ABSTRACT - USNCTAM15

Dynamic crushing of Duocel© aluminium foam

S.R. Reid, P.J. Tan, J.J. Harrigan, Z. Zou, S. Li
School of Mechanical, Aerospace and Civil Engineering, The University of Manchester, P.O. Box 88, Sackville Street, Manchester M60 1QD, UK

Duocel© is an open-celled aluminium foam, with a very regular cellular structure consisting of duodecahedronal-shaped cells connected by solid ligaments made of Al-6106 alloy. The reticulated cell structure is periodic, giving uniform density in test specimens. The foam has a high strength to weight ratio and a large densification strain under compression. As such it can be considered as an ideal material for impact energy absorbing and blast protection applications.

The key quasi-static mechanical properties are outlined for two cell sizes (10 and 40 pores per inch) both along and transverse to the largest principal cell dimension. Similarities to the quasi-static response of along and across the grain wood specimens are discussed with reference to the cell structure.

Direct impact tests were performed by firing foam targets at a Hopkinson bar load cell. A "shock" theory [1] is seen to capture the effects of the underlying deformation mechanisms responsible for the dynamic enhancement of the crushing stress that was noted experimentally. This phenomenon has been noted in a range of cellular materials, e.g. [2]. Duocel's regular structure and its behaviour raises and helps clarify a number of issues associated with the use of the "shock" theory. Predictions of the variation of normalised plastic collapse strength with impact velocity compare well with experimental results and differences are discussed. It is shown that inertial/velocity sensitivity is the most dominant effect. Significant stress enhancement can occur even at the lower velocity levels due to the translational and rotational inertia of the cell walls (analogous to the lateral inertia effects in Type II structures). Critical impact velocities for a "shock" response in the material are predicted and compared with experimental results.

Reports in the literature suggest that the cellular material can lead to enhancement rather than attenuation of blast pressures. Results for the Duocel foam and FE simulations of honeycombs are used to give an insight into the response of cellular materials to blast loading.

1. *Dynamic compressive strength properties of aluminium foams P.J. Tan,, S.R. Reid, J.J. Harrigan, Z. Zou and S. Li, : Part I Experimental data and observations, pp 2141-2173; Part II – Shock theory and comparison with experimental data, pp 2206-2230, J. Mech. Phys. Sol., volume 53, issue 10, 2005*
2. *High rate crushing of wood along the grain , J.J. Harrigan, S.R. Reid, P.J. Tan and T. Yella Reddy, Int.J. Mech.Sci., pp 521-544 Volume 47, Issues 4-5, 2005.*