nordtest method

NT BUILD 422
Approved 1993–11

WOOD:
FRACTURE ENERGY IN TENSION PERPENDICULAR TO THE GRAIN

UDC 691.11

Key words: Wood, fracture energy, testing

1. SCOPE

This standard specifies a method for determining the fracture energy of wood in tension perpendicular to the grain (mode I).

2. REFERENCES

ISO 3130 Wood - Determination of moisture content for physical and mechanical test.

3. SYMBOLS

a length of the tested volume, see Figure 1; in m
b width of tested volume and area, see Figure 1; in m
$G_{I,c}$ fracture energy in mode I; in N/m (or J/m^2)
g gravity acceleration; 9.81 m/s^2
h_c depth of tested area, see Figure 1; in m
m_{tot} mass of test specimen; in kg
m_{prism} mass of loading parts resting on test specimen, in kg
m_ω mass of tested volume at moisture content ; in kg
u deflection; in m
u_0 deflection at failure; in m
W work done by midpoint force; in Nm
ω moisture content; in per cent
ρ_ω density determined from mass and volume at moisture content ω; in kg/m^3

4. SAMPLING

The sample size depends on the purpose of the test and shall, if relevant, be sufficient for the results to be treated statistically.

5. TESTING

5.1 Test specimen geometry

The test specimen is a beam of cross-section ab and length 7a, produced by gluing two 3a long wood beams to the test volume a^2b, as shown in Figure 1.

The test volume is a right angle parallelepiped with four edges parallel to the grain. The orientation of the annual rings depends on the purpose of the test. Before testing a saw cut is made parallel to the grain.

The tested area is bh_c, with h_c=0,4a. The width, b, depends on the purpose of the test. The length parameter a = 0.060 m.

The width of the saw cut is 2 mm. The tip of the cut is shaped by the saw or by a file or cutter as shown in Figure 2a). Shapes with a sharp tip, Figure 2b), are to be avoided.

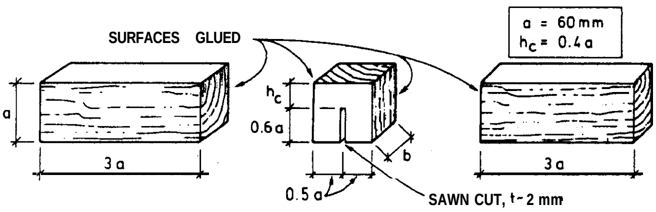

Figure 1. The test specimen is composed of three pieces of wood glued together to form a beam of cross section ab and length 7a.

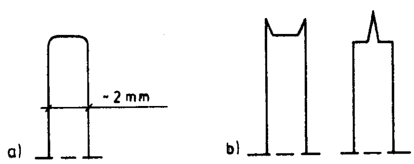

Figure 2. a) Shape of notch tip, b) Defective shapes.

5.2 Test specimen preparation

The three wood parts of the test specimen are to be shaped and joined after conditioning in a climate of (20±2)°C and (65±5) per cent RH until equilibrium, which is defined by change in weight less than 0.1 per cent after 24 hours.

The side lengths of the test volume a^2b are to be measured to the nearest 0.1 mm. Its mass m_ω is determined to the nearest 0.1 g.

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The two wood beams are to be glued to the test volume with PVAc or resorcinol glue or equivalent.

During and after curing of the glue, the test specimen is again stored in a climate of (20±2)°C and (65±5) per cent RH until equilibrium and kept in this climate until testing.

Immediately before testing the saw cut is made and the mass of the specimen m_{tot}, determined to the nearest 10 g.

5.3 Support and loading arrangement

The test specimen is simply supported – at one end on a steel prism resting on a steel ball, at the other end on a steel prism resting on a steel cylinder – and is loaded at midpoint through a steel ball and prism. The supporting cylinder and the ball at the point of loading must be able to roll with only negligible resistance. Dirt and roughness of the steel surfaces must therefore be carefully avoided.

Between the wood test specimen and the steel prisms, 1 mm thick rubber layers are placed. These layers can be excluded if the specimen surfaces are carefully prepared so that a good and close fit to the plane contact surface of the steel prisms is achieved.

