Zwick / Roell

Intelligent Testing

Standard Test Methods for Sandwich Composites

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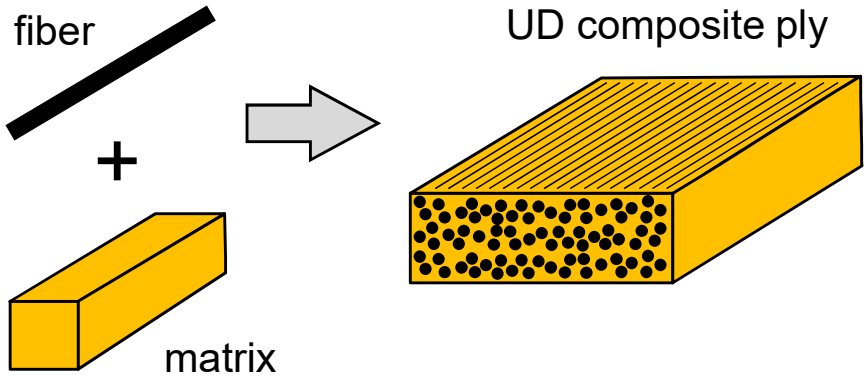
What is a Sandwich Composite?

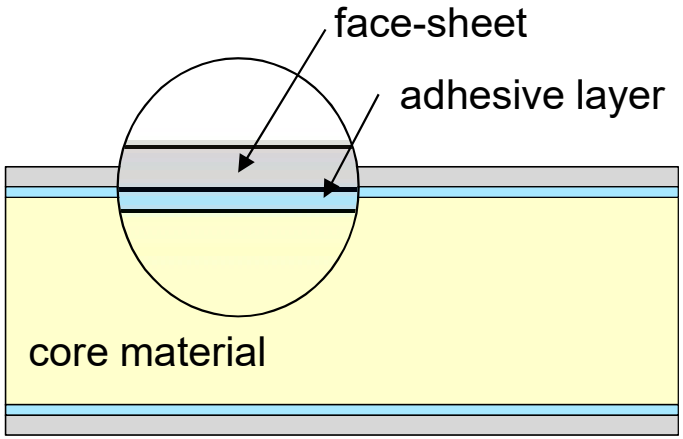
By combining different materials with different properties a new part with better characteristics is obtained.

Fiber Reinforced Polymer Matrix Composites
(FRPMCs)



"…a composite on the material level…"

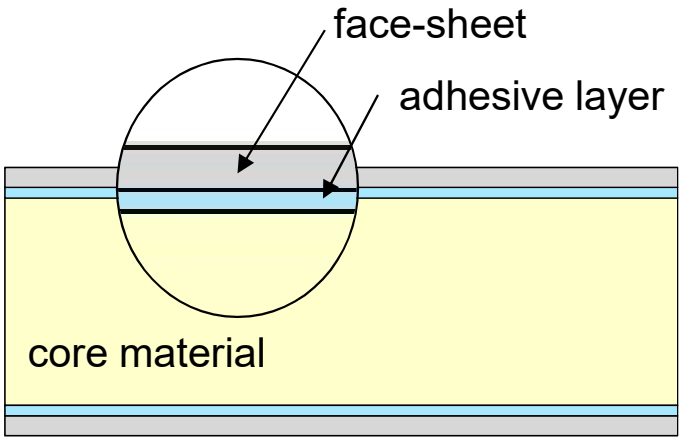
Sandwich Composites



"…a composite on the structural level…"

What is a Sandwich Composite?

By combining different materials with different properties a new part with better characteristics is obtained.



face sheets:

- carry the in-plane loads
- thin and made of high performance materials

core:

