

2.31 Assignment 9

Due Wed, Nov 7 at 9:30 am

I figured we need to do some work to get ready for shell models. The U-channel in the figure is loaded by a normal pressure on the top right edge $\sigma_{\text{top}} = 100 \text{ MPa}$, and constrained as indicated on the top left edge: the whole top left face cannot move in the vertical direction, and one point is encastered. The dimensions of the channels are: $R=2\text{m}$, $H=4\text{m}$, $W=2\text{m}$, $t=0.5\text{m}$. The material is foam, with $E=0.1\text{GPa}$, $\nu=0.3$.

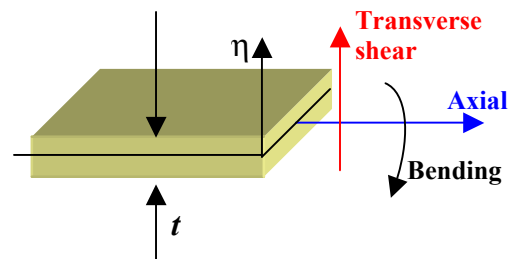
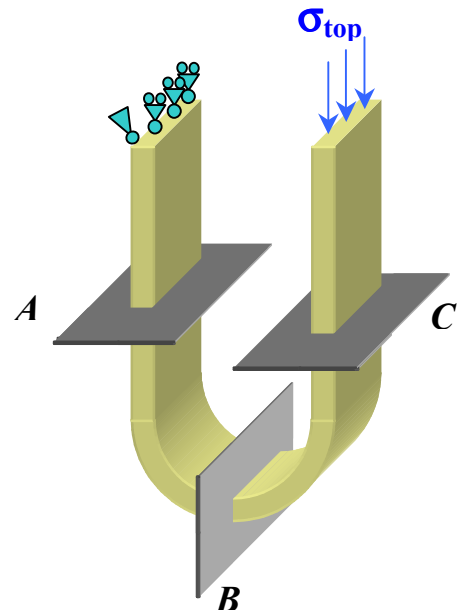
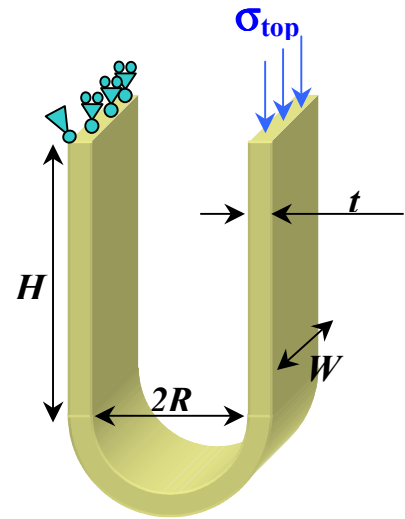
1) Pen and paper work (no FE)

Consider sections A, B and C along the profile of the channel: planes A and C are normal sections of the flat sides (you do not need the exact location), while B is a normal section of the curved side on the vertical symmetry plane. At each section calculate the following quantities (see figure below for interpretation):

1. F_{axial} : the total axial force on the section
2. N_{axial} : the axial force on the section per unit depth of the channel
3. $\sigma_{\text{m_axial}}$: the average (membrane) axial stress
4. F_{shear} : the total transverse shear force on the section
5. N_{shear} : the transverse shear force per unit depth of the channel
6. $\tau_{\text{m_shear}}$: the average (membrane) transverse shear stress
7. MT_{bend} : the total bending moment
8. M_{bend} : the bending moment per unit depth

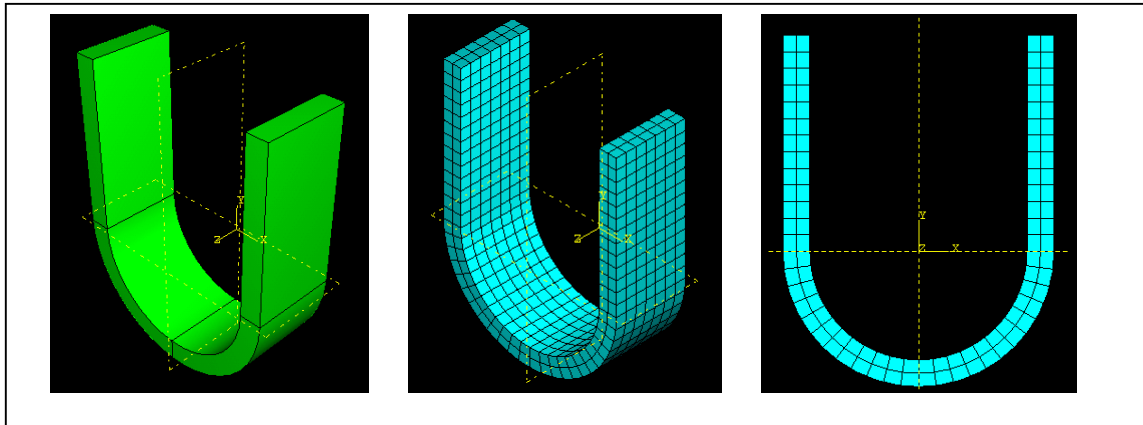
For sections A and C only, also calculate:

9. $\sigma_{\text{b_axial}}(\eta)$: the profile of axial stress associated with the bending moment (as a function of η : distance from the neutral plane)
10. $\sigma_{\text{top_axial}}$: the axial stress on the top surface ($\eta = t/2$): this is the superposition of $\sigma_{\text{m_axial}}$ and $\sigma_{\text{b_axial}}(t/2)$.
11. $\sigma_{\text{bot_axial}}$: the axial stress on the bottom surface ($\eta = -t/2$): this is the superposition of $\sigma_{\text{m_axial}}$ and $\sigma_{\text{b_axial}}(-t/2)$.



2) FE model

Create an FE model of the component using 3D continuum elements. Use quadratic full integration elements (C3D20) with a seed of 0.3 (you should get 2 elements through the thickness). Make sure you partition the model in two by the symmetry vertical plane so as to have a set of element faces along plane B. It is also a good idea to partition the curved part from the flat parts. Run the analysis. Plot and print profiles of S11, S22. What do they show? Interpret the contours on the basis of your pen and paper calculations.



Compare the results of the FE analysis with your pen and paper calculations: by postprocessing the results in the visualization module, try to obtain as many as you can of the quantities evaluated in part (1). As a minimum, you should obtain the numerical value of the following quantities for sections A and C: $\sigma_{\text{top_axial}}$, $\sigma_{\text{bot_axial}}$, M_{bend} , $\sigma_{\text{m_axial}}$, $\tau_{\text{m_shear}}$.

A good method to obtain stress profiles is by using the path tool. Also, to show only part of the mesh, (say the left part of the U) you can try playing with the **Tools** → display group → elements → pick from viewport → save as... If you cannot figure this out, do not go crazy. We will use it on Wed and you can see how it works.

Comparisons and extended calculations for section B will be part of the weekly project, so you do not need to do them for the assignment, unless you really feel like you need the extra work.