Aircraft Spar Beam Torsion

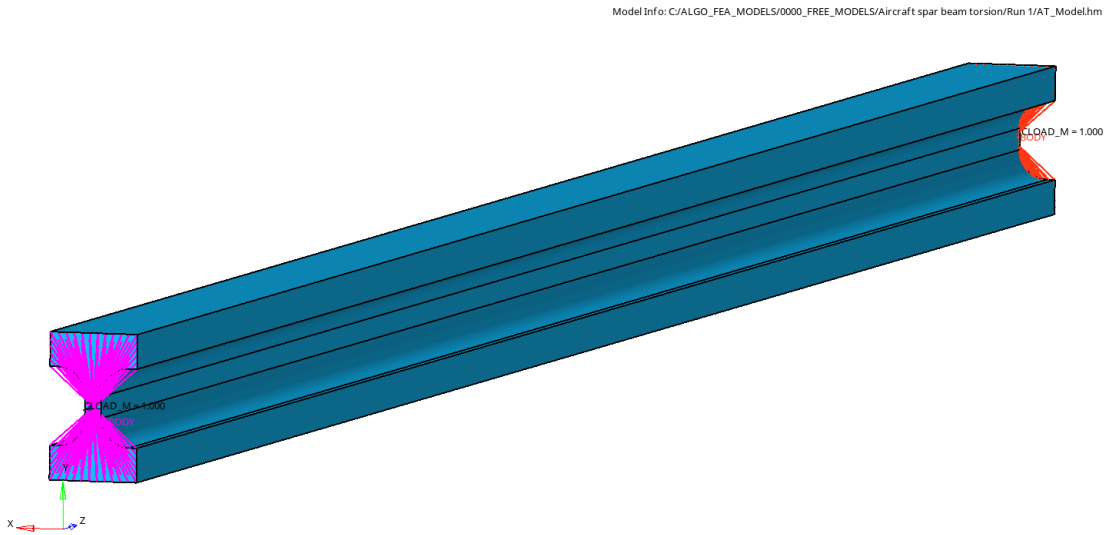
Sanka Dasanayaka

For questions, please fill out contact form

ALGO Engineering
Simplifying FEA

Model Description

- Torsion analysis of a spar beam based on example question 2 documented in page 385 of the following book :
  - J. Souza, *Roark's Formulas For Stress And Strain-.pdf*. Accessed: Nov. 06, 2022. [Online]. Available: https://www.academia.edu/37205286/Roarks_Formulas_For_Stress_And_Strain_pdf
- As mentioned in the book, spar beam is made out of spruce wood.



