Indentation response of metallic foams and sandwich panels

Kaveh R.Kabir, TaniaVodenitcharova and Mark Hoffman

School of Materials Science and Engineering, University of New South Wales

Sydney, NSW 2052, Australia

ARC Centre of Excellence
Design in Light Metals

Aim

Develop a set of design parameters to manufacture aluminium-skinned metal foam sandwich panels which can resist under localised damaged.

Why metallic foams?

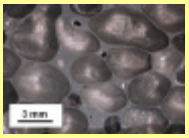
❖ Characteristics:

- ✓Low density
- ✓High energy absorption
- ✓Low thermal conductivity
- ✓High acoustic absorption
- ✓Mechanical damping

❖ Applications:

- ✓Light-weigh structures
- ✓Energy absorbers
- ✓Sound absorbers
- ✓Heat exchangers
- ✓Multi-functional structures

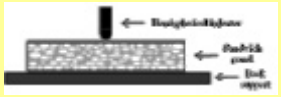
Materials and testing



❖Foam core

- ✓Closed cell aluminium foam (Trade name ALPORAS)
- ✓Density=0.2-0.3 g/cm^3
- ✓Relative density= 7-11%
- ✓Pore size= 2.5 mm
- ✓Modulus of elasticity[1]= 1.1 GPa
- ✓Yield strength[1]= 1.4-1.6 MPa
- ✓Bending strength[1]= 2.5-3.1 MPa

1 Alporas data sheet



❖Skin

- ✓Thin aluminium sheets
- ✓AA 3104- H19
- ✓ AA1100- O
- ✓Thickness 0.32 mm

❖Adhesive

- ✓Epoxy adhesive film (Redux 322)

❖Indenters

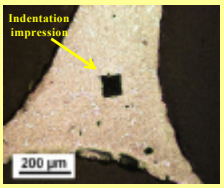
- ✓Hemispherical, D5,10,12 and 20mm

Materials characterization

❖Vickers hardness test
On cell walls of the foam → $\sigma_{y,cell}$ = 96 MPa

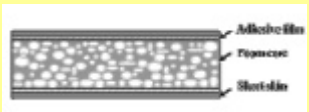
❖Tension test
Dog-bone samples(skins)

1. AA 3104-H19 — Thickness 0.32 mm, E= 69 GPa, σ_y= 236 MPa
2. AA 1100-O — Thickness 0.32 mm, E= 68.9 GPa, σ_y= 34 MPa



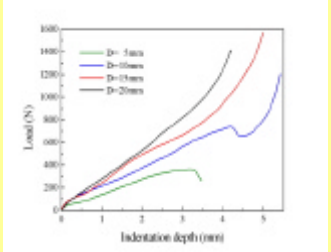
Sample preparation

- ✓ Cutting foam panels, Al sheets and film adhesive
- ✓ Degreasing and Abrading of foam core and skins
- ✓Assembling sandwich panels
- ✓Employing hot press machine to cure the adhesive

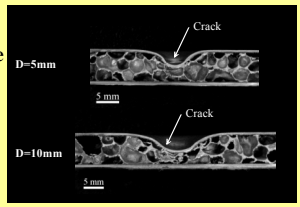


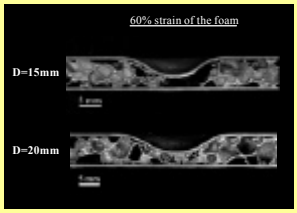
Load vs. Indentation depth

❖Panels manufactured by low yield strength aluminium and thinner foam core

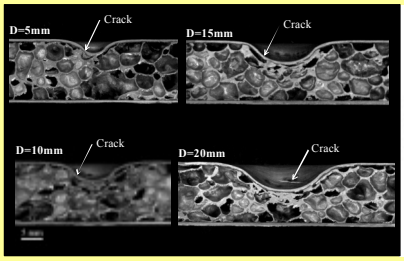


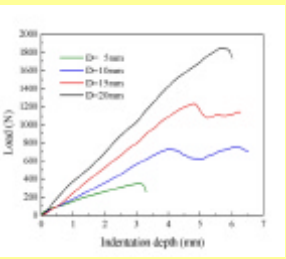
Skin failure only observed in panels indented by 15 and 20 mm indenter.



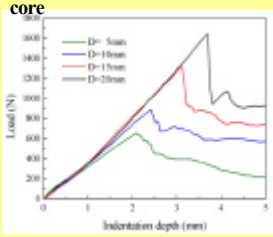


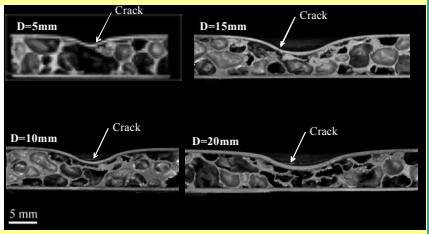
❖Panels manufactured by low yield strength aluminium and 12mm core



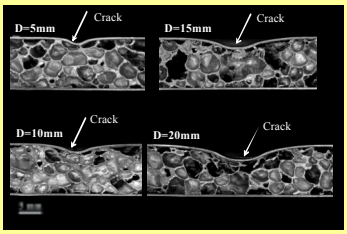


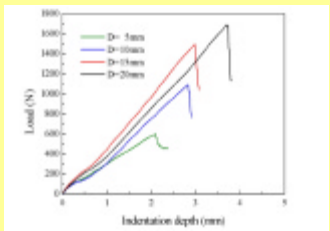
❖Panels manufactured by high yield strength aluminium and 6mm foam core





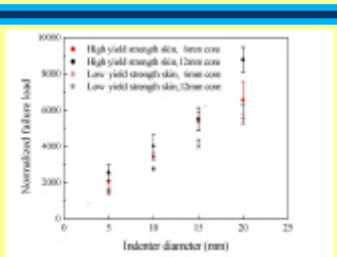
❖Panels manufactured by high yield strength aluminium and 12mm core





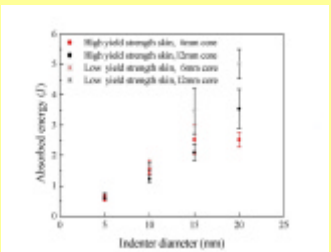
Load bearing capacity

- ✓Higher for the panels laminated by high yield strength aluminium
- ✓Increases with indenter diameter
- ✓Independent of core thickness



Absorbed energy(at failure)

- ✓Higher for the panels laminated by low yield strength aluminium
- ✓Increases with indenter diameter
- ✓Higher for the panels manufactured by thicker foam (in this investigation) due to densification of the foam core for the panels laminated with thinner cores.



Conclusion

Yield strength of the skin material and indenter size, in contrast to foam core thickness, have significant effect on load bearing and energy absorption capacity of the panels.