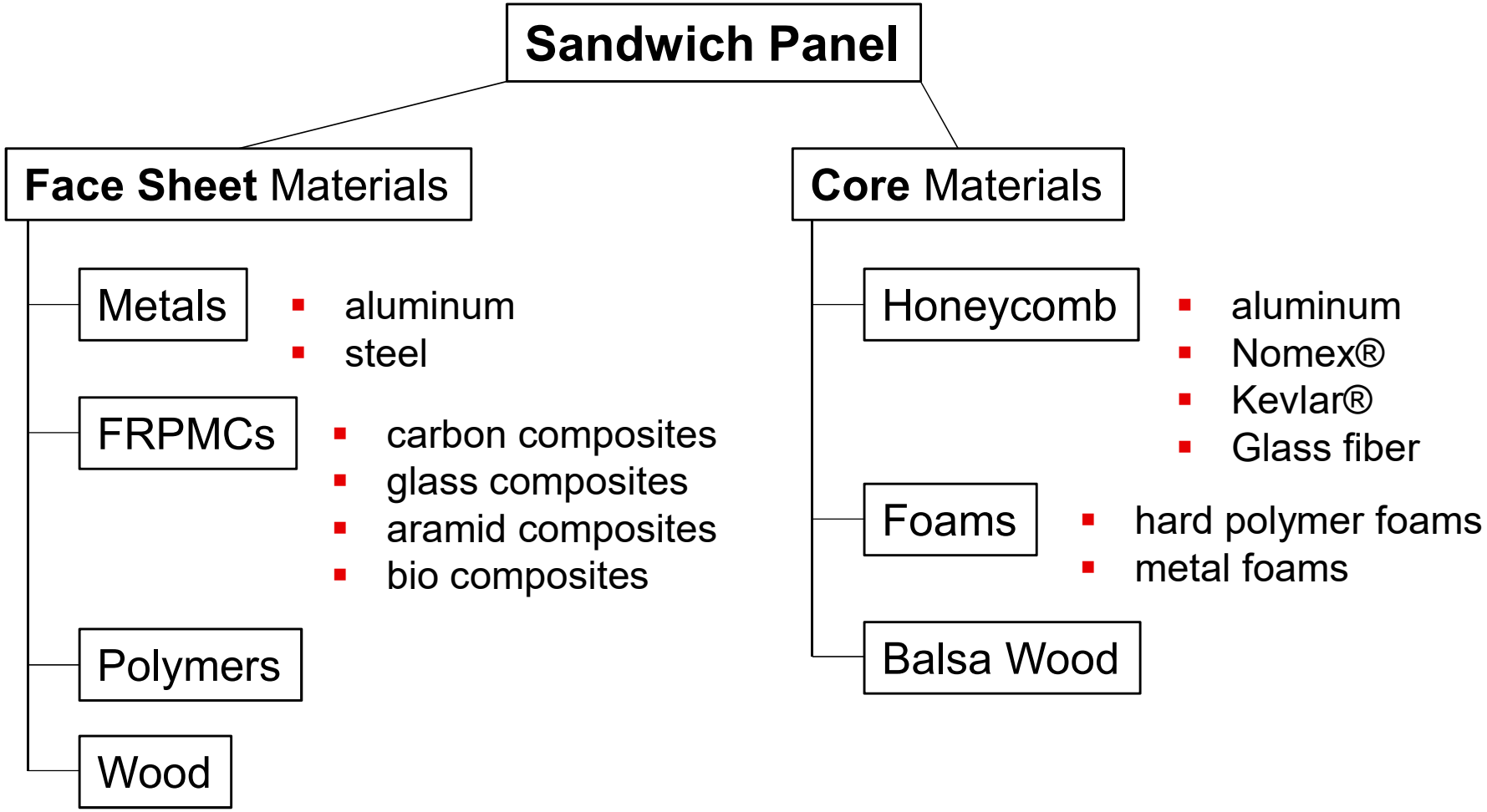
- carries through thickness and out-of-plane shear loads
- thick and made of low performance materials
- main purpose is to increase distance between faces
- low density

sandwich

- very high stiffness-to-weight ratio
- high bending-strength-to-weight ratio
- low face sheet buckling compared to other design concepts due to continuous support of core material

Which materials are typically used?

The material choice for face sheet and core is vast. This apparent complexity is advantageous, as the best material for a specific application can be chosen.



Applications

Zwick / Roell

Sandwich composites are used where lightweight design is important for structural performance, but they posses other features as well.

Aerospace

Transportation

Marine

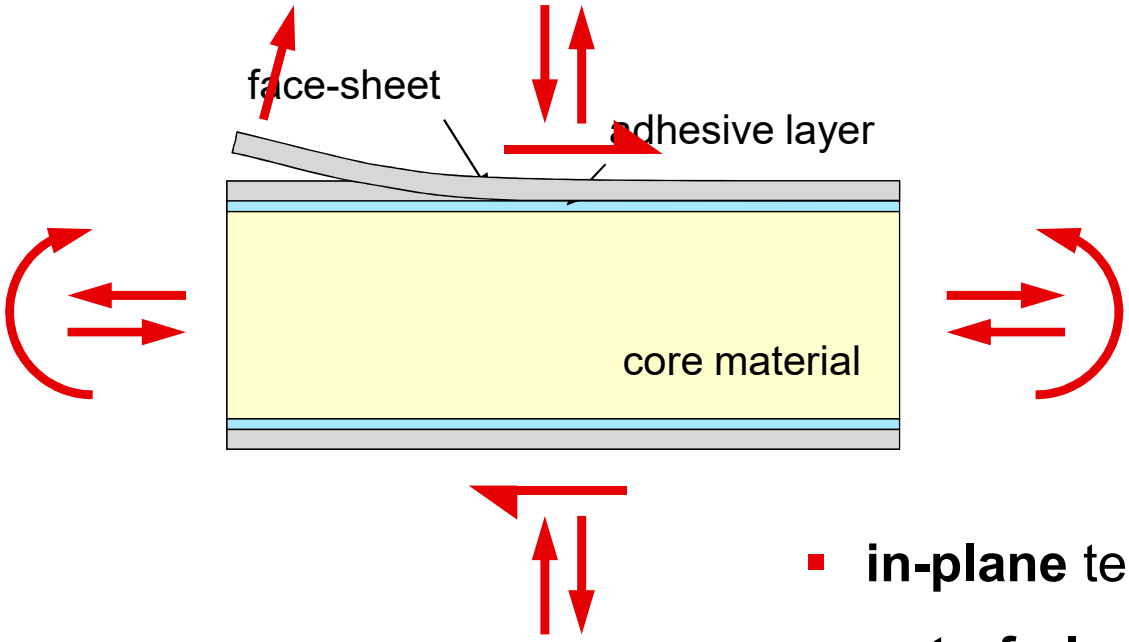
Construction

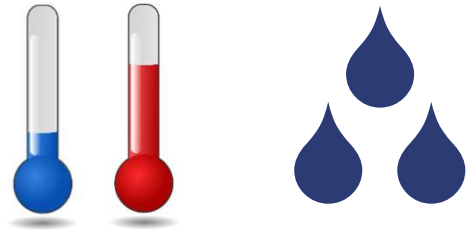
Other Applications

- Wind Energy
- Industrial Engineering
- Medical Technology
- Defense
- Off-shore Oil and Gas

Load Cases

Further load cases need to be considered for sandwich constructions, in addition to those considered for the load carrying face sheet layers.



