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WOOD PROPERTIES

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Aim

- Wood = material
- Different processing and utilisation
- Differences among timbers
- Important to understand properties
- Factors affecting properties

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Main features

Wood is:

- Anisotropic material
- Hygroscopic material
- Porous material
- Heterogeneous material

…..all the features are reflected in a properties variability.

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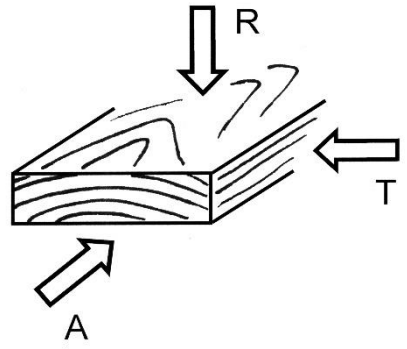
Anisotropic material

- Directionally dependent properties
- Opposed to isotropy
  (means homogeneity in all directions)
- Difference in a property for some material when measured along different axes.



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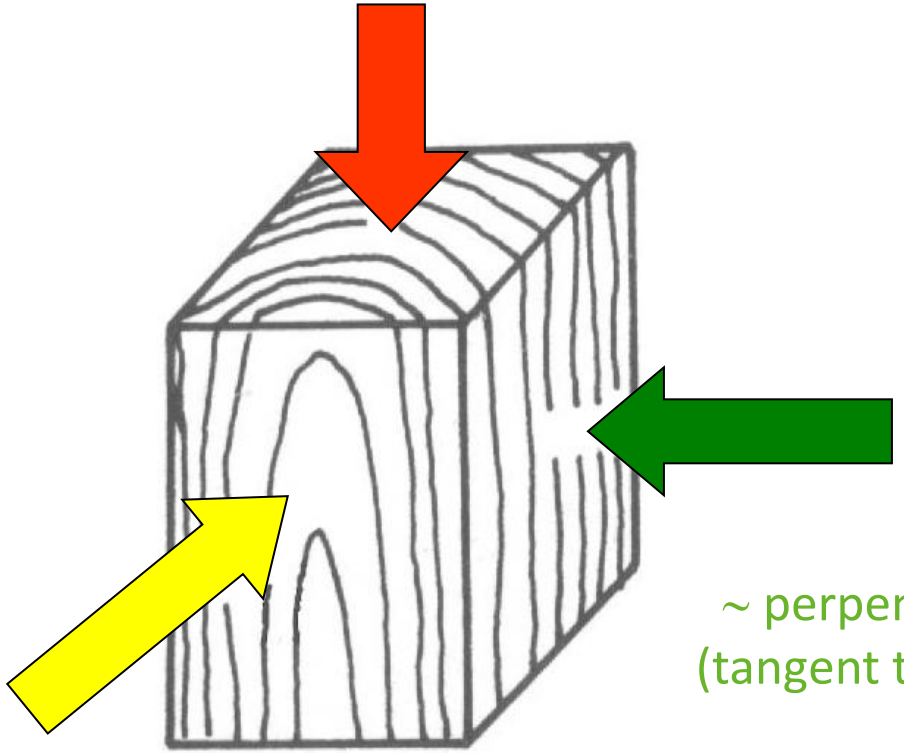
Basic directions

longitudinal
~ axial ~ along the grain (fibre) ~ parallel to the grain



tangential
~ perpendicular to the grain
(tangent to the growths rings)

radial
~ perpendicular to the grain
(in the radial direction)

section ≠ direction !!!

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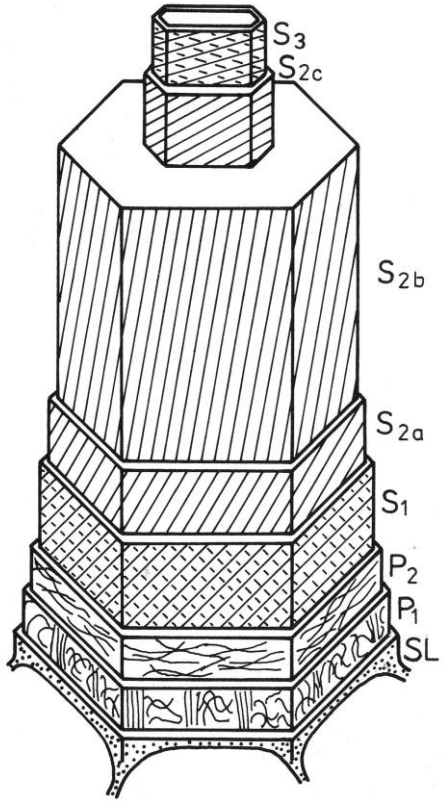
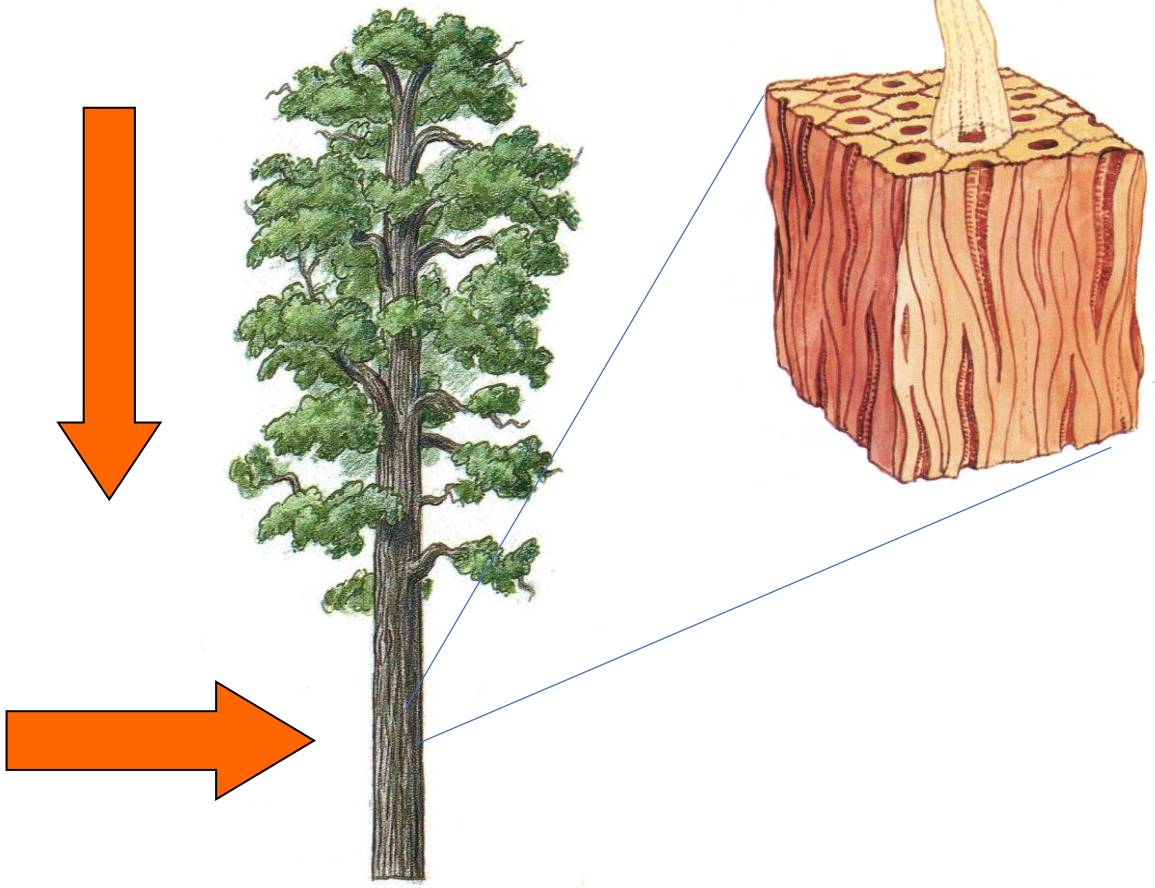
Anisotropy - reasons





