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FEA analysis on a beam of Hexacopter Drone Frame

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Presentation Outline

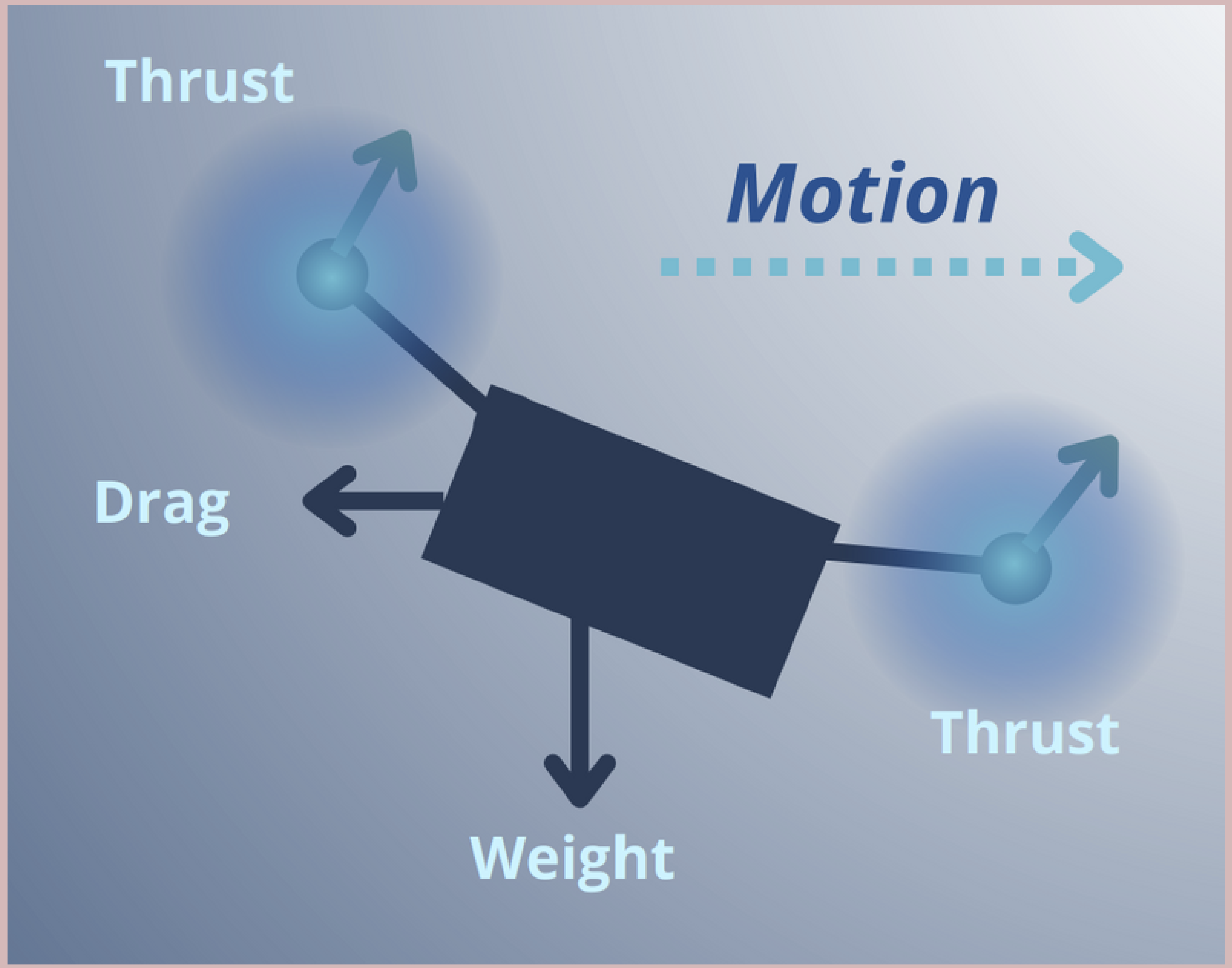
- Scope
- Drone physics
- Material Selection
- Design Reference
- Assumptions
- Calculations
- Simulation
- Results

SCOPE

Perform an analysis on the behavior of the beam constituting the hexacopter drone

- THE MEASUREMENTS OF A STANDARD DRONE
- LOAD ANALYSIS
- FAILURE SIMULATION
- RESULTS

DRONE PHYSICS



MECHANISM

- A machine that flies with the help of a remote-control system
- The aerodynamic shape of the drone is selected

PROBLEMATIC

- To identify the regions of stress concentration and why is it increased in that area in order to reduce it

