Bending of a beam with a shoulder and fillet

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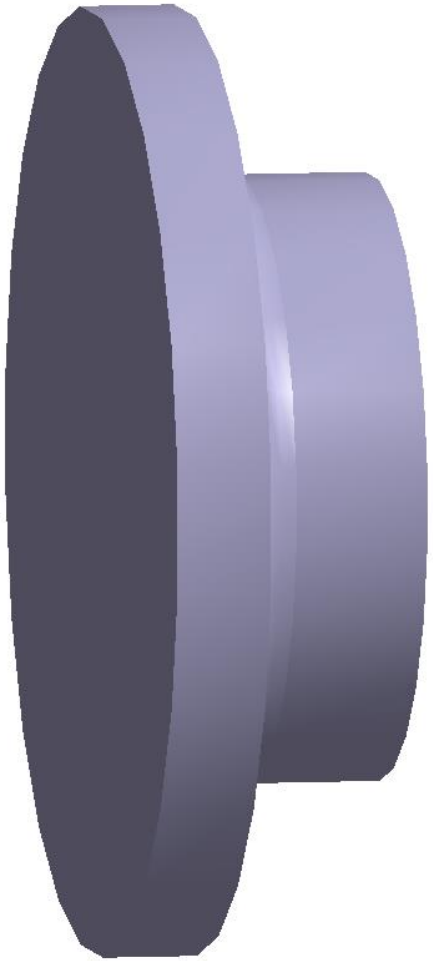
For questions, please fill out contact form

ALGO Engineering
Simplifying FEA

Model Description

- Bending analysis of a beam with a shoulder and fillet is based on example question documented in page 775 of the following book :
  - J. Souza, *Roark's Formulas For Stress And Strain-.pdf*. [Online]. Available: https://www.academia.edu/37205286/Roarks_Formulas_For_Stress_And_Strain_pdf

