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ScienceDirect

Procedia Structural Integrity 5 (2017) 653–658

Structural Integrity Procedia

www.elsevier.com/locate/procedia

2nd International Conference on Structural Integrity, ICSI 2017, 4-7 September 2017, Funchal, Madeira, Portugal

Impact response of polyurethane and polystyrene sandwich panels

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Abstract

Sandwich panels with aluminum faces and polyurethane or polystyrene core were tested in impact on an Instron Ceast 9340 impact tower at speeds from 0.77 to 4.5 m/s. The faces were made from Al 6082-T6 sheet with a thickness of 1.5 mm and the thickness of the polyurethane panel (Necuron 100 core of density 100 kg/m^3) and of the polystyrene panel (commercial extruded polystyrene core of density 30 kg/m^3) were 15 mm, respectively 22 mm. Specimens of 140x140 mm were impacted with a mass of 13.15 kg and the variations of the impact force were monitored during the initial impact at a data acquisition frequency of 200 kHz. The important events took place in less than 15 ms. Particularities of the impact response of the sandwich panels were observed and discussed. The influence of the speed of impact was analyzed for both types of panels. The force variation during impact has a different evolution as influenced by the core behavior. There are noticed differences in the size and shape of the produced penetration of the skins after low-velocity impact.

Peer-review under responsibility of the Scientific Committee of ICSI 2017

Keywords: sandwich panels; polyurethane and polystyrene core; low velocity impact; impact force variation; damage.

1. Introduction

Sandwich panels with lightweight structural cores were first used in the aircraft industry in the 1940s to reduce weight and increase flight distance. The heavier conventional sheets were replaced by sandwich structures which became the basic structural concept in the aerospace industry since the 1950s. Nowadays, virtually every commercial

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2452-3216 © 2017 The Authors. Published by Elsevier B.V.
Peer-review under responsibility of the Scientific Committee of ICSI 2017
10.1016/j.prostr.2017.07.035

and military aircraft or vehicle depends on the integrity and reliability offered by these sandwich panels with a lightweight structural core.

Typically, low speed impacts may result from the collision with roadside safety elements, e.g., guard and bridge rails, median barriers or sign supports, hail or debris thrown up from runaways and even from tool drops during maintenance. The prediction of impact response was analyzed by Pasha et al. (2008). Experimental determination of the impact behavior of sandwich panels is neither resourceful nor cost effective, and in many cases finite element modeling (FEM) and analysis are used for these types of studies to predict the behavior and failure of these panels. Some of the experimental analyses on sandwich panels were presented by Wang et al. (2016), Calfskin et al. (2017), Zhou et al. (2012). The damage localization in cellular foams after impact was presented by Rizov (2007). The response of foam core based sandwich panels under impact was analyzed by Harizan and Cantwell (2002), and for sandwich composites by Atas and Sevim (2010). Combined experimental and numerical studies of foam core and foam-core sandwich panels was performed by Kasparek et al. (2011) and Wang et al. (2013). However, the calibration of the FEM impact model should be carefully done and only experimental results can provide a good understanding of the impact phenomena and response of the sandwich panel in conjunction to the localized damage produced after the low-velocity impact.

2. Experimental low-velocity impact testing

2.1. Impact testing procedure

An instrumented Instron Ceast 9340 Drop Tower Impact System used a striker of 20 mm diameter and the impact force was measured during the impact. The initial impact velocity of the striker was measured with an optical cell. The sandwich plates of 140x140 mm were placed on an adjustable in height test specimen support with a circular hole of 100 mm diameter (Fig. 1), which eventually allowed the striker to fall if the plate was perforated. A clamping ring was pressed over the sandwich plate by a pneumatic system with a maximum force of 3 kN. A special attention was given to the positioning and the alignment of the specimen as to obtain the impact in the middle of the plate. Fig. 1 shows the sandwich panel fixed in between the specimen support and the clamping ring. The energy carrier of gravitationally accelerated type had a mass of 3.15 kg and two additional masses of 5 kg each were added. Therefore the total mass of the energy carrier was 13.15 kg. The European Standard ISO 6603-2 : 2000, "Plastics -- Determination of puncture impact behavior of rigid plastics -- Part 2: Instrumented impact testing" was used. This standard was last reviewed and confirmed in 2015. Data acquisition was done with a frequency of 200 kHz for an initial estimated time of 40 ms, which was later reduced to 20 ms as being sufficient. Only the first impact was considered for monitoring the phenomena and comparisons of the responses of the sandwich panels. The load cell is capable to record a maximum force of 47 kN.

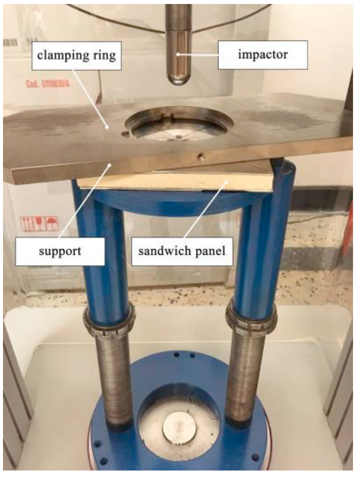

Fig. 1. Sandwich plate fixed for testing.