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On the dynamic response of sandwich panels with different core set-ups subject to global and local blast loads

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ABSTRACT

The recent increase in blast and impact threats has led to an emerging interest in sandwich structures due to their superior performance in such loading environments. The optimised architecture of this class in conjunction with additional benefits of high strength-to-weight and stiffness-to-weight ratios vital to weight-sensitive military applications has led to numerous research works on the topic. In this study, the dynamic response of four circular sandwich panel constructions with different core designs under global and local blast loading conditions has been investigated. Numerical finite element (FE) models have been set up to study the effect of additional core interlayers on blast resistance enhancement of these sandwich panels. The objectives are (1) to assess the existing blast resistance capacity, (2) to increase the dynamic energy absorption, (3) to improve the stress distribution through plastic deformation, and (4) to ensure sacrificial damage to the additional core layers; hence, to avoid the main part of the core being damaged by excessive shear deformation, the dominant failure mode in conventional sandwich panels. A ductile elastomeric layer of polyurea, and a fairly compressible Divinycell-H200 foam layer have been selected as the additional core interlayers, and they have been placed in different arrangements to improve the overall blast resistance of the standard sandwich panel with glass-fibre-reinforced plastic (GFRP) face-sheets, and balsawood core. Dynamic explicit FE analyses were carried out using the commercial package ABAQUS 6.9-1. Comparison of specific kinetic and strain energies shows the effect of additional core layers on the blast energy absorption of a sandwich system. The study shows the improvement in shear failure prevention of the core as a result of the use of additional core layers and a reduction in the level of kinetic and strain energies in the protected core in both absolute and relative terms. The stress contours show a smoother stress distribution in enhanced cases. These conclusions are confirmed and explained by using a qualitative two-degree-of-freedom system with an elastic–viscoplastic spring element representing the integral effects of sacrificial additional core interlayers and a nonlinear spring representing the stiffness of the conventional sandwich system and comparing the results of dynamic analysis with a similar qualitative single-degree-of-freedom model of a conventional sandwich panel.

1. Introduction

A conventional sandwich panel is a layered structure consisting of two thin high-strength stiff face-sheets separated by a low-density, thick core. The face-sheets, usually made of metal or laminated composites, provide the primary flexural load-carrying elements while the core bonded to skins serves as a shear-resisting element and transfers the load between the facings. High strength, bending rigidity and light weight are the main advantages of conventional sandwich panels.

While only recently has the blast resistance of sandwich panels attracted attention, the performance of monolithic plates under dynamic loading has been studied extensively over the past few decades. To mention an example, Wang and Hopkins [1] carried out theoretical analyses on the plastic deformation of simply supported and built-in circular thin plates under impulsive load in one of the earliest works on the topic. Jones [2] has conducted an extensive review of the literature on monolithic plates of elastic–plastic or rigid–plastic materials subjected to impact and blast.

In the past 40 years, considerable work has been devoted to studying the various response, failure modes, and performance of modern sandwich panels with a compliant low-strength, compressible core. A review of the early studies and their limitations is given by Vinson and Shore [3]. Dvorak and Suvorov [4–6] explored the behaviour of sandwich plates under quasi-static

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