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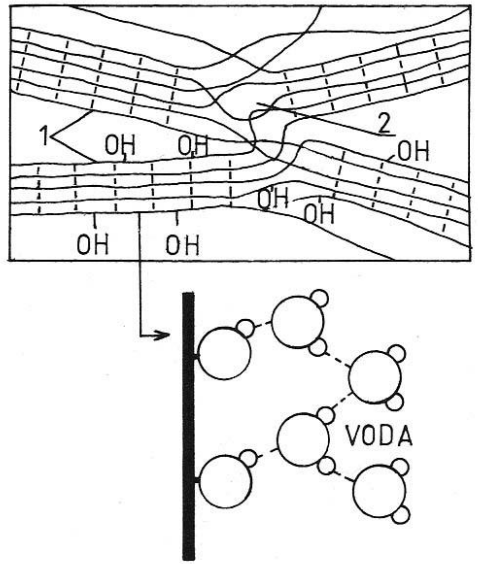
Hygroscopic material

- Absorbs or release water in gaseous form
- Changes moisture content according to surrounding conditions
- Result of wood chemistry
- Linked with dimensional changes
- Impact on propertis, processing, resistence against fungi



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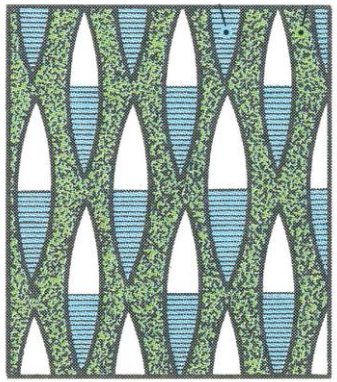
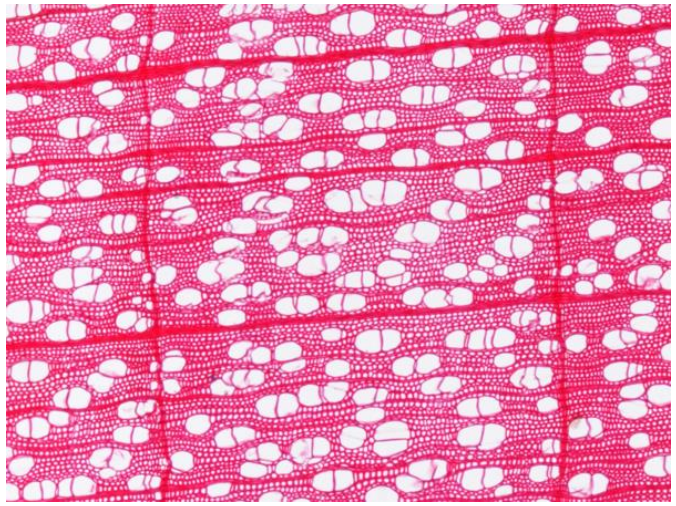


Porous material

- System of cavities, cells and intercellular spaces
- Impact on density and permeability
- Important for seasoning, surface treatment and impregnation



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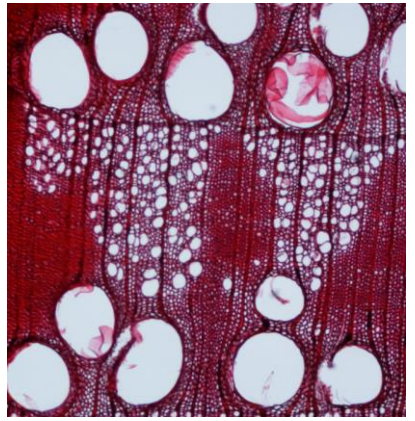
Heterogeneous material



- Differences in structure
- Among timbers
- Within one tree
- Macroscopic, microscopic level, …defects
- Reflected in properties variability

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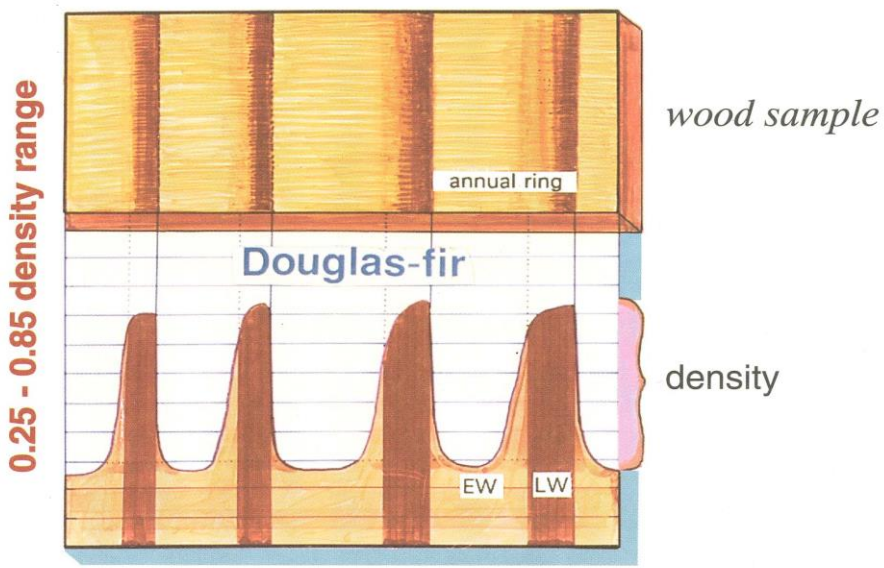
Variability

- Typical for natural materials
- Results of anisotropic nature, hygroscopicity …. differences in structure
- Makes processing difficult
- Problem to produce the same products (furniture)



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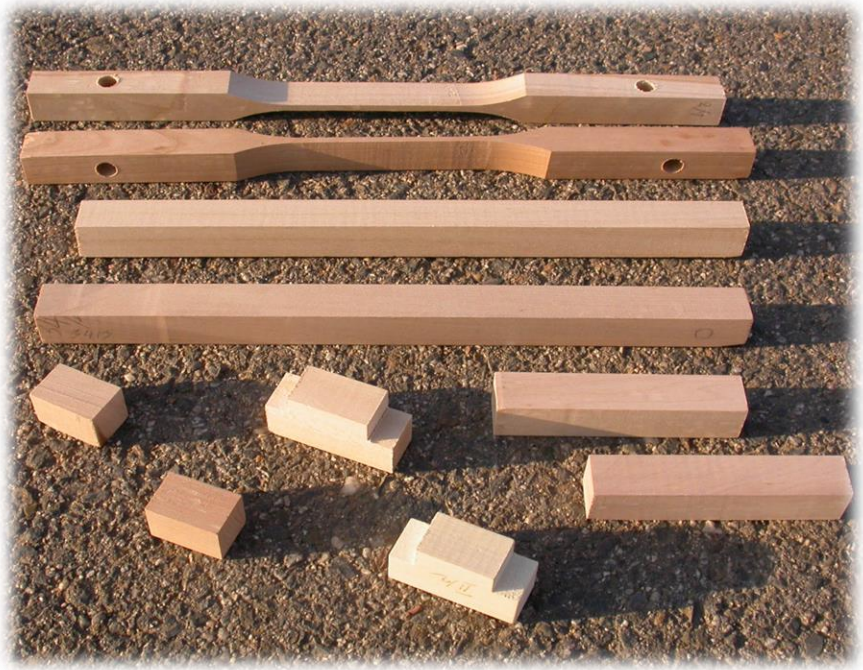
Testing

- Standards (= instructions)
- Testing samples
  - size
  - defects
  - orientation
  - moisture



