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Timber poles — Basic requirements and test methods

Poteaux en bois — Exigences de base et méthodes d'essai

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 15206 was prepared by Technical Committee ISO/TC 165, *Timber structures*.

Introduction

This International Standard covers the requirements for grading and assignment of characteristic values that can be used for the design of timber poles used as cantilevers and/or in compression.

It is the responsibility of the supplier to always ensure that all products supplied are in conformity with the requirements of this International Standard and any other specification with which they are provided. This International Standard is intended for the initial determination of the characteristic values for a given population of poles and additional determination when there is a reason to suspect that the characteristics of a population have changed.

This International Standard recognizes that there are many different visual strength-grading rules for timber in use internationally. These have come into existence to allow for

- different species or groups of species,
- geographic origin,
- different dimensional requirements,
- varying requirements for different uses,
- the quality of material available, and
- historical influences or traditions.

Because of the diversity of existing standards for wood poles for overhead lines in use in different countries, it is impossible to lay down a single set of acceptable visual grading rules.

This International Standard therefore gives the basic principles to be followed when drawing up regional, national, local or buyer requirements for some characteristics and sets limits for others.

In laying down visual grading rules, two main factors are relevant:

- they shall clearly define and limit the strength-affecting characteristics in poles, such that there is very high confidence that poles supplied meet the required characteristic strength value;
- the rules and the text are such that they can be easily understood and be suitable for implementation by grading personnel.

This International Standard is also concerned with the durability characteristics of wood poles for overhead power and telecommunication lines. It assumes that all such poles are constructed from round timber in which the finished product comprises either a central core of heartwood surrounded by a zone of sapwood or the heartwood only. Such assumptions dictate that where sapwood is present, preservative treatment is normally required in order to provide the poles with sufficient enhanced durability, unless the amount of sapwood present is such that its loss would not compromise the integrity of the pole during its service life and the heartwood has sufficient natural durability as required by this International Standard.

Some timber species do not allow an easy differentiation between heartwood and sapwood. Various standards provide recommendations to address this problem; for example, EN 351-1 and AS 2209:1994 (Appendix D) specify the method of treatment of such timber when preservation is required.

Timber poles — Basic requirements and test methods

1 Scope

This International Standard specifies the requirements for grading, test methods, determination of characteristic values, methods of specifying durability and sizes of single poles manufactured from solid timber for telecommunications and electrical distribution purposes, either preservative treated or untreated, under cantilever or compression loading.

It specifies the:

— methods of measuring the sizes of solid wood poles for overhead transmission and telecommunication lines and permissible deviations that are taken into account for the acceptance of the poles;

— requirements for handling and the characteristics for visual strength grading of softwood and hardwood poles, as well as the marking requirements;

— methods of test to determine characteristic values for modulus of elasticity and bending strength of any population of wood poles and moisture content of solid wood poles;

— requirements for durability and preservative treatment of wood poles.

This International Standard is applicable to both softwood and hardwood poles.

This International Standard does not quantify the service life that can be expected from a pole.

NOTE This depends on its geographical location, the associated climate of its service environment and either the natural durability of the heartwood of the species selected or the combination between selection of species, preservative type, and requirements of retention and any incised zones.

It is not applicable to poles used as beams.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3166-1, *Codes for the representation of names of countries and their subdivisions — Part 1: Country codes*

ISO 21887:2007, *Durability of wood and wood-based products — Use classes*

AS/NZS 1604.1, *Specification for preservative treatment — Part 1: Sawn and round timber*

AS 2209:1994, *Timber — Poles for overhead lines*

AS 2209:1994/Amd.1:1997, *Timber — Poles for overhead lines*

EN 252, *Field test method for determining the relative protective effectiveness of a wood preservative in ground contact*

EN 351-1, *Durability of wood and wood-based products — Preservative-treated solid wood — Part 1: Classification of preservative penetration and retention*

EN 599-1, *Durability of wood and wood-based products — Efficacy of preventive wood preservatives as determined by biological tests — Part 1: Specification according to use class*

EN 13183-1, *Moisture content of a piece of sawn timber — Part 1: Determination by oven dry method*

EN 13183-2, *Moisture content of a piece of sawn timber — Part 2: Estimation by electrical resistance method*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
bark pocket
bark that is partly or wholly enclosed in the wood