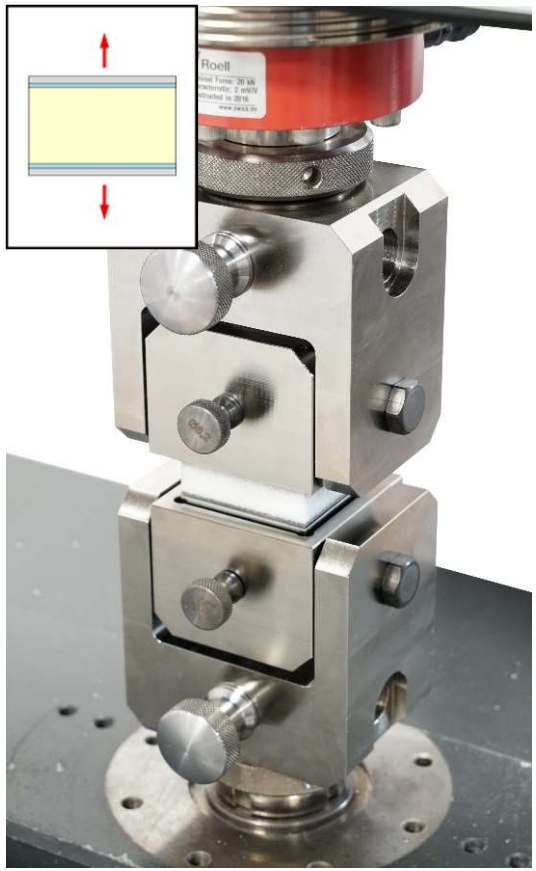


- **temperature**
- **humidity** & **fluids**

- **in-plane** tension & **compression**
- **out-of-plane tension** & **compression**
- **core shear**
- **flexure**
- **peel**

Flatwise Tension

The flatwise tension test determines the weakest strength of the sandwich construction under tensile loading in thickness direction.



setup as per DIN 53292

The aim of this test is to determine the strength of the

- core material
- adhesive bond between face sheet and core
- face sheet material (composites)

in the thickness direction of the sandwich panel.

The specimen

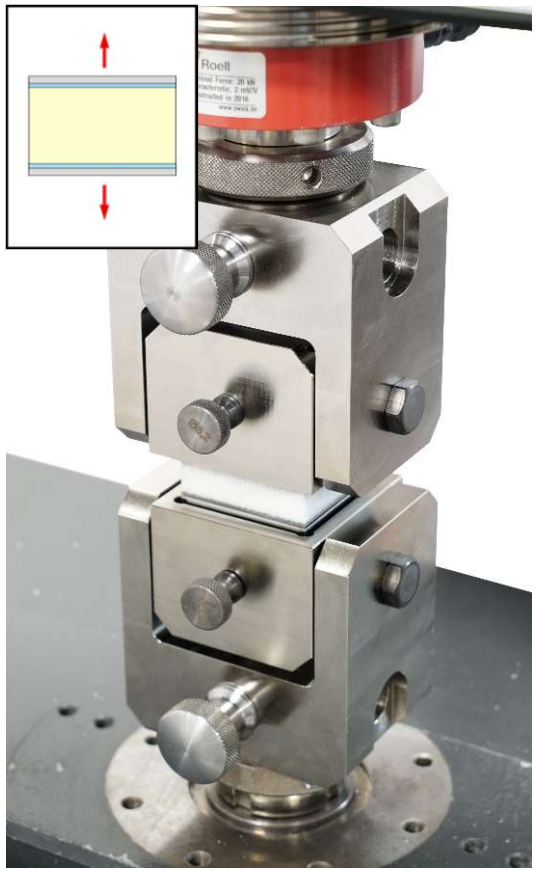
- is either the core material itself or the sandwich
- Is bonded to loading blocks for attachment to the test fixture
- size (cross-sectional area) depends on the homogeneity and size of the cellular structure of the core material

Typical sizes:	25 x 25 mm²
(cross-section)	50 x 50 mm²
	75 x 75 mm²

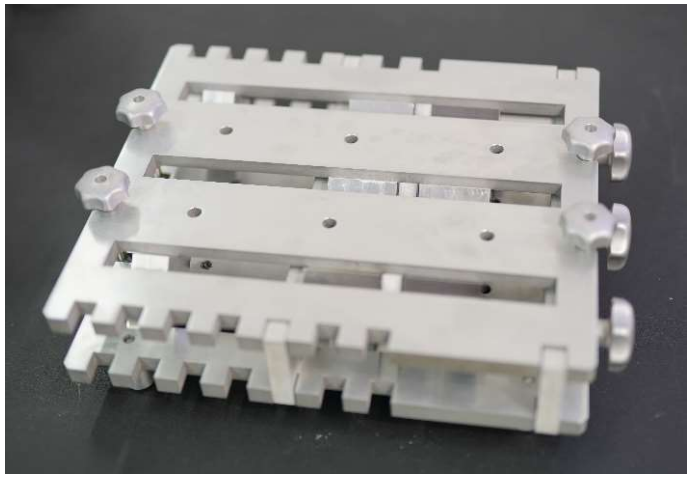
ASTM C 297	ASTM D 1623 B & C	DIN 53292	EN 2243-4	AITM 1.0025