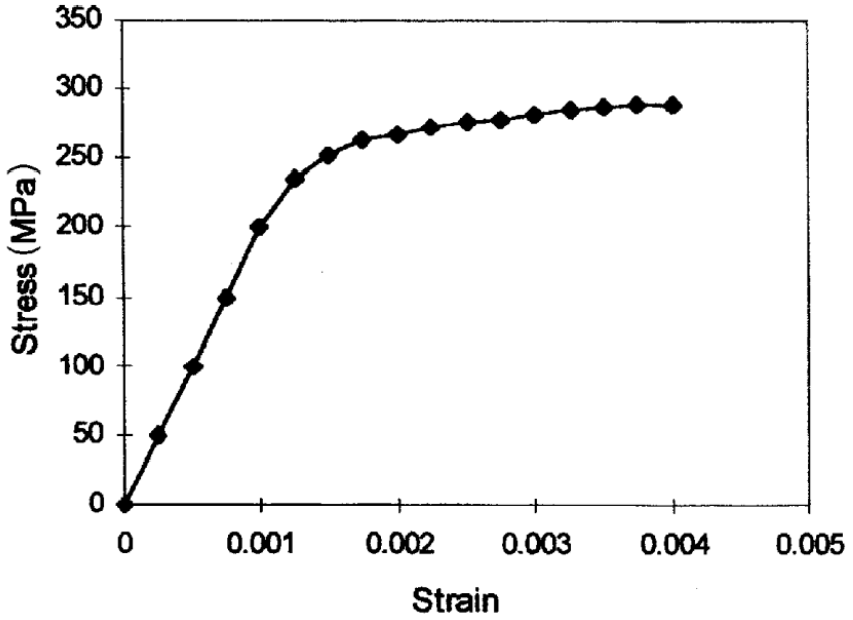


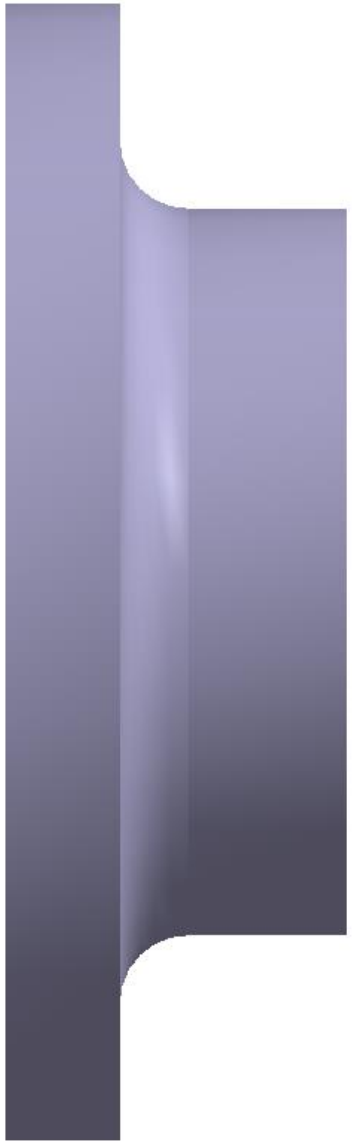
Model Description

Young's modulus – 200 GPa

Density – 7850 kg/m3

Poison's ratio – 0.33





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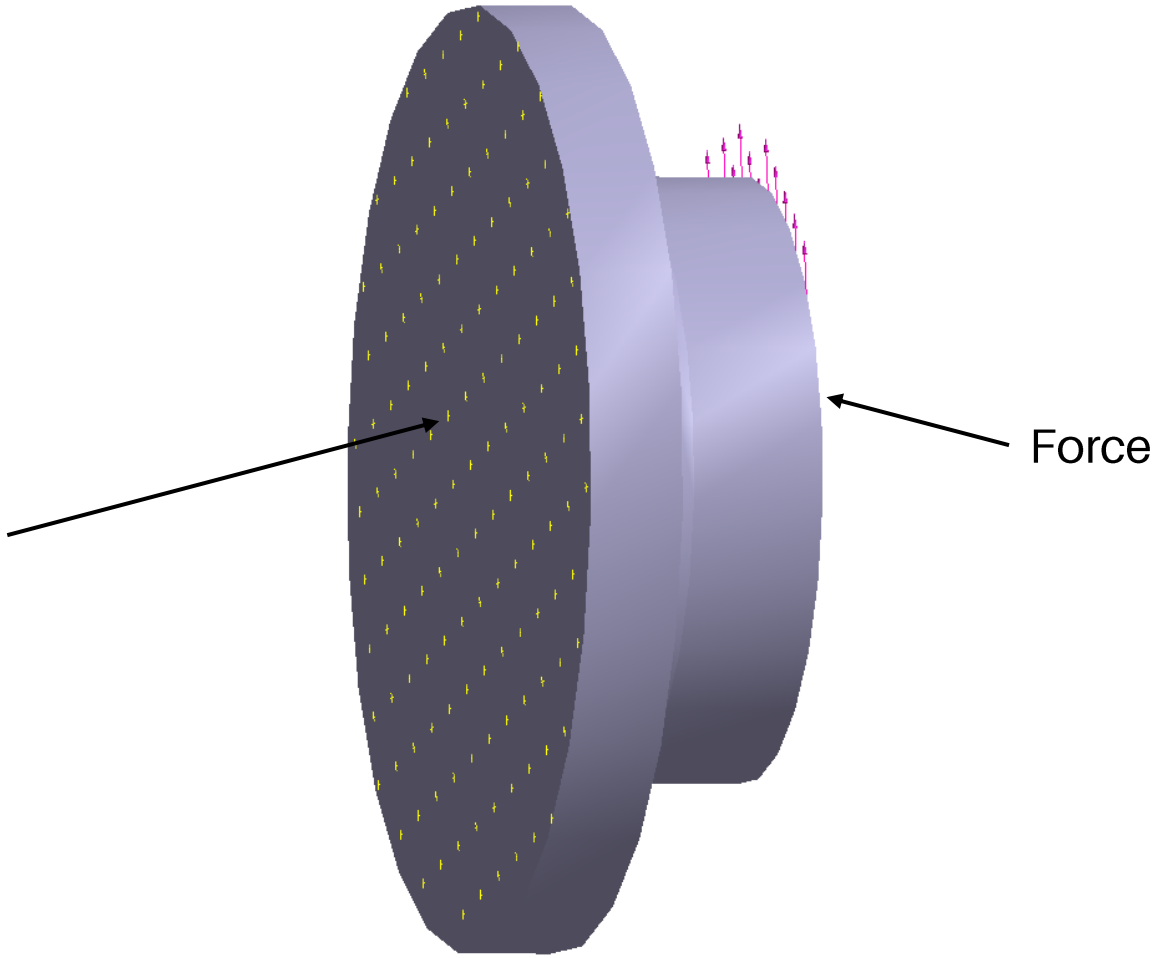
Model Parameters

Entity	Type
Solver	Altair SimSoild
Version	2022.2.1
CPU	Intel(R) Core(TM) i7-9750H CPU @ 2.60GHz

FEA Entities	Type
Analysis Type	Structural linear
Unit System	kg, m, s

Analysis Setup



Analysis Assumptions and Limitations

- Length of the beam was not mentioned in the question and is thus assumed as 15mm.
- Material of the beam was also not mentioned in the question and is thus assumed as steel.

