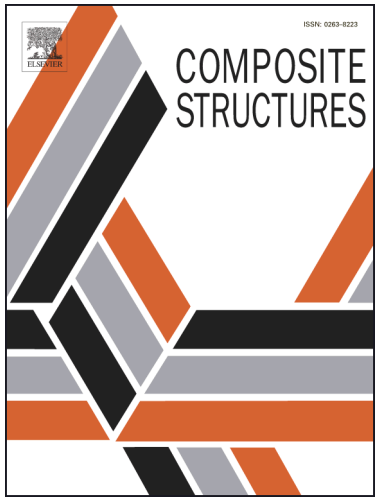

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Failure analysis and modeling of foam sandwich laminates under impact loading

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Abstract: This study made an effort to analyze the failure features of sandwich plates composed by composite faceplates and foam cores under impact. Drop weight tests were carried out involving different impact energy, foam density and stacking sequences. Ultrasonic microscope and cross section observation was conducted to reveal the failure details within the structure. The delamination among the top faceplate was found to follow the debonding law of composite laminates. The penetration of the top plate will change the shape of delamination region and stop the expansion of the delamination area as the impact energy increases. Sandwich structure with a hard core was proved to be more vulnerable to delamination than the one with a soft core, but this difference became negligible when penetration took place. Crush region and fracture region were located in the structure respectively, which was helpful for strength estimation and repair works. A new numerical model based on user-defined material subroutine was proposed for sandwich structures under impact. The model has the advantage of reproducing the failure features correctly and was proved to be effective.

Keywords: sandwich plates, CFRP, polyurethane foam, impact, failure, numerical simulation

1Introduction

Sandwich structure, which is composed by two pieces of stiff faceplates and one light core, play an important role in the area of energy absorption, weight reduction and structure protection. The faceplate is usually manufactured by materials with high stiffness and strength, such as metal and fiber reinforced composite, while the core is made of material like foam and honeycomb structure which have good performance in energy absorption. Along the direction that laminates were stacked, the structure is vulnerable since the different stiffness of faceplate and core. As a result, sandwich structure is easily damaged under bending or impact loading along the out-of-plane direction.

Various of studies have been made to reveal the mechanical behavior of sandwich structures under out-of-plane loading. Researches begin with quasi-static behavior of sandwich beams. Shuaeib [1] proposed a theoretical model to predict the failure load of sandwich beam under local indentation. The mechanical model was simplified as a line load bending an elastic beam attached to an elastic-plastic foundation. In the study of Steeves [2], Jiang [3] and Vitale [4], collapse of

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