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Most important properties

- Density
- Shrinkage
- Calorific value
- Strength

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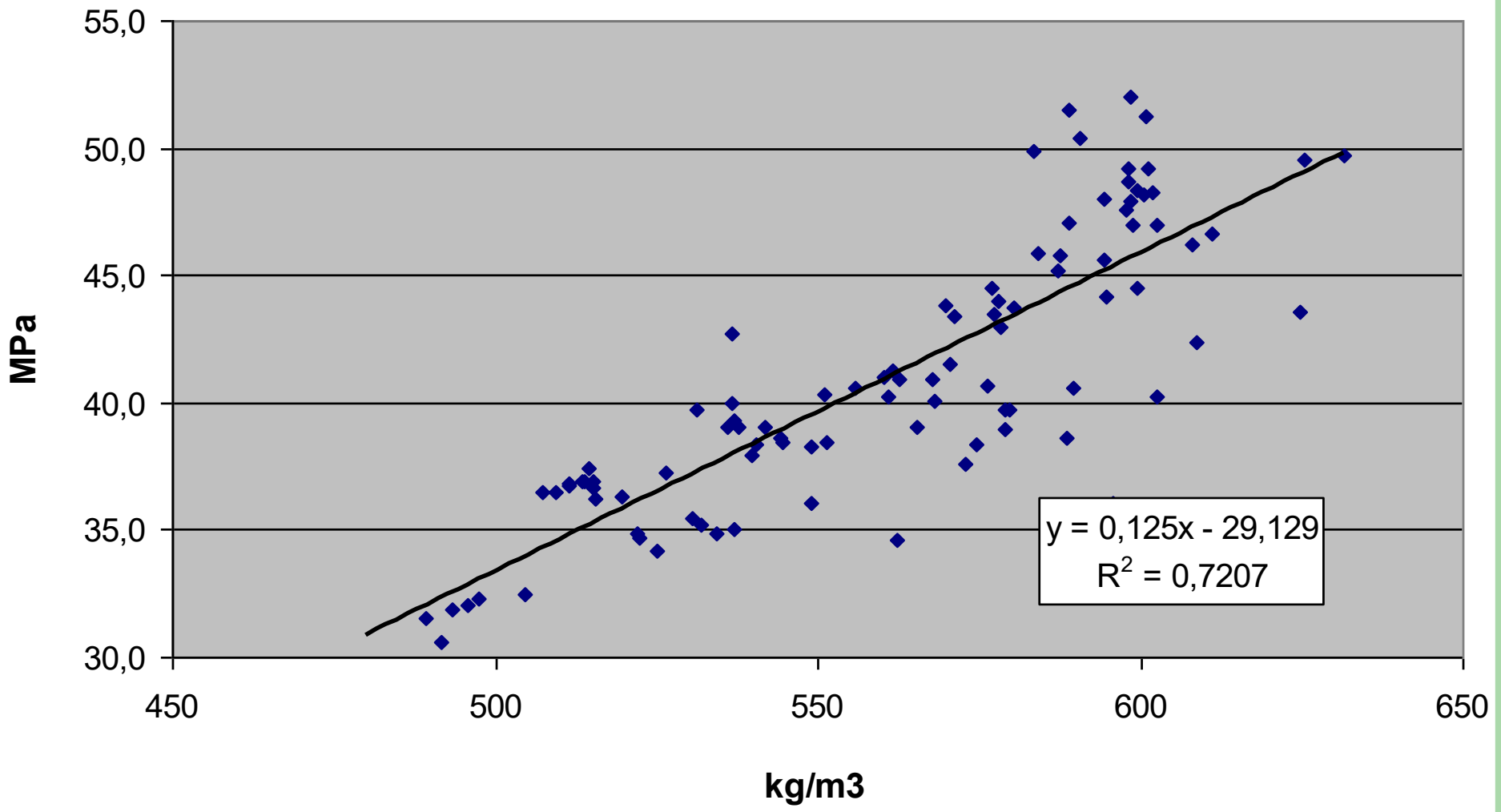
Density

- Property No. 1
- Influences seriously other physical and mechanical properties
- Easy (cheap) to evaluate
- Defined as material mass per its unit volume
  usually in $kg.m^{-3}$ or $g.cm^{-3}$
- Always related to MC

$$\rho = \frac{m}{V}$$

Correlation between the Compression Strength and the Density



Prunus serotina

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Density

- **Basic wood structure density**
  - density of woody mass (no space)
  - weight limit
  - ca 1 500 $kg.m^{-3}$
  - the same for all timbers
  - used for calculations (porosity)
  - take it as a fact
- **Densities** used in industry and research

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Density

- **Oven-dry density**
- **12% density**
  (used in standards)
- **Basic density**
  (oven-dry mass related to green volume)

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Density - evaluation

- Samples
  - rectangular (standards)
  - disk
  - core
  - irregular
- Weight = scales
- Volume = calliper
- Irregular samples = immersion into liquids

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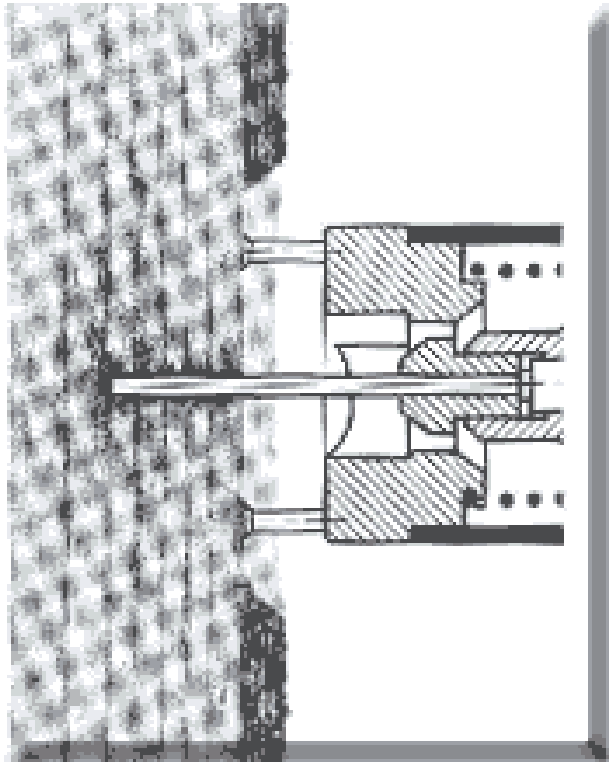
Density evaluation

- Indirect methods
- Absorption (beam of rays)
- Resistance (pressure or drilling)



