DAMAGE TOLERANCE OF CARBON FIBRE REINFORCED PLASTIC SANDWICH PANELS

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ABSTRACT

This paper presents an experimental evaluation of static strength and damage growth resistance under spectrum loading of impacted carbon fibre reinforced epoxy sandwich panels. The program includes determination of the influence of impact energy on damage visibility, damage size and distribution, and strength losses with respect to different skin thicknesses and core densities. In the case of barely visible impact damage the susceptibility of sandwich panels to impacts is reflected in large strength reduction and furthermore in damage growth during fatigue loading. The visibility of damage during the fatigue loading has been subsequently reduced. Damage growth and failure also occurred for non-visual impact damages.

I INTRODUCTION

The use of carbon fibre reinforced plastics in aircraft components has increased rapidly in recent years. Of great concern is the susceptibility of laminated composites to impact damage. The sensitivity of plain laminated skin to impact can result in a substantial decrease in strength especially in compression loading [1-2]. The problem arises since the strength can be reduced to the level of typical design strain used in aircraft structures. Furthermore the damage is not always visible from the front side which makes detection more difficult. Therefore, the application of carbon fibre reinforced plastics in primarily loaded structures necessitates consideration of the effect of impact damage to obtain sufficient confidence in safety of the structure. Moreover service experience with thin-skinned honeycomb composite structures has shown, [3], that they can be sensitive to low energy impacts, which raises the cost for maintenance, repair and replacement.
The object of this study was to determine the susceptibility of sandwich panels in terms of static and fatigue strength to damage as a result of impact and also to characterize the nature of the impact damage. The influence of impact energy on damage visibility, damage size and distribution, and strength reduction was evaluated for different skin thicknesses and core densities.

2. EXPERIMENTS

2.1 Specimen Configuration

The sandwich panels were fabricated with commercially available CFRP material and aluminium honeycomb cores. The skins were made from T300/914C in the form of unidirectional prepreg tape. The curing temperature in the autoclave was chosen to 190°C and held for two hours. No post-curing was performed. After curing the quality was examined using ultrasonic C-scanning. The two identical skins were bonded to the core with the adhesive FM300K. Two different skin thicknesses, 8-plies and 28-plies, were included in the test program. The stacking sequences of the two skins were (±45/0/90)s, 25/50/25 lay-up, and (±45/90/0/90/0/±45/90/0/90/0/±45)s, 29/42/29 lay-up, respectively. All three types of core had the same cell size, 3.2 mm, although the core density differed. The three different core densities were 72, 130 and 192 kg/m³. The thicker skin was combined with all of the three different cores whereas the thinner skin was only combined with the lightest core. The dimension of the sandwich panels was 1000mm long by 160mm wide. The height of the panels was in all cases 50mm.

2.2 Impact and Mechanical Testing

In this program all the impact locations were subjected to low velocity impacts using a falling weight with a 30mm hemispherical tip guided in a tube. These conditions were chosen to simulate tool drops etc. possibly occurring during assembly and maintenance. The test panels were clamped between two steel plates containing a square cut-out, 140 by 140mm where the skins were impacted in the centre. No loads were applied to the test panels in connection with impacting. To find the impact energy required to obtain barely visible impact damage (BVID), i.e. the energy level where it is likely to find the damage during visual inspection, trial impacts were performed. Barely visible impact damage was defined as a 2mm deep dent in the front surface. After impacting the maximum dent depth was determined. Ultrasonic C-scan evaluation was used to determine the size of the impact damage for each impact location. For a number of panels sectioning was employed to evaluate the damage distribution through the thickness of the damaged skin. In addition several impacts of lower energy levels were tested to obtain a wide range of damage sizes and indentations.

For the initial and residual static strength assessment the panels were tested in four point bending with the impact damage introduced in the compression loaded skin. For the fatigue loading a symmetrical fin spectrum was applied, tentatively, for two life-times. One life-time corresponded to 3000 flight hours. A maximum compression load occurred once in every 100 flight hours. The test frequency did not exceed 1.5Hz. The subsequent delamination development was monitored by C-scanning evaluation at a number of times during the fatigue testing. The mechanical testing was exclusively conducted at room temperature under ambient conditions, as were the impact tests.