



Mechanical Testing of Sandwich Panels

Technical Notes

Introduction

In order to evaluate the structural performance of a sandwich panel Hexcel Composites conducts various mechanical tests. Specifically, we use the widely accepted military standard (MIL-STD-401B) test methods, unless our customers request conformity to a different specification. The following tests are performed on sandwich panels:

- Long Beam Flexure Test
- Flatwise Tension Test
- Short Beam Shear Test
- Edgewise Compression Test
- Flatwise Compression Test
- Climbing Drum Peel Test

Long Beam Flexure Test

There are several possible failure modes for this test (See Figure 1). Some of the more typical failure modes include tension/compression failure of skin; localized face wrinkling failure; and localized face dimpling failure.

The typical span for a long beam flexure test is 20 inches. From the long beam flexure test the sandwich flexure strength and flexure modulus can be determined. The average skin stress and modulus can be determined with the following equations:

$$\text{skin stress } \sigma = \frac{Ps}{8(h-t)wt}$$

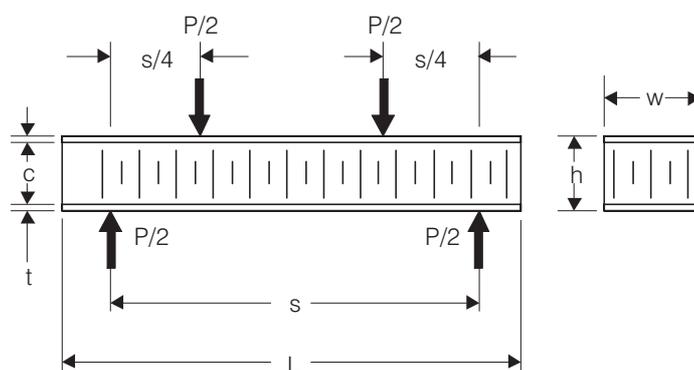
$$\text{skin modulus } E = \frac{11}{384} \frac{P}{d} \frac{s^3}{wt(h-t)^2}$$

where:

- s = span
- c = core thickness
- P = total applied load
- t = skin thickness
- d = deflection at mid-span
- w = width of panel
- h = panel thickness
- P/d = load-deflection curve slope
- L = specimen length

These equations are applicable for a symmetrical sandwich panel with thin face skins. For a more detailed discussion of the test and data interpretation, refer to MIL-STD-401B Sec.5.2.4 or ASTM C-393.

Figure 1 – Test Set Up and Test Specimen Configuration for Long Beam Flexure Test





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Short Beam Shear Test

The typical span for this test is 4 inches (See Fig. 2). Although there are several possible failure modes for this test, the typical failure mode is a shear failure in the core.

From the short beam flexure test, provided the failure occurs in the core, the core shear strength (average shear stress) can be calculated by the following equation:

$$\text{shear stress } \tau = \frac{P}{2cw}$$

where: P = total load
 c = core thickness
 w = width of panel

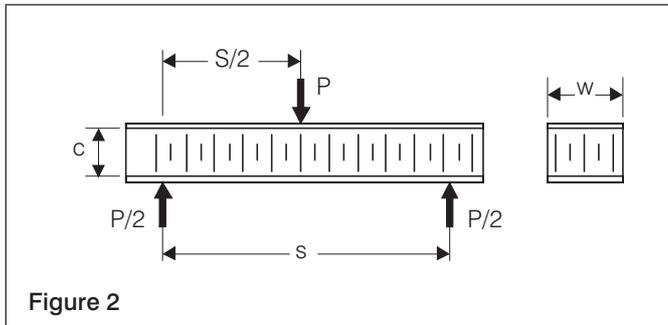


Figure 2

Flatwise Compression Test

This equation is applicable for a sandwich panel with thin face skins. For a more detailed discussion of the test and data interpretation, refer to MIL-STD-401B Sec.5.2.4 or ASTM C-393.

The purpose of this test is to determine the core compressive properties of the sandwich panel (See Figure 3). The typical specimen for this test is a 2 x 2 inch panel. With a complete load deflection curve it is possible to determine the core compressive strength and compressive modulus. The following equations can be used to determine the strength and modulus of the core:

$$\text{strength } \sigma = \frac{P}{lw} \quad \text{modulus } E = \frac{(P/d)c}{lw}$$

where: P = failure load
 l = length of the specimen
 d = deflection
 w = width of the specimen (2")
 c = core thickness
 P/d = slope of the load-deflection curve

A detailed description of the test can be found in MIL-STD-401B Sec.5.2.3 or ASTM C-365.