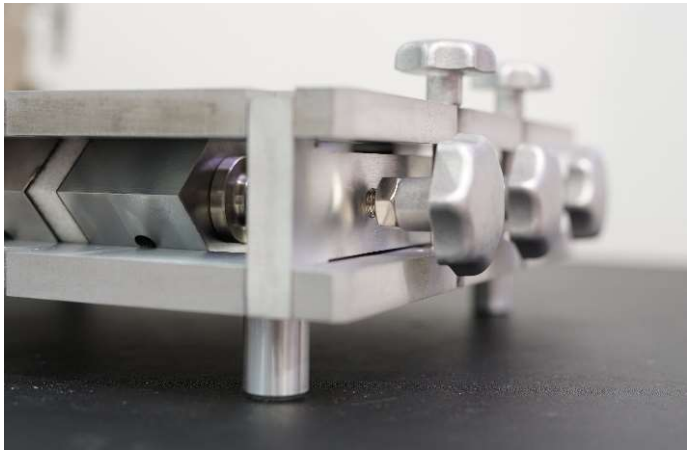
Flatwise Tension

For convenient and repeatable preparation of well aligned specimen-loading-block assemblies, a bonding jig is available.



setup as per DIN 53292

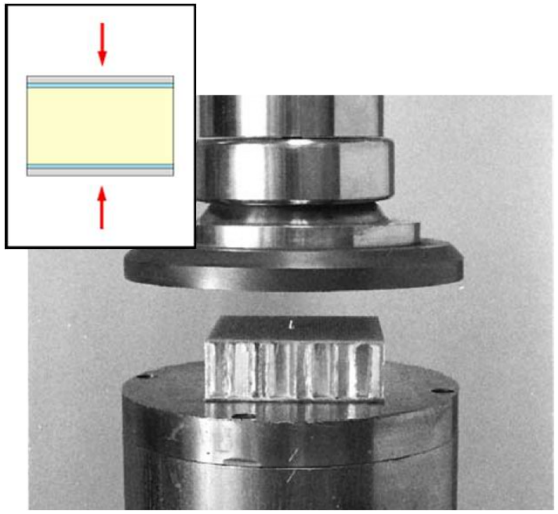




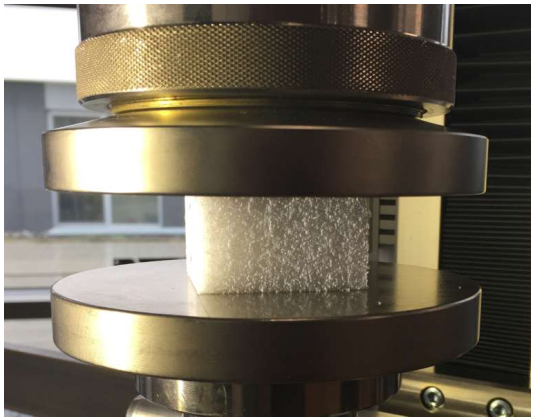
ASTM C 297	ASTM D 1623 B & C	DIN 53292	EN 2243-4	AITM 1.0025

Flatwise Compression

The flatwise compression test is crucially important due to the much lower mechanical performance of the core material.



setup as per [ASTM C 365]



setup as per ISO 844

The aim of this test is to determine the modulus and strength of the core material

ASTM C 365: - applicable to all core material types
- honeycomb with face sheet (stabilized properties)
- honeycomb w/o face sheet (non-stabilized properties)

ISO 844: - applicable to hard polymer foams only

The specimen

- is placed between carefully aligned compression platens and is loaded until failure
- size (cross-sectional area) depends on the homogeneity and size of the cellular structure of the core material

Typical sizes: (cross-sectional)	ASTM C 365:	25 x 25 to *75 x 75* mm²
	ISO 844:	50 x 50 to 150 x 150 mm²

ASTM C 365	***ISO 844***

Edgewise Compression

The edgewise compression test evaluates the load-carrying capacity of a sandwich construction in the direction of the face sheets.

- Applicable to all sandwich core material types
- Only the cross-sectional area of the face sheets are considered when calculating stress and strength

  → face sheet thickness must be known prior to manufacturing of sandwich panel

- Specimens are either clamped (left image) or bonded into end-supports

  → clamping requires very accurate preparation of specimen end surfaces

- Back-to-back strain gages, centrally located on opposite faces of the specimen are recommended to monitor superimposed bending (Percent Bending B_y)

