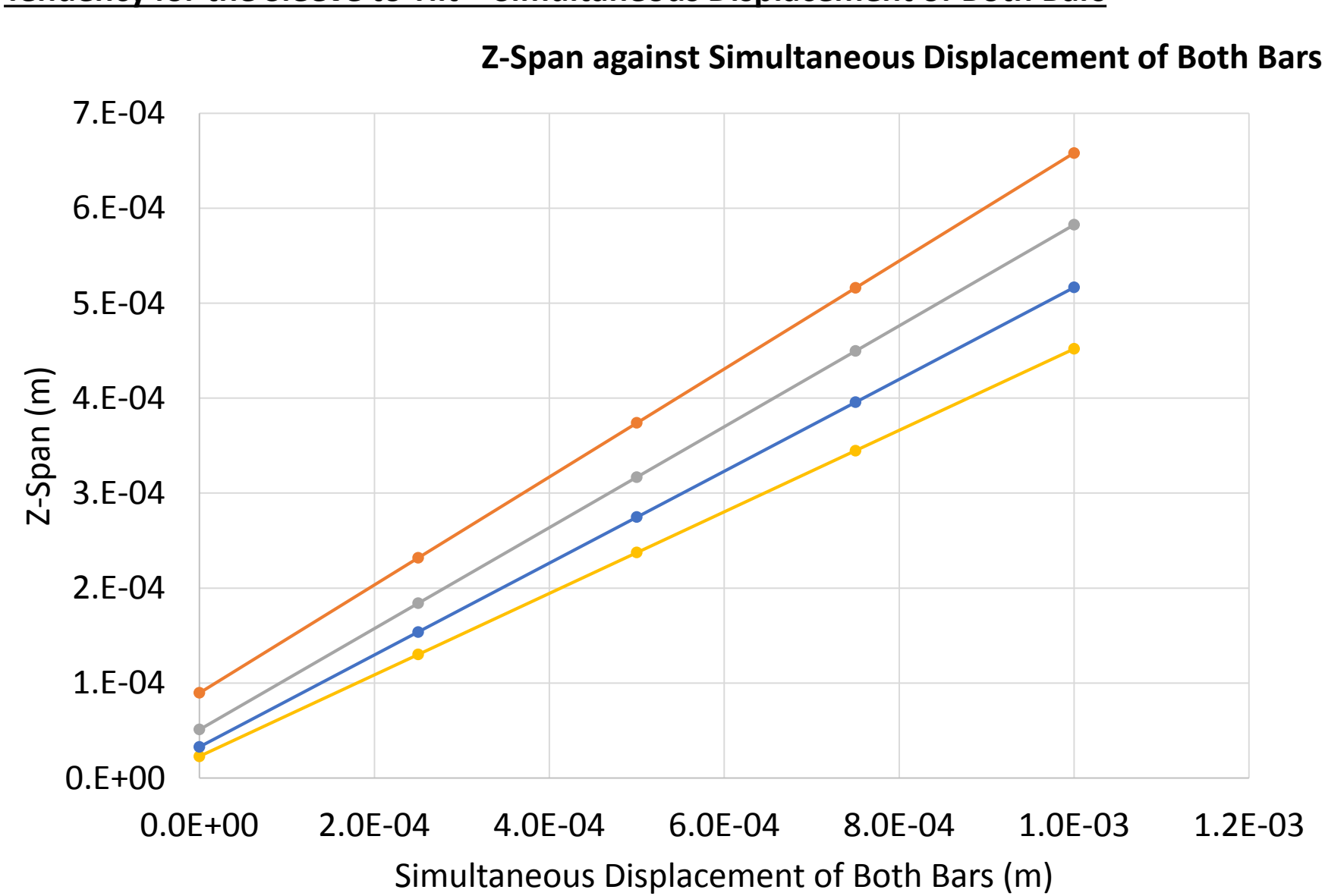
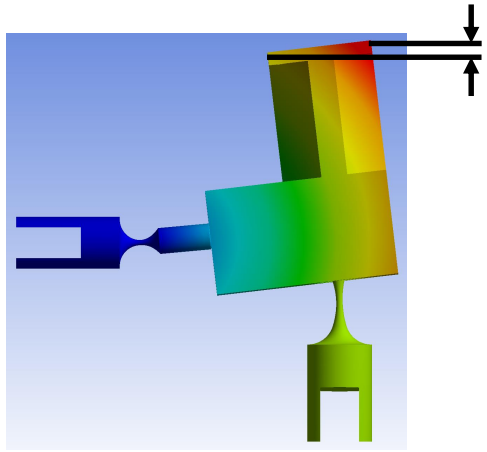
The tendency to tilt increases with displacement of the vertical bar.

