Harnessing Design Principles from Glass Sponges for Structurally Robust Lattices

Matheus C. Fernandes [1], James C. Weaver[1,2], and Katia Bertoldi[1,3]

[1] *John A. Paulson School of Engineering and Applied Sciences, Harvard University, Cambridge, MA 02138*
[2] *Wyss Institute, Harvard University, Cambridge, MA 02138*
[3] *Kavli Institute, Harvard University, Cambridge, MA 02138*

ASME-IMECE, November 2017
Mechanics of Solids, Structures and Fluids:
12-21 Mechanics and Design of Cellular Materials

Abstract:

Glass sponges are predominately deep sea sponges that live in ocean depths of 100-2000m. Beyond their fracture propagation inhibiting material composition, these sponges are perceived to exhibit large structural rigidity and strength against buckling. Since these sponges are primarily made of 'brittle silica', buckling strength may be a crucial property in making them resistant to impact and environmentally applied stresses. Structurally, they exhibit a base square-grid architecture and regular ordering of vertical and horizontal struts that form the skeletal system. Furthermore, their base structure is overlaid with double diagonal reinforcement struts, which create a checkerboard-like pattern of open-closed cell structure. This diagonal reinforcement design is conjectured to give the sponge greater buckling resistance and strength to localized damage then it would experience having a single diagonal reinforcement strut (while allocating the same amount of mass to the diagonal reinforcement.) Analogous to the sponge, many engineering structures, such as buildings and bridges, exhibit diagonal reinforcement struts as a stability mechanism. Based on this similarity, we explore the following research question: **Can we generate design principles for diagonal reinforcements of square beam lattices that are optimally designed to avoid global structural buckling?** Here, we present a numerical analysis of the structure deformation under various loading conditions as well as survey different arrangements within similar design space of the sponge. Through the various design iterations we look for the critical buckling strain and the elastic load caring capacity. Finally, we compare the results from the sponge design to what is typically used in engineering of structures such as buildings and bridges.