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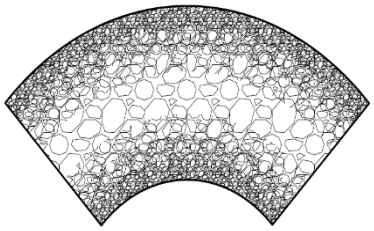
MECH 493 project: Mechanics of functionally graded porous beams

Background and research goal



Porous materials offer exceptional structural properties, the most important being low weight and high stiffness and strength. Nature has figured this out a long time ago by making bones porous. Size of pores in bones is gradually changing through the volume, as a function of loading and support. The goal here is to translate that to everyday devices and structures, making them much more efficient and allowing greater design flexibility by offering wider range of properties than traditional materials. Construction of porous structural elements was not feasible in recent decades, but with progress made in additive manufacturing, they can be used more freely on a larger scale.

Going a step further, porosity can be graded in different directions, making the structure even more efficient. Figure on the top right shows an example where pores are smaller closer to the surface of the curved beam. The intricate web of pores becomes very complex to model explicitly in analysis. Reduced order models based on beams, plates and shells can be used to predict certain types of responses. They have difficulty with predicting local deformation modes and local stress. This project aims to quantify the accuracy of beam models to predict local stress, buckling and vibrations of functionally graded porous beams. Finite element models need to be developed using Abaqus software, and compared with available results based on beam theory. This project is part of a research program that aims to provide design tools and advanced structural solutions for a new generation of ships for Canadian Coast Guard.

Tasks to be performed by the student

1) Survey scientific literature to get familiar with porous materials and their structural models
2) Create finite element models of porous beams using Abaqus software
3) Perform stress, buckling and vibrational analysis, and compare the results to beam models

You are expected to be a fast learner interested in structural analysis. Experience with finite element theory and software is beneficial, but not necessary.

Facilities and team:

You will periodically interact with Dr. Jelovica and his research group. You will need to create the models and run initial analyses using your own personal computer. Longer analyses will be run on a local cluster, with the help from the group.