Closed Cell Foams

Jean Fanuel

March 28, 2016

1 Young's modulus

$\frac{E^*}{E_s} = \phi^2 \cdot (\frac{\rho^*}{\rho_s})^2 + (1-\phi) \cdot \frac{\rho^*}{\rho_s} + \frac{P_0 \cdot (1-2\nu^*)}{E_s \cdot (1-\rho^*/\rho_s)}$

First component: edge bending
Second component: face stretching
Third component: gas compression

ϕ : volume fraction of solid on cell edges
if $P_0 = P_{atm} = 0.1MPa$, gaz compression term negligible, except for closed-cell elastomeric foams

Gas compression can be significant if $P_0 >> P_{atm}$. It also modifies shape of stress plateau in elastomeric closed cell foams.

2 Shear Modulus

$\frac{G^*}{E_s} = \frac{3}{8} \cdot [\phi^2 \cdot (\frac{\rho^*}{\rho_s})^2 + (1-\phi) \cdot (\frac{\rho^*}{\rho_s})]$ (isotropic foam)

3 Poisson's Ratio

Poisson's ratio = f(cell geometry only) $\nu^* \approx 1/3$

4 Elastic Collapse

$$\sigma^*_{el} = 0.05 \cdot E_s \cdot (\rho^*/\rho_s)^2 + P_0 - P_{atm}$$

4.1 Post-collapse behaviour

Stress plateau rises due to gas compresion (if faces don't rupture)
$\nu^* = 0$ in post-collapse regime

$$\sigma^*_{post-collapse} = 0.05 \cdot E_s \cdot (\frac{\rho^*}{\rho_s})^2 + \frac{P_0 \cdot \epsilon}{1-\epsilon-(\rho^*/\rho_s)}$$

$P_{atm} = 0.1 MPa$

5 Plastic Collapse

$$\sigma^*_{pl} = C_5 \cdot \sigma_{ys} \cdot (\phi \cdot \rho^*/\rho_s)^{3/2} + C_5' \cdot \sigma_{ys} \cdot (1-\phi)(\rho^*/\rho_s) + P_1 - P_{atm}$$

First component: edge bending
Second component: face stretching
Third component: gas compression
$C_5 \approx 0.3$

but in practice, faces often rupture around σ^*_{pl} often :
$$\sigma^*_{pl} = 0.3 \cdot (\rho^*/\rho_s)^{3/2} \cdot \sigma_{ys}$$
possible error in the notes, check against the following formula
$$\sigma^*_{pl} = 0.3 \cdot (\phi \cdot \rho^*/\rho_s)^{3/2} \cdot \sigma_{ys}$$

$P_{atm} = 0.1 MPa$

6 Brittle Crushing Strength

$\sigma^*_{cr} = C_6 \cdot \sigma_{fs} \cdot (\rho^*/\rho_s)^{3/2}$

$C_6 \approx 0.2$

7 Densification Strain

$\epsilon_D = 1 - 1.4 \cdot (\rho^*/\rho_s)$