Tendency for the Sleeve to Tilt – Simultaneous Displacement of Both Bars

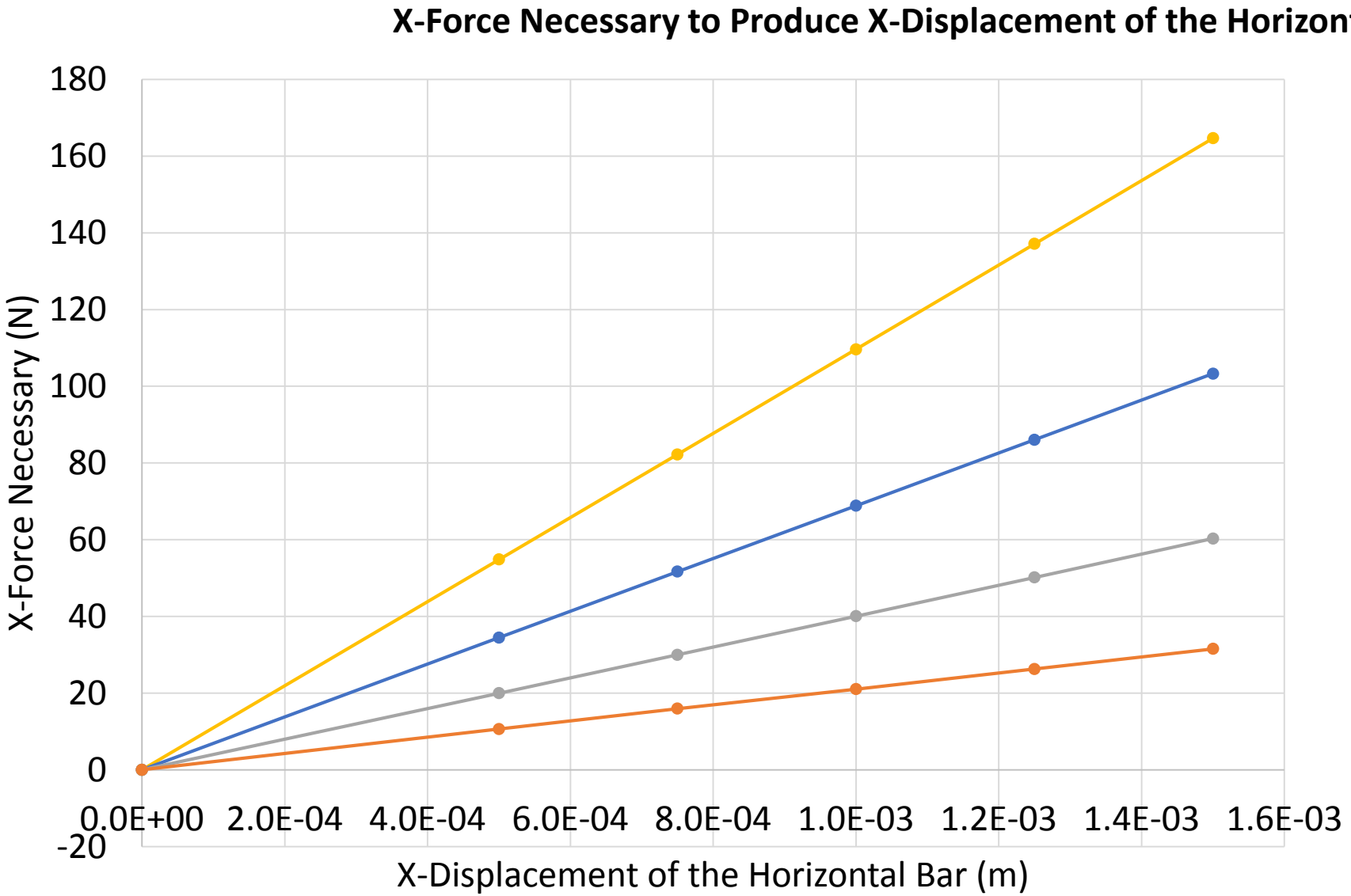


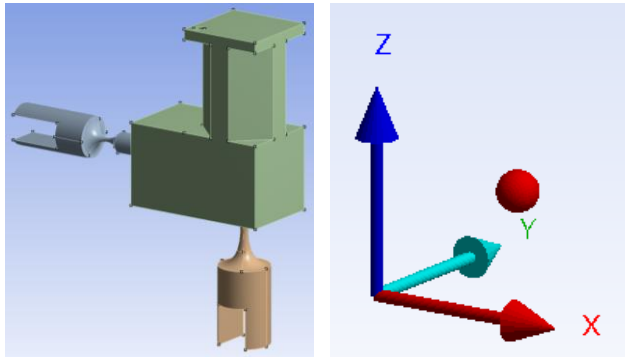


0.5 mm Thicker Vertical Bar
Original Thickness
