LAB 6: WOOD TESTS

1. Standards

- ASTM D143 – Standard Methods of Testing Small Clear Specimens of Timber

2. Purpose

- To determine the tensile strength of wood parallel and perpendicular to the grain.
- To determine the compressive strength of wood parallel and perpendicular to the grain.
- To determine the modulus of rupture and flexural behaviour of wood.

3. Material

- Spruce specimens for groups A1, A3, B1, B3, C1, C3, D1, D3
- Cedar specimens for groups A2, A4, B2, B4, C2, C4, D2, D4

4. Apparatus

- Universal testing machine to load specimens in tension and compression
- Micrometer callipers
- Gauge marker and extensometers
- Strain scale and dividers

5. Procedure

1. Record for each of the specimens:
   - kind of wood
   - number of annual rings per inch
   - defects in the specimen (knots)
   - whether it is heartwood or sapwood, if possible, and any other characteristics of the wood growth
2. Sketch the specimens, accurately measure their dimensions, and indicate the test done for each one of them.

5.1. Tension parallel to the grain test (ASTM D143, section 16)

1. Test shall be made on specimens of the size and shape in accordance with Figure 1(a). Measure the actual dimensions of the specimens used.
2. Insert the specimen in the test machine.
3. Apply a small initial load to take the slack out of the grips.

4. Deformation shall be measured over a 50 mm (2”) central gage length.
5. Take load-extension readings until the proportional limit is passed.
6. Sketch the specimen after failure.

5.2. Tension perpendicular to the grain test (ASTM D143, section 17)

1. Test shall be made on specimens of the size and shape in accordance with Figure 1(b). Strain cannot be measured on this specimen.
2. Measure the cross-section area at a minimum section.
3. Apply the load at a rate such that motion of the cross head is 2.5 mm/min.
4. Record the load at failure and sketch failure.

5.3. Compression parallel to the grain test (ASTM D143, section 9)

1. Test shall be made on specimens of the size and shape in accordance with Figure 1(c). Measure the actual dimensions of the specimens used.
2. Apply the load continuously throughout the test until failure at a rate of motion of the movable crosshead of 0.003 mm/mm of nominal specimen length per minute.
3. Measure deformations over a gauge length not exceeding 200 mm. Take readings of the load-deformation curve until the proportional limit has been well exceeded.
4. Sketch the specimen after testing.

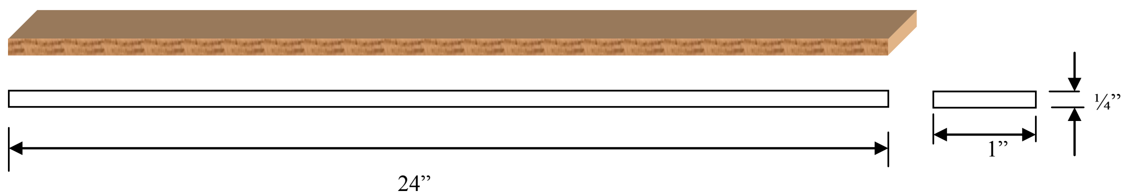
5.4. Compression perpendicular to the grain test (ASTM D143, section 12)

1. Tests shall be made on specimens of the size and shape in accordance with Figure 1(c). Measure the actual dimensions of the specimens used.
2. Lay the specimen flat on the long side with the grain horizontal. Set the 40-mm wide loading blocks at the centre of the length of the specimen. Measure the actual width of the block.
3. The load shall be applied at a rate motion of the movable crosshead of 0.305 mm/min. Apply load increments and measure compression deformations until a 2.5 mm compression is reached, after which the test shall be discontinued. Record the ultimate load reached (failure occurs when the compressive deformation has reached 2.5 mm).
4. Sketch the specimen after testing.