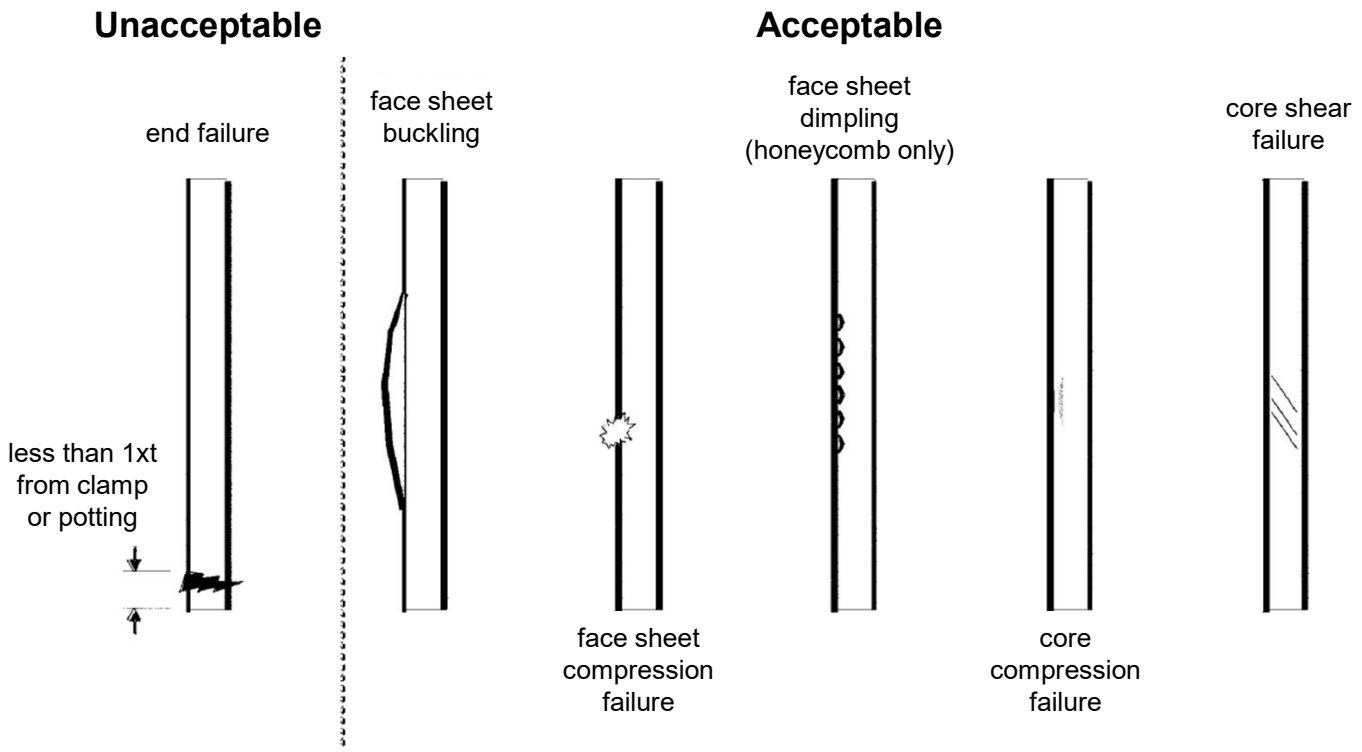
$$B_y = \frac{\varepsilon_1 - \varepsilon_2}{\varepsilon_1 + \varepsilon_2} \cdot 100 \leq 10\%$$

ASTM C 364

Edgewise Compression

The edgewise compression test evaluates the load-carrying capacity of a sandwich construction in the direction of the face sheets.

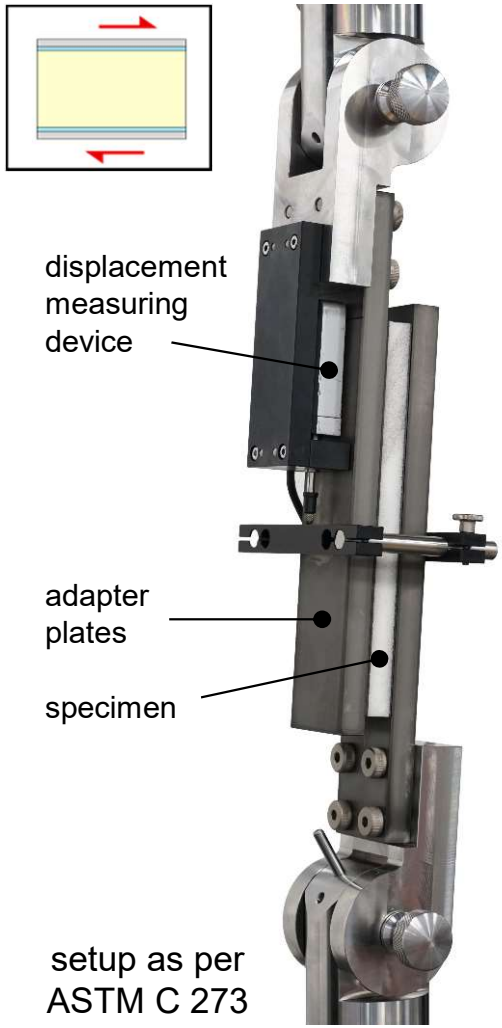
- Acceptable failure occurs away from the clamped or potted specimen ends



ASTM C 364

Core Shear

The core of a sandwich is mainly subjected to shear loading. While needing to be very light, it must exhibit sufficient shear properties.



setup as per ASTM C 273

The aim of this test is to determine core shear modulus and strength

The specimen:

- is either the core material alone or a section of the sandwich panel
- is bonded to adapter plates for attachment to the test fixture
- is not in a pure shear stress state, due to off-axis loading (ASTM C 283, DIN 53294 are applicable to all core and sandwich types)

  → ISO 1922 generates pure shear loading (for hard polymer foams only)
- size and adapter plate dimension depends on the specimen thickness