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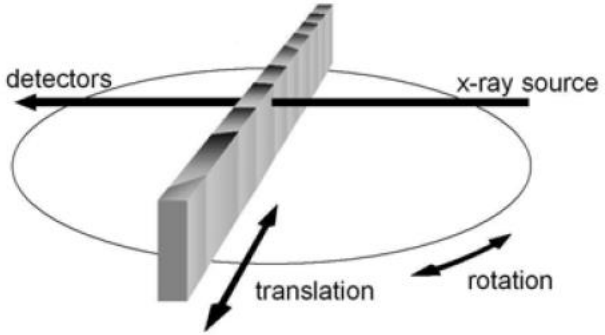
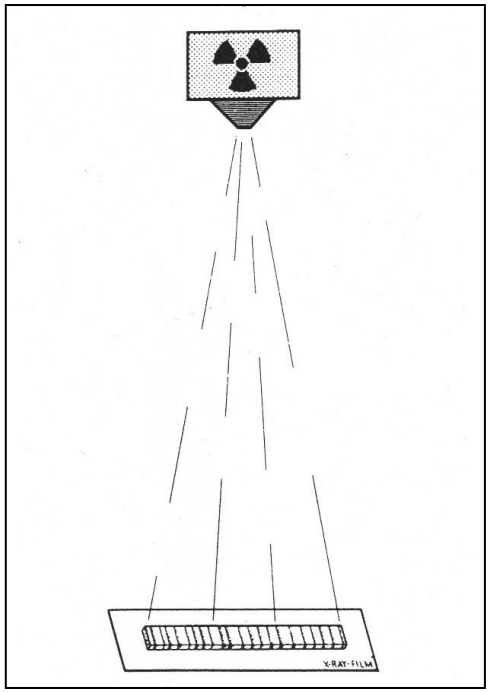
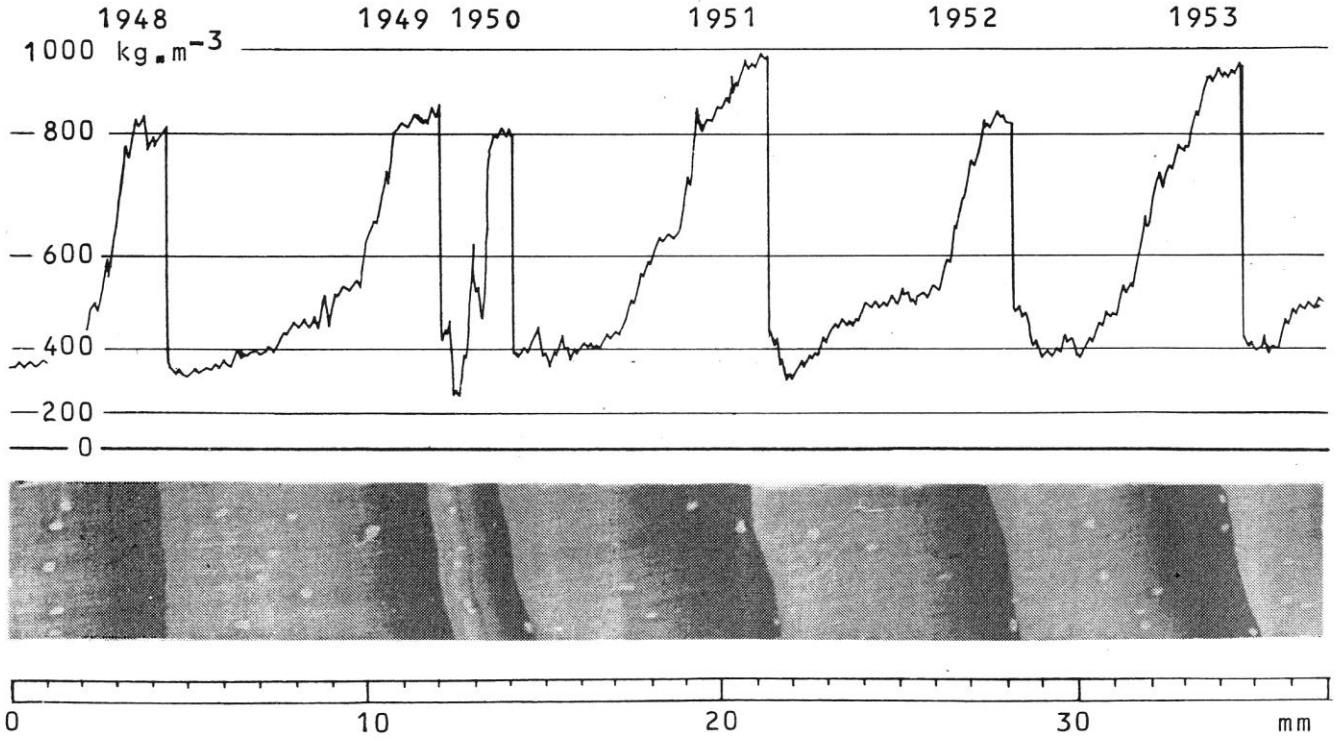
Silviscan







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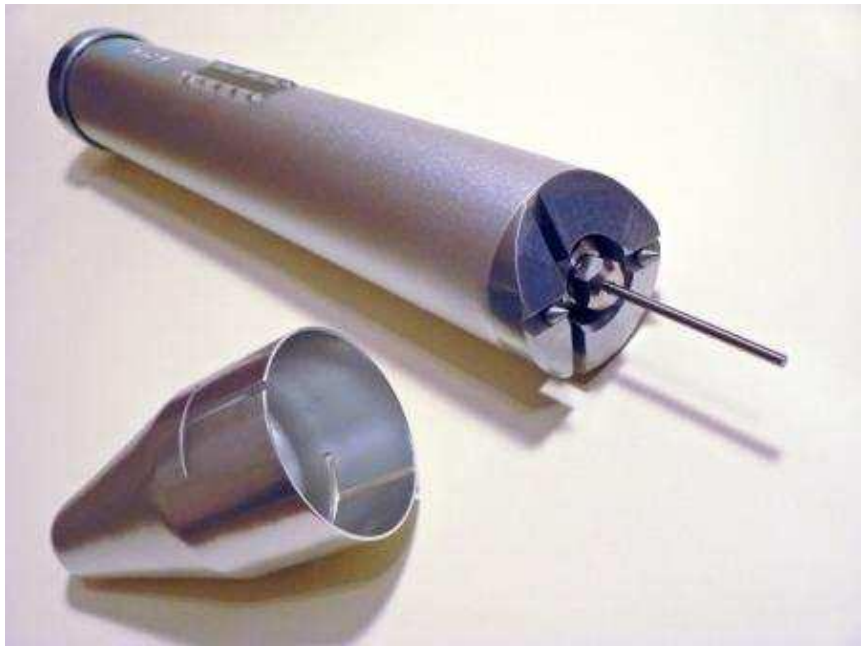

Pilodyn

PowerDrill

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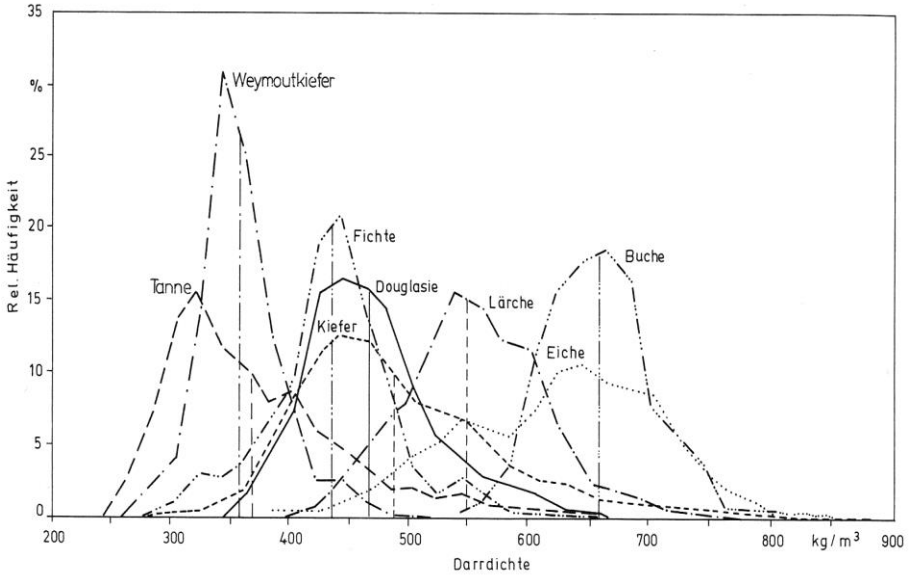
Density - variability

- Among timbers
  - Balsa about 150 kg.m^{-3}
  - „iron woods“ more than 1 000 kg.m^{-3}
- Within timber



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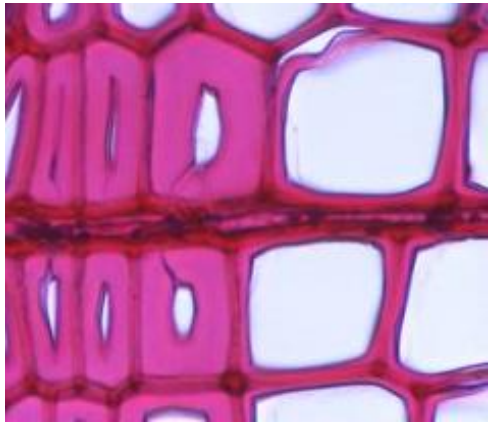
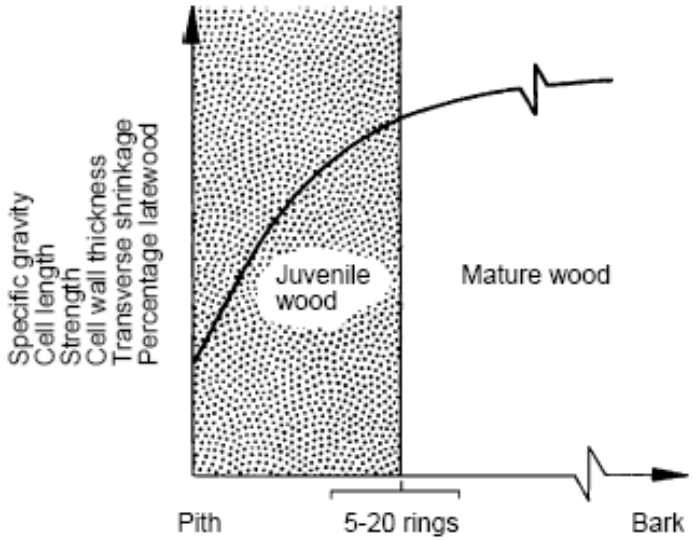
Density - factors