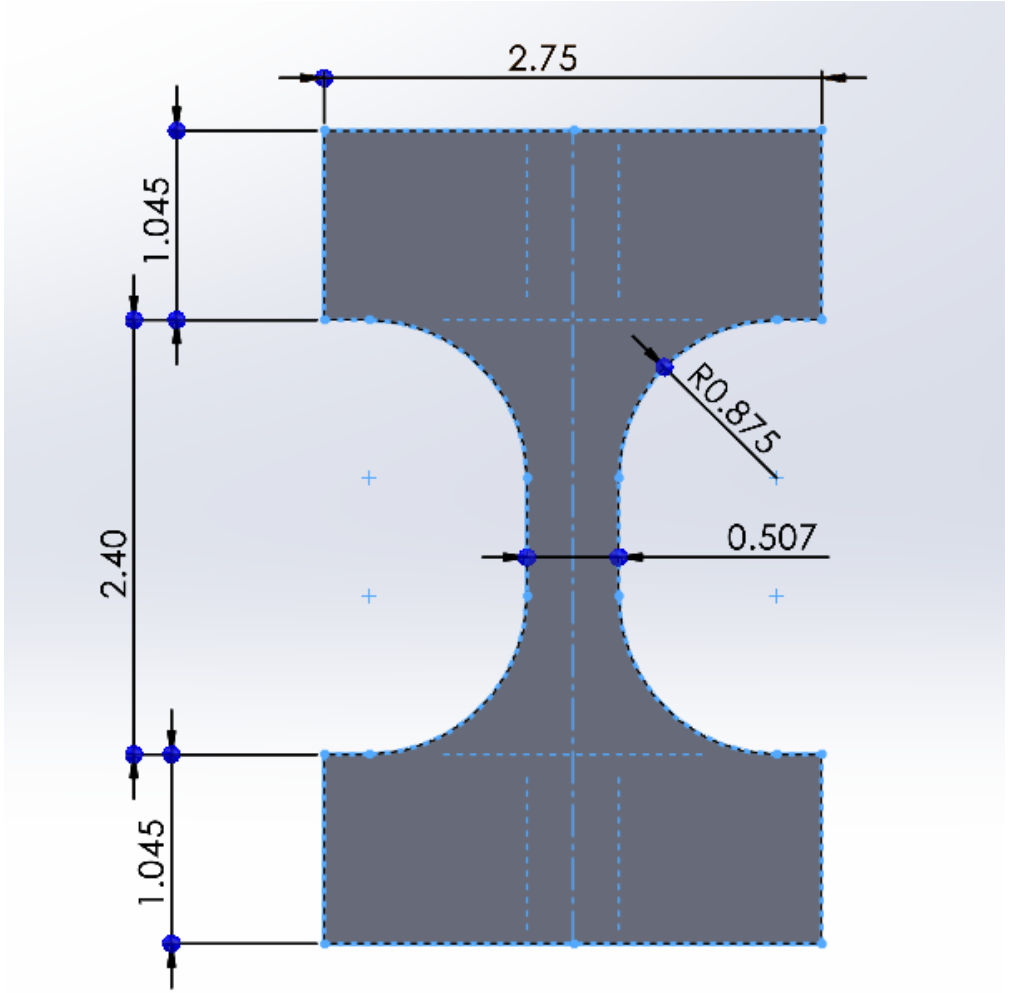
Model Description

Length – 8 ft

Young's modulus – 1500000 lb/in2

Modulus of rigidity – 100000 lb/in2

Poison's ratio – 0.38



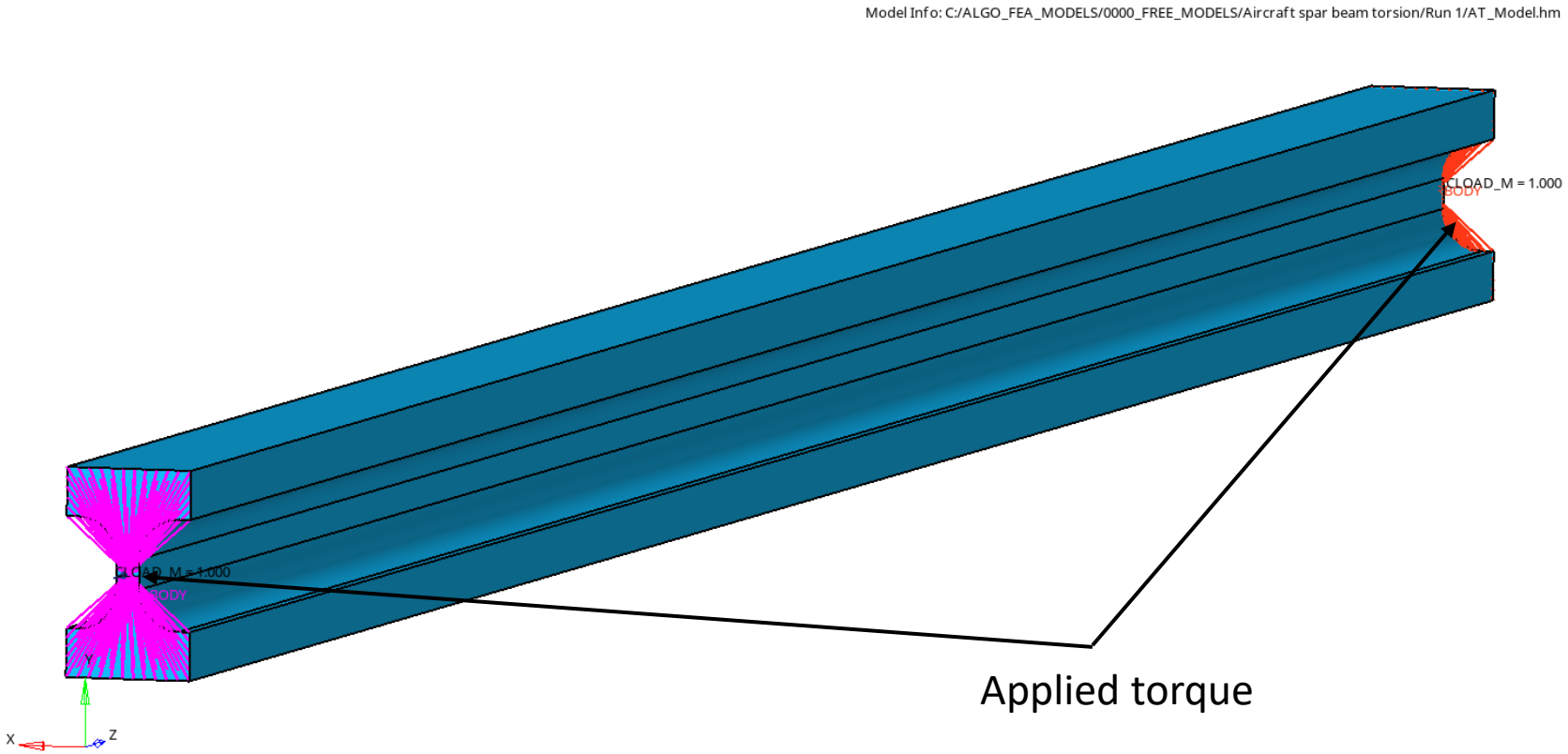
ALGO Engineering
Simplifying FEA

Model Parameters

Entity	Type
Solver	Altair Radioss
Version	2021.2.1
Processors	2
Threads	2
CPU	Intel(R) Core(TM) i7-9750H CPU @ 2.60GHz
Total run time	1 sec

FEA Entities	Type
Analysis Type	Dynamic Explicit
Unit System	lb, in, s
Element Type	HEXA8N
Material Type	M1_ELAST
Property Type	P14_SOLID

Analysis Setup



Analysis Assumptions and Limitations

- Standard density value and standard Poisson's ratio of spruce is assumed.

Hand Calculations

$K - Length\ to\ the\ fourth\ function\ of\ cross\ section \quad E - Young's\ modulus \quad \nu - Poisson's\ ratio \quad T - torque \quad l - length \quad G - modulus\ of\ Rigidity \quad A - Area\ of\ the\ section$

$$K = 2K_1 + K_2 + 2\alpha D^4$$

$$K_1 = ab^3\left[\frac{1}{3} - 0.21\frac{b}{a}\left(1 - \frac{b^4}{12a^4}\right)\right] = 0.796\ in^4$$

