Timber and Steel Design

Timber 1: Characteristics of Wood

Timber 2: Fasteners

Timber 3: Flexural Members

Timber 4: Tension & Compression Members

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Timber 1: Characteristics of Wood

- Advantages of Wood
- Wood Structure
- Mechanical Properties of Wood
- Strength-Reducing Characteristics
- Structural Timber Classification
Introduction

Wood is one of the oldest construction materials, and yet if wood were discovered today, it would be hailed as an important new construction material.

Advantage of Wood

1. High strength/weight ratio
2. Readily workable and easily fabricated for small jobs, yet can be glue laminated for large structures
3. Wood is beautiful
4. Wood is a good insulator
5. If properly treated, wood is very durable in a variety of environmental conditions

Disadvantage of Wood

1. Wood’s variability
2. Environmental conditions
### Comparison of Specific Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>$E/\rho$</th>
<th>$\sigma_l/\rho$</th>
<th>$\sigma_c/\rho$</th>
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<tbody>
<tr>
<td>Concrete</td>
<td>15</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Mild steel</td>
<td>26</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Aluminum</td>
<td>25</td>
<td>180</td>
<td>130</td>
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<tr>
<td>Wood</td>
<td>20-30</td>
<td>120-170</td>
<td>60-90</td>
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</tbody>
</table>
Tree Cross Section

- OUTER BARK
- INNER BARK
- CAMBIUM
- SAPWOOD
- HEARTWOOD
- EARLYWOOD
- LATEWOOD
- ANNUAL RING
- MEDULLARY RAY
Wood Microscopic Structure

Imagine that wood is made up of millions and millions of toilet paper rolls glued together. These rolls are the fibers that will make paper.

Chemical Composition

~50% Cellulose
~25% Hemicellulose
~25% Lignin
Wood has unique and independent mechanical properties in 3 mutually perpendicular directions respect to grain.

\[ L = \text{Longitudinal direction} \]

\[ T = \text{Tangential direction} \]

\[ R = \text{Radial direction} \]
Mechanical Properties of Wood

1. Compressive strength parallel to grain
2. Modulus of elasticity parallel to grain
3. Tensile strength parallel to grain
4. Compressive strength perpendicular to grain
5. Modulus of rupture
6. Longitudinal shear strength
7. Shear modulus
Test for Compression Parallel to Grain

UNIT STRESS ($\sigma = P/A$)

UNIT STRAIN ($\epsilon$)

$A = $ Fracture point

$B = $ Proportional limit
Types of Failure
Compression parallel to grain

CRUSHING
BROOMING
SHEARING

SPLITTING
WEDGE SPLIT
COMBINED SHEARING AND SPLITTING
Test for Compression Perpendicular to Grain
Test for Flexure

\[ f_b = \frac{M c}{l} \]

(a) ELASTIC

(b) AT ULTIMATE
Test for Shear Strength Parallel to Grain

Ability to resist internal slipping of one part upon another along the grain.

Values presented are averaged strength in radial and tangential shear plane.

\[ \tau = \frac{VQ}{lt} \]
Slope of Grain

Due to grain irregularities occurred while the tree was growing

AWAY FROM KNOT AVERAGE TENSILE STRESS = \( \frac{P}{A} \)

Strength properties at angle \( \theta \) from fiber direction:

\[
N = \frac{PQ}{P \sin^2 \theta + Q \cos^2 \theta}
\]

\( N = \) Strength at angle \( \theta \)

\( P = \) Strength parallel to grain

\( Q = \) Strength perpendicular to grain

AT KNOT, TENSILE STRESS PERPENDICULAR TO GRAIN
(IN COMBINATION WITH SHEARING STRESSES AND TENSILE STRESS PARALLEL TO GRAIN)
Effect of Cross Grain

Cross grain Bending failure

\[ f_b = \frac{Mc}{l} \]

MOHR’S CIRCLE

Compression
### Structural Timber Classifications

1. **Planks**

<table>
<thead>
<tr>
<th></th>
<th>1/2”</th>
<th>3/4”</th>
<th>1”</th>
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<tbody>
<tr>
<td></td>
<td>2”</td>
<td>4”</td>
<td>6”</td>
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2. **Beams and Joists**

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</thead>
<tbody>
<tr>
<td></td>
<td>4”</td>
<td>5”</td>
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3. **Posts**

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