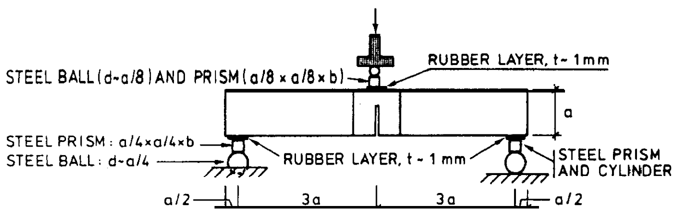


Figure 3. The simply supported test specimen is loaded at the midpoint.

5.4 Equipment

Equipment to support and load the specimen according to Figure 3 is required.

The loading equipment shall be able to load with a constant rate of movement of the cross head and to measure this movement or, alternatively, the mid span deflection, with an accuracy of ± 1 per cent of the movement to failure. A load cell or other equipment is required to measure the load with an accuracy of ± 1 per cent of the maximum load applied. The loading equipment including load cell and support arrangements must have sufficient stiffness. Low stiffness may yield sudden failure or other instability during loading.

5.5 Test procedure

Place the beam on the support and load it at midspan with a constant rate of movement of the cross head of the test machine, so that collapse is obtained in about 3±1 minutes.

Determine the complete load deflection diagram by measuring continuously corresponding values of load, F, and deflection or cross head movement, u.

Note: Deflection may be measured as midspan deflection, i.e. the movement of the point of load application relative to the supports, or as the movement of the cross head. In the latter case, the load equipment must cause only elastic deformations so that no energy-consuming irrecoverable plastic deformation occurs outside the test specimen.

Note: For the test results to be valid it is required that the load deflection response is stable. The response is unstable if the load decreases momentarily at some instant during the test. An unstable response may be due to excessive width, b, of the test area or insufficient stiffness of the load equipment.

Measure the depth, h_c, and width, b, of the tested area.

After the test, the moisture content is determined in accordance with ISO 3130 (weigh - dry - weigh), by taking a reasonable part of the material of the tested volume.

5.6 Results

Calculate the density of the tested volume as

$$\rho_\omega = m_\omega/(a^2 b)$$

Calculate the fracture energy as

$$G_{I,c} = (W + mgu_0) / (h_c b)$$

where

W is the work done by the midpoint force, F, and obtained as the area under the load deflection curve, see Figure 4.

m = 5/6 m_{tot} + 2m_{prism}, where m_{tot} is the mass of the test specimen and m_{prism} the mass of the steel prism and ball resting on the specimen when F=0.

g the gravity acceleration

u_0 the deflection at failure.

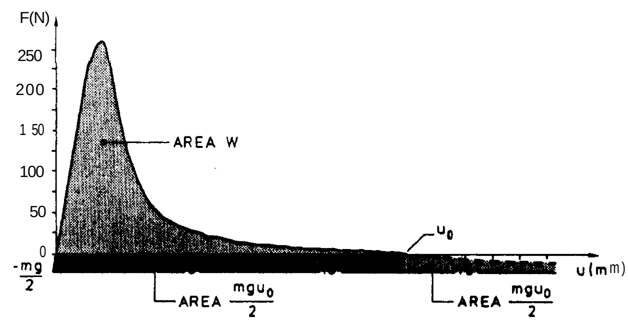


Figure 4. From the complete and stable load deflection curve the work is calculated as W+mgu₀.

6. TEST REPORT

The test report should include at least the following information. Information which should be given individually for each test specimen is indicated by *)

I. General information

a) Address of the testing laboratory and name of the person responsible.

b) Purpose of the test.

c) Date of the test.

II. Description of material tested:

a) Method of sampling.

b) Botanical identification of the tested wood.

c) Conditioning (time and climate).

d) Density, ρ_ω and moisture content, ω.*)

e) Width, b, of the tested volume.

f) Growth ring width, direction and pattern of the tested volume.*)

III. Test method:

a) Geometry of test specimen.

b) Device and setup for loading, support, measurement and recording.

c) Rate of cross head movement and time to failure.

d) Climate in test laboratory.

