Influence of gelatine as a transmission layer on the transient response of panels subjected to an explosion

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Abstract

This paper reports on the development of a novel experimental setup to measure the deformation behaviour of ballistic gelatine when subjected to blast loading. Digital image correlation (DIC) was used to measure the transient deformation of the panel's surface. The DIC data showed that the gelatine played a significant role in the load transmission to the aluminium alloy panel and highlighted that ballistic gelatine experiences complex deformation behaviour under loading from an explosion.

Possible Sessions

7. Dynamic Behaviour of Materials
9. Impact, Blast and High Strain Rate

Introduction

The devastating physical harm to people caused by the detonation of explosive devices motivates the need for further research into the transmission of blast effects through the human body. Organic gelatine, with a concentration of 10% at 4°C, is traditionally used as a human soft tissue simulant [1]. However, organic gelatine has limitations, including storage requirements, inherent property variability and a relatively short shelf life [2]. Synthetic gelatine overcomes these drawbacks while having the advantage of reliably consistent material properties under quasi-static compression loading [3]. The stability of the material (at room temperature) enables the study of the blast transmission behaviour under controlled test conditions. This paper reports on the development of a novel experimental set-up that uses stereo-imaging and digital image correlation (DIC) to ascertain the dynamic behaviour of ballistic gelatine during loading from an explosion.

Specimen design and manufacture

The synthetic gelatine was delivered as a pre-formed block (16” L x 6” W x 6” H). Pieces of gelatine were removed from the block, weighed to the required mass, and placed in a purpose-built mould to produce 305mm diameter disc-shaped specimens with a height of 10 mm. The mould was heated to 125 °C for 4 hours to liquefy the gelatine, then left to cool overnight. The completely cooled specimens were removed from the mould and adhered to the front face of a 1 mm thick, 1050 H14 aluminium alloy panel. A black-and-white speckle pattern was applied to the rear surface of the panel using a speckle roller with a pattern size of 2.54mm (Fig. 1). This speckle pattern allowed the transient out-of-plane displacement to be measured using a stereo-imaging system.

Figure 1: Test arrangement of the gelatine sample (left) and speckle pattern on the rear aluminium panel (right).

Experimental arrangement

The test arrangement consists of the clamped panel mounted with the front gelatine surface facing downwards towards the explosive and the back surface facing upwards (Fig. 2). The blast load was generated by detonating 25 g cylinders of plastic explosive PE4 at a stand-off distance of 650 mm from the front surface. Two high-speed cameras were mounted above the panel at an angle of 15° to enable measurement of transient out-of-plane displacement across a 300mm by 140mm area of the rear panel surface. Two sets of tests were performed: (1) a baseline set without gelatine, with the 1mm thick Aluminium Alloy panel mounted in the clamp frame, and (2) a set of tests with a 10 mm high gelatine disc adhered to the front of the Aluminium Alloy panel. Differences in back surface response were used to infer the influence of the gelatine layer on load transmission to the panel.

Results

Digital image correlation of the transient back surface images was performed to extract the transient out-of-plane displacement across a 300mm by 140mm area of the rear panel surface. This approach provided more consistent (and less noisy) results than early trials that involved embedded pressure transducers within the gelatine block. The results showed that gelatine plays a significant role in reducing the load transmission to the aluminium alloy panel and affects the spatial and temporal characteristics of the transient deformation.

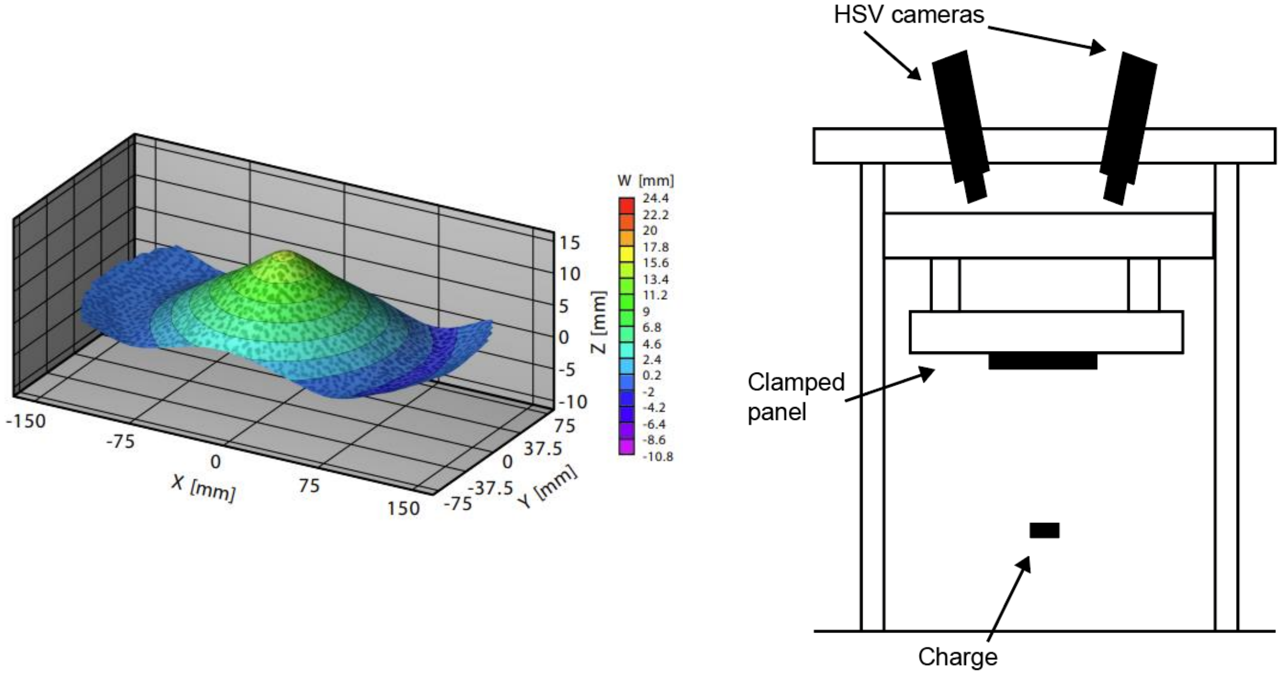

Figure 2: Displacement distribution across the rear panel surface calculated from DIC (left) and DIC testing arrangement (right).

Summary

A novel alternative arrangement for ascertaining the influence of gelatine on blast transmission through a structure was proposed. It relies on inferring the blast load transmission properties of the gelatine by examining the transient deformation behaviour of an adhered Aluminium Alloy panel, both with and without the gelatine layer. Data from these tests have allowed us to characterise the complex deformation behaviour that the ballistic gelatine contributes to the hybrid structure's response to blast loading. Insights from this work could inform the development of computational blast injury models and help to improve the design of protective equipment to mitigate harm from explosions.

References

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