3.2
characteristic value
value corresponding to the 5th percentile of the statistical distribution of strength or the mean value of modulus of elasticity, at a 75 % confidence level

3.3
charge
all the wood treated together in one treatment at one time (one complete treatment cycle)

3.4
crack
separation of wood fibres across the grain

NOTE These can be due to internal strains resulting from unequal longitudinal shrinkage, or the fibres being crinkled by compression or other external forces

3.5
critical zone
1,6 m length of pole measured from a point 1 m above the nominal ground line to 600 mm below the nominal ground line

NOTE If the pole is nominated as a stayed pole, an additional zone measured from the top of the pole equivalent to the length between the nominal ground line and the butt of the pole shall be included.

3.6
decay
rot
decomposition of wood by fungi or other micro-organisms resulting in softening, progressive loss of mass and strength, and often a change of texture and colour

3.7
direct testing
testing the preservative treatment achieved by the direct measurement of the penetration and retention of preservative

3.8
double sweep
sweep characterized by two or more bends in one or several planes

3.9
fibre saturation point
FSP
state of a piece of timber when the cell walls are saturated with moisture but no moisture exists in the cell cavities

3.10
fissure
longitudinal separation of fibres

3.11
grain detector
device for detecting the angle of grain in timber

3.12
growth rate
mean number of growth rings per 25 mm

3.13
heart shake
radial end shake originating at the pith

3.14
incised zone
area of the lateral surface of the pole, which has undergone an incising process as an aid to securing deeper and more uniform penetration of preservative

NOTE The minimum limit of the incised zone should be 400 mm above and 400 mm below the specified ground line for the pole in service.

3.15
included sapwood
presence in the heartwood of a complete or incomplete ring, having the colour and the properties of sapwood

3.16
indirect testing
testing the preservative treatment achieved by measurement of a property found to exhibit a correlation between itself and the penetration and retention of preservative

3.17
kerf
groove or slot formed in wood during the process of sawing

3.18
knot
portion of a branch embedded in wood

3.19
knot cluster
knots located such that no grain recovery is evident between adjacent knots

3.20
knot diameter
dimension of the knot measured on the surface of the pole and perpendicular to the axis of the pole

NOTE The diameter takes the entire knot into account, including the sapwood.

3.21
length
distance from the pole butt to the pole tip

3.22
maximum diameter
largest diameter of the pole at the section of measurement

3.23
minimum diameter
smallest diameter of the pole at the section of measurement

3.24
moisture content
ratio of the mass of the quantity of water in a material to the mass of the dry material

3.25
nominal diameter

3.25.1
nominal diameter
⟨pole with 5 % or less ovality⟩ theoretical diameter, usually the diameter measured at the nominal ground line

3.25.2
nominal diameter
⟨pole with greater than 5 % ovality⟩ minimum diameter

3.26
nominal ground line
plane normal to the axis of the pole usually located at a distance of 600 mm plus 10 % of the nominal length from the butt end

3.27
ovality
difference between the maximum and minimum diameter at a cross-section expressed as a percentage of the minimum diameter

3.28
pith
innermost part of the pole

3.29
pole
long, round timber for use in a free-standing application

3.30
pole butt
lowermost point of the thicker end of the pole

3.31
pole tip
uppermost point of the narrow end of the pole

3.32
population
group of poles defined by having the same species, source and grade

3.33
resin pocket
cavity that contains or has previously contained resin

NOTE This may be similar to rind galls.

3.34
rind gall
surface wound that has been partially enclosed by the growth of a tree

3.35
ring shake
fissure following the line of a growth ring

3.36
sample
one or more poles taken from a single population

3.37
sampling unit
single preservative-treated pole taken from a charge

3.38
scribe
cranked rod with a swivel handle and a needle at the tip, set to a slight trailing angle

NOTE This is used as a grain detector by pressing the needle into the timber and drawing it across the surface in the apparent direction of the grain.

3.39
section of maximum stress
section of pole where the diameter equals 1,5 times the diameter at the point of application of load if this section is above ground line; otherwise the actual ground-line section

3.40
short crook
local deflection
natural deviation of the axis of the pole occurring on a length less than 1,5 m

3.41
simple sweep
sweep characterized by one bend only

3.42
slope of grain
divergence of the direction of the fibres from the longitudinal axis of the piece

NOTE The slope of grain in poles is usually observed as an inclination of the wood cells on the surface, which is referred to in some International Standards as spiral growth angle.

