2.31 Project 1
The macroscopic stress-strain behavior of a porous elastic solid

Team 1: Costanzo, Goldenshteyn, Peoples

Due October 17

Your task is to use ABAQUS to estimate the macroscopic stress-strain properties ($E_{\text{eff}}$, $\nu_{\text{eff}}$) of an elastic porous material. The material consists of a steel ($E=200.E9$, $\nu=0.3$) matrix with with a 34.1% porosity. A standard approach to predict macroscopic mechanical behavior of two-phase systems (steel+voids) relies on the introduction of a periodic unit cell, or RVE (Representative Volume Element) that tries to capture the essence of the material behavior. Read the background info in section 2.1 of [1] and use ABAQUS to construct an axisymmetric unit cell for the porous material according to the SHA model.

Be careful to apply the appropriate periodic boundary conditions to the top and side of the unit cell. In order to do this you need to use the equation option in the ABAQUS Interaction module. You will need to know a trick or two to do this, and if you cannot figure this out on your own, I can help out. Load the FE model with an axial stress of 100 MPa, run the job, and evaluate the macroscopic axial and radial strain for the cell. Compute the corresponding elastic properties, $E_{\text{eff}}$, $\nu_{\text{eff}}$. How do they compare to a simple volume average? What micromechanical model does a simple volume average of $E$ correspond to?

From the ABAQUS results, obtain the tangential stress in the steel at the surface of the void at the pole ($\sigma_{\text{pole}}$) and at the equator ($\sigma_{\text{eq}}$). Compare them with the corresponding theoretical estimates for a void in an infinite steel matrix (reference [2] has the corresponding equations). Where do the differences come from?

Reference 1: Micromechanics of toughened polycarbonate. (JMP S, Socrate, Boyce 2000)
Reference 2: Concentration of stress around spherical and cylindrical inclusions and flaws. (Tr ASME, Goodier 1933).

The references are available on the table outside my office.