Lab 3 Report ME 371

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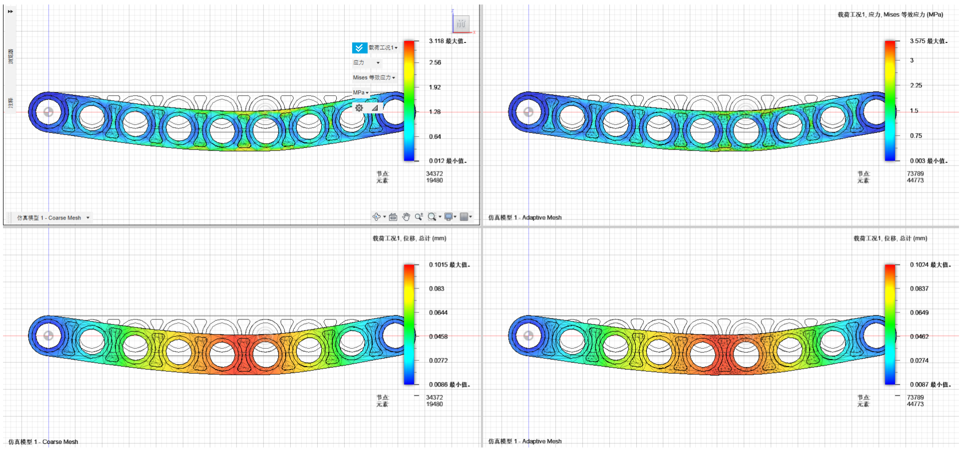
Question 1

Submit <u>screenshots</u> of the FEA solution contour plots of the <u>Total Displacement</u> and <u>von Mises stress</u> contours for both the initial solution using default mesh settings and the AMR solution.
Consider using the "Compare" tool along the upper ribbon when viewing the results. You can set each panel to display the results of one of the two studies using the drop down menu in the bottom left of the panels displayed in the "Compare" view.

a) How does the maximum displacement compare in each model?
b) How does the maximum von Mises stress compare in each model?
c) How is the AMR mesh different than the mesh using default settings? Does this change make sense to you based on the loading conditions and resulting deformation?



From comparison we found

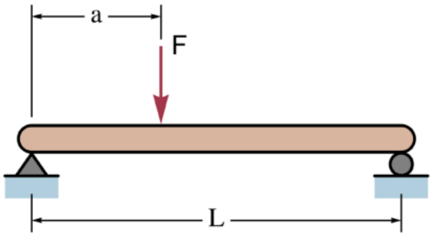
$$\Delta x_{Max,Default} = 0.1015\,mm < \Delta x_{Max,AMR} = 0.1024\,mm$$

$$\sigma_{VM,Max,Default} = 3.118\,MPa < \sigma_{VM,Max,Default} = 3.575\,MPa$$

AMR mesh has finer mesh in the small "I" shape trench. Yes, it makes sense.

Question 2

The loading situation modeled in this lab is similar to the one shown below. The equation for the maximum vertical deflection for this beam according to Euler beam theory is as follows.



$$\delta_{max} = \begin{cases} \dfrac{Fa(L^2 - a^2)^{\frac{3}{2}}}{9\sqrt{3}LEI}, & \text{if } a \le \dfrac{L}{2} \\ \dfrac{Fb(L^2 - b^2)^{\frac{3}{2}}}{9\sqrt{3}LEI}, & \text{if } a > \dfrac{L}{2} \end{cases} \quad \text{where } b = L - a$$

a) How are the boundary conditions (supports and load) different in the Euler beam model in the figure above compared to the FEA simulation?

Supports condition are the same. But the load condition is different within the force direction

b) Obtain a <u>lower and upper bound on the maximum deflection</u> of the solid beam in this lab with the following procedure

i. Find the values of E, a, L, and F based on the solid model geometry, load conditions, and material properties.

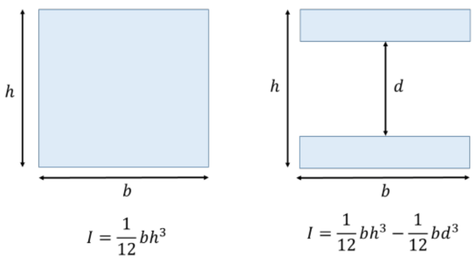
$E = 2.24\ GPa$

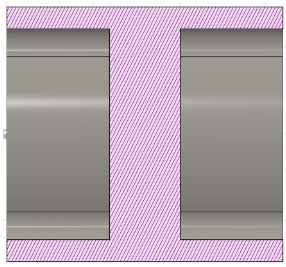
$a = 24.195\ mm$

$L = 64.52\ mm$

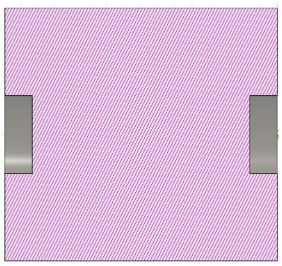
$F = 10N$

ii. The moment of inertia I varies along the section because of the periodic pattern of holes and cutouts along its length. Find an upper bound on the 2nd moment of inertia I by assuming the part is a solid rectangle through its entire length. Find a lower bound on I by assuming that the part has a hollow rectangular cutout through its entire length (as if the middle section was missing everywhere instead of just periodically along the beam length).





I_Min



I_Max

$$I_{Max} = \frac{1}{12}bh^3 = 2.768 \times 10^{-10}m^4$$

$$I_{Min} = 1.604 \times 10^{-10}m^4$$

iii. Does the FEA prediction of maximum deflection fall between your upper and lower bound estimates on the deflection of the beam? Does this calculation give you confidence that the FEA results are accurate?

$$\delta_{Max} = \frac{Fa(L^2 - a^2)^{\frac{3}{2}}}{9\sqrt{3}LEI_{Min}} = 0.14319\ mm$$

$$\delta_{Min} = \frac{Fa(L^2 - a^2)^{\frac{3}{2}}}{9\sqrt{3}LEI_{Max}} = 0.083\ mm$$

Yes, this gives me confidence in FEA analysis.