3.43
standard size pole
pole of a size 8 m or 10 m long and 180 mm to 220 mm diameter at 1,5 m from the butt end, and used for the determination of characteristic values

3.44
star shake
two or more heart shakes

3.45
sweep
deviation of the longitudinal axis of round timber from a straight line

3.46
taper
gradual reduction in diameter of a stem along its height or round timber along its length

3.47
theoretical diameter
diameter of a circle with the same circumference as the actual circumference at the section of measurement

4 Symbols and abbreviated terms

d_g nominal diameter at assumed ground line, in millimetres

d_q nominal diameter at point of load application, in millimetres

d_{max} nominal diameter at section of maximum stress, in millimetres

E modulus of elasticity parallel to grain in bending, in newtons per square millimetre

f_m bending strength — maximum stress at assumed ground line or point of maximum stress if this is above the assumed ground line, in newtons per square millimetre

I_q second moment of area of cross-section at point of load application, in millimetres to the fourth power

l pole length measured from butt to tip, in millimetres

l_g distance from butt to assumed ground line, in millimetres

l_g distance from butt to section of maximum stress or ground line, whichever is the greater, in millimetres

l_q distance from tip to position of applied load, in millimetres

Q applied load, in newtons

$s_a - s_0$ movement of load application point parallel to longitudinal axis of the pole during testing, in millimetres (see Figure C.2)

$t_a - t_0$ deflection at point of load application, in millimetres (see Figure C.2)

E_{mean} mean value of modulus of elasticity parallel to direction of grain, in newtons per square millimetre

$f_{m, k}$ characteristic value of bending strength, in newtons per square millimetre

$f_{m, 05}$ sample fifth percentile of bending strength, in newtons per square millimetre

k statistical factor

m mean value (the variable is given in parentheses)

$m(E)$ sample mean values of modulus of elasticity, in newtons per square millimetre

$m(f_m)$ sample mean value of bending strength, in newtons per square millimetre

$m(f_{m, 05})$ mean of $f_{m, 05}$ values

n number of test poles in a sample

s standard deviation (the variable is given in parentheses)

$s(E)$ sample standard deviation of modulus of elasticity, in newtons per square millimetre

$s(f_m)$ sample standard deviation of bending strength, in newtons per square millimetre

5 General requirements

5.1 Marking

The manufacturer shall declare the species and ensure that all poles are clearly marked to identify the species, in accordance with Clause 8.

NOTE Common names are different depending on language version.

5.2 Tree felling and wood preparation

5.2.1 Tree felling

At the time the trees are felled, it is advisable to ensure that the rising sap is low, except for timber which is to be treated by a sap displacement process. If the trees are felled when the sap is high, it is recommended that measures be taken to avoid pre-treatment decay or attack by insects.

5.2.2 Handling of untreated wood

The method of handling shall avoid any damage that could alter the mechanical performance and durability of the pole, as well as the suitability of the pole for preservative treatment. Species permitted for use in poles are generally specified in the referenced local standards.

5.2.3 Mechanical pre-treatments

Where poles are mechanically pre-treated before preservation, e.g. through incising, testing in accordance with Clause 6 shall be carried out after the mechanical pre-treatment.

5.3 Requirements for pole sizes, tolerances, permissible deviations and damage

For poles used in structural applications, the minimum diameter of a pole shall be not less than 80 % of the maximum diameter at any cross-section over a maximum of 80 % of the length of the pole.

The manufacturer shall declare the size of the poles, specified by the overall length, the nominal diameter at 1,5 m from the butt and the nominal diameter at the tip, measured in accordance with 6.1. The permissible dimensional tolerances are:

— length: −1 % or +2 %;

— diameter: −0 or +40 mm unless otherwise declared by the manufacturer.

NOTE A list of commonly used pole sizes (minimum nominal diameter at 1,5 m from the butt, and length) is given in Annex A.

5.4 Characteristic values

The manufacturer shall declare structural properties in accordance with 8.2.