The test can be done under tension and compression

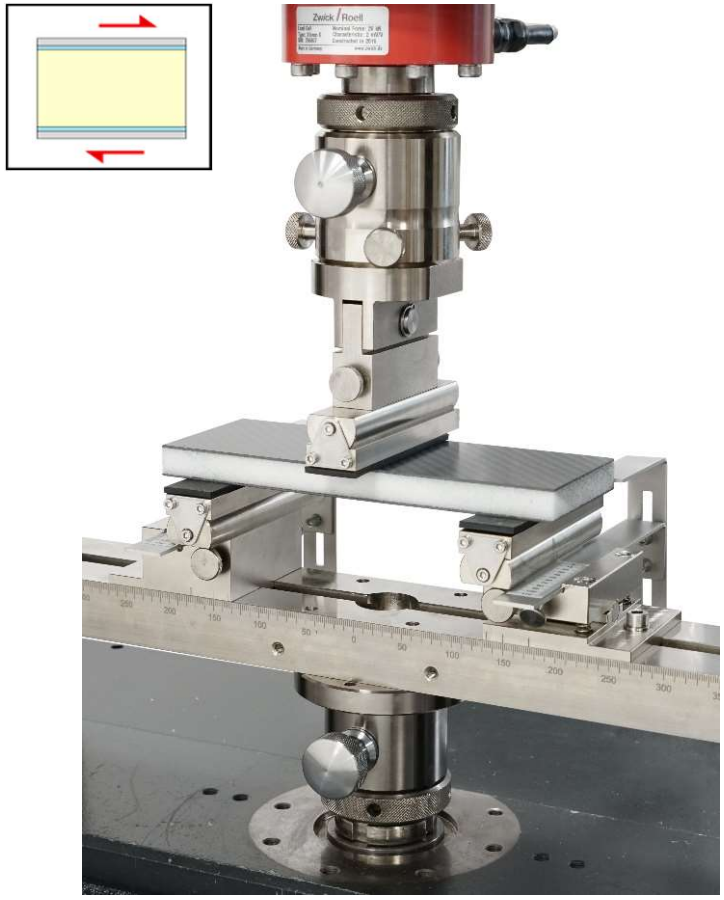
A separate displacement measuring device is required to correctly determine shear strain

Core shear failure is the only acceptable failure mode

ASTM C 273	*DIN 53294*	*ISO 1922*

Core Shear

The short beam flexure test is another method to measure core shear properties. It is comparable to the ILSS test for composite laminates.

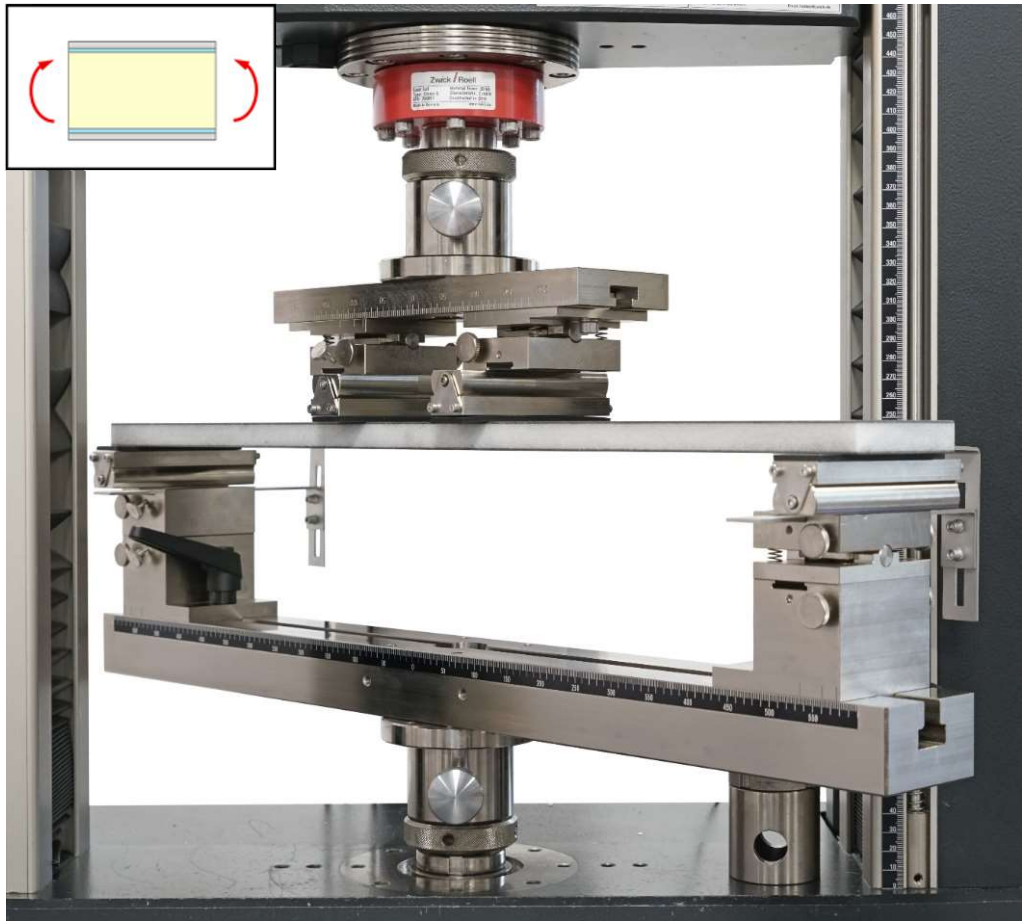


standard 3-point flexure setup
as per ASTM C 393

- Applicable to all sandwich core material types
- Acceptable failure: - core shear strength
  - core-to-facing shear strength
- Standard configuration is 3-point flexure setup with 150 mm support span (at center line of support bars)
- Due to comparable low compression strength of the core material, flat loading and support bars with added rubber pads are recommended
- A deflectometer shall be used to measure deflection at the center of the support span
- Standard Practice ASTM D 7250 required to calculate the core shear modulus
- ASTM C 273 recommend for core shear properties
- ASTM D 7249 recommend to measure facing strength

Flexure

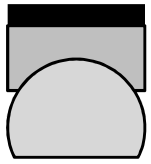
4-point flexure is the standard configuration for sandwich flexure tests. The intended failure mode is face sheet failure.