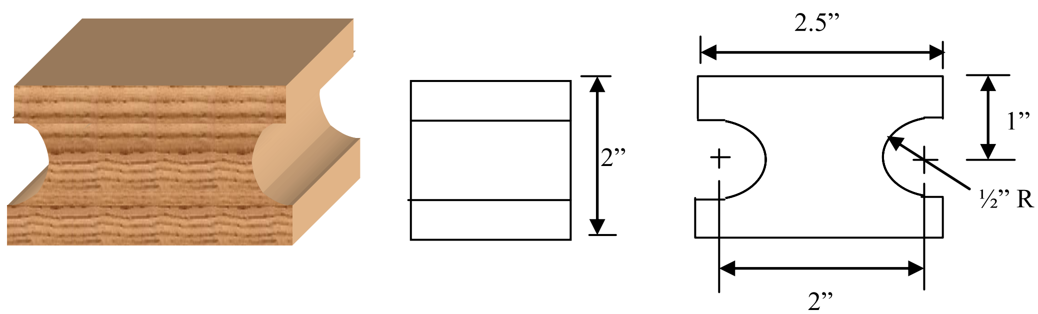
5.5. Static bending test (ASTM D143, section 8)

1. Tests shall be made on specimens of the size and shape in accordance with Figure 1(d). Measure the actual dimensions of the specimens used.
2. Load the specimen at its centre on a span length of 752 mm. Supports will be provided.
3. Apply the load continuously at a rate of 2.5 mm/min of the movable crosshead.
4. Record the load-deflection curve up to or beyond the maximum load. Continue recording up to a 150 mm deflection, or until the specimen fails to support a load of 890 N.

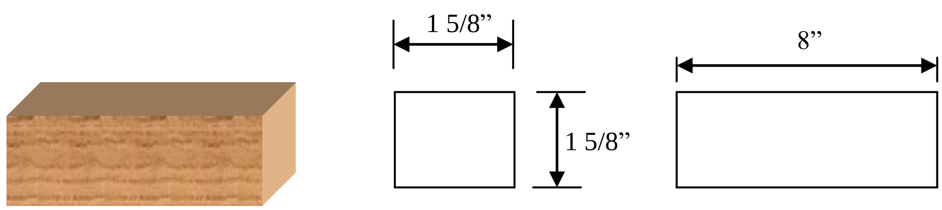
5. Measure the deflections at the centre of the beam under the load point to 0.02 mm, using the testing machine cross head movement.
6. Read the load and deflection of the first failure, the maximum load, and points of sudden change. Show them on the curve, although they may not occur at one of the regular load or deflection increments.
7. Sketch the beam after failure.



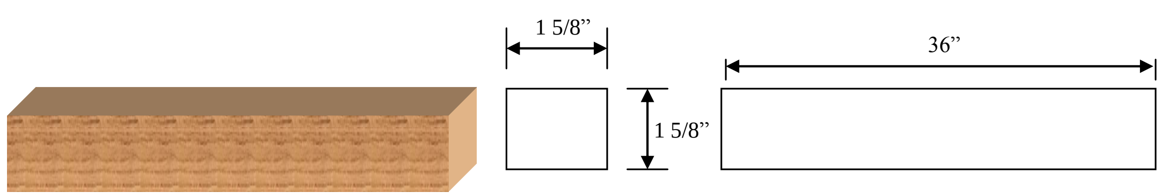
(a) Tension parallel to the grain



(b) Tension perpendicular to the grain



(c) Compression parallel and perpendicular to the grain



(d) Static bending

Figure 1: Test specimens

6. Results

You will be reporting the requested information for both spruce and cedar specimens. Your TA will send you the test data for specimens of the wood type that your group did not test.

6.1. Tension parallel to the grain

1. Plot the stress-strain curve.
2. Locate the proportional limit and the ultimate stress at failure.
3. Calculate the modulus of elasticity *E* as the slope of the straight portion of the stress-strain curve.

6.2. Tension perpendicular to the grain

1. Calculate the failure stress.

6.3. Compression parallel to the grain

1. Plot the stress-strain curve.
2. Locate the proportional limit and the ultimate stress at failure.
3. Calculate the modulus of elasticity *E* as the slope of the straight portion of the stress-strain curve.
4. Classify the compression failure by the appearance of the fracture surface (see Figure 2). In case two or more kinds of failures develop, all shall be described in the order of occurrence (e.g., shearing followed by brooming).