MATERIAL SELECTION

Failure Stress	276 MPA
Failure Strain	207 MPA
Factor of Safety	2
Density	2,7 g/cm^3
Modulus of Elasticity	68,9 GPA
Poisson's Ratio	0,33

Design Reference

Frame Weight	810g
Arms Diameters	16mm
Motor to Motor	695mm
Center Body Dimension	195x195x2 mm
All up Weight	2.8kg
Payload	1.8-2kg
Propellers	13in
Thrust per arm	800-1000g
Material	PCB
Density	1.850g/cm^3

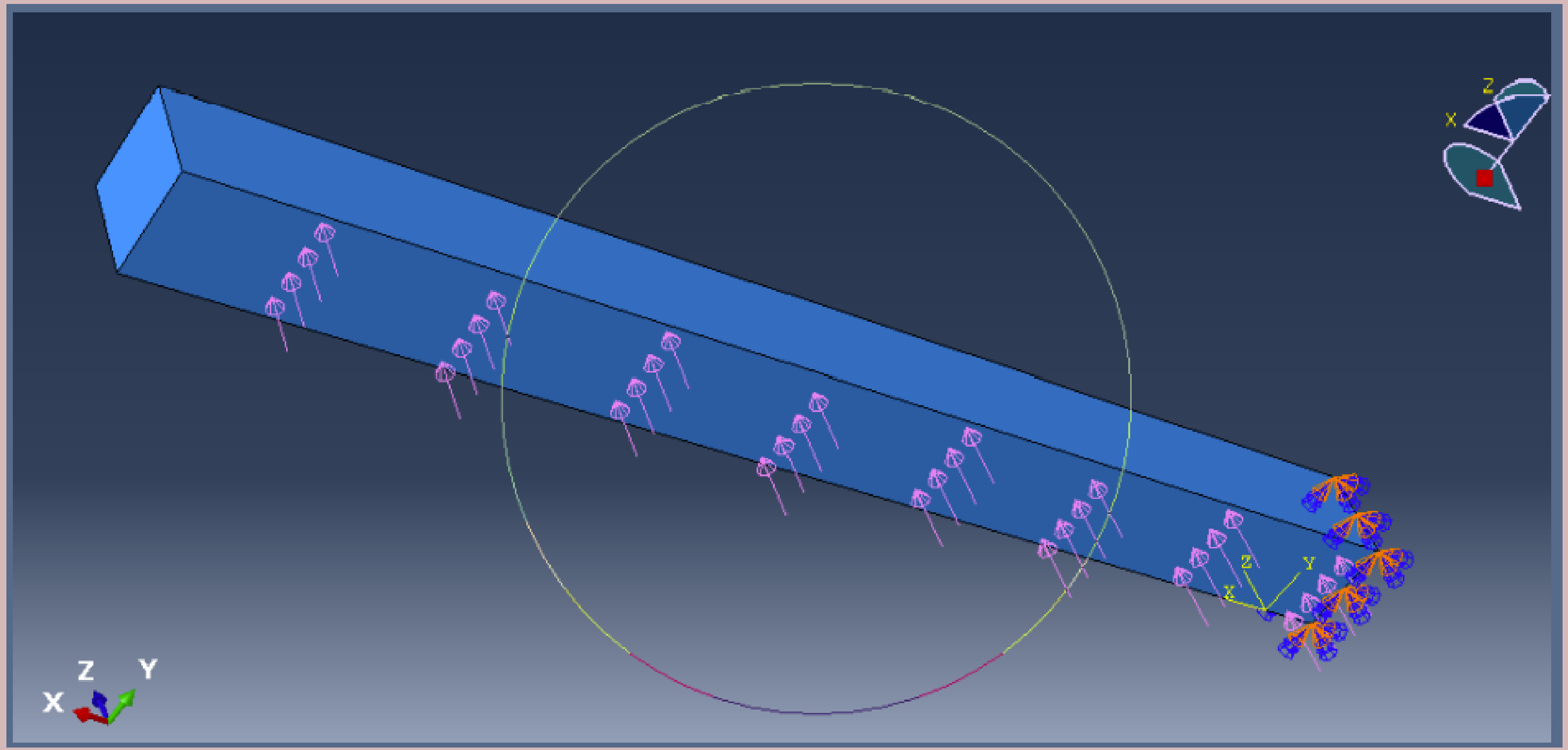
Assumptions

- The twist is neglected, as it is small in a drone
- The angle formed between every two consecutive arms is 60°, for the sake of symmetry;
- The material used is isotropic (homogeneous) ($E = constant \rightarrow \varepsilon xy = \varepsilon yx$); Friction with air neglected.
- We assume that the deflection is small, because the smaller the deflection, the better the stability.