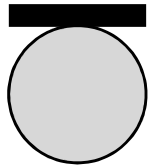
standard 4-point flexure setup as per ASTM D 7249

- All sandwich core material types
- Deflectometer required to measure deflection at the support span center
- Strain gages shall be used for strain measurement (ASTM D 7249)
- Support and loading span distances varies for each standard
- Shape of loading and support bars:

ASTM D 7249
(flat with rubber pads)



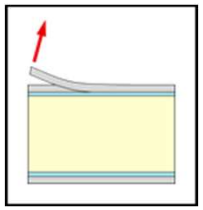
DIN 53293 & AITM 1.0018
(round with rubber pads)

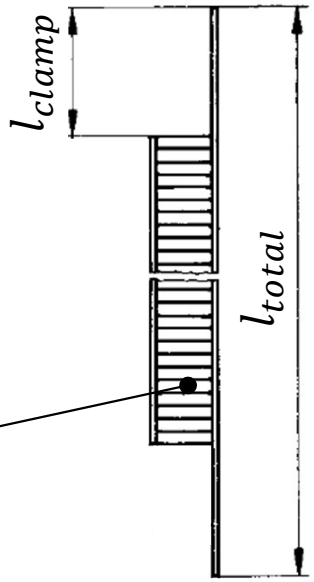


ASTM D 7249	DIN 53293	AITM 1.0018

Climbing Drum Peel Test

This test measures the peel resistance of the adhesive bond between face sheet and core material.





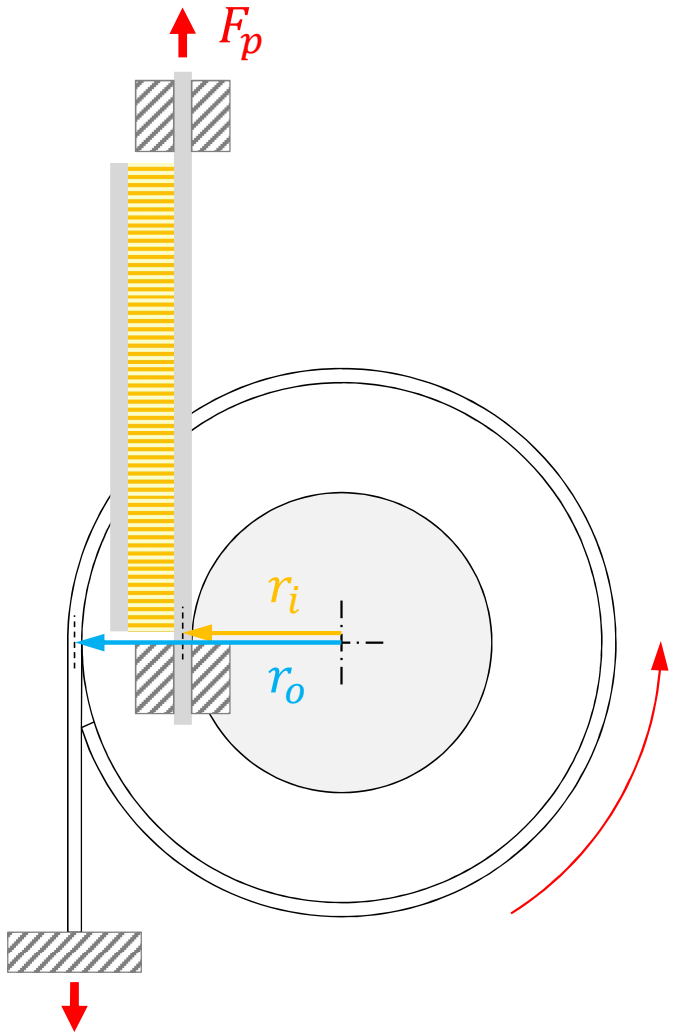
[mm]	ASTM	DIN
$width$	76	75
l_{total}	305	300
l_{clamp}	25	25

- The climbing drum peel test can be applied for relatively thin and thus flexible face sheets
- Generates comparative results for process and quality control (not a material property)
- Requires calibration to:
  - account for influence of face sheet bending on measure load
  - find the load required to set the drum in motion

ASTM D 1781	***DIN 53295***	***Airbus QVA-Z10-46-05***

Climbing Drum Peel Test

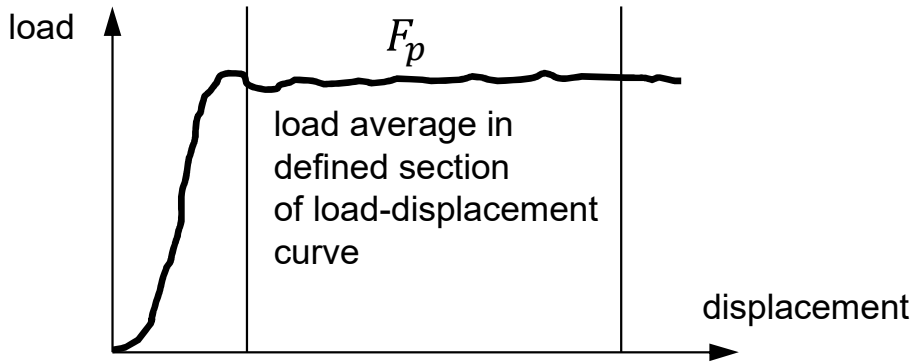
This test measures the peel resistance of the adhesive bond between face sheet and core material.



