Macro Tech-Mod: Auxetic Origami Tessellations

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Introduction

Inspiration from specific auxetic origami tessellations led to the development of a novel pattern that harnessed similarly auxetic properties. The resulting output demonstrated a negative Poisson's Ratio when stretched. Future applications might take advantage of these attributes to enhance structurally reactive behavior.

Concept

Certain origami tessellations may afford auxetic behavior, resulting in interesting properties to examine and explore. The Miura-Ori is an origami technique with a negative Poisson's ratio that is created by alternating mountain and valley folds. Figure 1 below demonstrates a graphic depiction of this concept, and two precedents.

Figure 1: Miura-Ori Concept[1] and Precedents: Solar Panels[2] and Surgical Applications[3]

The tessellation alters material properties to allow for compressibility, rigidity, and increased structural integrity. It was intended for the use of Japan's Space Flyer Unit by the creator, astrophysicist Koryo Miura, but has since evolved to a wider range of applications. The Ron-Resch pattern (demonstrated in Figure 2) is composed of star pleats joined together that exhibits pronounced shape flexibility and geometry forming that may be utilized for load dissipation and damping due to its high deformation and strain values.

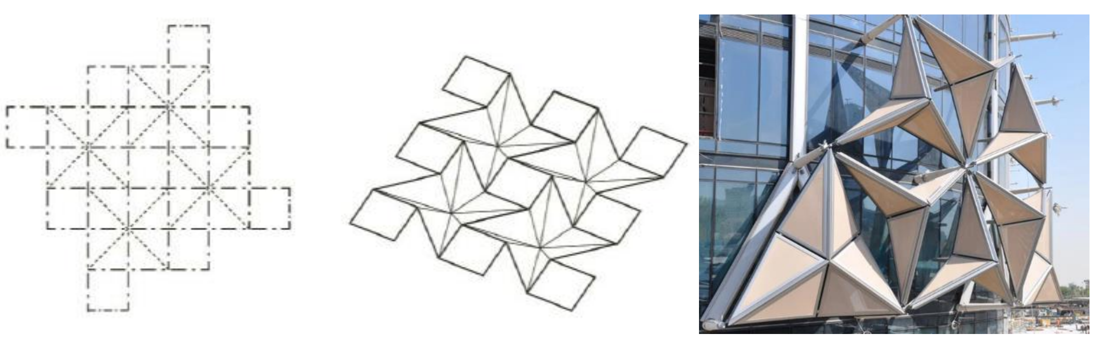

Figure 2: Ron-Resch Pattern[4] and Architecture Precedent: the 'al-bahr towers'[5]

These tessellations provided a rich starting point for exploring similarly inspired patterns.

Prototype Design

The design factors in star elements from the Ron-Resch pattern to imitate the auxetic behavior. Figure 6 below shows the 2D design modeled in Rhino, followed by the physical and prototype (fig 7).

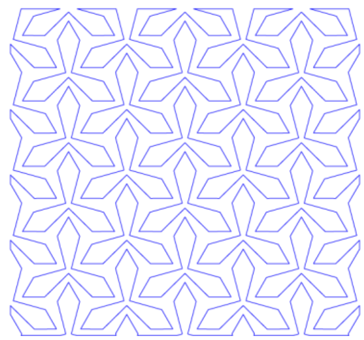

Figure 6: 2D Pattern

Figure 7: Physical Prototype

Results

While no nonlinear behavior was recorded, our mold displayed auxetic behavior under tensile stress. Figure 8 below shows the COMSOL simulation output under pressure and when stretched. From the second image, the negative Poisson's ratio is apparent in the expansion of all sides after stretching.