IV. Test results:

a) Special features of the load deflection curve, e.g. whether it is stable or not.*)

b) Fracture energy.*)

c) Maximum load (beam weight excluded).*)

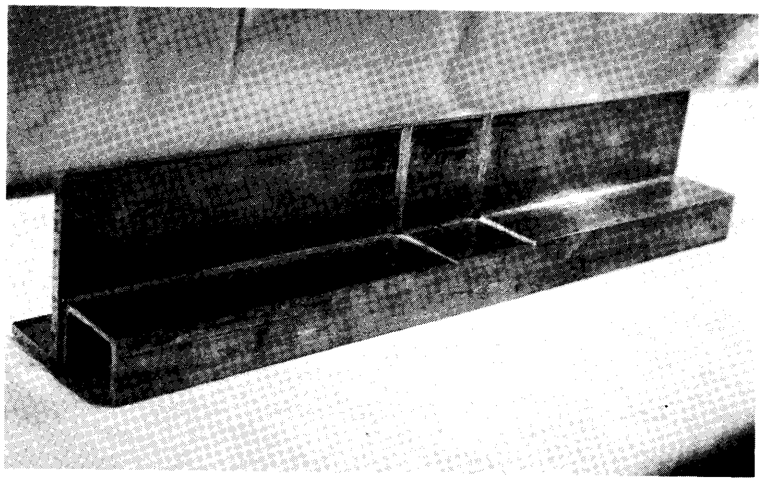
Depending on the purpose of the test and the number of specimens, it may be relevant to also include e.g. the load deflection curve of each specimen and statistical evaluation of the test.

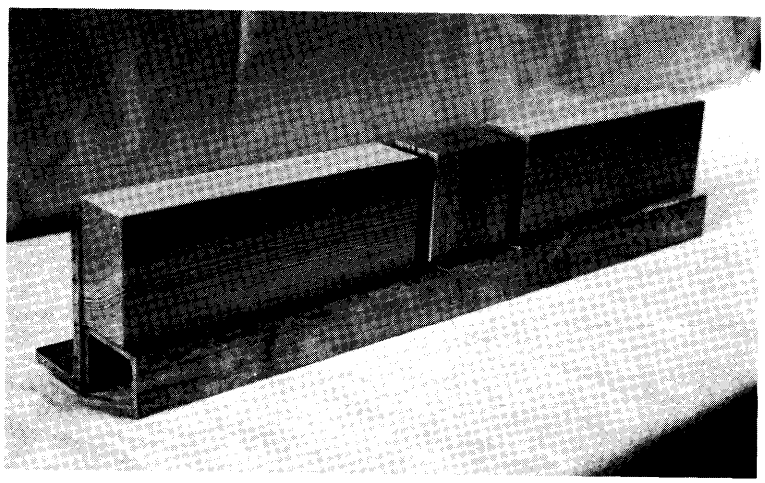
Note: Growth ring width, direction and pattern can conveniently be reported by taking a Xerox copy of the top side of tested volume.

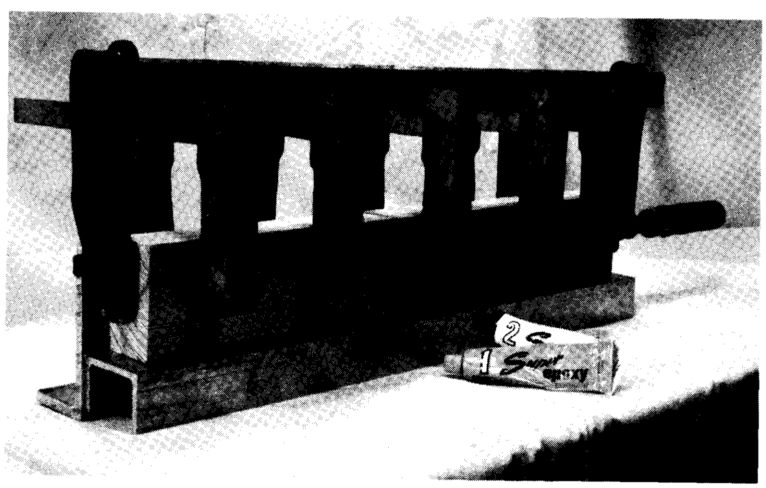
7. APPENDIX

The three appendices below, A-C, are included for information only and do not form integral parts of the NORDTEST method.