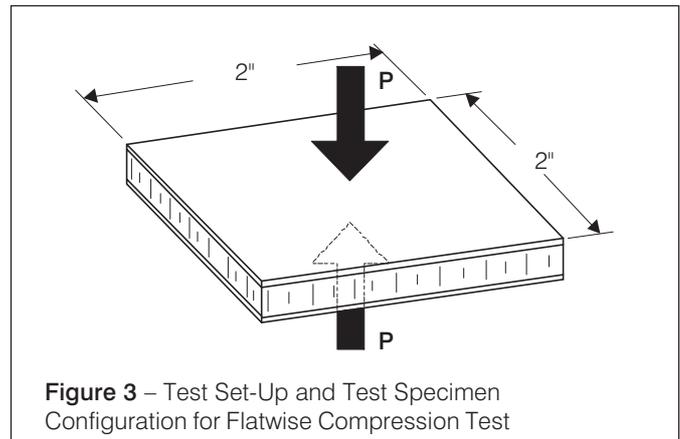


Figure 3 – Test Set-Up and Test Specimen Configuration for Flatwise Compression Test

Flatwise Tension Test

The test is used to determine the core tensile strength or the facing skin to core bond strength. The test is performed on 2 x 2 inch specimens bonded between heavy metal loading blocks. These are then pulled apart in a testing machine (See Figure 4). The average sandwich flatwise tensile strength can be calculated by the following equation:

$$\text{strength } \sigma = \frac{P}{lw}$$

where: P = ultimate load
 l = length of the specimen (2")
 w = width of the specimen (2")

A detailed description of the test can be found in MIL-STD-401B Sec.5.2.3 or ASTM C-297.

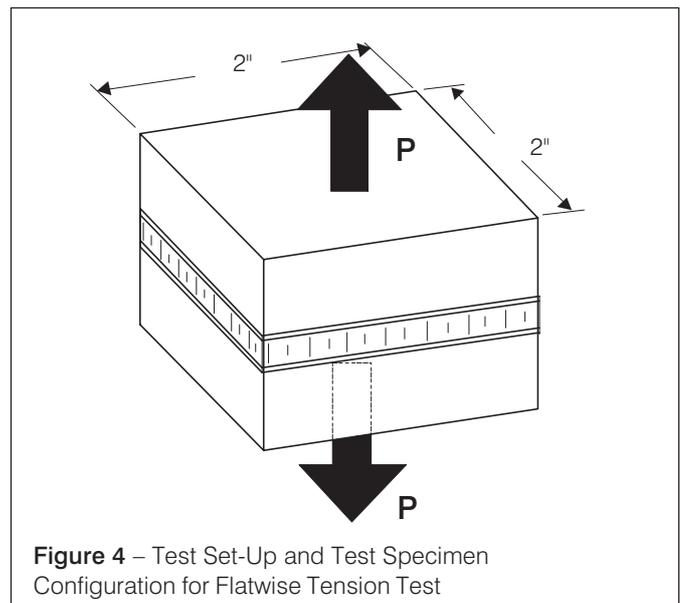


Figure 4 – Test Set-Up and Test Specimen Configuration for Flatwise Tension Test

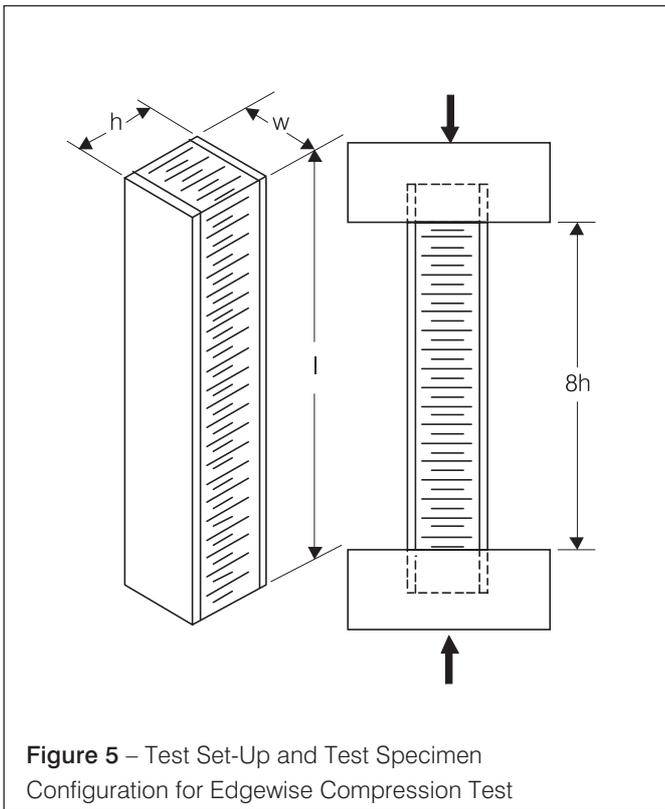


Figure 5 – Test Set-Up and Test Specimen Configuration for Edgewise Compression Test

Edgewise Compression Test

This test provides a basis for judging the load carrying capability of the sandwich panel in its facing skins (See Figure 5).

There are several possible failure modes for this test, namely, column buckling; shear crimping; face dimpling; and face wrinkling (See Figure 6).

The specimen size should be at least 2 inches wide and the unsupported length should be at least 8 times the sandwich thickness. Due to the nature of this test, take extra measures to ensure that the specimen has good flat ends, in order to prevent premature failure at the ends of the specimen. Casting of the ends by an appropriate moulding material – quite helpful in preventing the premature end crushing failure mode – is permitted per ASTM C-364.