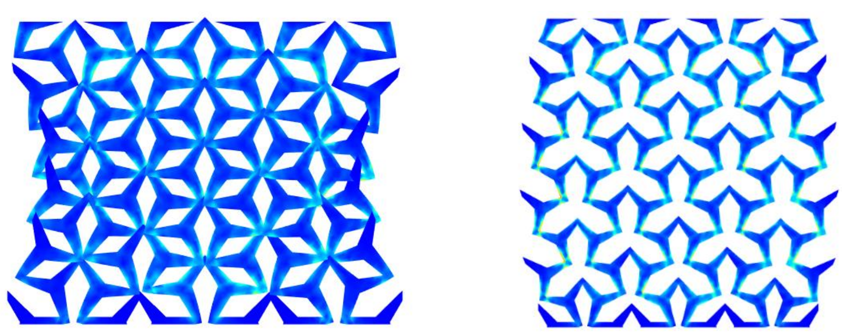

Figure 8: COMSOL Simulation Results

Figure 9 shows the results of the FEM and Intron plotted together. Both outputs were linear despite visual buckling of the structure.

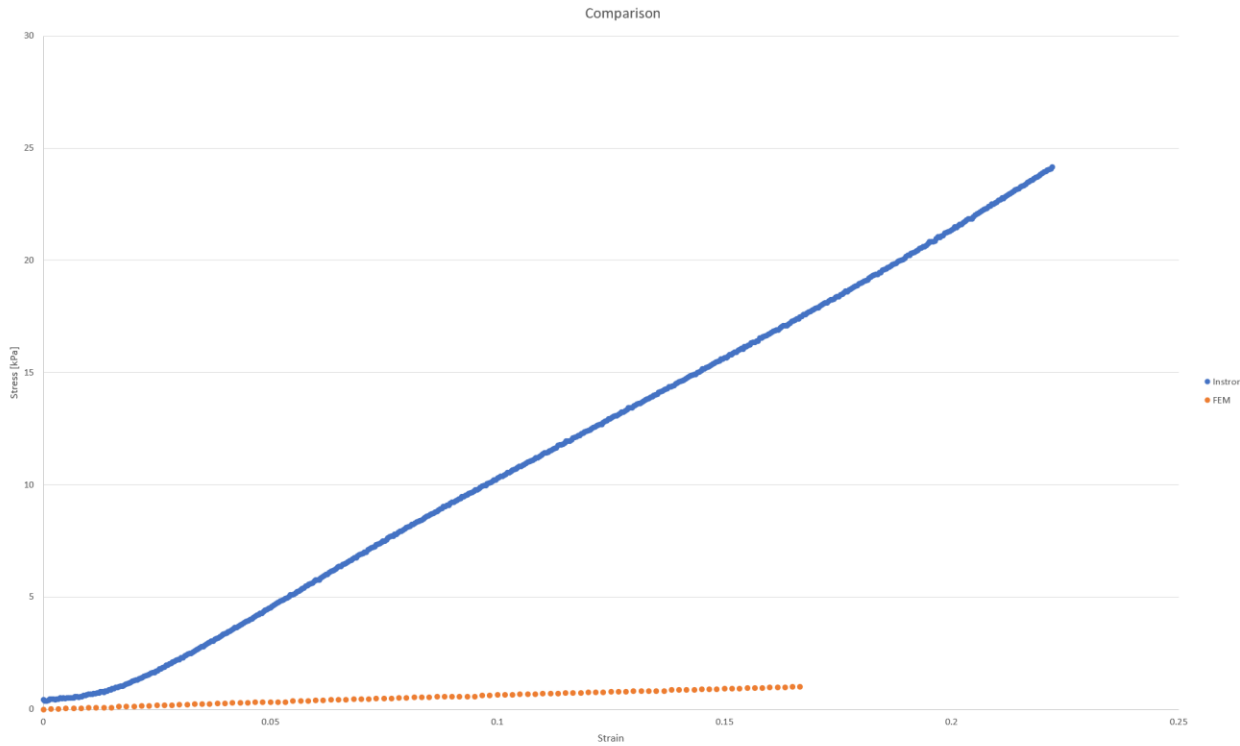

Figure 9: Plotted Results

Next steps would include exploring potential applications of the auxetic behavior, such as medical rehabilitation devices like back braces or ligament recovery accessories, or packaging and sponge applications.

References

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