

Bonding of LKWS – Part 1 (standards, methodology)

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May 9, 2023



EDU2
WOOD+ Project

**This event has been funded with support from the European Union.
2020-1-CZ01-KA203-078483.**

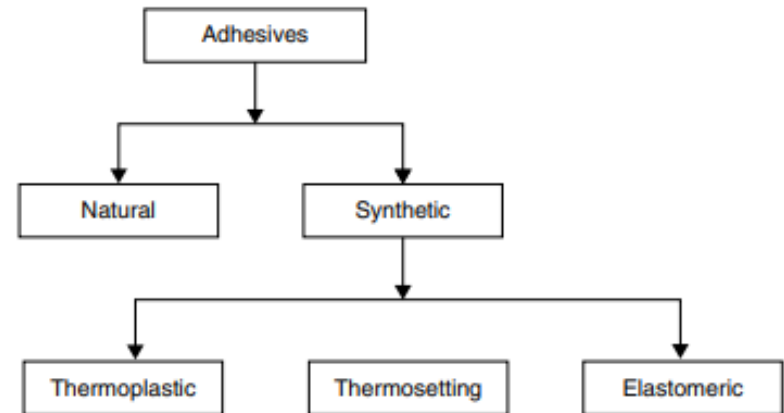
Outline of the presentation

1. **Standards for adhesive bond testing**
 - EN 12765
 - EN 205
2. **Methodology for bonding of LKWS with LW**
3. **Formation of working groups**

Classification of adhesives

1. Classification by:

1. Source
2. Chemical composition
3. Physical form
4. Curing mechanism
5. Application
6. ...
7. Standards



EN 12765

- **Classification of thermosetting wood adhesives for non-structural applications**
 - UF
 - Tanin, lignin, liquefied wood, ...

Description of durability classes

Durability class	Examples of climatic conditions and fields of application
C1	Interior, in which the moisture content of the wood does not exceed 15 %
C2	Interior with occasional short-term exposure to running or condensed water and/or to occasional high humidity provided the moisture content of the wood does not exceed 18 %
C3	Interior with frequent short-term exposure to running or condensed water and/or to heavy exposure to high humidity. Exterior not exposed to weather
C4	Interior with frequent long-term exposure to running or condensed water. Exterior exposed to weather but with protection by an adequate surface coating

The adhesive shall be tested in accordance with EN 205

Minimum values of adhesive strength for thin bond lines

Conditioning sequences		Adhesive strength in N/mm ² Durability classes			
Sequence number	Duration and condition	C1 ^c	C2 ^c	C3 ^c	C4 ^c
1	7 days ^a in standard atmosphere ^b	≥ 10	≥ 10	≥ 10	≥ 10
2	7 days in standard atmosphere 1 day in water at (20 ± 5) °C	—	≥ 7	≥ 7	≥ 7
3	7 days in standard atmosphere 3 h in water at (67 ± 2) °C 2 h in water at (20 ± 5) °C	—	—	≥ 4	—
4	7 days in standard atmosphere 3 h in boiling water 2 h in water at (20 ± 5) °C	—	—	—	≥ 4