0.5 mm Thinner Vertical Bar
1 mm Thinner Vertical Bar

The tendency to tilt increases with simultaneous displacement of both bars.

Force Necessary to Produce Displacement – Displacement of the Horizontal Bar Only





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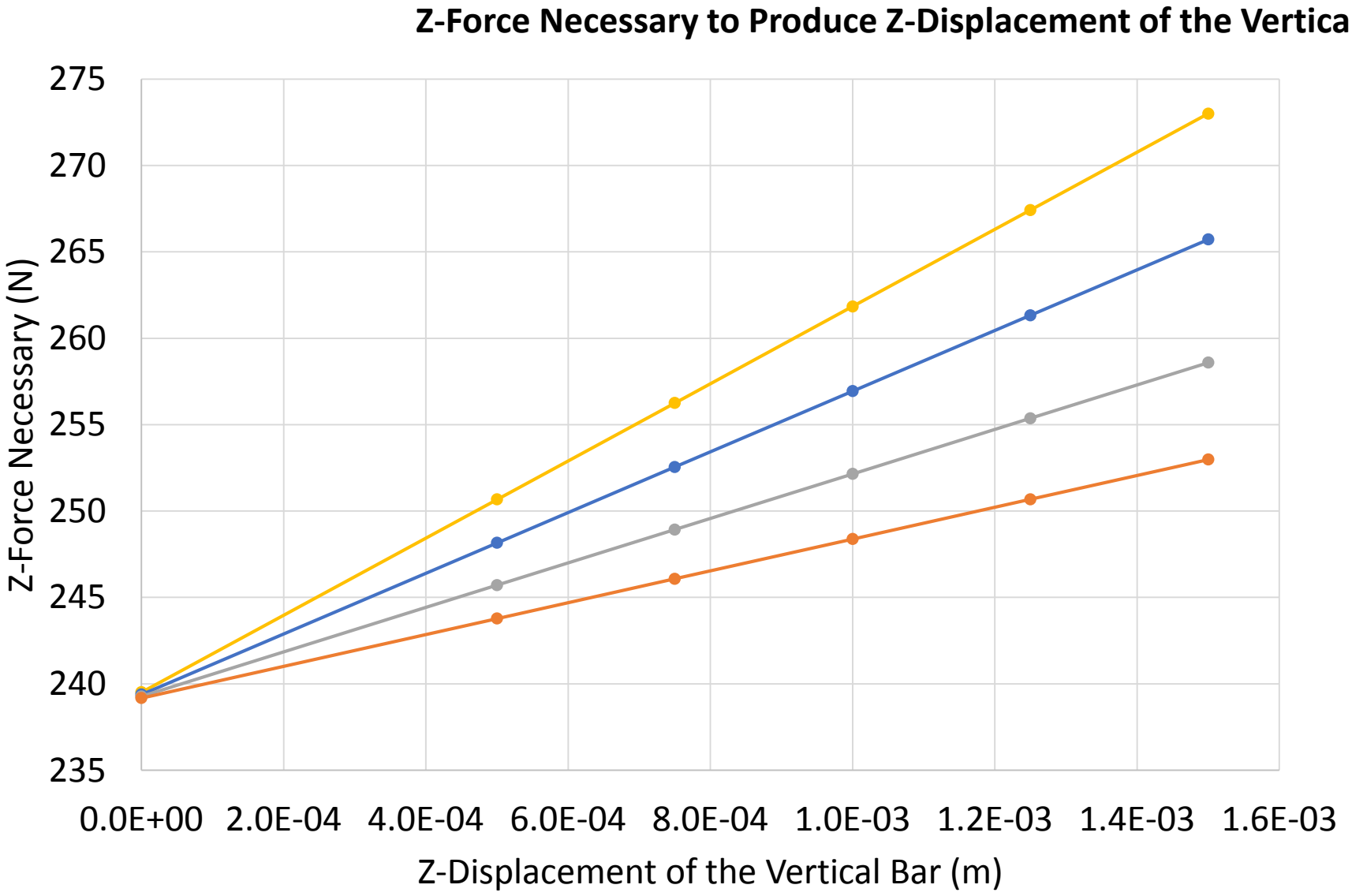
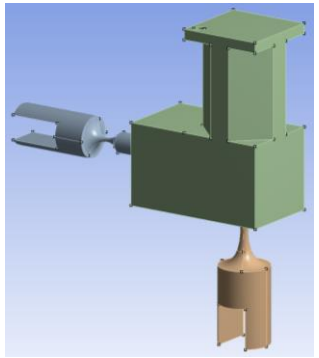
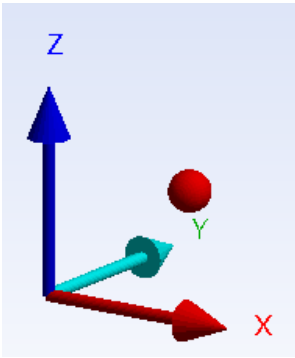
Friction was not accounted for.