Average peel torque: $\bar{T} = \frac{(r_0 - r_i)(F_p - F_0)}{w}$

where:

r_0	outer drum radius + half loading strap thickness
r_i	inner drum radius + half face sheet thickness
F_p	load average measured during the test
F_0	load average measured during calibration
w	specimen width



Static testing machines

For static sandwich testing, a test machine up to a maximum load range of 100 kN is usually sufficient. For composite face sheet testing, the load range may need to be expanded to lower and higher forces.

ZwickiLine

- easy to operate single column load frames for loads up to 5 kN

ProLine

- can be an optimal and economic choice for tests that do not require complex sensor equipment

AllroundLine – Table Top

- for loads up to 150 kN
- very light and flexural stiff
- optionally with two test areas to minimize reconfiguration efforts
- support legs to position test area at optimal operator height

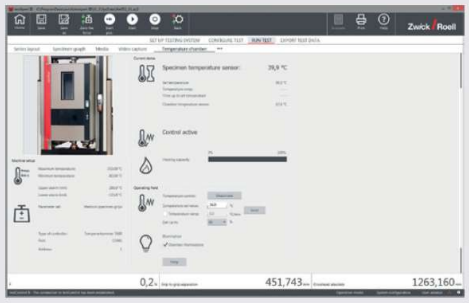
AllroundLine – Floor Standing

- for loads from 100 kN to 1200 kN
- four guide columns for most accurate alignment of test axis
- optionally with two test areas to minimize reconfiguration efforts
- tension-torsion machines available

Temperature testing

ZwickRoell temperature chambers provide highest level of integration with the testing system and ensure safe and reliable operation.

Door-in-door access
to minimize time between tests



Full integration of the temperature chamber in testXpert III for maximum control and traceable results

Near specimen temperature measurement
to monitor and regulate temperature where it matters

Temperature variation (+/- 1 °C)
Very precise temperature control creates homogeneous and accurate conditions for the specimens throughout the entire chamber.

Strain and Displacement Measurement

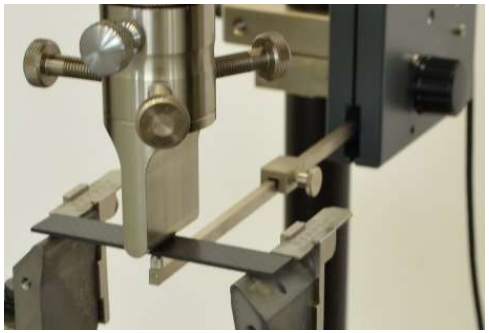
Often the displacement of the cross-head of the testing machine is sufficient. If not, you may chose from our wide range of strain and displacement measuring solutions.

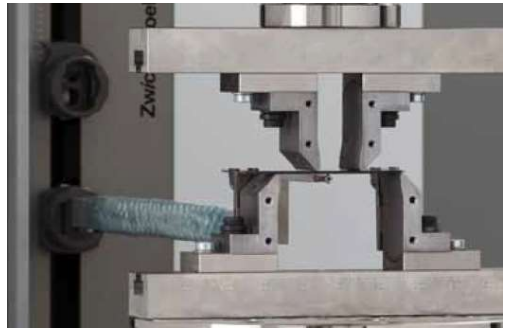
Linear
strain gage…

…connected to preconfigured
strain gage box…

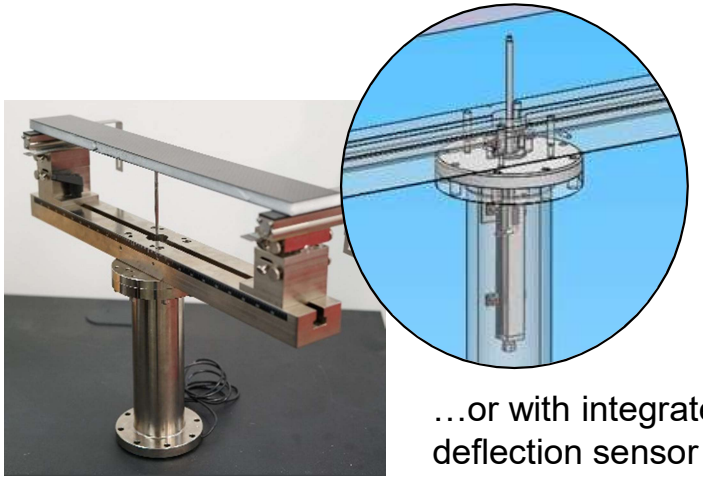
…or HBM QuantumX
universal amplifier

Opto-electronic
measurement transducer
used for core shear testing





Deflection measurement with deflectometer (left) or with
makroXtens and sensor arm for flexure tests…



…or with integrated
deflection sensor

Questions & Answers