5.5 Strength-reducing characteristics

5.5.1 Knots

The maximum dimension of knots, knot holes and knot clusters shall be recorded in the following manner:

a) individual knots or knot clusters — maximum diameter of knots or knot clusters, expressed as a factor of the circumference of the pole at the point where the knot occurs;

b) multiple knots, etc. — maximum sum of all the knot diameters in any 300 mm length of the pole, expressed as a factor of the circumference of the pole at the midpoint of the 300 mm length (e.g. factor = knot diameter in mm/circumference of pole at cross-section in millimetres).

The measurement of the individual knot or knot clusters shall be according to 6.2.

Different limitations on knot sizes may be specified for different portions of the pole, e.g. the top third of poles over 13 m long could have different knot limitations from the rest of the pole.

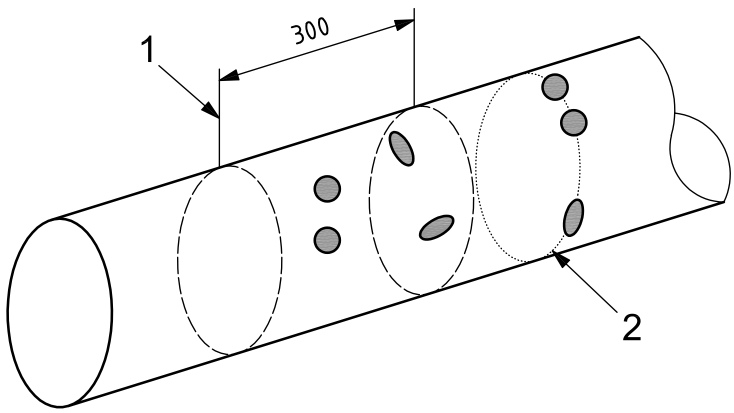
5.5.2 Slope of grain

The slope of grain relative to the longitudinal axis shall be measured according to 6.3. Significant changes in the slope of grain shall not be allowed.

5.5.3 Heartwood

For hardwood poles, the minimum area of heartwood when measured at the butt shall be recorded.

Dimensions in millimetres



1 case 2: multiple knots in any 300 mm length of the pole
2 case 1: individual knots or knot clusters

Figure 1 — Measurement of knots

5.5.4 Rate of growth

If the rate of growth is required, it shall be declared as the minimum number of growth rings per 25 mm when measured in accordance with 6.4 (i.e. maximum growth rate).

5.5.5 Straightness

A single sweep shall be permitted to the extent that a straight line drawn from the centre of the tip to the centre of the butt shall remain in the pole.

Where double sweep and short crook exist, these shall be declared by the manufacturer.

5.5.6 Bark pockets and rind galls

Bark pockets and rind galls shall be permitted in the first 1 m of length from the butt. Above the first 1 m length from the butt, bark pockets and rind galls shall be measured according to 6.5. Depth, position and number shall not exceed those given for mechanical damage. They shall be specified by length, width and depth, expressed as a percentage of the nominal diameter of the pole at that point.

5.5.7 Mechanical damage

Mechanical damage shall not extend to a depth that will reduce the diameter by more than 5 % of the diameter at any cross-section when measured in accordance with 6.6. No more than two occurrences of mechanical damage shall be permitted and no part of these shall be less than 500 mm apart.

5.5.8 Ring and star shake

The tip shall be free from ring shake or star shakes with five or more points. At the butt, one complete ring or one star shake is acceptable, provided not more than two points extend to within 5 mm from the pole circumference. If they extend to the circumference, they shall not extend along the pole more than 500 mm from the butt.

5.5.9 Fissures, splits and checks

Seasoning fissures and splits along the grain are expected and are not recognized as defects, provided they do not have a depth greater than half the diameter at one point along the pole or do not exceed 50 % of the length of the pole, when measured according to 6.7.

5.5.10 Damage

Any damage in poles manufactured from trees subjected to snow breakage, frost damage, windfall or forest fires, shall be limited to ensure that any such poles meet the grading requirements of this International Standard and are fit for purpose.

5.5.11 Decay and insects

Poles shall be sound and free from decay and attack by insects. Minor insect holes are acceptable provided these are, either not larger than 1,5 mm in diameter and do not exceed 5 in number, or not larger than 1,0 mm in diameter and do not exceed 20 in number, evenly distributed in any 100 mm length of the pole.