BOUNDARY CONDITIONS

we consider the arm to be a clamped beam.

the beam is clamped, the deflection is zero



Pressure load

BEAM ANALYSIS

On the y-axis we have:

$$+\uparrow \sum F_y = 0 \rightarrow F - R_{ay} = 0$$

$$F = R_{ay} = 15N$$

For the moments we have:

$$\sum M_z = 0 \rightarrow F \text{ x L} - M_{az} = 0$$

$$M_{az} = F \text{ x L} = 15 \text{ x } 0.25$$

$$M_{az} = 3.75\text{N. m}$$

To find the shear force (V) and the moment (M) we need to cut the beam.

On the y-axis we have:

$$+\uparrow \sum F_y = 0 \rightarrow V - R_{ay} = 0$$

$$V = R_{ay} = 15N$$

For the moment we have:

$$\sum M_z = 0 \rightarrow M_{az} - M_x - V \text{ x } x = 0$$

$$M_x = M_{az} - V \text{ x } x$$

$$M_x = 3.75 - 15x$$

At the support:

$$\text{x} = 0 \quad \rightarrow \text{M=3.75N.m}$$

For the slope we know that:

$$\theta = \int \frac{M}{EI} dx$$

Because EI is constant we get:

$$\theta = \frac{1}{EI} \int M dx$$

$$\theta = \frac{1}{EI} \int (3.75 - 15x) dx$$

$$\theta = \frac{1}{EI} (3.75x - \frac{15}{2} x^2 + c_1)$$

At the support: $\rightarrow \theta = 0$

$$\theta = \frac{1}{EI} \left(3.75x - \frac{15}{2} x^2 + c_1 \right) = 0$$

We replace x=0 :

$$\theta = \frac{1}{EI} \left(3.75 \text{ x } 0 - \frac{15}{2} \text{ x } 0^2 + c_1 \right) = 0$$

$$c_1 = 0$$

The final equation of the slope is:

$$\theta = \frac{1}{EI} \left(3.75x - \frac{15}{2} x^2 \right)$$

For the deflection we know that:

$$\vartheta = \iint \frac{M}{EI} dx$$

Because EI is constant we get:

$$\vartheta = \frac{1}{EI}\iint M\,dx$$

$$\vartheta = \frac{1}{EI}\iint (3.75 - 15x)\,dx$$

$$\vartheta = \frac{1}{EI}\int \left(3.75x - \frac{15}{2}x^2 + c_1\right) dx$$

$$\vartheta = \frac{1}{EI}\left(\frac{3.75}{2}x^2 - \frac{15}{6}x^3 + c_1 x + c_2\right)$$

We deduced previously that $c_1 = 0$ so:

$$\vartheta = \frac{1}{EI}\left(\frac{3.75}{2}x^2 - \frac{15}{6}x^3 + c_2\right)$$

At the support $\vartheta = 0$:

$$\vartheta = \frac{1}{EI}\left(\frac{3.75}{2}x^2 - \frac{15}{6}x^3 + c_2\right) = 0$$

