Development, testing and computational simulations of auxetic crash panel

Nejc Novak, Hasan Al-Rifaie, Alessandro Airoldi[1], Matej Vesenjak[2], Zoran Ren[2]
[1] Politecnico di Milano, [2] University of Maribor

The macro-scale auxetic crash absorbers with inverted honeycomb structures were fabricated by bending and glueing the aluminium sheets. The auxetic panels were fabricated using the relatively cheap and straightforward fabrication method, which was extended by adding the PU foam to obtain foam-filled samples. The samples were tested under compression loading at two different loading velocities using the universal testing machine (quasi-static) and drop tower (dynamic).

Detailed quasi-static and dynamic drop tests were conducted and compared with a non-linear computational model. The stress-strain relationships, deformation patterns, specific energy absorption, crash force efficiency and Poisson's ratio were comprehensively evaluated. Foam-filled panels revealed higher specific energy absorption and more stable deformation than non-filled panels. The developed computational models successfully describe mechanical and deformation behaviour and can be used for future virtual testing of other configurations [1]. The DIC and the FE models confirmed that the auxetic panel provides the auxetic response up to very large strains. The validated FE models enable the development of new foam-filled auxetic panels with a tailored response, where different geometries, sheet thicknesses, densities and distributions of the foams can be virtually tested before fabrication. This will hopefully lead to the application of modern crash absorption systems on newly built roads or blast protection elements in buildings.

Keywords: cellular materials, auxetic panel, foam-filled, polyurethane foam, crash absorber, drop test, experimental testing, computational modelling

Literature:

[1] N. Novak, H. Al-Rifaie, A. Airoldi, L. Krstulović-Opara, T. Łodygowski, Z. Ren, M. Vesenjak, Quasi-static and impact behaviour of foam-filled graded auxetic panel, Int. J. Impact Eng. 178 (2023) 104606. https://doi.org/10.1016/j.ijimpeng.2023.104606.