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Explosive driven shock tube loading of aluminium plates: experimental study

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ABSTRACT

To accurately identify the material characteristics in material testing, the control of the initial and boundary conditions is very important. Among these conditions, obtaining a repeatable and known loading is a sensitive point especially for tests in the dynamic and impulsional range. Several techniques are used to generate blast wave loads. This paper focuses on the use of an explosive driven shock tube (EDST). The results of a series of tests using an EDST are discussed, with regard to the pressure, the impulse, the wave planarity and the repeatability of the loading. The EDST and free air blast are used to generate blast loading on fully clamped square aluminium plates. The response from both loads is measured with a high-speed 3D digital image correlation (DIC) system and compared to each other. The DIC measurements are compared to strain gauge measurement for validation purposes. It is found that EDST allows to reach higher levels of pressure and impulse than the free air blast leading to higher deformations and strain rates. It is also observed that the EDST tests show a higher repeatability and symmetry relative to the free air blast tests.

1. Introduction

The study of the behaviour of structures and materials under blast loading is essential to determine the efficiency of protective measures and the survivability of personnel and equipment in case of intentional or accidental explosions. The use of numerical tools to achieve this purpose is undeniably efficient, but a numerical model needs reliable material models and boundary conditions (among other points) in order to accurately predict the behaviour of a structure under blast loading. These material properties can only be derived and validated by experimental testing which can be usual tests in tension, compression, etc., or tests with more complex stress/strain fields and using an inverse method [1–4]. The free air detonation of a high-explosive (HE) is a widely used way to generate a blast wave. However, for small scale tests, small variation in the charge (shape, mass, position, etc.) can significantly affect the loading and hence, bias the test results. The use of an explosive driven shock tube (EDST) to channel the blast wave from the detonation of a HE is a way to reduce the effects of these variations in the load case. This would result in a more predictable loading that can also be reproduced more realistically in a numerical model.

The blast response of simple structural components such as plates is investigated in order to study the behaviour of both materials and structures under high strain rate conditions. In the literature, several types of materials are considered such as composites [5–13], and metals [4,14–20]. The blast load is generated using different techniques: free air detonation of a high explosive (HE) [4,5,12,13,18,19], using a gas driven shock tube [6–11,14] or an explosive driven shock tube (EDST) [6,15,20]. Several practical problems related to the use of free air explosions are reported in Refs. 4, 18, and 19 regarding the repeatability of the tests and the distribution of the generated blast wave. This explains why gas driven shock tubes are widely used. The use of an EDST is an alternative for the two previous techniques which allows to obtain well selected pressure–impulse combinations. Moreover, the confinement and the multiple reflections permit to obtain relatively important pressures and impulses with small charges in comparison with free-air blasts.

In order to experimentally analyse the response of specimens under an impulsive loading, several methods are applied such as high-speed imaging with digital image correlation (DIC) to measure

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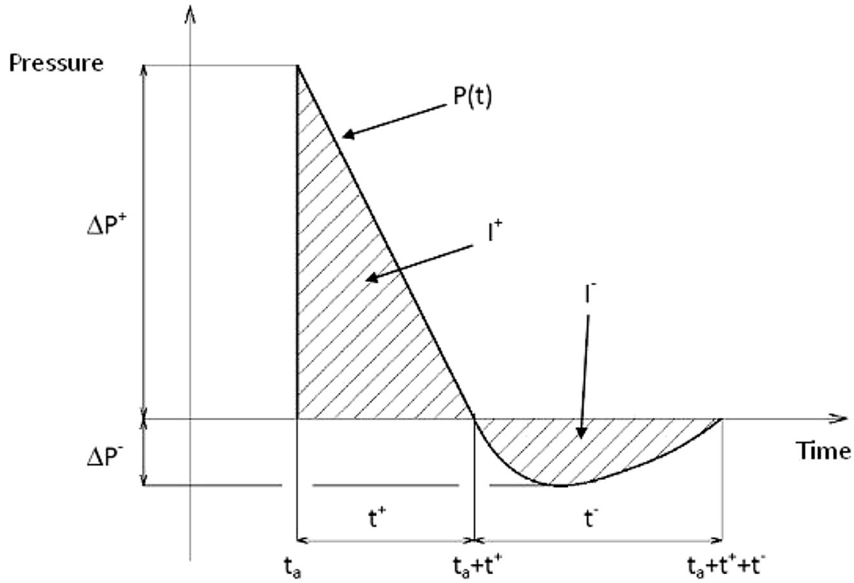

Fig. 1. Profile of characteristic pressure wave [21].

