Mechanical Properties of Wood

Sections 10.4, 10.8-10.9†

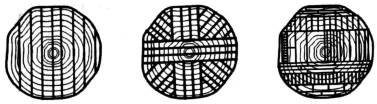
† Mamlouk, M.S., and Zaniewski, J.P. (2006). ***Materials for Civil and Construction Engineers***, 2nd ed., Prentice Hall

What we are going to talk about …

- Wood production
- Mechanical properties

Sawing Techniques

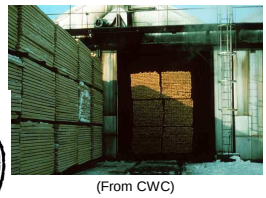
- Live (plain) sawing – most rapid and economic
- Quarter sawing – maximum amount of prime (vertical) cuts
- Combination – most typical



Live (Plain) Sawing Quarter Sawing Combination

Seasoning

- Process of controlled drying of lumber
- Two methods for drying wood:
  - Air drying
  - Kiln drying



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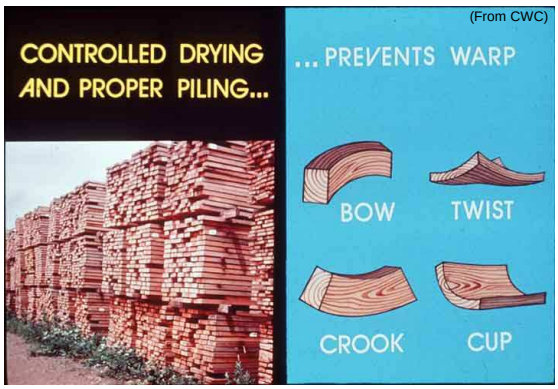


Lumber Grading

- Process by which wood is classified according to the number of flaws that affect strength & durability
  - ⇨ ***stress grades***
- Two types of grading:
  - Visual inspection
  - Machine-stress rating (MSR)

Visual Grading

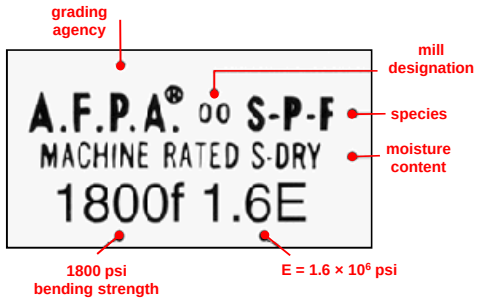
- Characteristics used to sort lumber:
  - decay
  - slope of grain
  - defects (knots, checks, splits, …)

Visual Grade Stamp

Machine-Stress Grading

- Measurement of the bending stiffness
  - ⇨ related to E
- Grade can be modified by visual inspection
- Detects high & low quality lumber more effectively & efficiently

Machine Grade Stamp

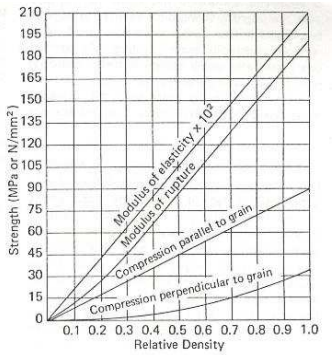


Mechanical Properties

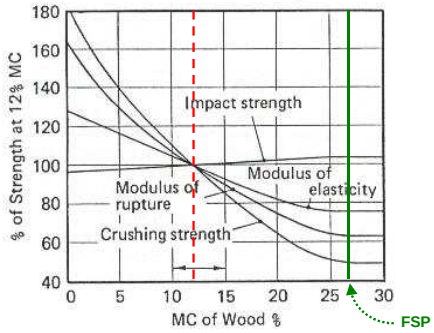
Wood Compared to Other Materials

Materials	E/ρ	σ_T/ρ	σ_C/ρ
Wood	20-30	120-170	60-90
Mild steel	26	30	---
Aluminium alloys	25	180	130
Concrete	15	3	30