- Amount of fibres / vessels
- Position in a stem
- Age (juvenile wood)
- Site





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Density - importance

- The most frequent parameter for wood quality evaluation
- Correlation with strength and other properties
- First idea about usage of a timber
- Information about posible yield (paper industry)

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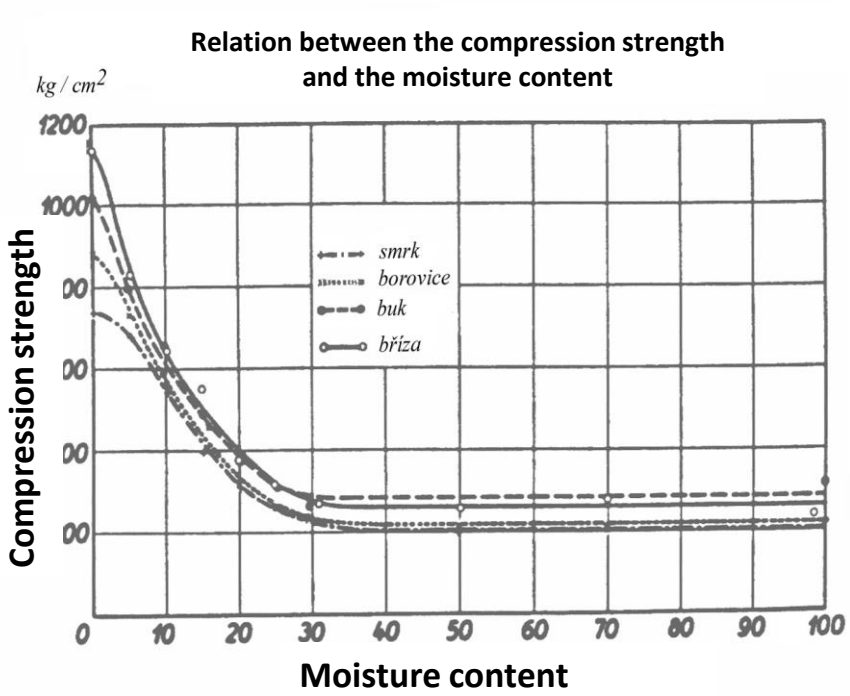
Wood – water relationship

- Always water in wood!!
  (because of hygroscopicity)
- Cannot be avoided
- Negative impact
  (changes in size,
  decrease of strength)



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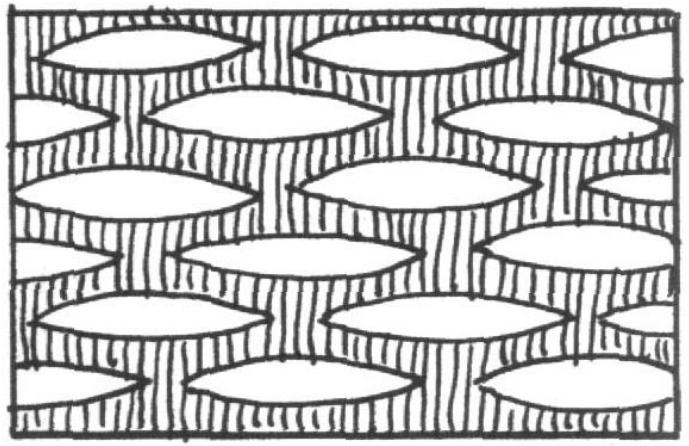
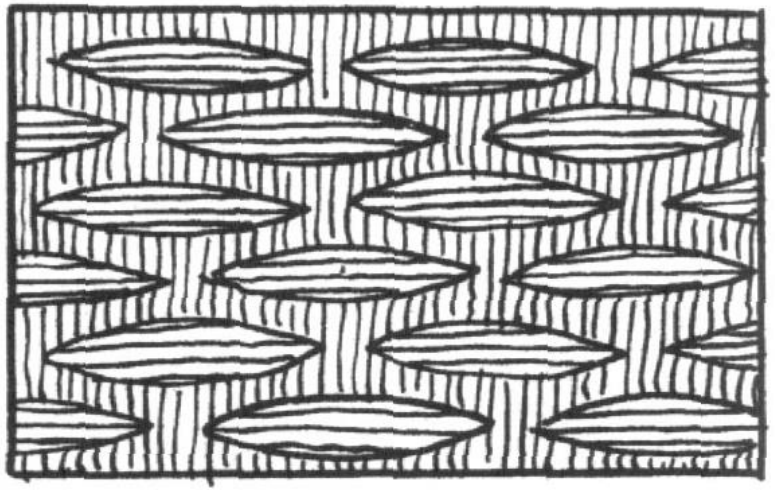
Moisture in wood

- **Bounded water**
  (cell walls)
- **Free water**
  (cell lumens)
- **Fibre saturation point**
  (30 %)





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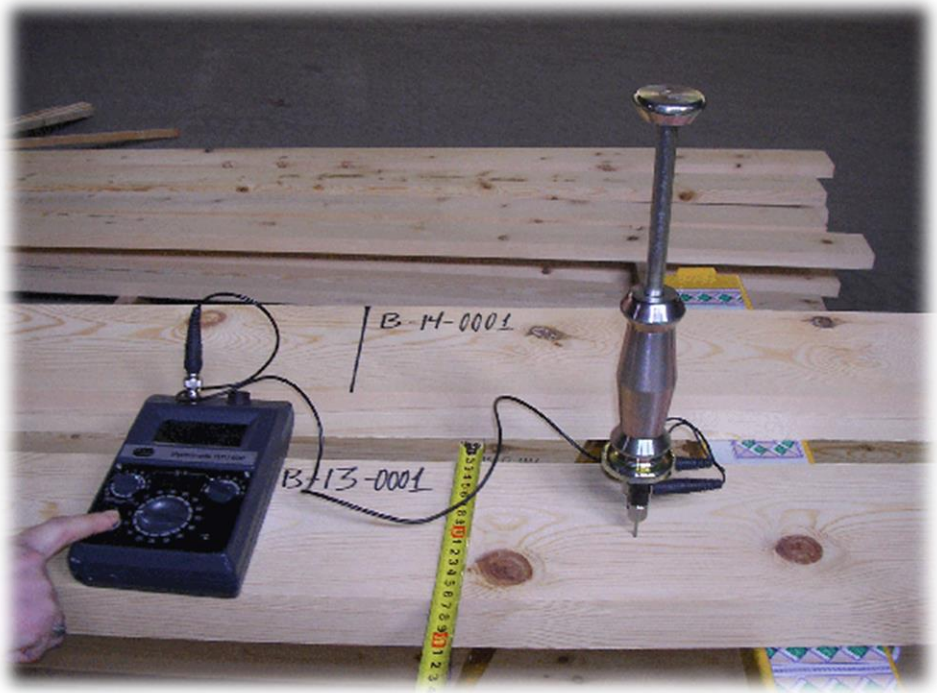
Moisture determination

- Moisture = amount of water in %
- Oven-drying method (laboratory)
- Electric moisture meters (industry)