5.5.12 Included sapwood

No included sapwood in heartwood shall be permitted in hardwood poles.

5.5.13 Cracks

Cracks across the pole and the grain shall not be permitted.

5.6 Other characteristics

5.6.1 Other criteria

Circumstances of specific or regional use may call for additional criteria and limits to be declared by the manufacturer. These shall only be criteria that affect the strength.

5.7 Untreated wood poles

The natural durability to wood-destroying fungi of the heartwood of a pole shall be described by reference to the relevant use classes and biological hazards defined in ISO 21887, to ensure that the pole meets its intended purpose and design life.

5.8 Preservative-treated wood poles

5.8.1 General

The poles shall be free from features which would prevent a proper application of preservative and thus impair the function of the preservative-treated poles when in service.

All dressing, notching, pre-cutting and boring shall be completed before preservative treatment. Prior to preservative treatment, the moisture content of the pole shall be at a level appropriate to the wood preservative and method of treatment used.

Preservative treatment shall be defined in terms of depth of lateral penetration of preservative into the treated pole and retention of preservative within that treated zone in accordance with the requirements of ISO 21887:2007, A.3.

The preservative treatment used shall not compromise the performance of the pole in service.

5.8.2 Requirements for wood preservatives

The wood preservatives used shall conform to the performance requirements of Use Class 4 preservatives as defined in EN 599-1 or AS/NZS 1604.1. For the purposes of this International Standard, determination of compliance with the performance requirements of EN 599-1 shall include data from the field test EN 252 and any of the additional local tests given in EN 599-1 applicable to the place of use of the product.

5.8.3 Penetration requirement

The penetration requirement shall be defined in terms of the penetration classes listed in EN 351-1 or the durability classes noted in AS 2209.

— EN 351-1: for permeable species, full sapwood penetration P8 is required. For resistant species, P7 is required in any incised zone and P5 is required elsewhere.

— AS 2209: sapwood penetration requirements for timber poles shall range between 12 mm and 20 mm for hardwoods (depending on the durability class) and be not less than 35 mm for permeable softwoods.

5.8.4 Retention requirement

Following completion of the preservation process, the retention requirement specified by the user for treated poles shall be equal to or greater than the critical value for End Use Class 4 of the preservative used (see EN 599-1) or the retention requirements for treatment to Hazard level H5, in accordance with AS/NZS 1604.1. This critical value shall be calculated from the prescribed biological tests defined in the relevant national standards.

NOTE Multiples greater than one may be applied to the critical value to specify higher retentions as a means of increasing the service life. In the case of established preservatives where a critical value has not yet been determined, the retention should be specified using service experience as its basis.

5.8.5 Tolerances for preservative-treated charges

5.8.5.1 Penetration tolerances

Sampling for penetration shall be as detailed above (in 5.8.3) and shall be subject to an acceptable quality level (AQL) of 10 % using inspection level II (see EN 351-2:1995, Table 1 or AS/NZS 1604.1). A lower percentage AQL may be declared.

5.8.5.2 Retention tolerances

The mean retention in the complete analytical zone shall be equal to or greater than the retention requirement specified according to 5.8.3.

6 Test methods

6.1 Length and diameter

Length shall be measured using a tape measure. Maximum and minimum diameters shall be measured using callipers. Alternatively, the theoretical diameter may be calculated from the circumference measured by using a tape measure.

All measurements shall be made when poles are at or above FSP, determined in accordance with 6.8.

Where one or both ends are not cut square, the minimum length shall be recorded.

NOTE The taper of poles covered by this International Standard is expected to be between 6 mm and 16 mm per metre.

6.2 Knots and knot clusters

The dimension of a knot or knot cluster shall be measured as the diameter of a knot measured on the surface of the pole and perpendicular to the axis of the pole. Knot clusters shall be treated as a single knot. The diameter of an encased knot shall be measured to the sound wood of the pole on either side of the knot.

6.3 Slope of grain

The slope of grain shall be measured over a minimum 1 m length of pole, e.g. a slope of 1 in 8 represents 1/8 metre (125 mm) deviation over a 1 m length along the axis of the pole.