Effect of SG on Strength



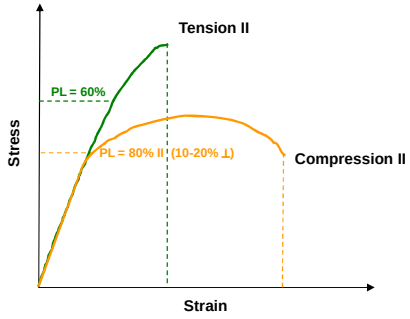
Moisture Effects on Strength

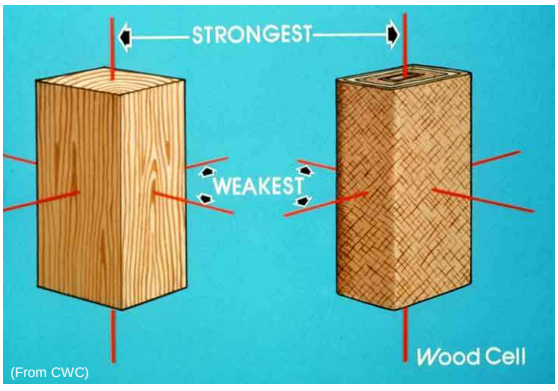


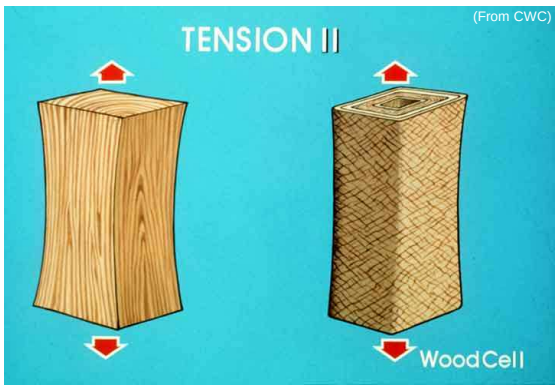
Modulus of Elasticity

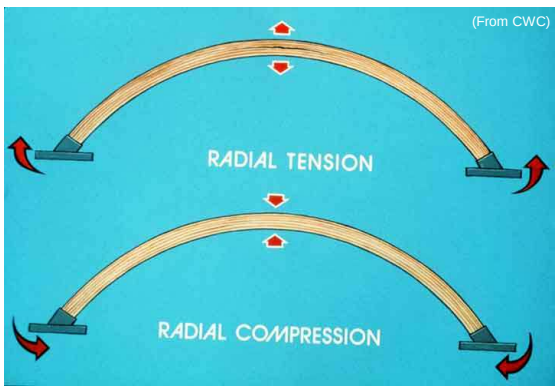
- Highest in the longitudinal direction
  - 7–14 GPa at MC = 12%
- Along radial direction ⇨ 10% of longitudinal
- Along tangential direction ⇨ ½ of radial