Force Necessary to Produce Displacement – Displacement of the Vertical Bar Only







- 0.5 mm Thicker Vertical Bar
- Original Thickness
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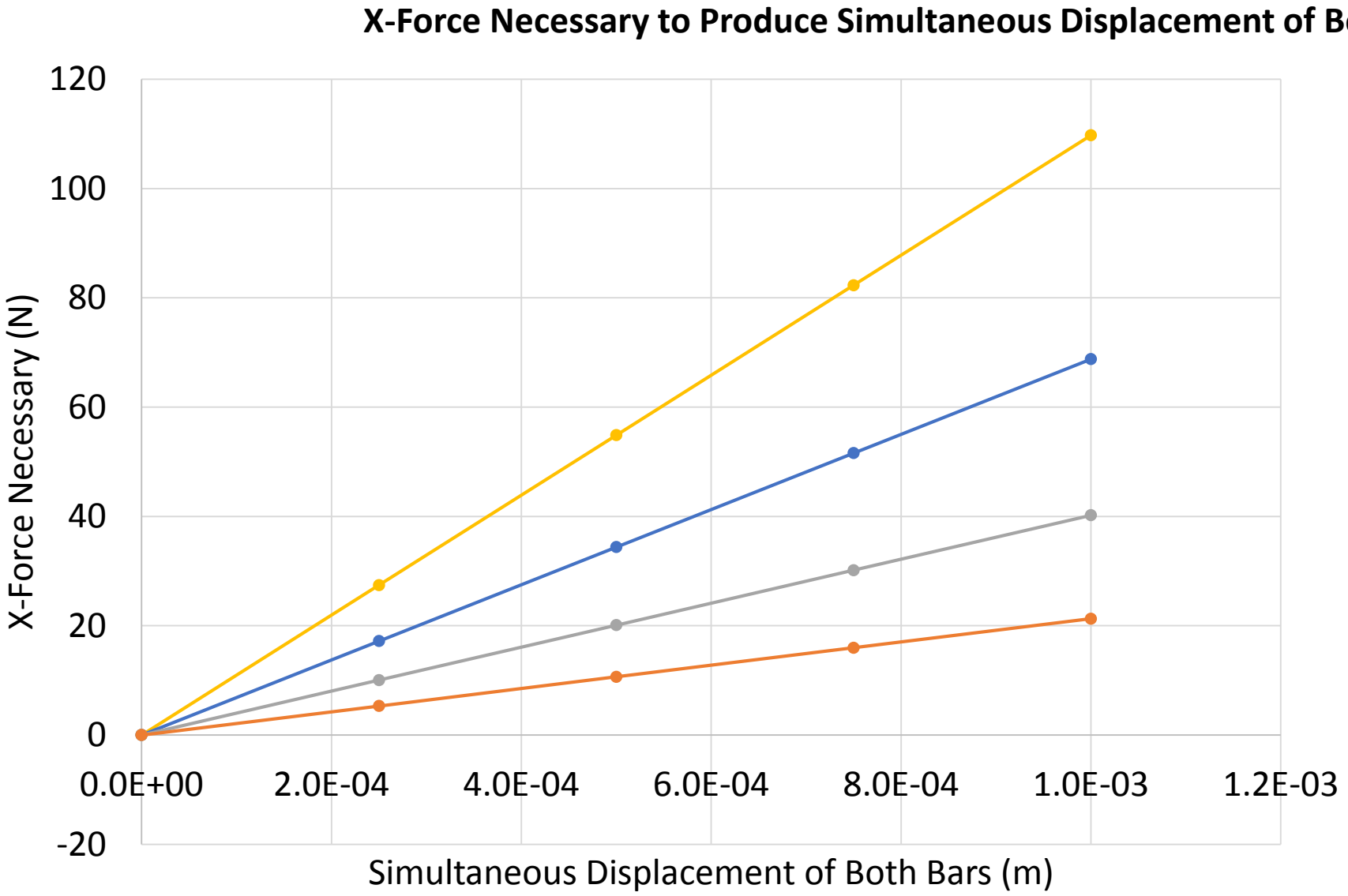
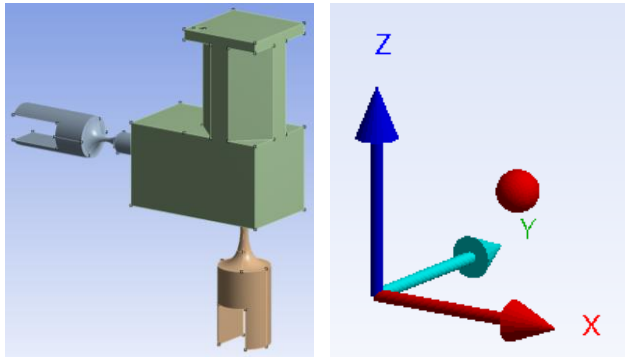
Friction was not accounted for.