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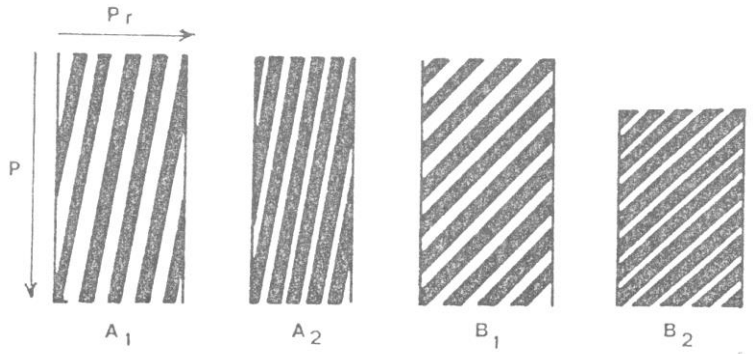
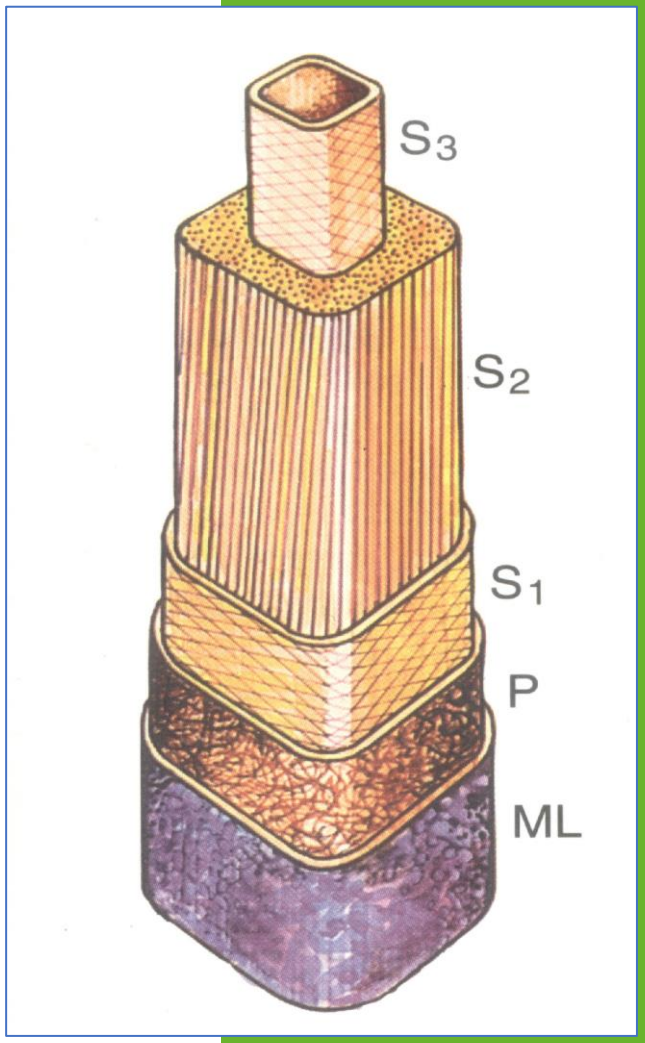
Shrinkage / swelling

- Dimensional changes related to changes in bounded water content
  (free water = no impact on dimensional changes)
- Principle = position of cellulose fibrils in the cell wall
- Anisotropic behaviour
  (axial = min; tang = max)





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Shrinkage

- Changes in length, area and volume of beams, boards, ...
- Reversal process (shrinkage – swelling)
- Longitudinal 0,1 – 0,4 %
- Radial 3 – 6 %
- Tangential 6 – 12 %
- $\alpha_t : \alpha_r : \alpha_l = 20 : 10 : 1$

$$\alpha_i = \frac{a_{w\max} - a_{w0}}{a_{w0}} .100$$

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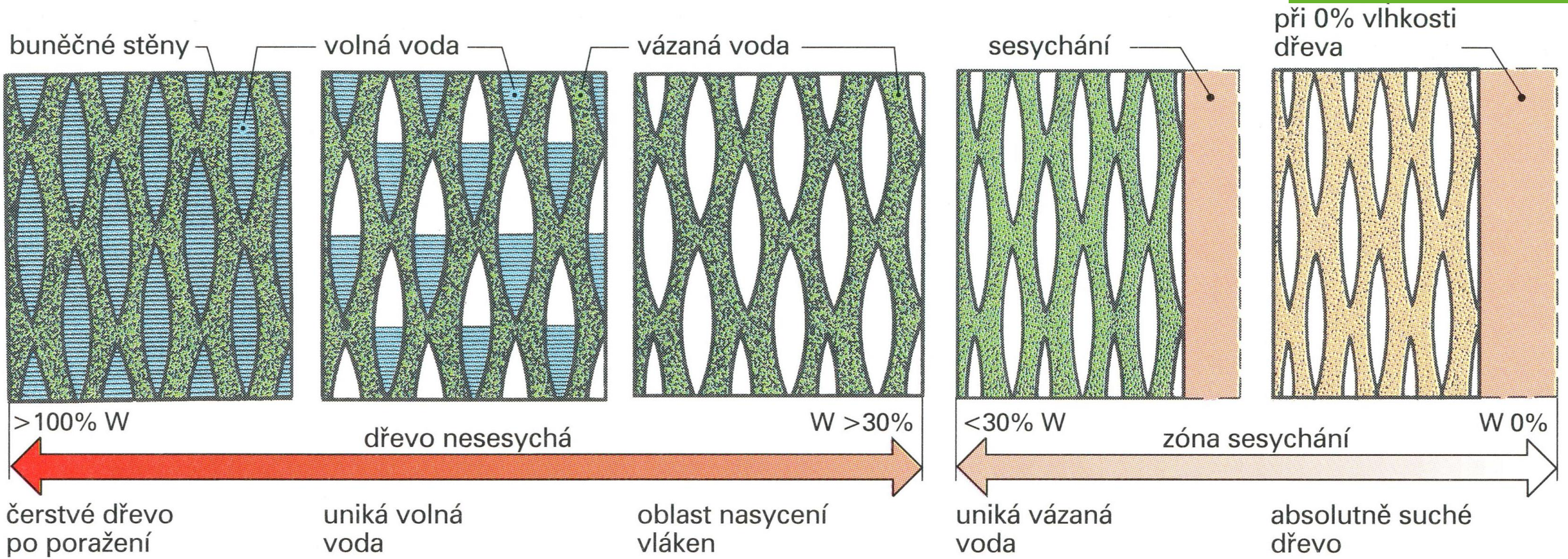
Shrinkage



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Shrinkage - implications

- Large parts of wood dry unevenly (moisture gradients)
- Inner stresses in wood during drying (cracks)
- **warping**
  = deviation from flatness in timber as a result of stresses and uneven shrinkage

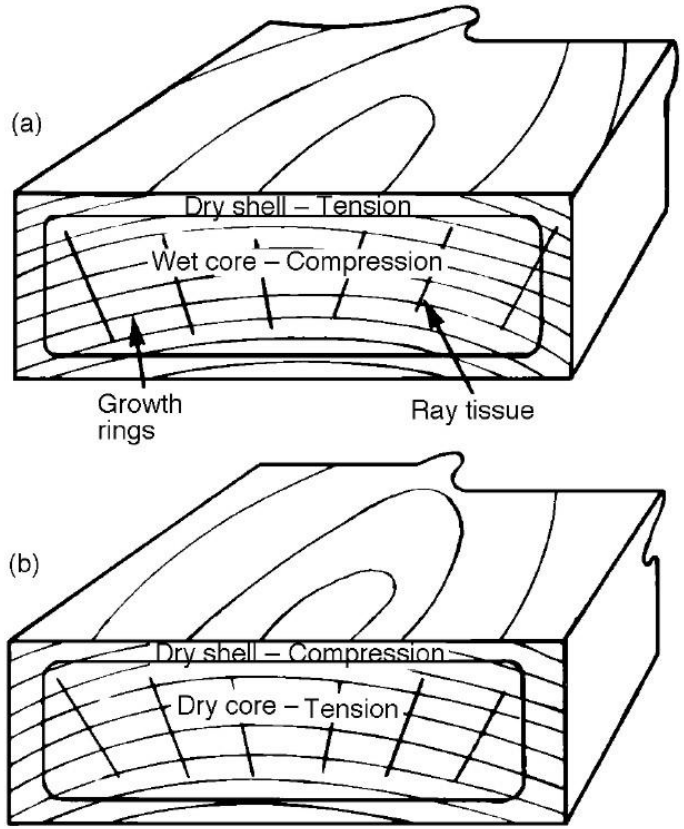

Figure 12–3. End view of board showing development of drying stresses (a) early and (b) later in drying.