Stress-Strain Curve



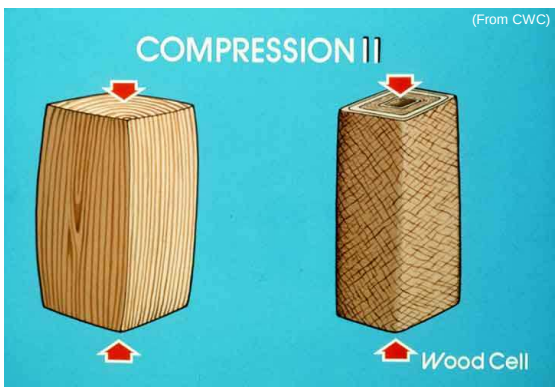


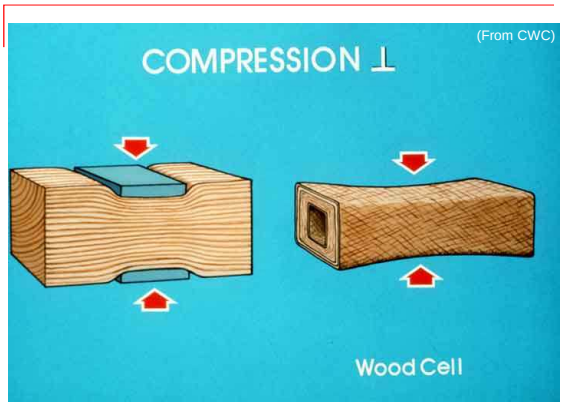


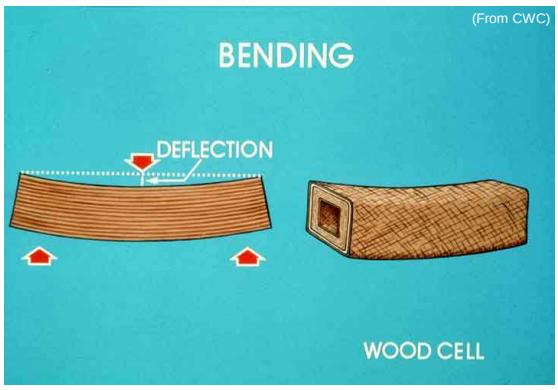


Compressive Strength

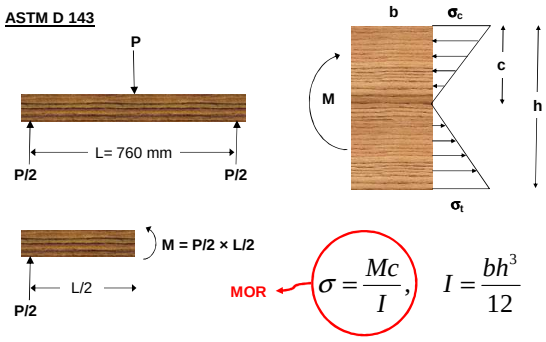
- Parallel to grain much higher than perpendicular
- For softwood lumber,
  - parallel → 14–28 MPa in green condition
  - perpendicular → 12–18% of parallel



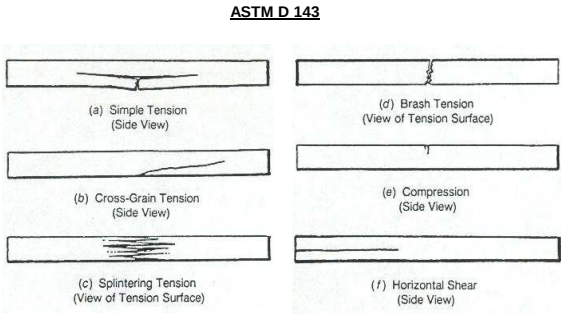




Bending Behaviour

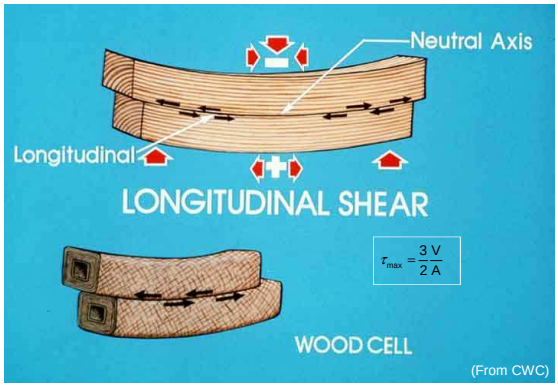


Types of Failure in Static Bending



Shear Strength

- Small (5–10 MPa)
- Most hardwoods ⇨ higher shear strength than softwoods
- Decreased by presence of defects



Example 1

- A static bending test was performed on a 50 mm×50 mm×760 mm wood sample according to ASTM D143 procedure. If the load at failure was 4 kN, calculate the modulus of rupture & maximum shear stress.

Time Dependency

- Wood is a viscoelastic material
- Rate of loading
- Load duration
- Creep
- Fatigue

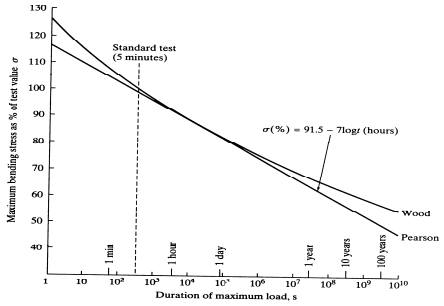
Rate of Loading

- Increase in strength as rate of loading increases
- Not well-understood
- *(Dipping finger in boiling water)*

Duration of Load

- Wood which is to carry a dead load for 50 years may be stressed to only about one-half of the value from short term tests

Load duration



Fatigue

- Fatigue strength ~ 60% of static strength at 2x10^6 cycles

Creep