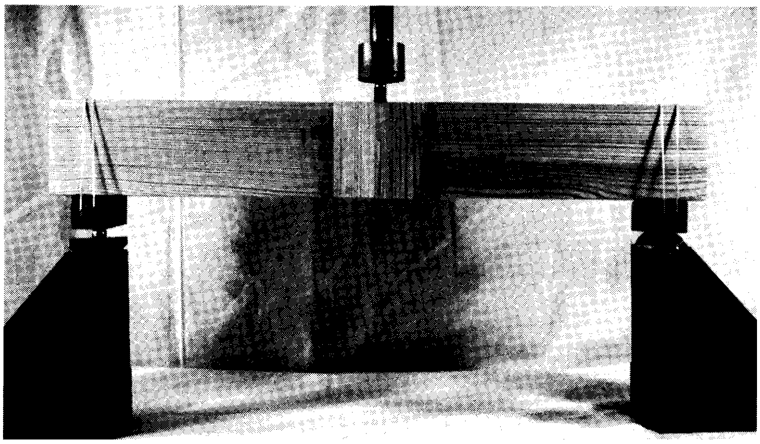
Example of jig for producing test specimens. Clamping is done with a number of clamps perpendicular to the length of the specimen, and one clamp in the longitudinal direction.

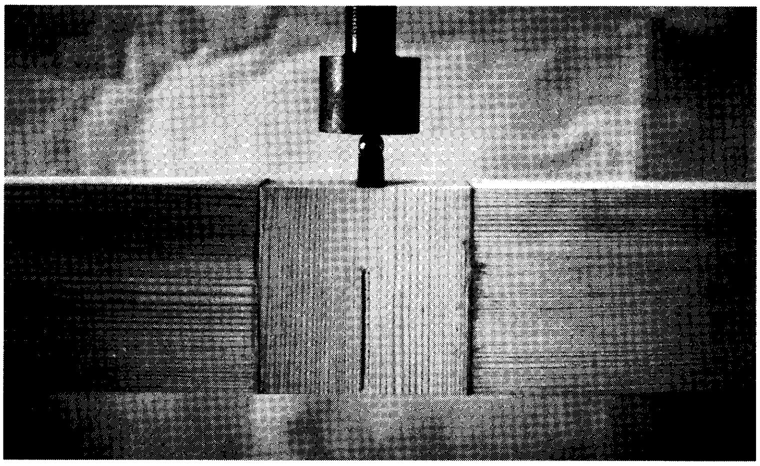


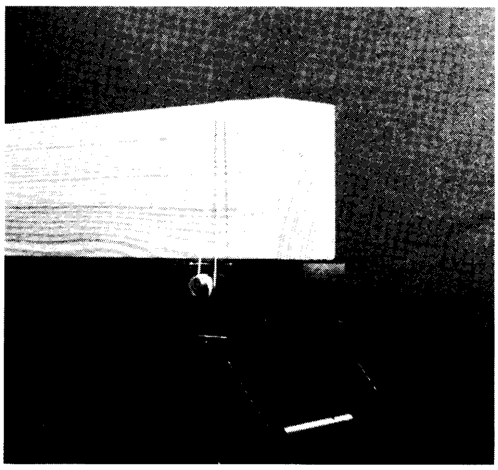


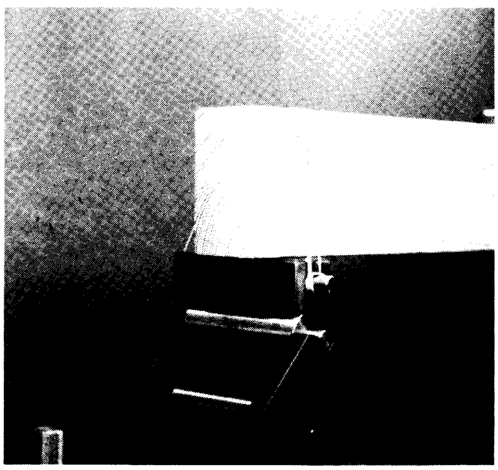


Examples of details in test setup.









Examples of unstable and stable load deflection curves.