Impact Damage of Light Metal Foams and Laminates

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• Aim

Develop a set of design parameters for the manufacture of metal foam laminate systems with impact damage resistance.

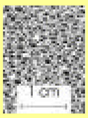
• Metallic Foams

? Characteristics:

? Low density
? High energy absorption
? Low thermal conductivity
? High acoustic absorption
? Mechanical damping

? Metallic foams:

? Open cell
? Closed cell



Open cell foam (Douce) Al alloy

Closed cell foam (Alporas) Al alloy

? Applications:

? Energy absorbers
? Blast protection
? Filters
? Biomaterials
? Heat exchangers
? Construction material

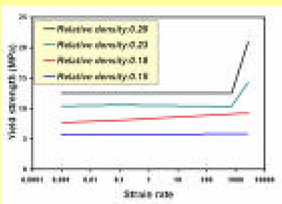
Sandwich Panel

? Properties are influenced by:

? Material of which foam is made
? Cell topology and shape
? Relative density (?/?$_s$)

• Relative Density & Yield Strength

The foams with higher relative density have higher yield strength.



Open cell aluminum alloy foams
Replotted (Yi et al., 2001)

•Strain Rate & Yield Strength

? Yield strength of the foams increases by increasing strain rate.

? At higher strain rate foams can absorb more energy.

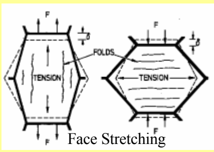
• Mechanical Behaviour

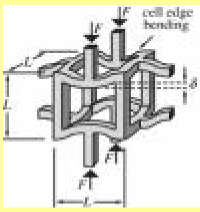
1) Initial Linear Elasticity:

The material is elastic with modulus E up to the elastic limit.

Open cell → Cell edge bending

Closed cell → Cell edge bending & face stretching



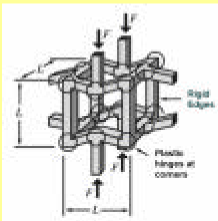


(Gibson & Ashby, 1997)

2) Plastic collapse plateau:

? The cells deform plastically and collapse at a constant load.

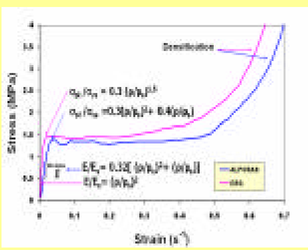
? Important region for their application as energy absorber.



(Gibson & Ashby, 1997)

3) Densification:

Opposing cell walls in the cell touch each other and the stress increases sharply.



Replotted (Gibson et al., 2001)

• Reasons for Strain Rate Sensitivity

? The pressure of the trapped air inside the cells
? The rate sensitivity of the parent material
? The shock enhancement

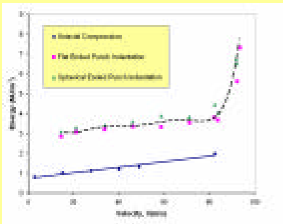
? Closed cell foams: sensitive to strain rate.
? Open cell foams: less sensitive to strain rate.

• Absorbed Energy

? Integration of the area under the stress-strain curve.

$$W_V = \int_0^{e_0} s(e)de$$

? Required energy to deform a specimen to a specific strain.

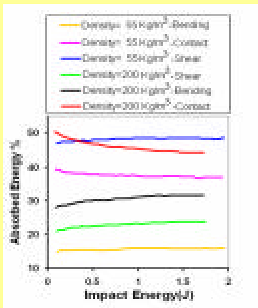


Replotted (Ramachandra et al.,2003)
Investigation on Alporas

? Independent of cell size.
? Dependent on velocity.
? Effect of additional mechanisms of tear and shear in indentation.

?Density & absorbed energy

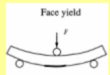
? Decrease in energy dissipation in core shear.
? Increase in energy dissipation in both contact effect and bending of the beam.

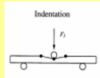


Replotted (Akil Hazizan, 2002)
Aluminium honeycomb sandwich structures

• Failure Modes of Impacted Beam

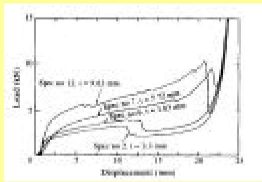
? Face yielding
? Core failure
? Bond failure





• Effect of skin Thickness

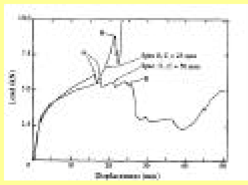
? Large effects on failure.



Sandwich beam with GRP skins and PVC foam
(Shuaeib & Soden, 1997)

• Effect of Foam Thickness

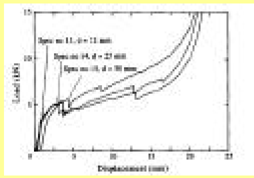
? Small effects on failure.



Sandwich beam with GRP skins and PVC foam
(Shuaeib & Soden, 1997)

• Effect of Indenter Size

? No significant effects on failure



Sandwich beam with GRP skins and PVC foam
(Shuaeib & Soden., 1997)

•Future Work:

?. Investigate the effect of thicknesses of the foam and skin.
??. Investigate the effect of yield strength of skin material and foam material.
???. Investigate the effect of indenter size on failure.