Experimental determination of initial velocity distribution in blast loaded plates.

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Abstract. This paper discusses the experimental technique that was applied to extract an improved impulse distribution calculated from an initial plate velocity measured on localised blast loaded plates. In this experimental work, Armox 440T plates were subjected to a localised explosive load which resulted in localised central plastic deformation of the plate. The transient deformation was measured utilising Ultra High speed stereo video and Digital Image Correlation (DIC) to determine the spatial deformation of the plate. This information was processed to determine the spatial impulse distribution on the plate.

Introduction

Determination and measurement of experimental data during blast experiments is an extremely challenging undertaking. The shock, thermal energy and light emitted during detonation of explosive are chiefly responsible for these challenges. The most robust and reliable data from tests is the post failure analysis and measurement which will give users the final deformed shape of the plates but adds no information about the path the plates and structures take to get to that deformed shape. Potential information in the transient response of blast loaded plates which can be used to uncover important differences in the structural response of these plates as seen in literature [1,2]. Traditional measurements using contact techniques like strain gauges and transducers, become challenging as the actual transducer mass starts to have an effect on the structural response of the plates due to the extremely short durations of blast loading events and the high accelerations experienced. Non-contact measurements such as DIC have become more widely used in recent years leading to an increase in the potential information that can be extracted from a single test [2].

In previous work conducted, the authors have shown that it's possible to infer an initial impulse distribution from experimental data obtained using stereo high speed video and DIC [3]. The test data in the tests was correlated to experimental data obtained on the CoBL facility at the University of Sheffield and indicated definitively that the two separate methods gave the same result. The test data obtained in those tests also showed some limitations specifically the speed at which the cameras were able to operate in the blast environment (about 35 000 fps). Newly acquired Shimadzu cameras at the University of Sheffield are now capable of filming at rates up to 5 million fps which allows for the techniques to be extended into new time domains showing in much finer detail the spatial impulse distribution across these plates.

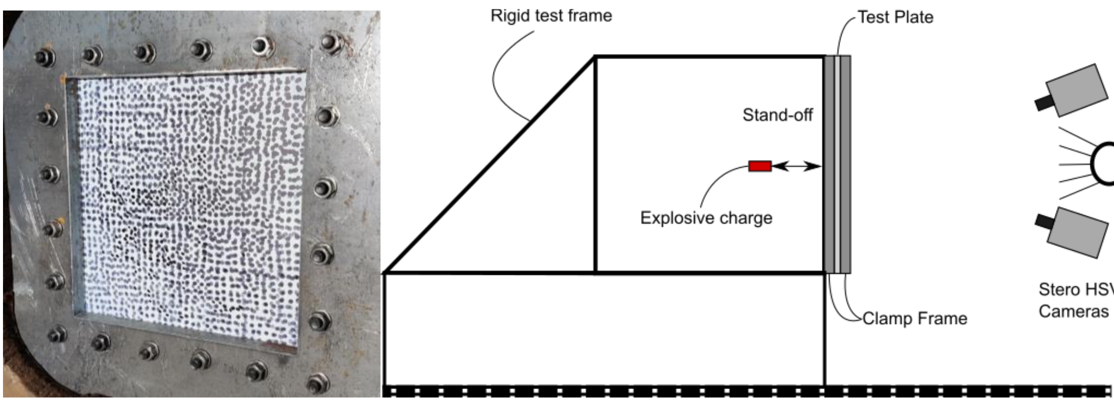

Figure 1: Experimental schematic showing the test plate (left), frame and camera setup schematic (right).

Experimental design

The experimental setup used in these experiments can be seen in Figure 1.

In the tests, 400x400mm Armox 440T plates were fastened in a square clamp frame resulting in an exposed area of 300x300mm. A 38mm diameter cylindrical charge of Pe10 weighing 20-30g with an aspect ratio of

about 3:1 was placed at a stand-off distance of 50mm from the back side of the test plate in its centre. The charge was detonated from the rear using a Euronel 2 detonator. The front side of each plate was painted with a speckle pattern and filmed from the front using two Shimadzu HPV-X2 cameras and lighting was achieved with a Luminys 30k High speed lab light. A key difference in these tests is that it’s now possible to make use of a stationary clamp frame which is mounted to the ground in these test. Uniquely these tests still allow us to measure an initial impulse load inferred on the plates without the use of traditional blast pendulums or load cells.
Two different filming speeds were attempted to capture the deformation of the plates. The first tests were filmed at 100 000 fps which extended the experimental capability beyond the initial tests from previous work. The second set of experiments were performed at 120 000 fps which was four times the speed of initial tests. The images captured were post processed using Correlated Solutions VIC3D software.

Results

The test results seen in Figure 2 show the deformed plate and DIC results used to infer the spatial impulse distribution obtained from these tests. As the frame rate of the cameras increased, the resolution improved on the initial impulse distribution. These results are compared to the expected pressure loading from an identical charge measured on the CoBL experimental setup.

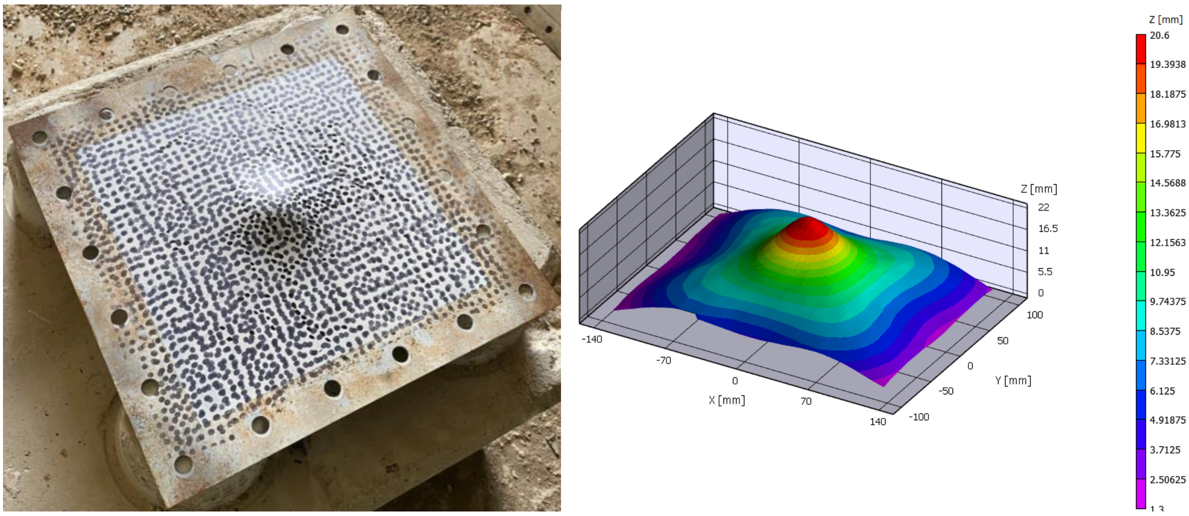

Figure 2: Results of the spatial impulse distribution shown for a strip of the plate.

These results closely match with the previous results and prove that the technique works and is a feasible means of measuring the spatial initial velocity of plates and the inferred impulse distribution.

Conclusion

The findings prove that it’s possible to now extract an initial impulse distribution from a blast loaded plate in a laboratory environment using Ultra high Speed DIC. As the frame rate of the camera system increase, the resolution of the initial impulse calculation improves. Lighting remains a challenge and further improvements to the lighting and speckle pattern application will improve the reliability of the results from the tests.

References

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