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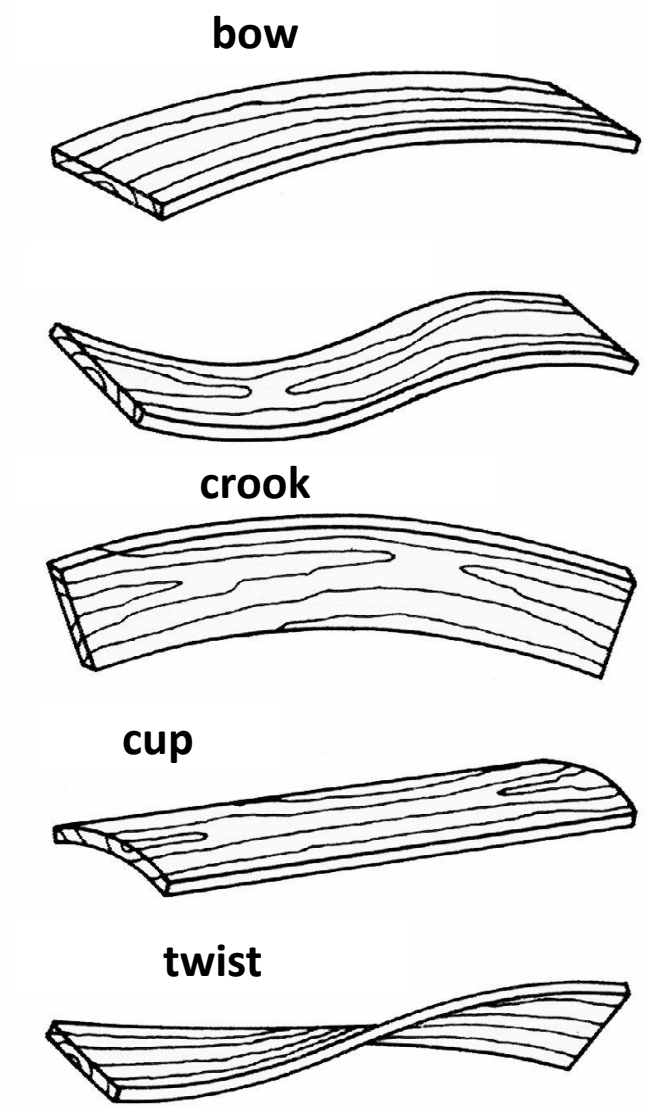
Warping

- Deviation from flatness in timber as a result of stresses and uneven shrinkage
- Reasons:
  - anisotropy
  - fibre deviation
  - compression wood
  - juvenile wood etc.



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Thermal properties

- Conductivity
- Heat capacity
- Thermal expansion
- **Calorific value**

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Calorific value

- Wood as a source of energy
- = amount of energy obtained from 1 kg of wood
- Average value ca 18 MJ/kg
- Independent of density (timber)
- Impact of MC (decrease in energy gain)

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Thermal modification

- Idea
- Changes in structure
- Impact on properties

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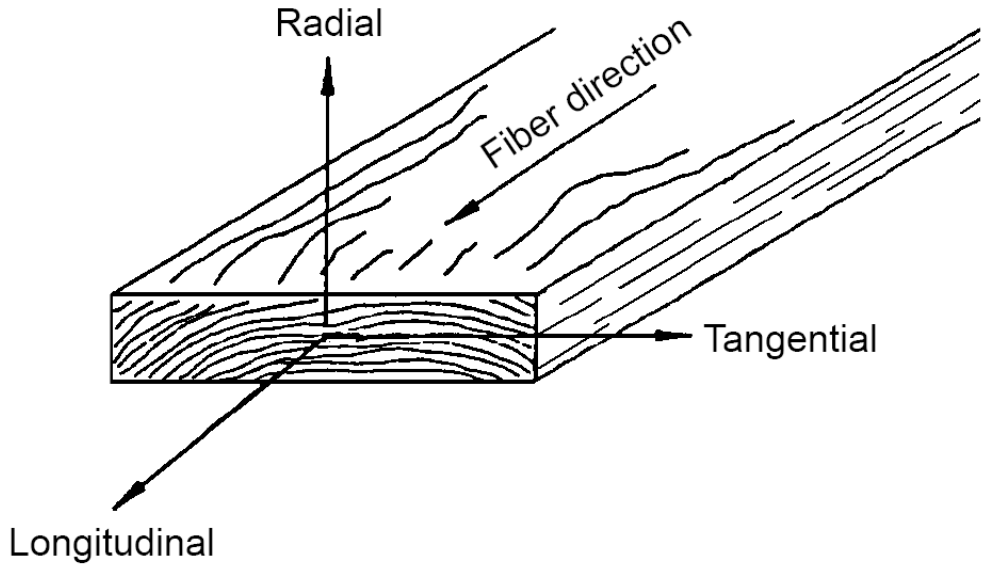
Mechanical properties

- Ability to resist a load
- Orthotropic nature
- Stiffness (MOE)
- Mostly strength properties:
  - bending
  - compression
  - tensile
  - shear
  - impact bending
  - hardness



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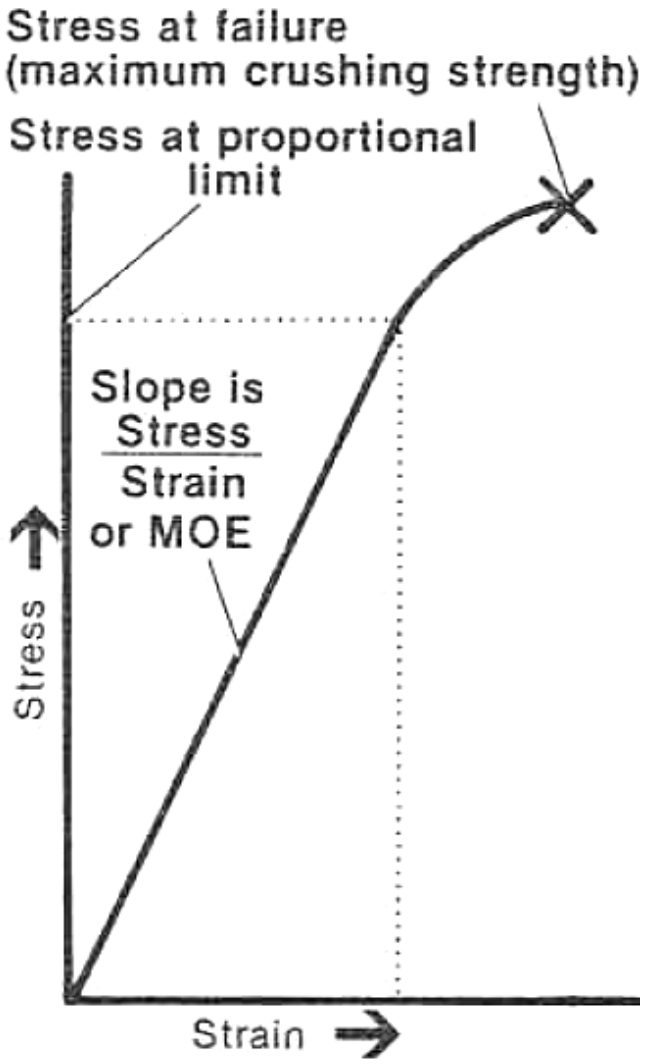
Terminology

