SHEAR CHARACTERIZATION OF ALUMINUM FOAM SANDWICH PANELS

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Introduction

The interest in metallic foams has greatly increased in recent years, due to technological improvement in manufacturing aluminum foam sandwich panels (AFS). The use of AFS is spreading in various fields, such as naval, aerospace, railways and automotive [1].
However, it is still difficult to completely understand how the mechanical properties of AFS are linked to the specific manufacturing process. The mechanisms of deformation, crack growth and fracture are still not completely known and are the subject of recent studies [2-6]. In particular, the shear response of AFS panels is an important issue, also in view of the lack of official standard specific for sandwich panels with metallic foam core [7-9].
The aim of this work is to study the shear mechanical properties of AFS panels through the discussion on three different testing procedure. The tangential modulus G and the shear stress τ have been calculated.

Experimental tests

AFS panels tested in this work are produced by the Fraunhofer Institute in Brema (IFAM): an aluminium alloy (AlMgSi0.5) with an amount of particulate foaming agent (TiH2) is fitted between two solid panels of the same material, through the powder-rolling technique. When the sandwich is assembled, it is heated at the foaming temperature, so that the foam layer expands. With this process aluminium foam core and aluminium skins are bonded together through a metallurgic link.
The specimens have been obtained from sandwich panels with skin nominal thickness: t_{skin} = 1.5 mm. The nominal thickness of the foam is t_{foam}= 18 mm.
The relationship between length and core thickness is fixed at 12:1, as suggested in [8], while the width of each specimen is 50 [mm].
As it is well known, a state of pure shear is rather difficult to reproduce, particularly on foam core sandwich material. Three different testing procedure, partially suggested from the standard related to traditional sandwich composites [7-9] have been implemented and experimental results have been compared.
The shear stress have been generated in three different ways - called T1, T2 and T3 - using different load frames (Fig.1). The T3 test mode requires to bond two specimens to three thick aluminum plates.

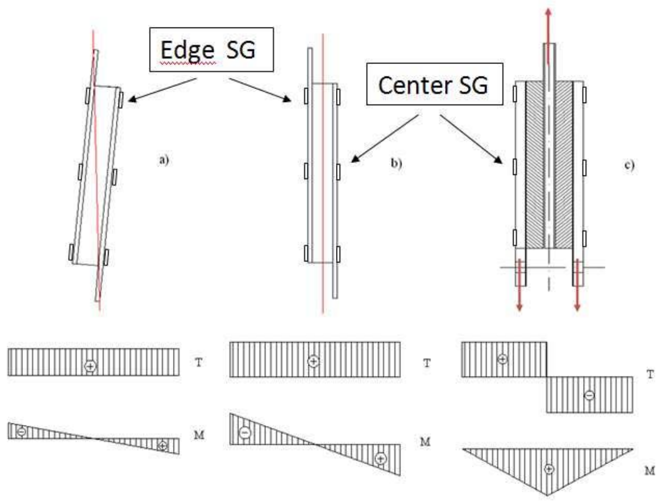

Figure 1 – Load lines and trends of bending moment M and shear stress T for the three types of tests: a) T1 b) T2, c) T3.

At least six electrical strain gages (SG) have been bonded along the longitudinal axis of the specimens, three for each skin, in order to assess the real type of load – shear or bending – reproduced by the different load frames. Consequently, the section where to measure the shear properties of material have been individuated for each specimens.

Experimental plan

Nine specimens have been tested with T1 type of test, eight specimens with T2 and seven with T3.
Ti and T2 test have been performed on a MTS electromechanical testing machine (load cell 30 kN); T3 tests have been executed on a servo-hydraulic testing machine (Instron with 100 kN load cel). The displacement rate was 0.5 mm/min. Strain gages data have been acquired by means of System 5000 - Micro Measurement, USA.

Experimental results and discussion

In all cases, strain gages show that secondary bending is a relevant phenomenon in the area close to clamping devices, particularly in the case T1 and T2 with respect of T3. In T3 configuration, in fact,

aluminum thick plates bonded to the skin of AFS collaborate to increase the flexural rigidity of specimens of one order of magnitude. However, it should be observed that T3 type of test requires the most complicated preparation of set up.
Comparing T1 and T2 type of test, secondary bending is slightly larger in T2 than in T1. Moreover, in T1 tests the bending effect is rather constant throughout the test at increasing values of applied load. Figure 2 shows the strain increment versus the applied load: center SG (green lines) show a regular and identical trend in both T1 and T2 type of tests; edge SG (red and purple lines) show a different trend, particularly when load increases, which means presence of bending especially in T2.

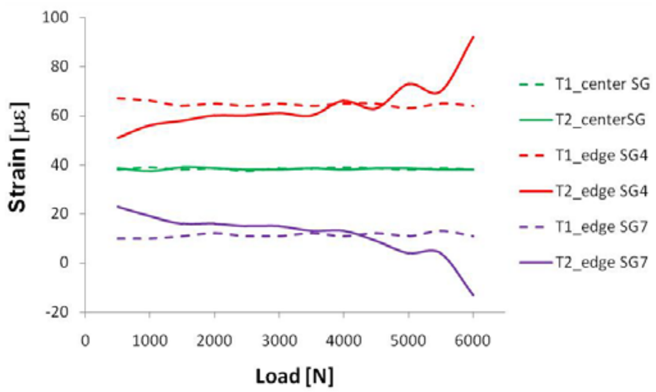

Figure 2 – Strain gages increments versus load for T1 and T2 type of tests

Quasi pure shear has been found in the middle of the specimens. So, shear mechanical properties of AFS have been evaluated from strain values measured in the centre of specimens, far from the clamping area. Table 1 summarizes the experimental results.

Test	Shear Stress [MPa]		
	average value	stand.deviation	(s.dev./av.value)*%
T1	0,611	0,0678	11,11
T2	0,549	0,0581	10,57
T3	1,108	0,1204	12,78
Test	Shear Modulus [MPa]		
	average value	stand.deviation	(s.dev./av.value)*%
T1	1112,22	31,53	2,84
T2	982,5	53,39	5,43
T3	7390	1361,25	18,42

Table 1 – Shear stress τ and shear modulus G

Shear stress and shear modulus G have been calculated as suggested in [8]. Being foam relatively inhomogeneous material, measured mechanical properties are consequently rather scattered. Fractures are always achieved at the interface between core and skin; few fractures have occurred into the core in case of T3 test.
Figure 3 reports one representative shear stress - strain curve for each type of test.

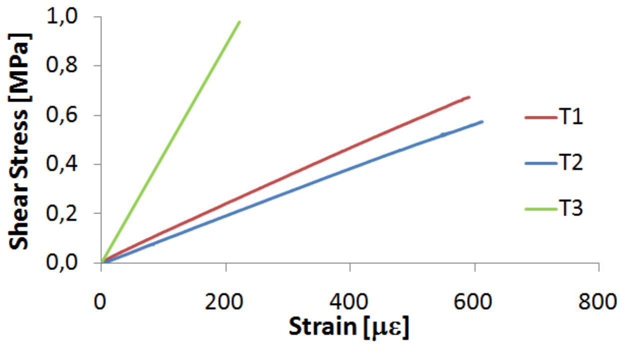

Figure 3 – Shear stress-strain curve for one representative test of T1, T2 and T3 type

Experimental data obtained from T3 test are higher and much more scattered than T1 and T2. These results are now subjected to a deep investigation and a comparison with shear properties derived from bending test [7] will be executed.

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