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Procedia Engineering 88 (2014) 216 – 221

Procedia Engineering

www.elsevier.com/locate/procedia

International Symposium on Dynamic Response and Failure of Composite Materials, DRaF2014

Impact damage detection in light composite sandwich panels

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Abstract

The paper presents a comparative study on impact damage detection in light composite sandwich panels. Three different nondestructive testing methods were used to characterize damage in a test specimen that resulted from a controlled low velocity impact event. The analyzed test methods include the ultrasonic c-scan, vibrothermography and shearography. All considered techniques were positively verified for detecting damage in a sandwich panel. The paper gives details about the experimental procedures and equipment required to perform the tests.

Peer-review under responsibility of the Organizing Committee of DRaF2014

Keywords: sandwich panels, damage detection, ultrasonics, vibrothermography, shearography.

1. Introduction

Composites are multiphase materials that are designed to obtain a desirable combination of the best properties of the constituent phases. Structural composites, which include laminates and sandwich panels, are widely used in many engineering areas including aerospace, automotive, energy industries, civil engineering and sporting goods [1,2]. Sandwich panels, which are in the scope of the present work, have desirable mechanical properties combining high strength and stiffness with low densities. The face sheets of sandwich panels are made of stiff and strong materials, such as steel, aluminum alloys or carbon fiber reinforced polymers (CFRPs). They are designed to withstand the tensile and compressive stresses that result from the applied loads. The core material on the other hand needs to be lightweight and typically has low modulus of elasticity. There are different materials that are used for

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Peer-review under responsibility of the Organizing Committee of DRaF2014
doi:10.1016/j.proeng.2014.11.147

this purpose which include rigid polymeric foams, wood (balsa), honeycomb and chiral structures [2]. Sandwich panels have desirable mechanical properties combining high strength and stiffness with low densities. This in combination with their flexibility in design makes them an interesting construction material. There are however some important drawbacks of sandwich panels. One of the most important being their susceptibility to incur impact damage. Because structural integrity of sandwich panels is of major concern in engineering applications, efficient nondestructive testing (NDT) methods are necessary to assure the desired level of safety. There are numerous experimental techniques to reveal structural damage in composites including the classical NDT methods [3-5] and non-classical nonlinear approaches [5-10]. This paper considers the use of three methods: ultrasonic c-scan, vibrothermography and shearography. A comparative test was performed on a sandwich panel with barely visible impact damage.

2. Test specimen

The test specimen was a light composite sandwich panel. The overall dimensions of the panel were 400×120×13.2 mm, as shown in Fig. 1. The face sheets were made of *Seal Texipreg HS300/ET223* prepreg system, with $[0/90_3/0]$ ply stacking sequence. The total thickness of the face sheet laminate was 1.6 mm. The core material was a closed cell PVC foam *DIAB Divinycell HP60* with the total thickness of 10 mm.

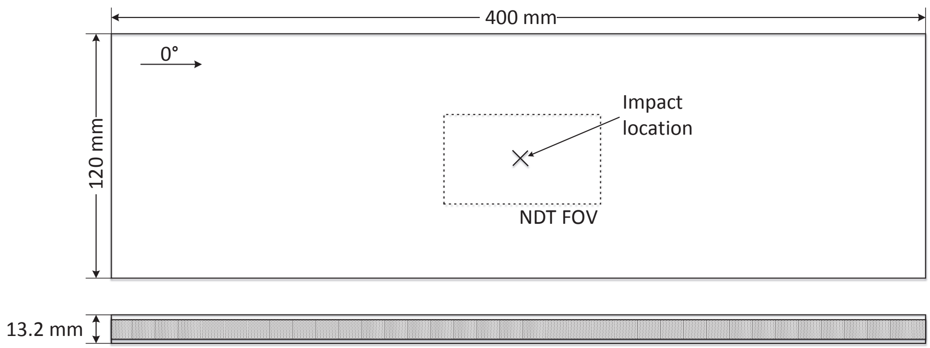

Fig. 1. Geometrical dimensions of the test specimen.

The panel was damaged in a low velocity impact event. Impact testing was performed using an instrumented drop-weight testing machine. An impact of 9.8 J energy was introduced at the central position of the panel, as shown in Figure 1, which resulted in a BVID in the upper face sheet of the panel.

3. Measurement techniques

Three measurement techniques were used to evaluate the damage caused by the impact, namely (1) ultrasonic c-scan, (2) vibrothermography and (3) shearography.

3.1. Ultrasonic C-Scan

Ultrasonic measurement in the pulse-echo mode is based on a principle that a pulse of energy is sent into the material and the reflected echoes are recorded as shown in Fig. 2a. Depending on the experimental configuration one or two ultrasonic transducers may be used to send and record the signals. At least two echoes will be present in the measured signal coming from the reflections from the front wall and back wall of the material (Fig. 2b.). Internal flaws may be identified as additional echoes in measured signals. These additional echoes will be located between the two main echoes. This type of measurement is especially useful when only one side of a material is accessible.