Force Necessary to Produce Displacement – Simultaneous Displacement of Both Bars





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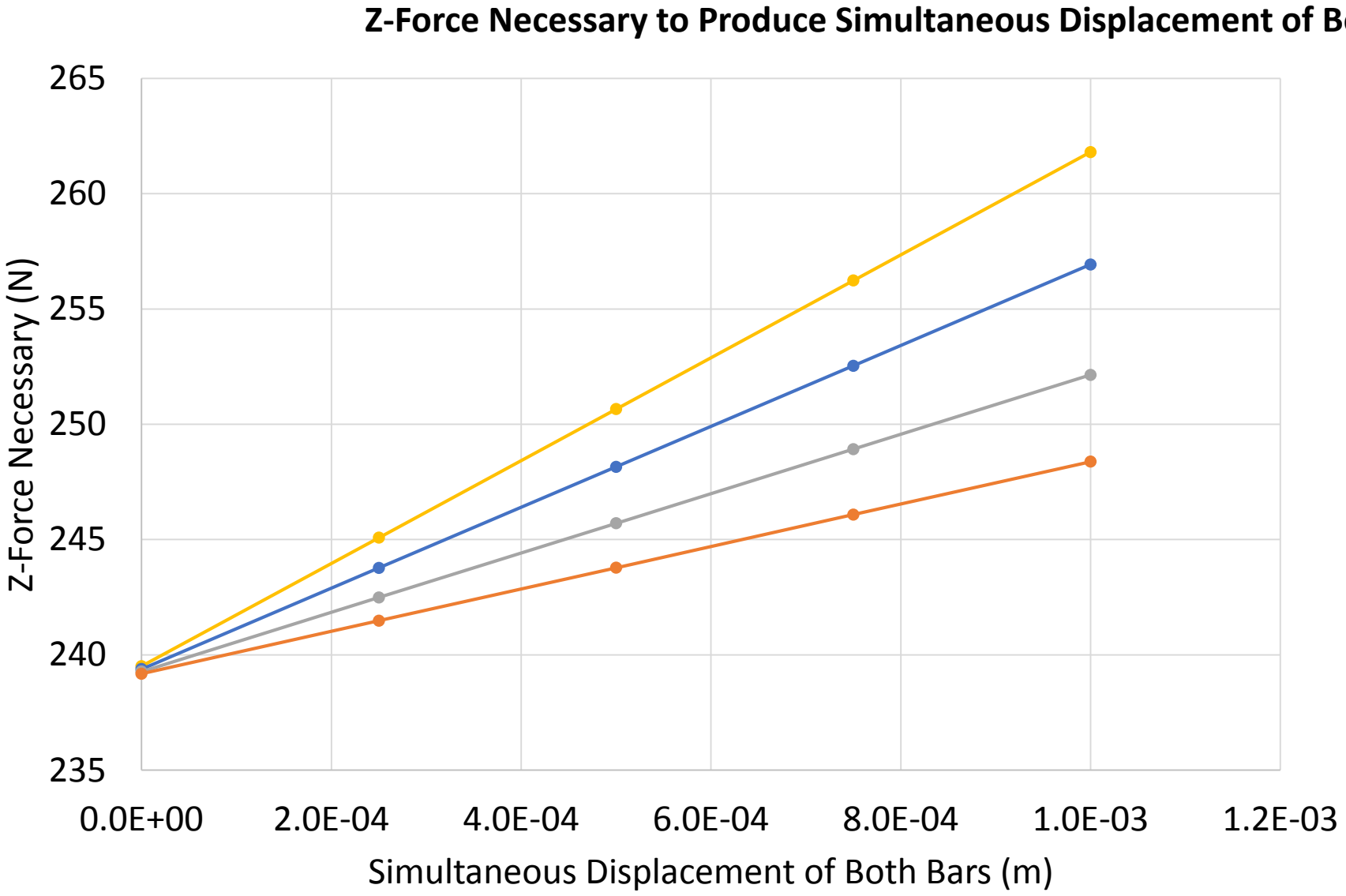

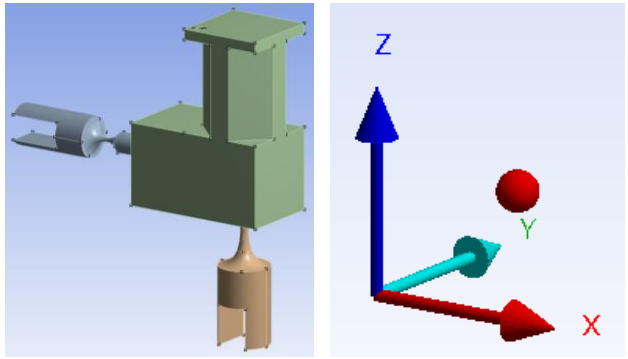

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- Original Thickness
- 0.5 mm Thinner Vertical Bar
- 1 mm Thinner Vertical Bar

Friction was not accounted for.

1. Thinner vertical bars create lower stresses and increase the adjustment range.
2. Thinner vertical bars as well require smaller forces to perform adjustments.
3. Thinner vertical bars, however, makes the sleeve more likely to tilt – may need to take into consideration in actual application.

Thank you.