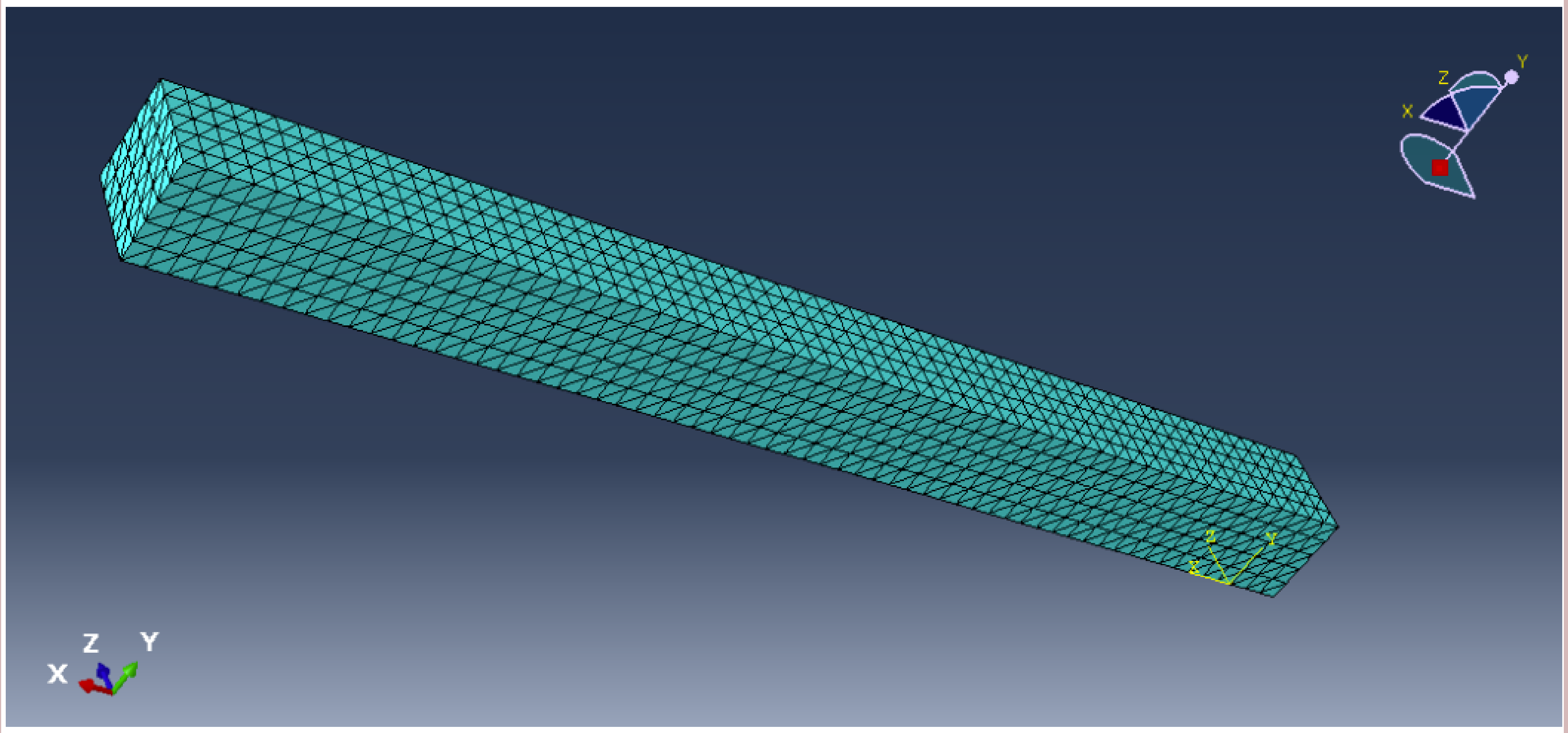
We replace x=0:

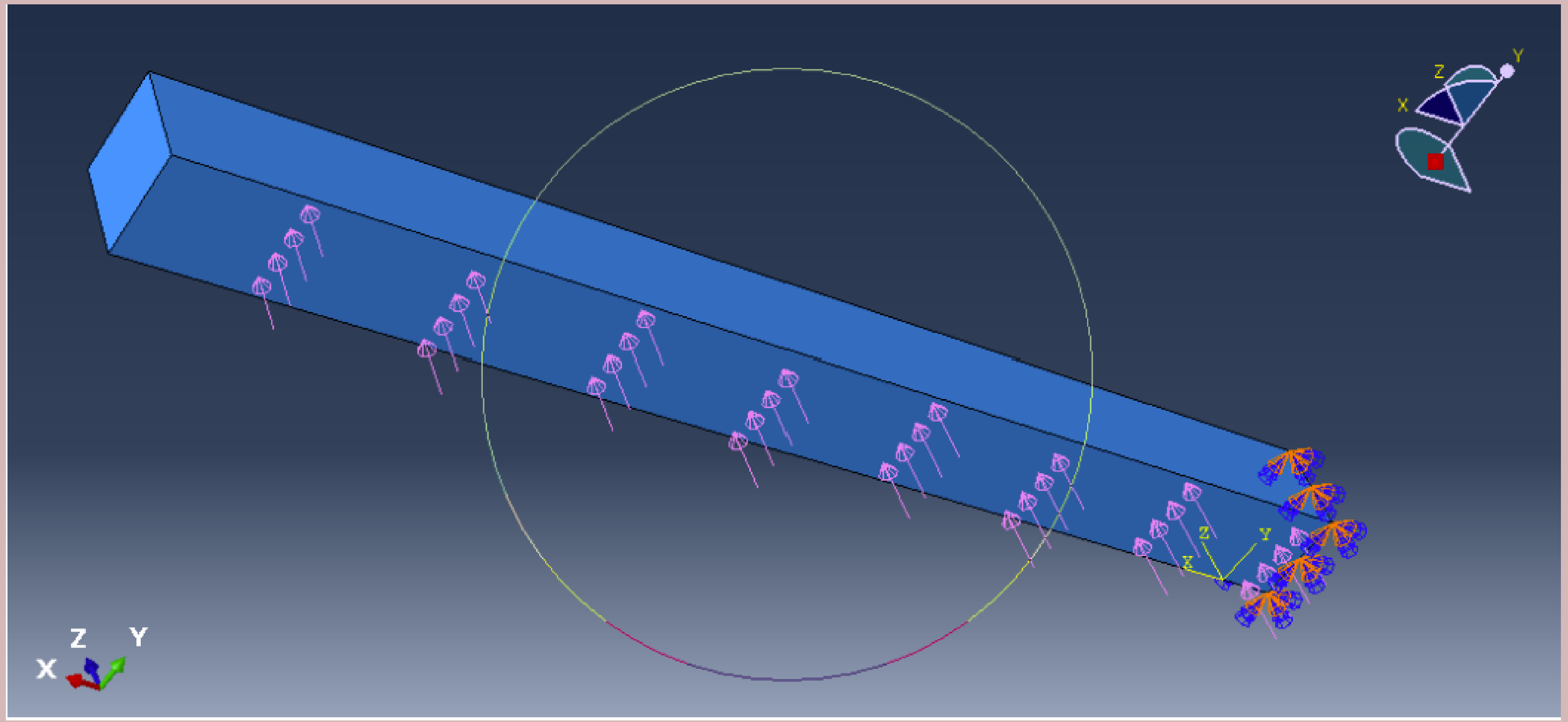
$$\frac{1}{EI}\left(\frac{3.75}{2}\,\text{x}\,0^2 - \frac{15}{6}\,\text{x}\,0^3 + c_2\right) = 0$$