$$K_2 = \frac{1}{3}cd^3 = 0.104\ in^4$$

$$\alpha = \frac{t}{t_1}\left(0.15 + 0.1\frac{r}{b}\right) = 0.1133$$

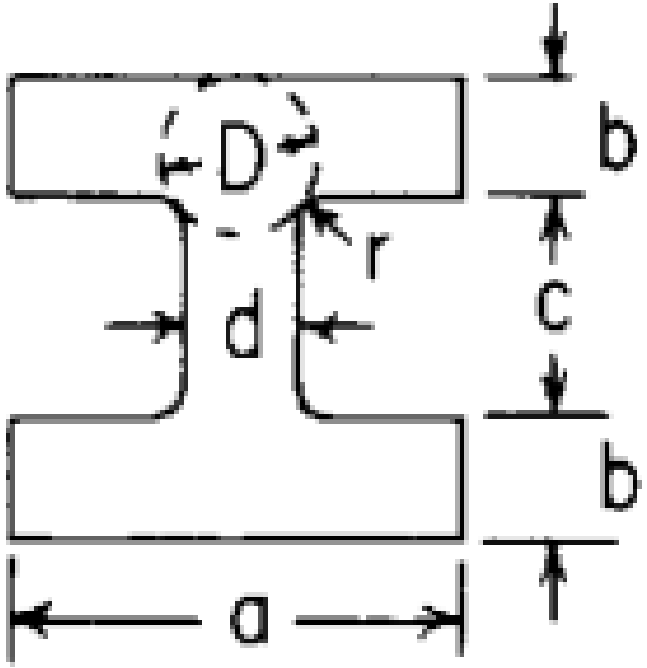


Figure – from above book

Hand Calculations

Here, $t_1 = d$

$$\theta = \frac{Tl}{KG} = 0.168\ rad$$

$$\tau_{max} = \frac{T}{K} C$$

Where,

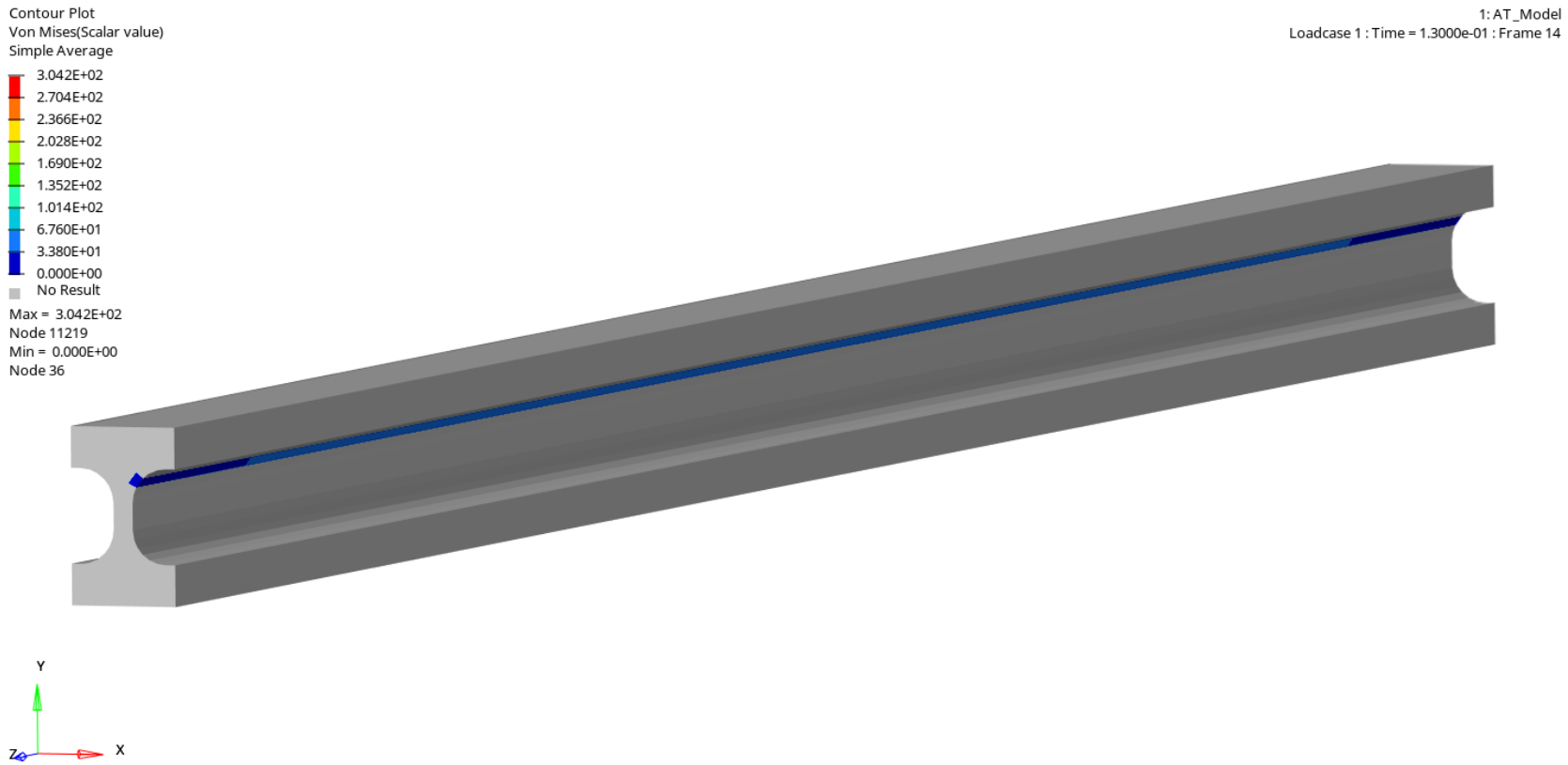
$$C = \frac{D}{1 + \frac{\pi^2 D^4}{16A^2}} \left[1 + 0.15 \left(\frac{\pi^2 D^4}{16A^2} - \frac{D}{2r} \right) \right] = 1.73\ in$$

Therefore,

$$\tau_{max} = 303\ lb/in^2$$

Analysis Results

Units – lb/in2



Analysis Results

- Maximum stress,

  Based on hand calculations – 303 ln/in2

  From the simulation – 304.2 lb/in2

Conclusions

- Torsion analysis of a spar beam conducted using Altair Radioss based on the book listed in slide 2.
- Results of the simulation correlate well to the expected hand calculation value.