During the test, exercise additional caution to ensure that the sample is straight and parallel to the load direction. This will help prevent the premature column buckling failure mode. The column buckling failure mode usually indicates a column instability rather than a measure of the facing skin load carrying capability. Therefore, every effort should be made to prevent this mode of failure.

In addition, strain gauges should be used to monitor the strains on both of the facing skins during the early stage of testing. The strain of both sides of the facing skins should be within 10% of each other. This will signal widely varying results due to different effective eccentricities. The average edgewise compressive strength can be determined by the following equation:

$$\text{strength } \sigma = \frac{P}{2tw}$$

where: P = ultimate load
 t = skin thickness
 w = width of the specimen

A detailed description of this test method can be found in MIL-STD-401B Sec.5.2.1 and ASTM C-364.

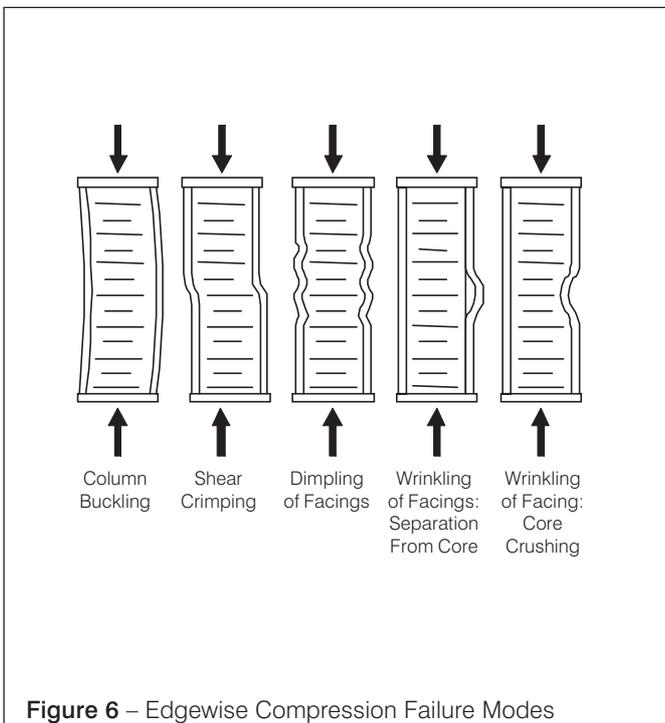


Figure 6 – Edgewise Compression Failure Modes



Climbing Drum Peel Test

This test method is intended to determine the peel resistance of the adhesive bonds between the facing skins and the core of the sandwich panel (See Fig. 7).

The length of the test specimen should be at least 10 inches long, with the typical width 3 inches. As the test progresses, an average constant torque level necessary to peel the adhesive will be reached. However, this torque level will include the amount of torque required to roll the bare skin, so this level should be predetermined. That number can then be subtracted from the actual reading to arrive at a meaningful measure of the peel strength of the adhesive. The average peel torque can be calculated by the following equation:

Peel Torque per unit width:

$$T = \frac{(R_o - R_i) (F_o - F_i)}{W}$$

where: R_o = radius of the flange plus one-half of the thickness of the loading straps

R_i = radius of the drum

F_o = measured average load

F_i = load required to bend and roll the bare skin

w = width of the specimen

Detailed information on the testing procedure and necessary calibrations are all described in MIL-STD-401B Sec.5.2.6 or ASTM D-1781.

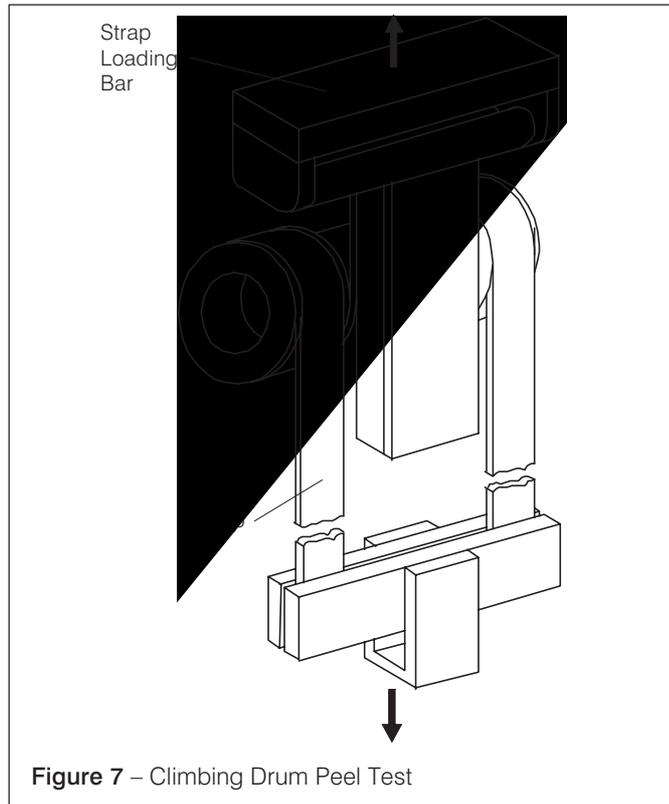


Figure 7 – Climbing Drum Peel Test

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