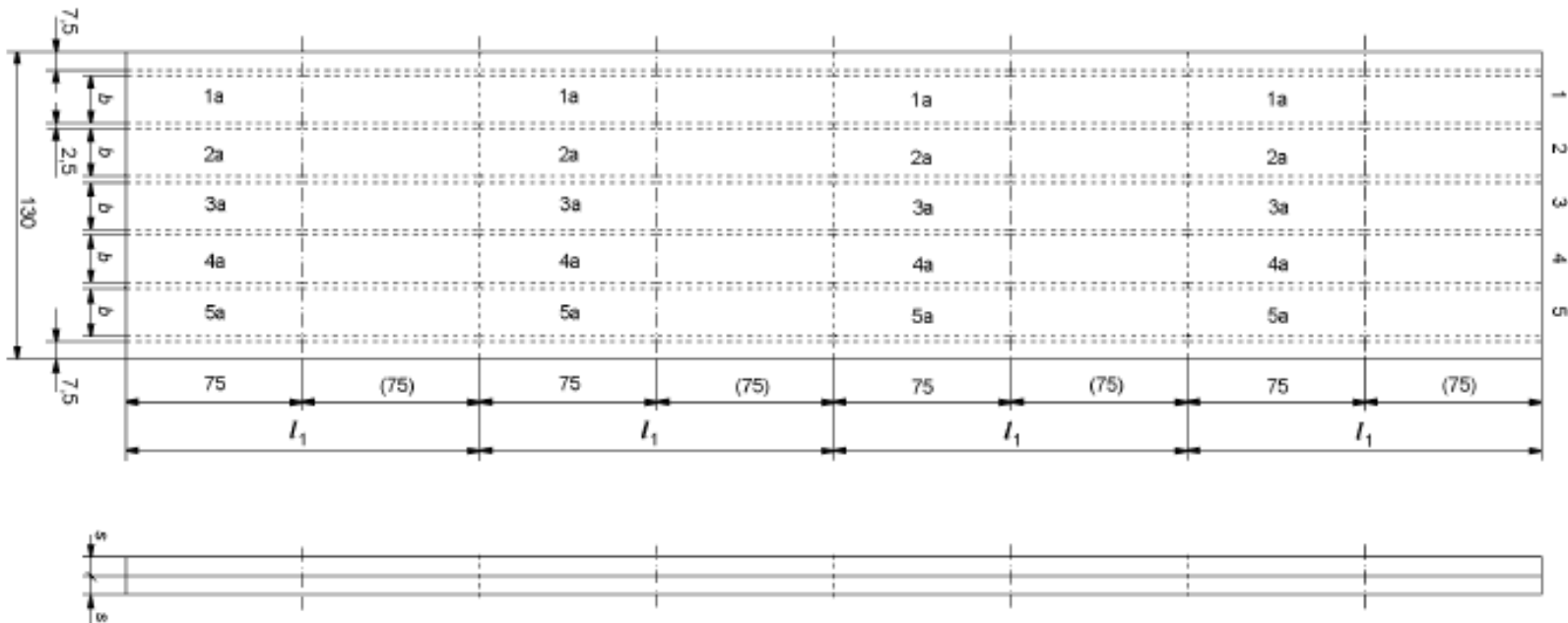
b = (20 ± 2) °C and (65 ± 5) % relative humidity

EN 205

- **Adhesives - Wood adhesives for non-structural applications - Determination of tensile shear strength of lap joints**
- Principle - a symmetrical bonded single lap joint between two symmetrical wooden adherends is subjected to specified conditioning treatments and strained to rupture by a tensile force parallel to the grain.

Preparation of bonded assemblies

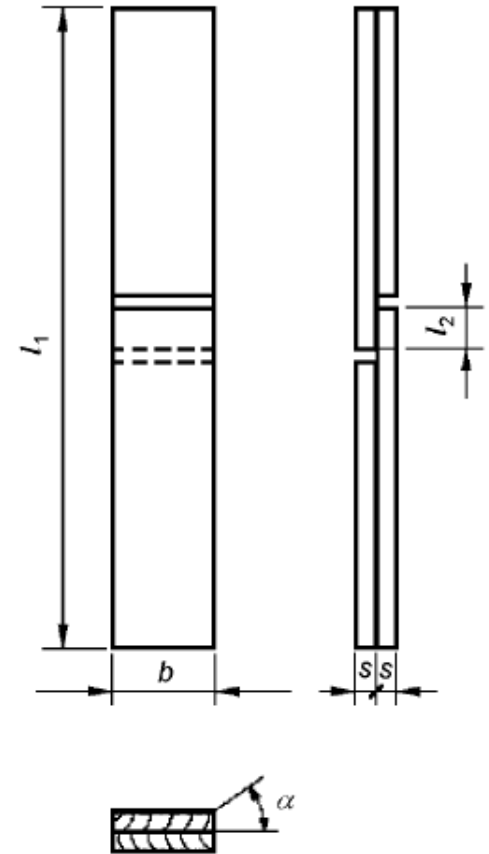
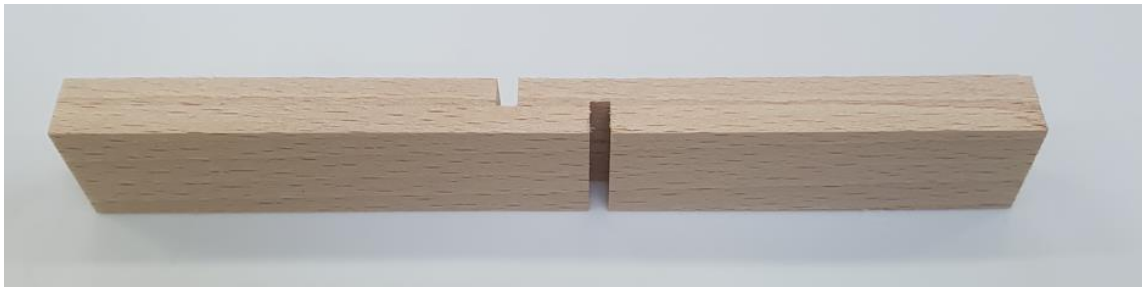
- Prepare two panels from a thick unsteamed, conditioned, straight-grained board of beech (*Fagus sylvatica* L.) with:
 - a nominal density of (700 ± 50) kg/m³
 - a moisture content of (12 ± 1) %.