- Stress
- Strain
- Deformation
- Proportional limit
- Young‘s modulus



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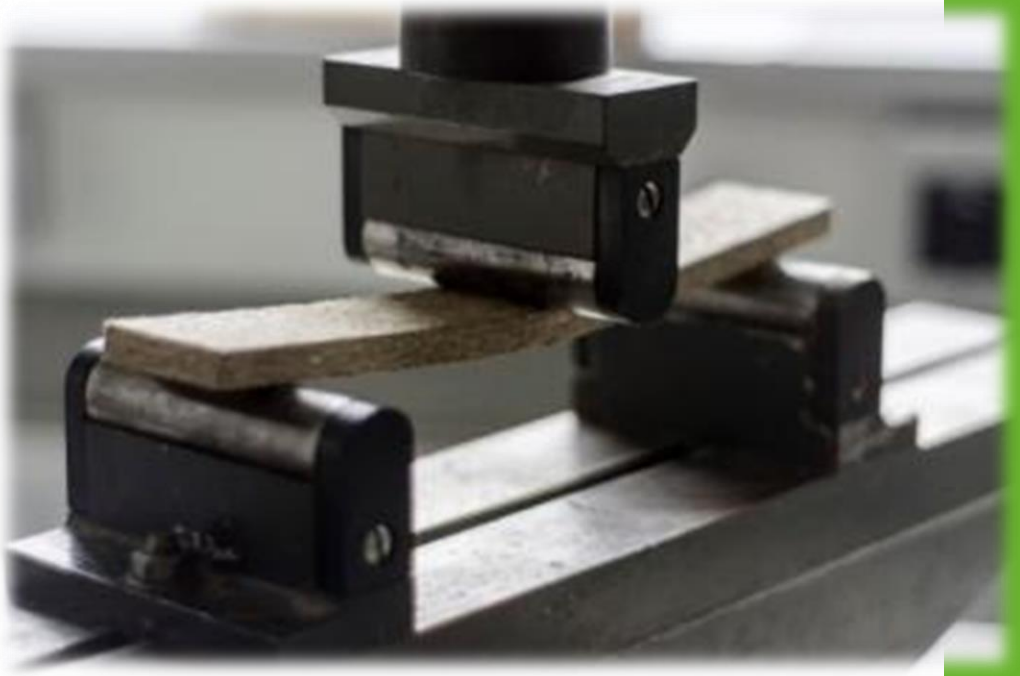
Properties evaluation

- Destructive x non-destructive
- Testing samples
- Standards



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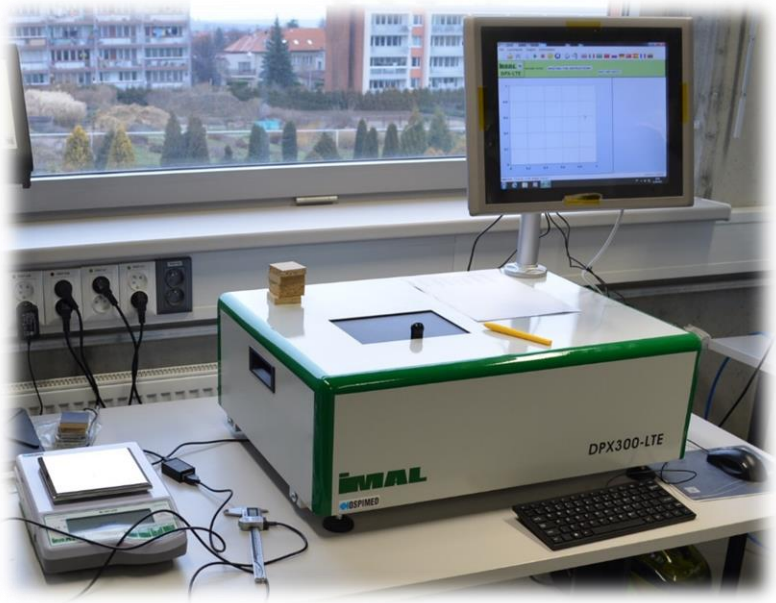
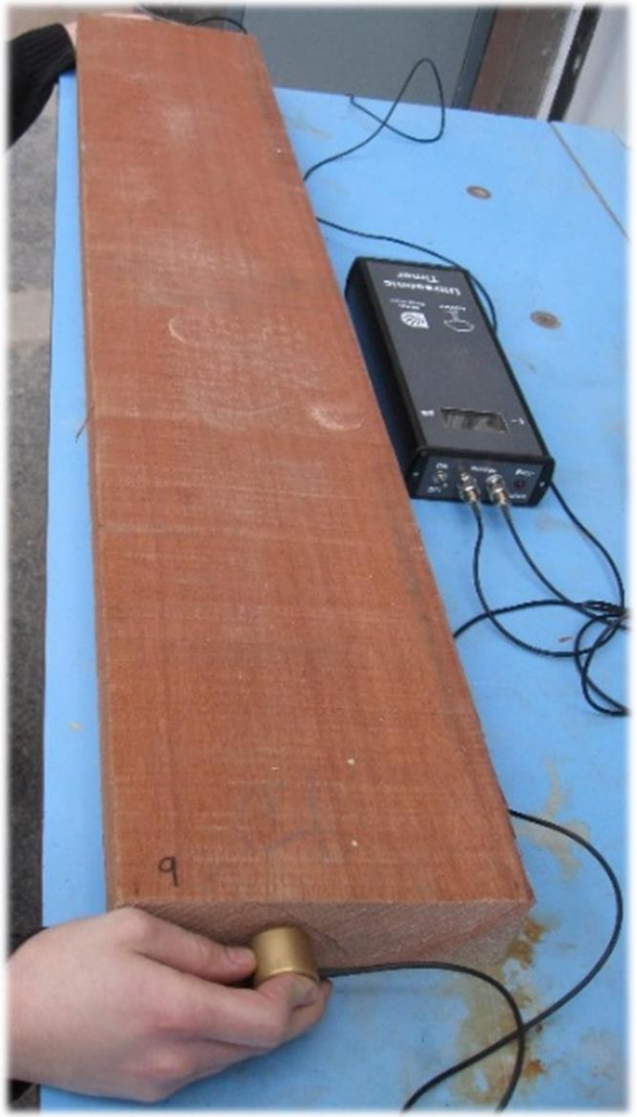
Non-destructive testing

- Principle





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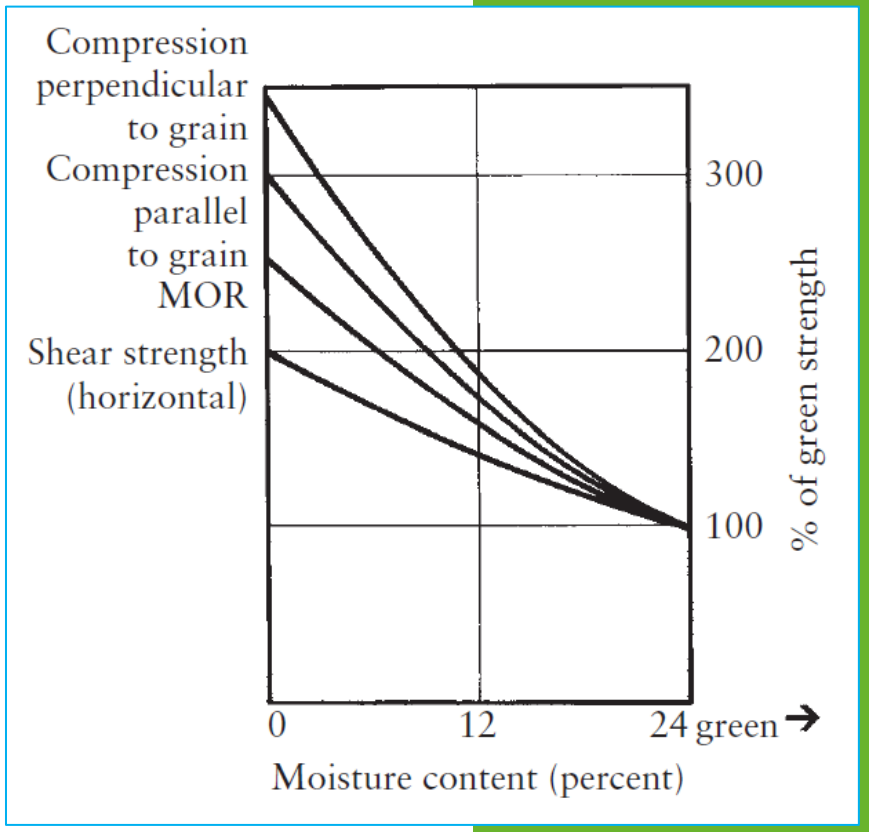
Factors affecting strength

- Density
- Defects (knots)
- Fibre orientation
- Moisture content
- Juvenile and compression wood
- Temperature



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Take-home message

- Anisotropy, hygroscopicity and variability cannot be avoided
  (ways how to minimise their effect)
- Relationship between
  structure x properties
- Choose a suitable timber
  for the right applications