$$c_2 = 0$$

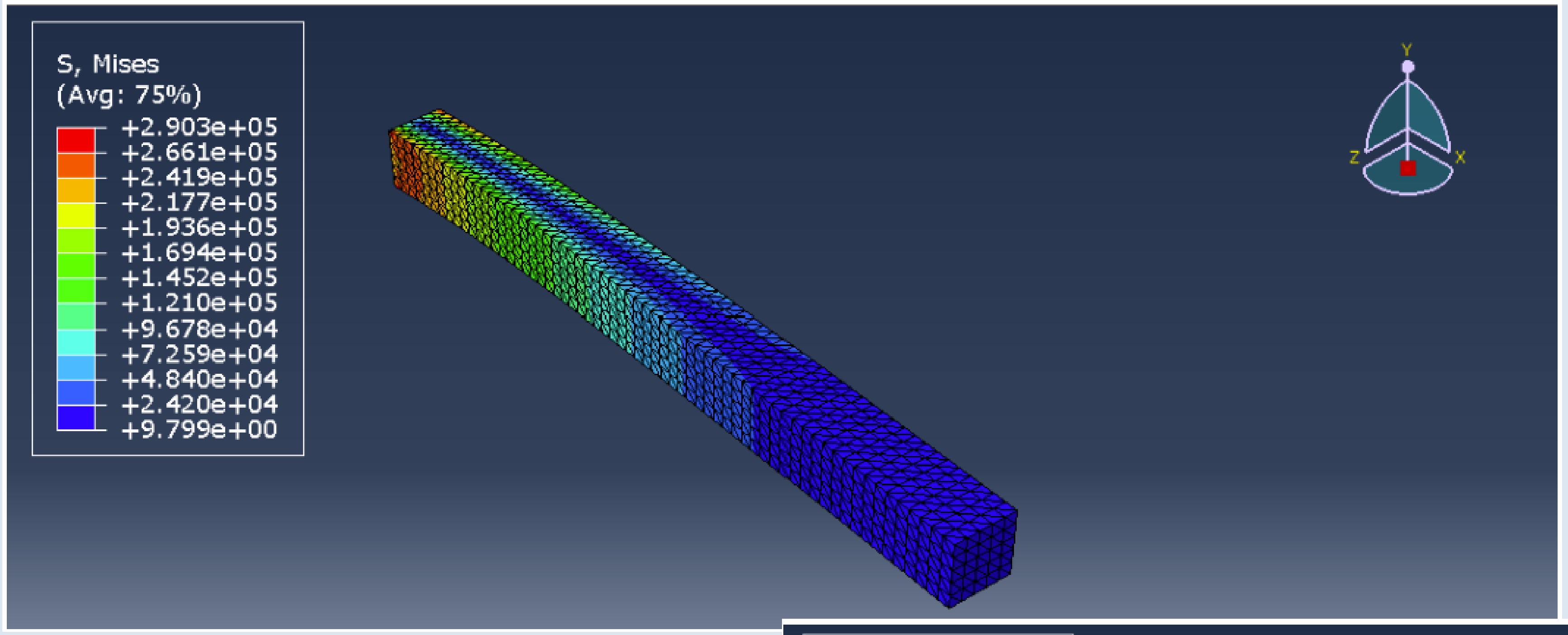
The final equation of the deflection is:

$$\vartheta = \frac{1}{EI}\left(\frac{3.75}{2}x^2 - \frac{15}{6}x^3\right)$$





SIMULATIONS


S, Mises
(Avg: 75%)
+2.903e+05
+2.661e+05
+2.419e+05
+2.177e+05
+1.936e+05
+1.694e+05
+1.452e+05
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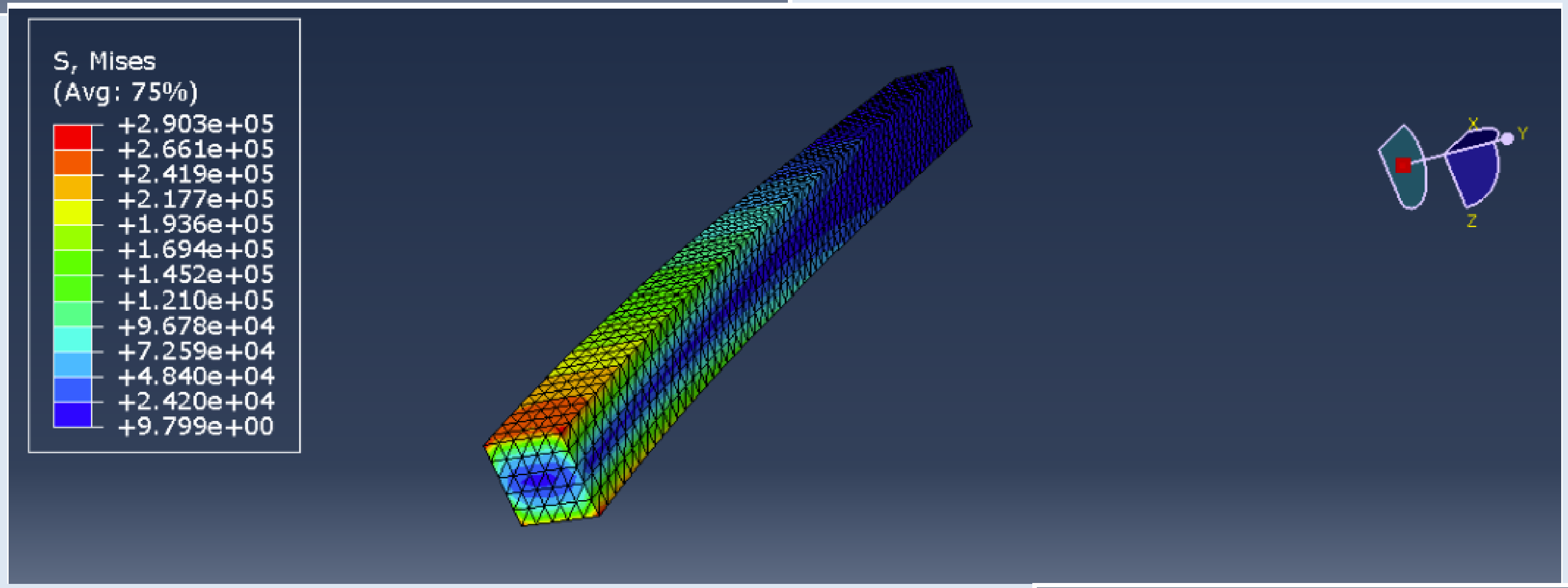
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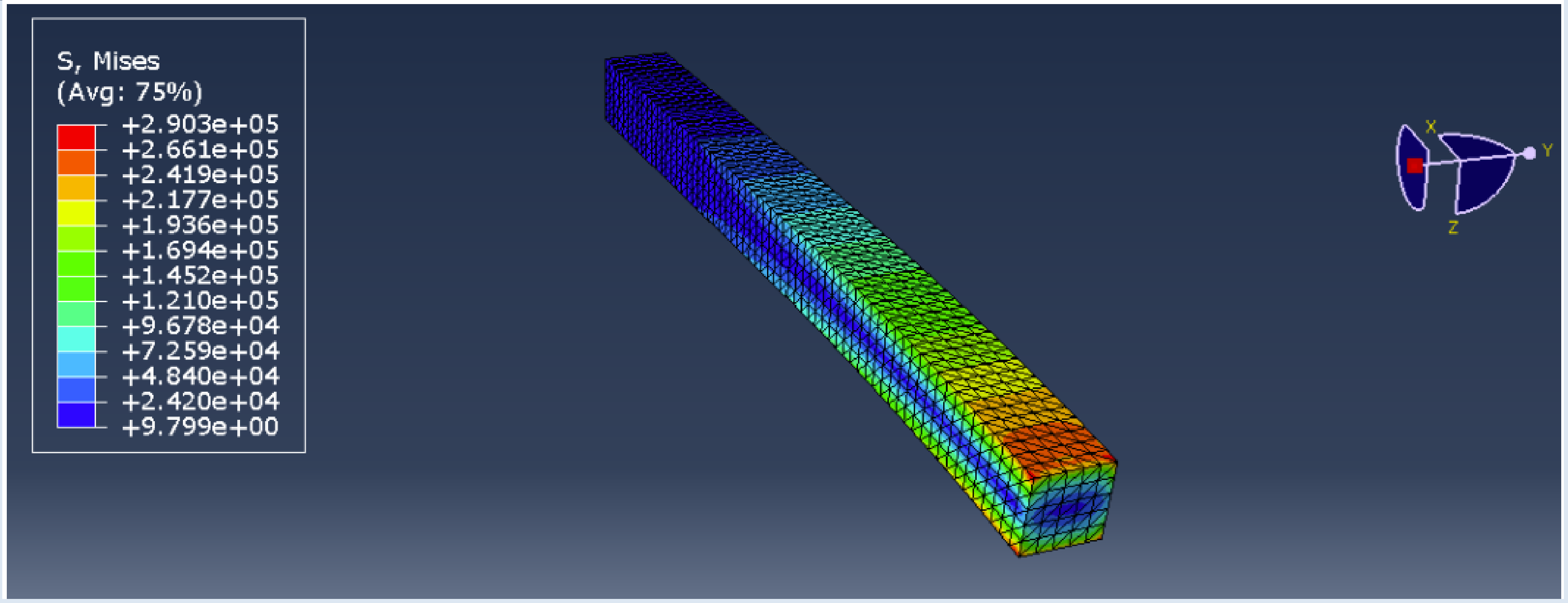
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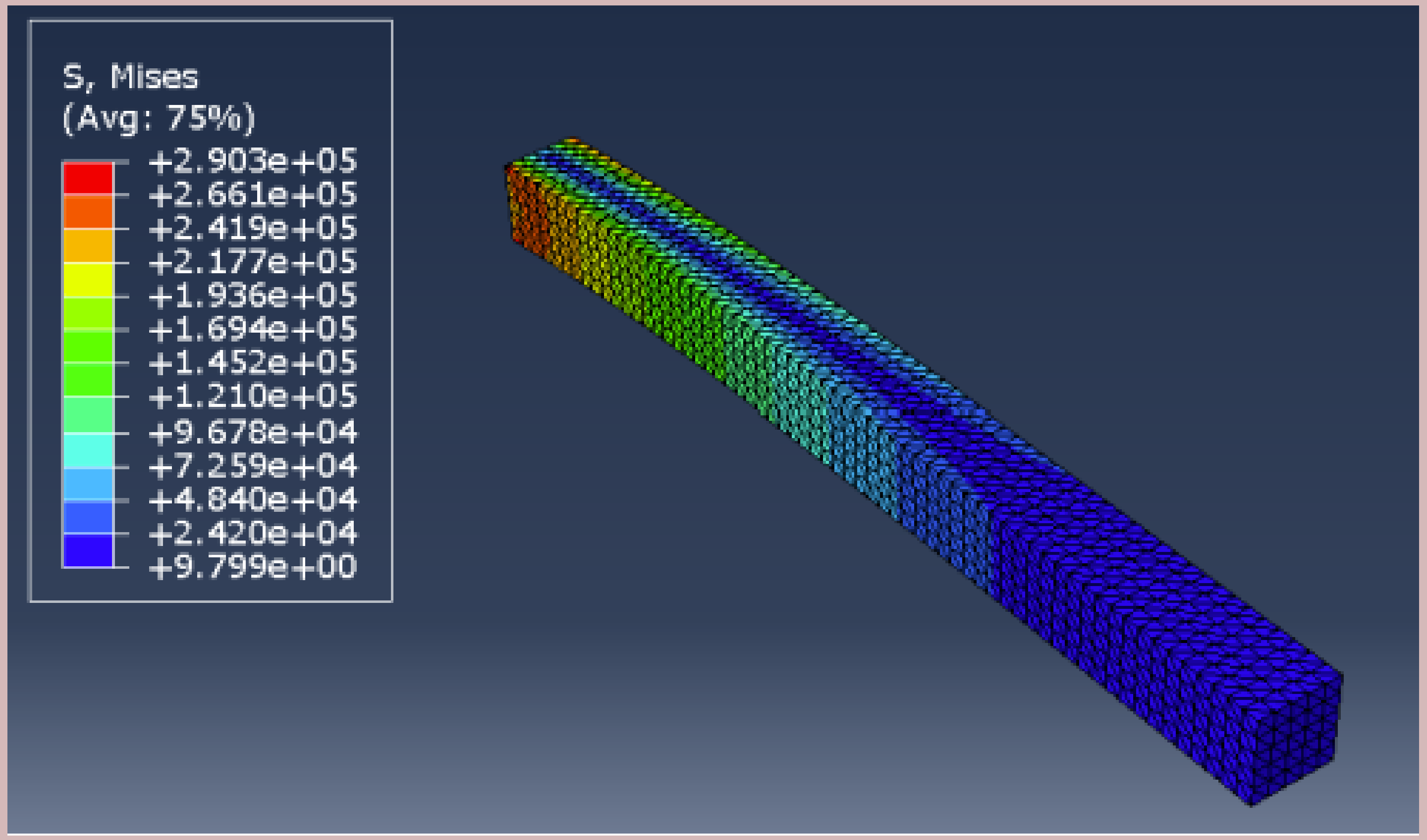