Preparation of test pieces

Key:

- l_1 total length of test piece (150 ± 5) mm
- s thickness of the panels ($5,0 \pm 0,1$) mm
- b width of test piece / width of tested surface ($20,0 \pm 0,2$) mm
- α angle between growth ring and surfaces to be bonded $30^\circ - 90^\circ$
- l_2 length of overlap / length of tested surface ($10,0 \pm 0,2$) mm



Number of test pieces

- Test 20 test pieces for each of the conditioning sequences chosen.
- Subject the test pieces to the appropriate conditioning sequences.

Conditioning sequences		Adhesive strength in N/mm ² Durability classes			
Sequence number	Duration and condition	C1 ^c	C2 ^c	C3 ^c	C4 ^c
1	7 days ^a in standard atmosphere ^b	≥ 10	≥ 10	≥ 10	≥ 10
2	7 days in standard atmosphere 1 day in water at (20 ± 5) °C	—	≥ 7	≥ 7	≥ 7
3	7 days in standard atmosphere 3 h in water at (67 ± 2) °C 2 h in water at (20 ± 5) °C	—	—	≥ 4	—
4	7 days in standard atmosphere 3 h in boiling water 2 h in water at (20 ± 5) °C	—	—	—	≥ 4

Tensile shear test

- Clamp the ends of the test pieces in the jaws of the tensile testing machine (40 - 50 mm).
- Ensure that the force is applied centrally and in the plane of the bond.
- Load the test piece until rupture and record the applied maximum force.
- Conduct the test at a rate of traverse of 50 mm/min (rupture 5 - 15 s).



Expression of results

- τ the shear strength (N /mm²)
- F_{\max} the applied maximum force (N);
- A the bonded test surface (mm²);
- l_2 the length of the bonded test surface (mm);
- b the width of the bonded test surface (mm).

$$\tau = \frac{F_{\max}}{A} = \frac{F_{\max}}{l_2 \cdot b}$$

- **Shear strength** of 20 test pieces rounded to 0,1 N/mm².
- **Wood failure** as a percentage graded as follows:
 - 0%, 25 %, 50 %, 75 %, 100 % breakage of wood.

Materials

1. Wood

- *Ailanthus altissima* (AA)
- *Gleditsia triacanthos* (GT)

- *Fagus sylvatica* (FS), reference

2. Adhesive

- Liquefied wood (LW)

Adhesive bonding

- Wood lamellas (EN 205)
 - 5 mm
 - 10 %
- Pressing parameters
 - 200 g/m²
 - 180 °C
 - 12 min
 - 10 bar



Adhesive - calculation

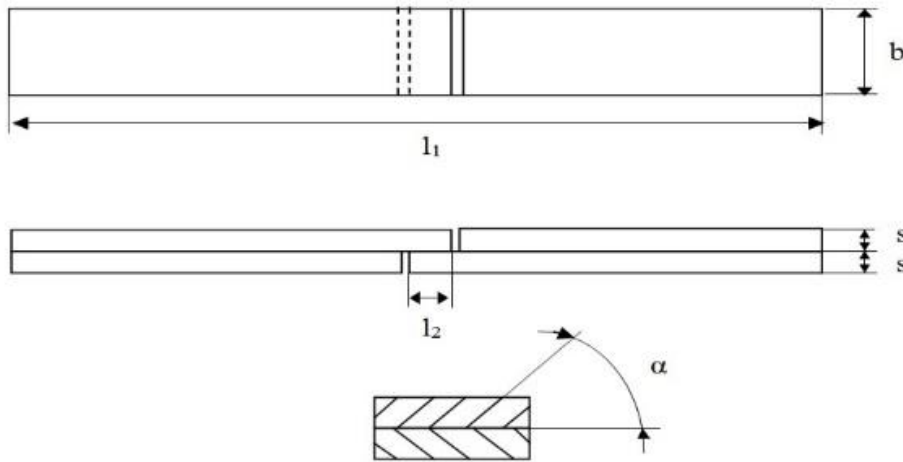
- 200 g/m²

Pressure - calculation

- 10 bar

Pre-treatments of the samples

- Preparation 1: testing dry samples after 7 days conditioning in standard climate (20 °C / 65% RH).



- Testing

- Shear strength (N/mm^2)
- % of wood failure



Formation of working groups

- Three groups:

1. AA

2. GT

3. FS