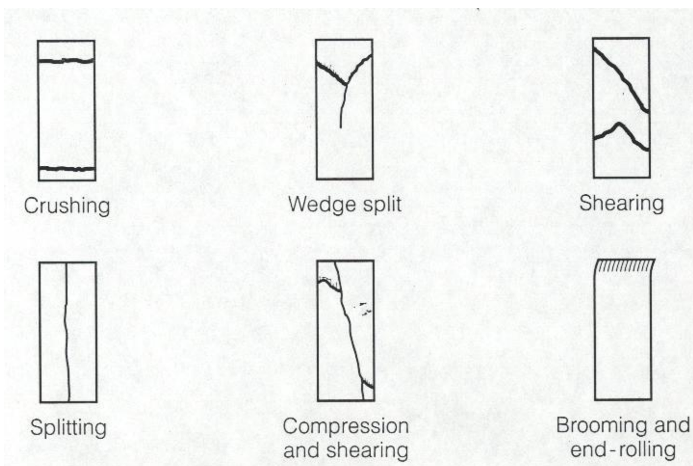


Figure 2: Types of failure in the compression parallel to the grain test (reproduced from ASTM D 143)

6.4. Compression perpendicular to the grain

1. Plot the readings of load versus deformation. From this curve, select the point of the proportional limit, and determine the stress applied at the load point to the specimen.
2. Compute the ultimate stress at 2.5 mm deformation using the loading point area.

6.5. Static bending

1. Plot the load-deflection readings.

2. Calculate the proportional (elastic) limit stress at the outer fibre and the modulus of rupture as:

$$\sigma = \frac{Mc}{I} \quad \text{(MPa)} \tag{1}$$

where σ is the stress at the outer fibre (also called modulus of rupture when referring to ultimate load), M is the bending moment ($= PL/4$, N·mm), P is the applied load (N), L is the span length (mm), c is the distance from the neutral axis to the edge of the sample ($= 1/2\,h$, mm), I is the moment of inertia ($= bh^3/12$, mm^4), b is the average width of the beam (mm), and h is the average depth of the beam (mm).

3. Calculate the modulus of elasticity as:

$$E = \frac{(P/\Delta)L^3}{48I} \quad \text{(MPa)} \tag{2}$$

where P/Δ is the slope of the load deflection diagram (N/mm).

4. Calculate the maximum shearing stress according to:

$$\tau_{\max} = \frac{3}{2}\frac{V}{A} \quad \text{(MPa)} \tag{3}$$

where V is the maximum shear force at mid-span (N) and A is the cross-sectional area of the beam ($= bh$, mm^2)

5. Classify the static bending failure according to the appearance of the fracture surface and the manner in which failure develops (see Figure 3). The fracture failure may be roughly divided into *brash* and *fibrous*, the term brash indicating abrupt failure and fibrous indicating a fracture showing splinters.

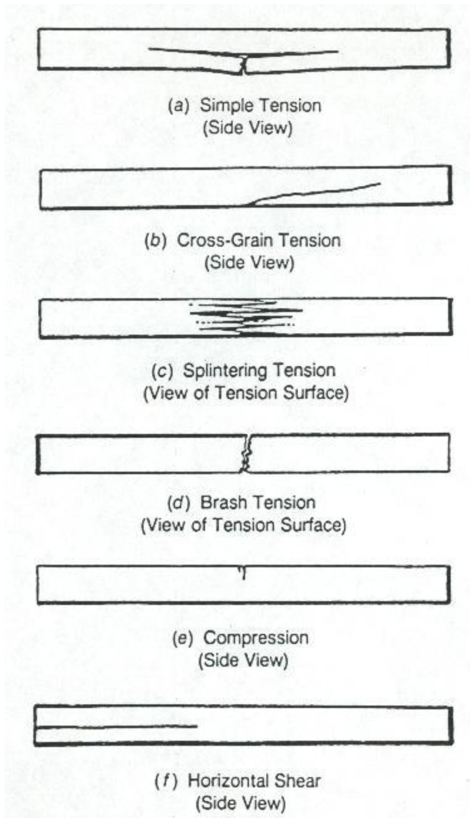


Figure 3: Type of failure in static bending (reproduced from ASTM D 143)

7. Discussion

Discuss the reasons for the difference in values in the tensile strengths parallel to the grain for the types of wood tested and published data for the same woods.

Discuss the reasons for differences in values between the tensile strengths parallel and perpendicular to the grain. Use published data in your comparisons with your test results.

Compare the tensile and compressive strengths parallel to the grain of the woods tested. Make comparisons to published compressive strength values parallel to the grain.

Compare the load-deformation results of compression test perpendicular to the grain with published data.

Compare the static bending tests results with published data. How does the maximum tensile and compressive strength values parallel to the grain compare with the modulus of rupture? Compare the modulus of elasticity values in tension and compression to the value computed from the static bending test. Discuss these results.