

Modelling of the response of aluminium-based sandwich panels to indentation

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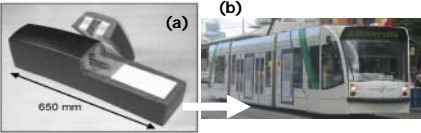
Summary of project

Following an intensive experimental program on the response of aluminium-based sandwich panels to local damage, an analytical model has been developed of the same phenomenon. The model was based on the observations during indentations of the panels with hemispherical indenters, which simulate the damaging process. In indentation, the foam core collapses irreversibly, however, the panel failure is triggered by skin fracturing. To predict the deformation response of the sandwich panel, linear equations of equilibrium of the skin were employed, as well as the energy method which accounts for both bending and membrane capabilities. The foam was assumed of being rigidly plastic. The model predicted the failure load for the panels, as well as the dimensions of the imprint.

Why this project?

Why aluminium foam sandwich panels?

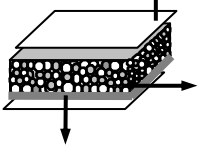
- Transportation: (a) sacrificial crash boxes
 (b) crash energy absorbers
 (c) mechanical vibration absorbers



Sound absorption: (d) in halls and underside bridges

What materials?

What? – sandwich panels



skin: (i) carbon fiber ~ 0.25 mm, MTM56/ CF0300
 (ii) thin Al sheets 3104 -H19

foam: ALPORAS core ((Al + 1.5 % Ti + 1.5 % Ca) of panels: d = 8, 10, 15 mm

Why indentation with hemispherical punches?

– simulates local damage (due to flying debris, dropped objects)

What do we want to achieve? – deformation response (load-penetration curves, failure modes, failure loads)

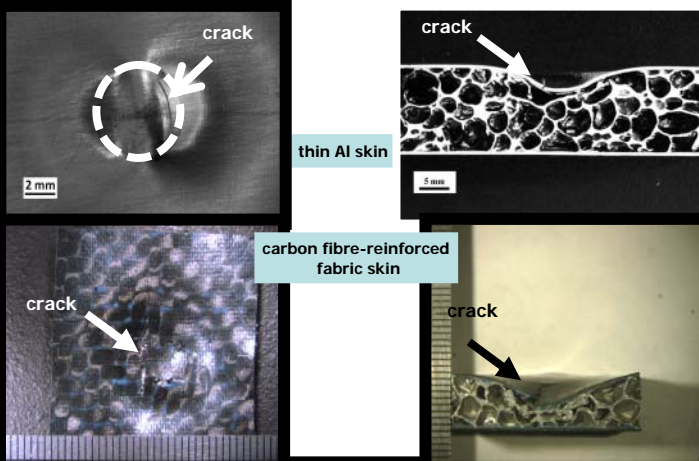
How do we achieve this? – combined approach: experimental + analytical + numerical studies

Conclusions

- Analytical modelling of indentation of sandwich panels reinforced with carbon fibre-reinforced fabric skin should account for both bending and membrane capacity of the skin, in order to closely represent the deformation of the panels
- The current study predicts failure loads which are close to the experimental results
- However, further study is needed to assess the response of radially unrestrained panels, as well as to account for higher terms in the membrane energy expression

Experimental investigation

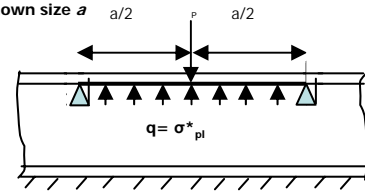
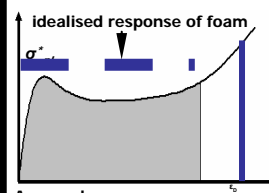
Failure of sandwich panel: by skin failure in fracture



Modelling of deformation of fabric skin

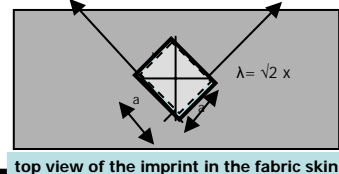
Assumptions:

- linear elastic skin material
- square plate of skin material of unknown size a
- simply-supported ends
- rigid foam: reaction $q = \sigma^*_{pl}$
- loads: applied force P and σ^*_{pl}



Approach:

- using linear equations of equilibrium in a deflection form
- using energy method and applying the principle of virtual displacements



What did we find?

foam density	foam plastic strength (MPa)	t/w ₀ membrane only	$\epsilon_1 = 0.0092$ (principal strain theory)		$\epsilon_1 = 0.013$ (principal stress theory)		$\lambda = a\sqrt{2}$, mm
			w _{0,max} (mm) (experiment)	P _{max}	w _{0,max} (mm) (experiment)	P _{max} (N) (experiment)	
	1.5	0.08	0.36	110.1	0.29	83.1	6.6
0.35	2.24	0.127	0.61 (0.9)	280.4 (277.3)	0.49 (0.9)	203.0 (277.3)	8.2
0.38	2.61	0.139	0.68 (0.64)	337.8 (203)	0.54 (0.64)	243.2 (203)	8.6