Hand Calculations

$D = 50\ mm, h = 9\ mm, r = 3\ mm$

$\frac{h}{r} = 3$

Hence,

$$C_1 = 0.927 + 1.149\sqrt{\frac{h}{r}} - 0.086\frac{h}{r} = 2.634$$

$$C_2 = 0.011 - 3.029\sqrt{\frac{h}{r}} + 0.948\frac{h}{r} = -2.902$$

$$C_2 = -0.304 - 3.979\sqrt{\frac{h}{r}} - 1.737\frac{h}{r} = 1.587$$

$$C_2 = 0.366 - 2.098\sqrt{\frac{h}{r}} + 0.875\frac{h}{r} = -0.3182$$

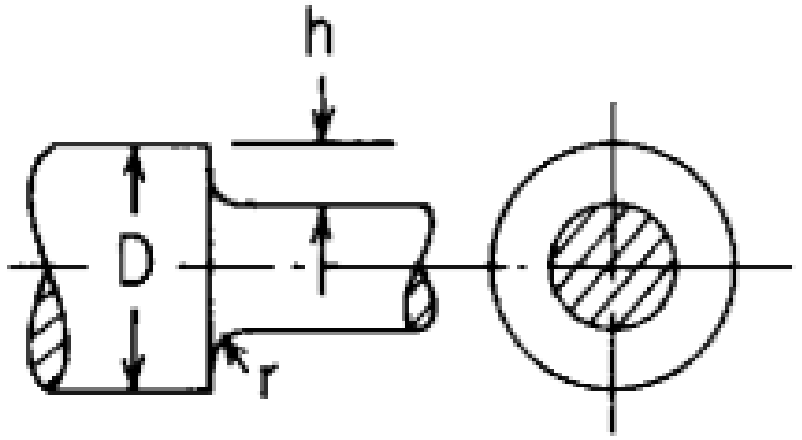


Figure – from above book

Hand Calculations

$$with, \frac{2h}{D} = 0.36$$

$$K_t = C_1 + C_2\left(\frac{2h}{D}\right) + C_3\left(\frac{2h}{D}\right)^2 + C_4\left(\frac{2h}{D}\right)^3 = 1.780$$

Bending moment = 500 Nm

$$Stress\ at\ the\ minor\ radius\ \sigma_{nom} = \frac{32M}{\pi(D-2h)^3} = 155.4\ MPa$$

If is in the elastic range, then

$$\sigma_{max} = K_t\sigma_{nom} = 276.6\ MPa$$

Hand Calculations

This value exceeds elastic limit of 200 MPa.

$$\varepsilon_{nom} = \frac{\sigma_{nom}}{E} = 77.7 \times 10^{-5}$$

Thus,

$$K_t^2 \sigma_{nom} \varepsilon_{nom} = 0.3826\ MPa$$

From the tabulated data,

σ (MPa)	0	50	100	150	200	235	252	263	267
$\sigma\ \varepsilon$ (MPa)	0	0.0125	0.05	0.1125	0.2	0.29375	0.378	0.46025	0.534

Hand Calculations

Using interpolation,

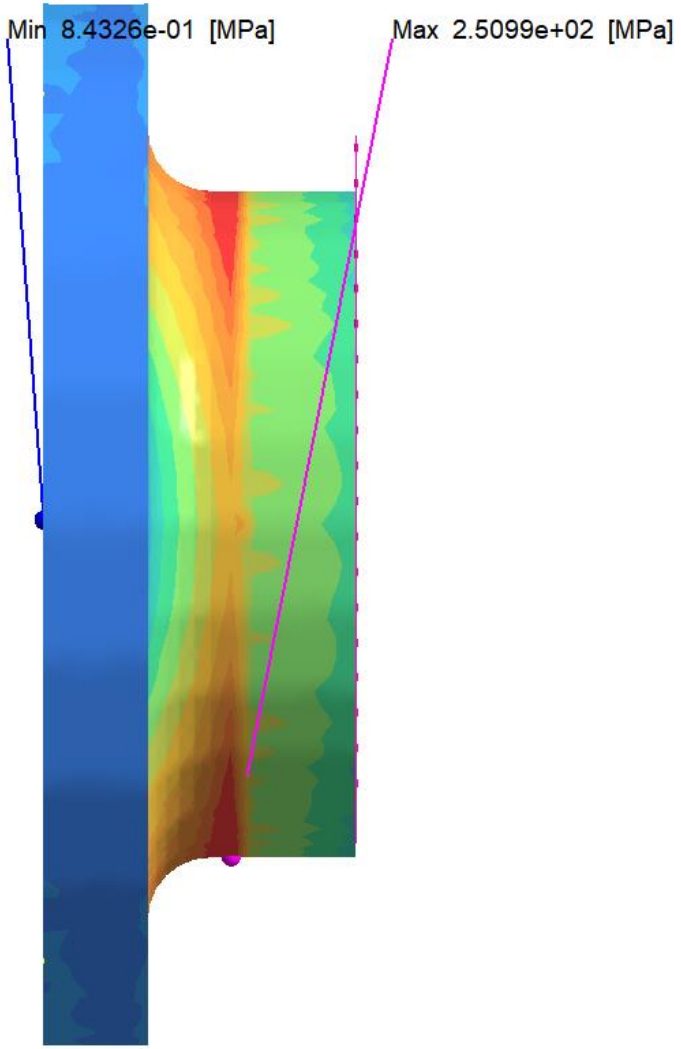
$$\frac{\sigma_{max} - 252}{0.3826 - 0.378} = \frac{263 - 252}{0.46025 - 0.378}$$

Therefore,

This yields $\sigma_{max} = 252.6\ MPa$

Analysis Results

Units – MPa



Analysis Results

- Maximum stress,
  - Based on hand calculations – $252.6\ MPa$
  - From the simulation – 250.99 MPa

Conclusions

- Bending analysis of beam with shoulder and fillet is conducted using Altair SimSolid based on the book listed in slide 2.
- Results of the simulation correlate well to the expected hand calculation value.