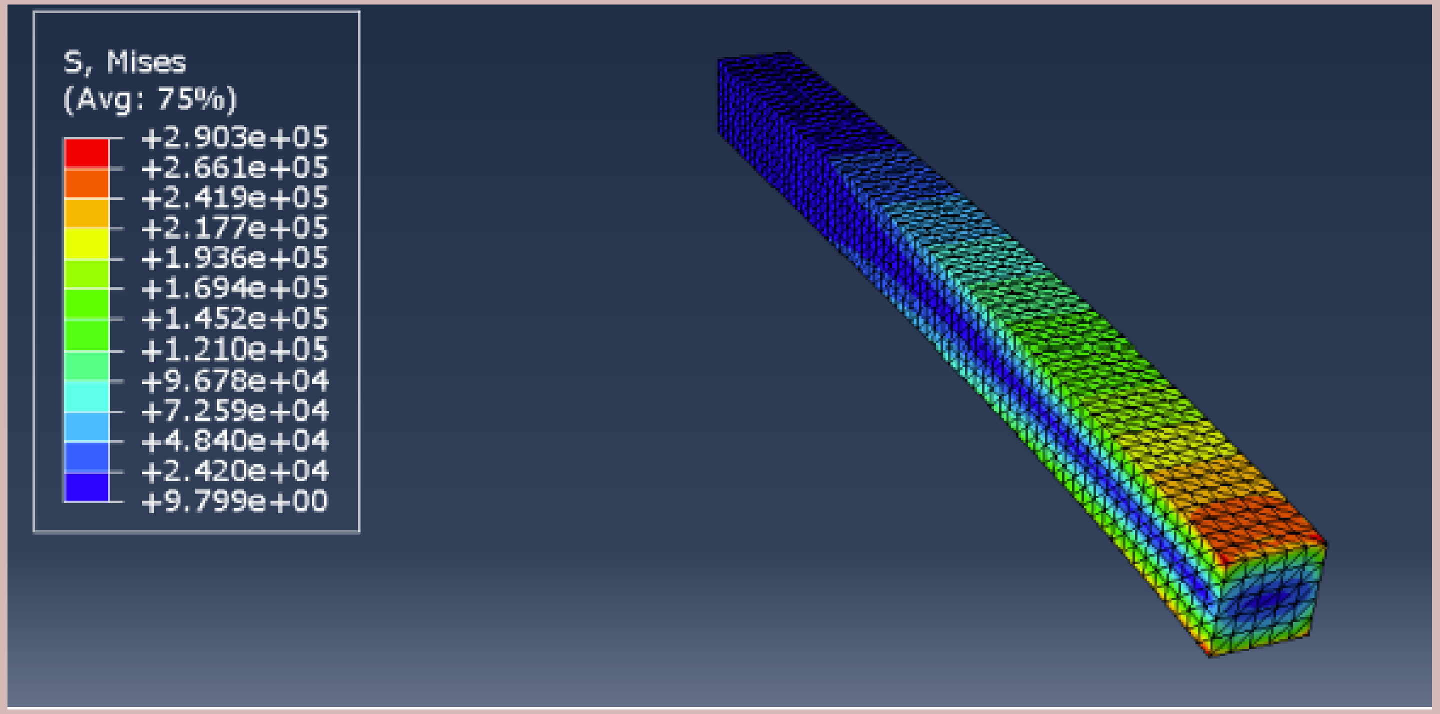

RESULTS AND DISCUSSION

- the stress concentration is higher when getting close to the fixed part.
- the stress concentration is cancelled in the neutral axis
- the clamped part should be stronger and well built so as to avoid any failure.

THANK YOU FOR YOUR ATTENTION