The direction of grain shall be determined by one of the following methods from which the slope of grain shall be calculated:

a) by taking a line parallel to the surface fissures;

b) through the use of a grain detector (scribe).

6.4 Rate of growth

The rate of growth shall be measured at either the tip or butt of the pole and expressed as the mean number of growth rings per 25 mm. The measurements shall be made over a radial line, as long as possible, commencing 50 mm from the pith. For poles that have a theoretical diameter of less than 150 mm, measurement shall be made over a radial line as long as possible commencing from the circumference.

6.5 Bark pockets and rind galls

The dimensions of each bark pocket and rind gall shall be measured as the overall length, width at the widest point and depth at the deepest point.

6.6 Mechanical damage

The pole diameter on which the measurement of the damage is based shall be calculated on the nominal diameter at the cross-section where the damage occurs. To determine the nominal diameter, the nominal diameter of the sound pole immediately above and below the damage shall be measured and averaged. The minimum diameter of the damaged cross-section shall be measured and the reduction in diameter determined.

6.7 Fissures, splits and checks

The depth of fissures, splits and checks shall be measured by inserting a 0,2 mm feeler gauge as far as possible into the fissure.

6.8 Determination of moisture content

6.8.1 For untreated poles, the moisture content of test specimens shall be determined in accordance with the procedure of EN 13183-1 on a disc of timber cut from the pole. The disc shall be of full cross-section, free of knots and resin pockets and shall be at least 50 mm in thickness and 300 mm from the tip or butt.

6.8.2 In the case of preservative-treated poles, the determination of moisture content using the above method shall be restricted to material cut from untreated areas. If the moisture content of treated material is required, methods appropriate to the specific preservative treatment shall be used. The presence or otherwise of treatment in the specimens shall be recorded. Moisture content may be determined in accordance with EN 212.

6.8.3 In the case of ultimate strength tests, the disc shall be cut as closely as possible to the fracture.

6.8.4 For determining the moisture content of a pole prior to treatment or test, the procedures given in EN 13183-1 may be applied to borings taken in accordance with Annex B (of this International Standard). The boring sample used for determination of moisture content shall include the full depth of sapwood or the innermost 75 mm of sapwood, whichever is the lesser. Alternative methods of measurement, such as electrical resistance moisture meters in accordance with EN 13183-2, may be used provided it can be demonstrated that the measurements taken relate to measurements taken in accordance with the method specified in 6.8.1 and 6.8.2.

7 Evaluation of conformity

7.1 General

The conformity of wood poles with the requirements of this International Standard and with the specified values shall be demonstrated by

— initial type testing, and

— product assessment.

7.2 Initial type testing

Initial type testing shall be performed to show conformity with this International Standard. Tests previously performed in accordance with the provisions of this International Standard (same product, same characteristic(s), test method, sampling procedure, system of attestation of conformity, etc.) may be taken into account. In addition, initial type testing shall be performed at the beginning of the production of a new type of pole or at the beginning of a new method of production (where this may affect the stated properties).

Poles shall be inspected after they have been dressed and not more than one month prior to preservative treatment when required. All characteristics in 5.4 shall be subject to initial type testing, where they are relevant for the poles in question.

Whenever a change occurs in the product, the raw material or supplier of the components, or the production process, which would change significantly one or more of the characteristics, the type tests shall be repeated for the appropriate characteristic(s).

Sample sizes for initial type testing shall be in accordance with Annex F.

Initial type testing reports shall be held by the manufacturer for at least 10 years after the date of last production of the poles to which they relate.

7.3 Product assessment

Product assessment shall consider controls and tests on measuring equipment, raw materials and constituents, processes, machines and manufacturing equipment and finished components, including material properties in components, to assess whether or not, the poles placed on the market conform with the declared performance characteristics.

A product assessment system may be part of a quality management system, for example ISO 9001.

8 Marking and declarations

8.1 Marking (mandatory)

Each pole shall be marked with the following information:

a) the species and origin designated by code letters (the country code shall be in accordance with ISO 3166-1);

b) the preservative [designated by its reference code (where applicable)] and retention;

c) the pole classification and the year of manufacture.

The information shall be in a form that can readily be interpreted by utility staff working from ground level.