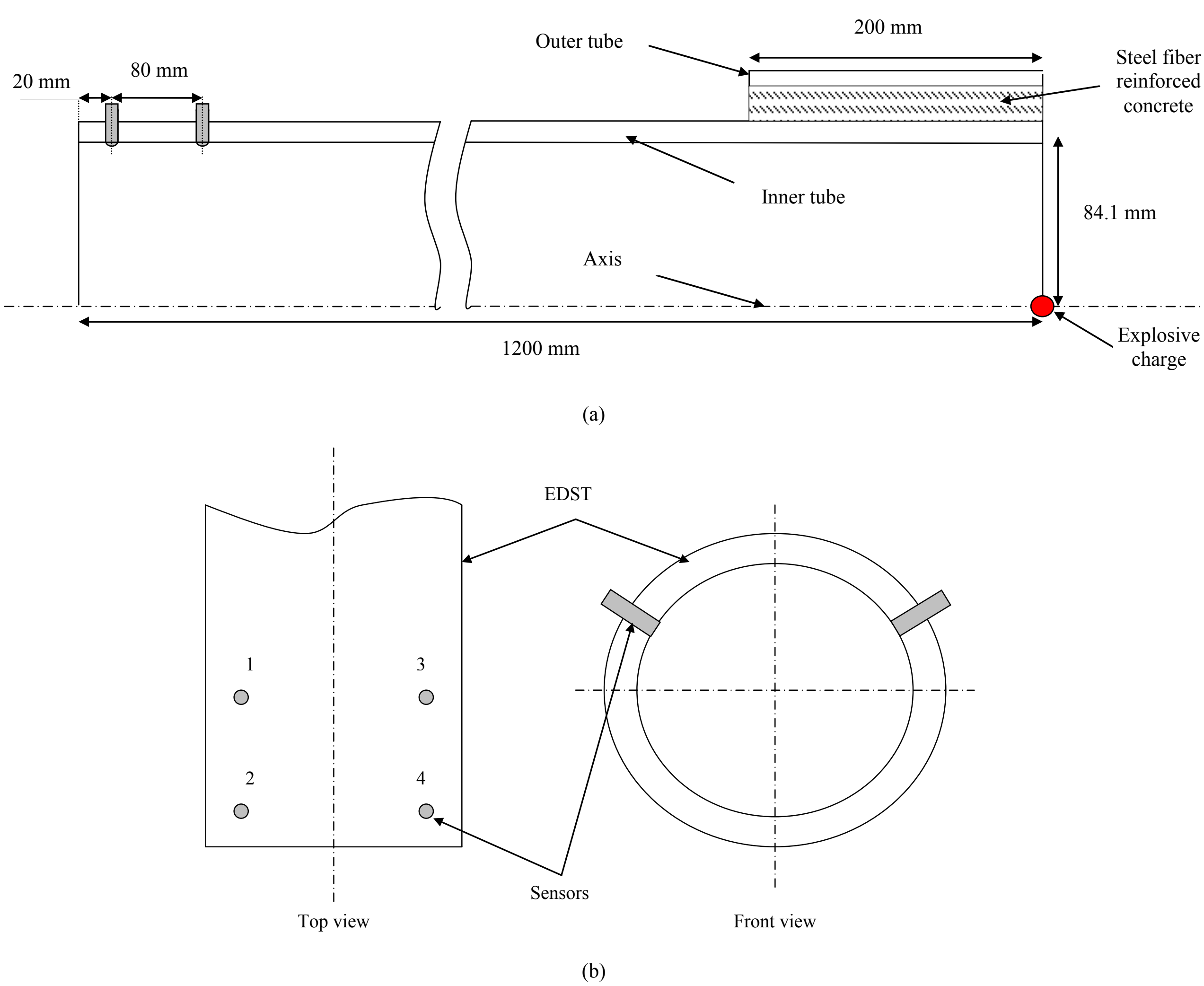

Fig. 2. Schematic representation of (a) the explosion driven shock tube (EDST) and (b) the position of the pressure sensors on the EDST.