CERIS Civil Engineering Research and Innovation for Sustainability

Development and study of a high performance protective solution against blast loads

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Summary

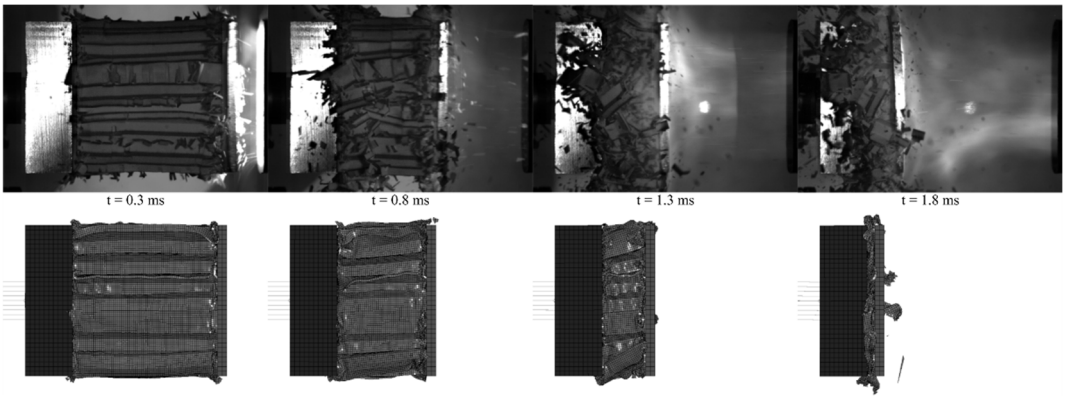
The increasing use of improvised explosive devices in terrorist attacks against civil targets has challenged the scientific community to find new strengthening or protective solutions able to mitigate the effects of the blast loads. As a response to this demand, the main purpose of the present thesis is the development and study of a high performance protective solution based on the concept of sacrificial claddings.

Due to the high flexibility, precision and relatively low costs, additive manufacturing has been increasingly used in the search of new material disposition patterns that improve the mitigation capabilities of crushable cores. The present work assesses the performance of a PLA crushable core manufactured through fused deposition modelling 3D printing. An experimental campaign is conducted to determine the mechanical behaviour of the PLA. These results allow the selection and calibration of an adequate numerical constitutive model, which considers the anisotropy and compressive/tensile asymmetry exhibited in additively manufactured materials.

Once the constitutive material calibrated, the results of a second experimental campaign resorting to an explosive driven shock tube are used to validate a numerical model that allows the deterministic design of a sacrificial cladding which successfully improves the blast resistant capabilities of a given structural element. However, when verified taking into account the model's uncertainties and the probabilistic distribution of the structural element's properties, the cladding solution might, for certain blast scenarios, negatively impact the performance of the structural element it intends to protect. Therefore, one may conclude that the use of a probabilistic approach in the design of such protective solutions is recommended, as the deterministic approach might yields results against safety.

Keywords

Blast loads, sacrificial cladding, additive manufacturing, explosive driven shock tube, robustness assessment.



Side view of the sacrificial cladding solutions under dynamic compression (experimental and numerical).