Aspects of fluid-structure interaction on the dynamic response and ductile failure of blast-loaded metallic plates

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Abstract

Blast-loaded structures may experience severe interaction between the propagating blast wave and the structural response. Depending on the blast and structural properties, the structure typically behaves as either a rigid or a deformable surface. Fluid-structure interaction (FSI) takes place if the structure is allowed to move or deform. Previous research has shown that FSI effects can mitigate the blast load acting on the structure, especially in situations involving large deformations. Utilizing ductile materials and accounting for finite deformations and inelastic strains in the design of structural members, may therefore reduce the pressure acting on it and lead to different load paths.

This work presents results from an experimental and numerical investigation on the influence of FSI on the dynamic response and ductile failure of thin metal plates subjected to blast loading. The loading was generated by a shock tube facility designed to expose structures to blast-like loading conditions. The plates had an exposed area of 0.3 m x 0.3 m, and experienced large deformations during the tests (including failure at the highest blast intensities). Piezoelectric pressure sensors were employed for pressure recordings, and these measurements were synchronized with two high-speed cameras operating at 37,000 fps in a stereoscopic setup to capture the dynamic response using 3D-DIC. In addition to the blast tests, tensile tests were performed to determine the material behaviour.

The experimental results were used to evaluate a numerical model in EUROPLEXUS in predicting the dynamic behaviour and ductile failure during the FSI. It was found that the numerical model was able to predict both the global deformation and the crack growth observed in the plates during the experimental tests with good accuracy. The most important features in order to predict the observed failure patterns were an accurate description of the material behaviour and the blast-structure interaction during the event.

Keywords: Lightweight structures, shock tube, blast, structure interaction, ductile failure, EUROPLEXUS

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