USING AUXETIC CORES IN LIGHTWEIGHT COMPOSITE SANDWICH STRUCTURES FOR BLAST PROTECTION

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Introduction and Motivation:
- Increased global hostility necessitates the development and enhancement of blast mitigation structures.
- During an explosion, a shock front of very hot and high-pressure gas travels radially outward, Fig. 1.

Criteria for Blast Proof Structures:
- High Energy Absorption
- Response Mitigation
- Lightweight and Moveable

Auxetic Materials and Structures:
- Auxetics are a subset of meta-materials and structures which possess a negative Poisson’s ratio. Under tension, an auxetic will expand perpendicular to loading, Fig. 2.

Conventional sandwich panels consist of:
- Upper Face Sheet
- Core e.g. Honeycomb, Foam
- Lower Face Sheet

Fig. 3: Conventional Sandwich Panel

Novelty: Use of auxetic cellular structures as cores within composite sandwich panels for blast protection.

Fig. 4: Auxetic Core Topologies

Computational Modelling:
- Blast explosions involve an instantaneous pressure rise from atmospheric to peak pressure. This pressure then decays, first to atmospheric (positive phase), then below, forming the negative phase.
- Pressure loading, Fig. 5, was applied to the top surface of the sandwich panel.
- Sandwich panels with various cellular cores were modelled within Abaqus® Explicit, Fig. 6 - 7.

Fig. 6: Sandwich panels with varying core topologies under air blast

Discussion of Results:

Peck Displacement: Panels deflect in the loading direction prior to deformation. With increased peak pressure, panel displacement increases. Fig. 9 shows the deflection history of a DA panel, with lower face sheet out-of-plane displacement (where \( P_m = 10 \text{ MPa} \)).

Geometry Impact: The DA unit cell has two associated angles, \( \theta_1 \) and \( \theta_2 \). Quasi-static yield stress is presented in Fig. 10. Future work will investigate the impact of geometry on blast performance.

Fig. 9: Displacement of DA panel with increased loading

Fig. 10: DA geometry and normalised yield stress

Conclusions:
Auxetic cored panels provide lower peak displacements and superior performance to conventional cores for blast protection.
3D printing has been utilised for manufacture, Fig. 11.

Fig. 11: 3D Printing

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