(In)efficacy of Architected Auxetic Materials for Impact Mitigation: Investigations of Energy Absorption and Force Distribution

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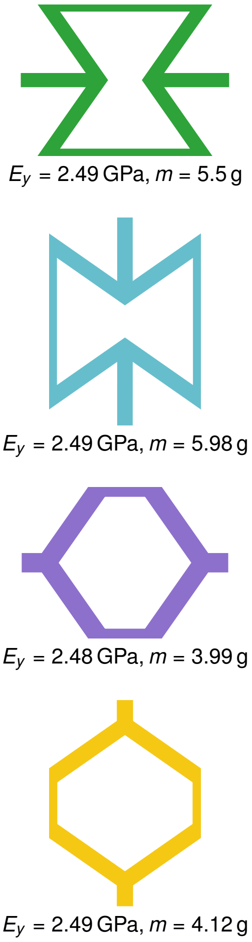

Figure 1: Investigated unit cells

Background

Auxetic materials are claimed to offer beneficial capabilities for impact mitigation, such as higher indentation resistance and energy absorption. To further investigate the load-transmission characteristics four architectures are compared:

- auxetic re-entrant honeycomb
- rotated auxetic re-entrant honeycomb
- conventional honeycomb (W)
- conventional honeycomb (L)

(see Fig. 1 for unit cells)

Physical Modeling

- patches of approx. 130 mm × 65 mm manufactured and impacted by 1.2 kg plungers at 70 m s^{-1} (see Fig. 2)
- the auxetic and rotated auxetic structures show high peak loads (see Fig. 3)
- both conventional honeycombs (W and L) show more spread out loading (see Fig. 3)

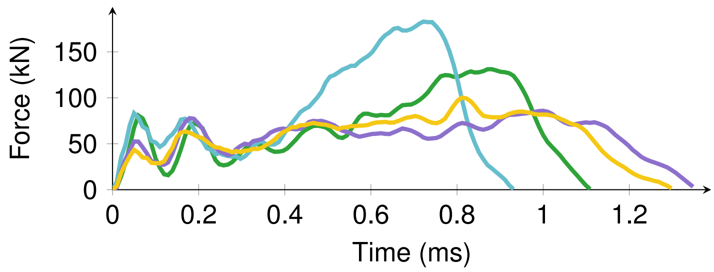

Figure 3: Force on the back-face over time from experiments

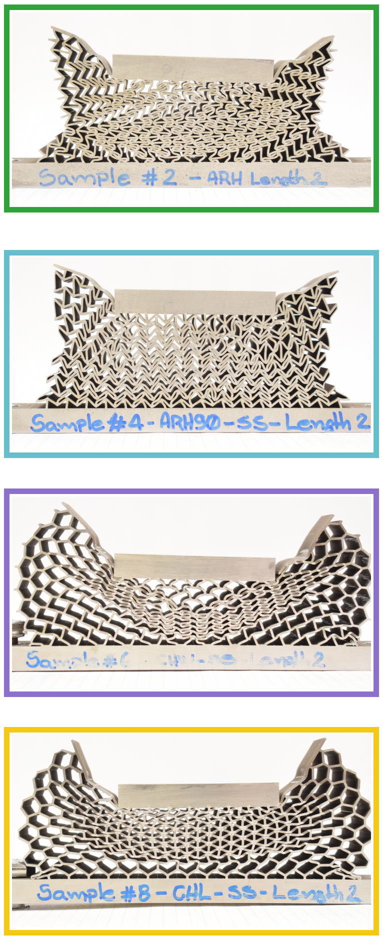

Figure 2: Test samples after the experiments

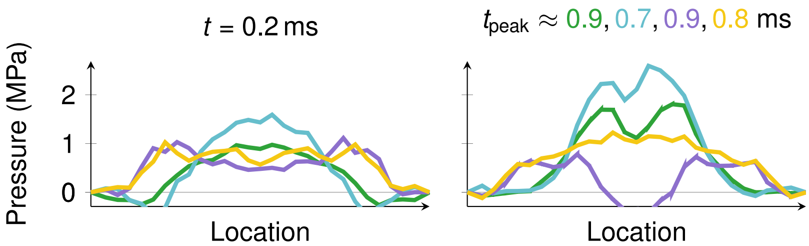

Figure 4: Pressure over the back-face from simulations

Numerical Modeling

- numerical experiments using ABAQUS to extract forces at arbitrary locations
- material densification in auxetics leads to force densification (see Fig. 4)
- material spread leads to load spread in conventional honeycombs
- effect observable throughout the loading

Discussion

The auxetic structures (both re-entrant and rotated re-entrant) show a higher peak-load in time (Fig. 3) and location (Fig. 4) compared to the conventional honeycombs (W and L). These results show that the efficacy for impact mitigation is not solely determined by the initial configuration of the lattice, but requires a deeper understanding of the processes inside through time and space.

Further Investigations

- Design studies using fast, beam-based FEA are being conducted
- Initial results showcasing elastic effects available

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