AERO 4630 - Aerospace Structural Dynamics

Project 2

Assigned: Friday, Friday 8 2019
Due: Friday February 22 2019 at 17:00, uploaded as PDF on Canvas

Office Hours: Davis 335, Wednesdays 1300-1400 hrs

Problem 1: Conducting a tensile test

Let's try to recreate the tensile test we did in class. We are recreating the experiment done by the Instron machine. The idea is to take a beam of rectangular cross section, clamp it on one end and provide a displacement on the other.

Assume we have a beam of length $L = 150mm$, $W = 25m$ and $H = 25mm$ just like in class. Let's say we are working with steel. This makes the density $\rho = 7800kgm^{-3}$, the Young's modulus $E = 200GPa$ and the Poisson ratio $\nu = 0.3$. We are clamping the left face $x = 0$ and providing a displacement δ on the right face $x = L$.

(1a) Compute the Lame' parameters, λ and μ from E and ν.

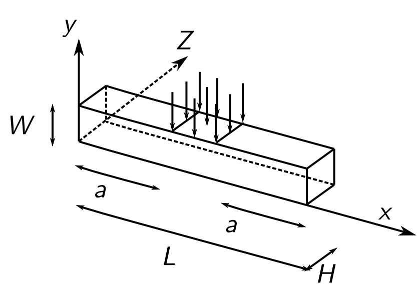
(1b) Modify the code to perform a tensile test for a given displacement $\delta = 1.0mm$. The average strain is given by $\varepsilon_{avg} = \delta/L$. Using paraview, obtain the total force F_{right} on the right face $x = L$. To do this you need to plot the normal stress $\sigma_1 1$ on the face, perform an area integral, and get the total force on that face. Compute the average stress $\sigma_{avg} = F_{right}/A$ where A is the area of the face.
Hint: Features like weighted area integral and slicing might be useful

(1c) Repeat the above for multiple displacements and plot a stress-strain curve $\sigma_{avg} - \varepsilon_{avg}$. Compute the slope of the stress-strain curve.

Note the units of the problem. Any code starts to behave weird if you have really large values (like GPa) and really small values (like mm) at the same time. It might be wise to non-dimensionalize your equations. You can non-dimensionalize an equation in many different ways.

Problem 2: Applying force on a beam clamped at both ends

Let's modify our problem. Imagine a beam of length L, width W and height H clamped at $x = 0$ and $x = L$.



The beam is subjected to a total force F spread on the top face as shown in the figure. As a increases, the force is more and more concentrated on a smaller and smaller region.

(2a) Assume the dimensions of the beam and material properties are the same as previous question. Let's pick a total force $F = 10N$ and $a = L/4$. Simulate this force and obtain the vertical displacement of the point $(L/2, W, H/2)$. Remember that you need traction (force per unit area) for the code.
Hint: To get the displacement at a point from Fenics, read the tutorial ft02_poisson_membrane.py on the website. Line 61 might give you a hint.

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(2b) Repeat these simulations for $a = L/N$, where $N = 6, 5, 4, 3$ and plot the vertical displacement of $(L/2, W, H/2)$. If you are curious, try to see if you can make $L/2$ work !

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