8.2 Specific marking and declarations

The manufacturer shall declare the following:

a) the length of pole (in metres);

b) the nominal diameter at 1,5 m from the butt (in millimetres), or size code;

c) the gauge or depth mark at 3 m from the butt (or as agreed on by the buyer and the manufacturer);

d) the characteristic properties (such as bending strength and modulus of elasticity) to two significant figures;

e) the minimum diameter at 1,5 m from the butt and the minimum diameter at the tip, determined in accordance with either Annex C or Annex D.

8.3 Marking (optional)

a) the code of the manufacturer (where applicable);

b) the last two digits of the year of preservation (where applicable);

c) the natural durability class (where applicable);

d) the buyer specification against which the pole is supplied (where applicable).

Annex A
(informative)

Commonly used sizes for wood poles

Length m	**Minimum nominal diameter** (at 1,5 m from butt) mm													
6	120	130	140	150	160	170								
7	130	140	150	160	170	180	190	200	210					
8	140	150	160	170	180	190	200	210	220					
9	150	160	170	180	190	200	210	220	230	240	250	260	270	280
10	160	170	180	190	200	210	220	230	240	250	260	270	280	290
11	170	180	190	200	210	220	230	240	250	260	270	280	290	300
12	190	200	210	220	230	240	250	260	270	280	290	300	310	320
13	210	220	230	240	250	260	270	280	290	300	310	320	330	340
14		230	240	250	260	270	280	290	300	310	320	330	340	350
15		250	260	270	280	290	300	310	320	330	340	350	360	
16		260	270	280	290	300	310	320	330	340	350	360	370	
17		280	290	300	310	320	330	340	350	360	370	380		
18		300	320	340	360	380	400	420						
19		330	350	370	390	410	430							
20		340	360	380	400	420	440							
21		350	370	390	410	430	450							
22		370	390	410	430	450								
23		400	420	440	460	480								
24		420	440	460	480	500								

Annex B
(normative)

Scheme for sampling preservative-treated wood poles by taking borings

B.1 General

Borings shall be taken with a sharp increment borer (e.g. Mattson borer), which extracts a core of minimum diameter 4 mm.

If the poles have been incised, borings shall be taken at a point midway between adjacent incisions.

At the selected point on the surface of each pole, the borer shall be held at right angles to the direction of grain and directed towards the pith. The borer shall penetrate each pole to a greater depth than the penetration being measured.

After removal of the borings, borer holes shall be promptly plugged with a tight-fitting wooden plug treated with a preservative in a similar way to the poles themselves.

One boring shall be taken from each pole where both penetration and retention determinations can be completed using one boring. However, two borings shall be taken from each pole (i.e. one boring for penetration and one for retention determinations) where this cannot be achieved.

B.2 Examination of borings

B.2.1 Penetration of preservative

Differentiation of heartwood and sapwood, and the limit of penetration of the preservative, may be apparent because of colour differences. Where this is not possible, the application of physical or chemical agents is necessary to reveal the sapwood zone and the penetration of the preservative chemicals.

B.2.2 Retention of preservative

The complete analytical zone associated with the selected penetration class as defined in EN 351-1 shall be separated from each boring. These shall be combined into a single sample and converted to a form suitable for quantitative chemical analysis and thus analysed.

Annex C
(normative)

Test method for bending properties — Cantilever method

C.1 Principle

The bottom section of the pole under test is rigidly clamped up to 1,5 m from the butt or the assumed position of the ground line. A load is applied 150 mm from the tip of the pole in a direction perpendicular to the original axis of the pole.

NOTE As the direction of loading imposed on the pole in practice is not known, it is important that the value of f_m determined relates to the apparent weakest direction of the pole. A procedure for determining the direction of test is given in C.4.

C.2 Preparation

Prior to testing the following data shall be measured and recorded:

a) the length of the pole in accordance with 5.3;

b) the circumference intervals from butt to tip, measured to an accuracy of ±1 %, and including the following positions:

   1) the butt;

   2) the point of application of the test load;

   3) 1,5 m from the butt or the assumed ground line;

   4) the tip;

c) the location and size of any strength-affecting characteristics, as defined in 5.5, including:

   1) decay and insects;

   2) straightness;

   3) knots;

   4) mechanical damage;

   5) slope of grain;

   6) thickness of sapwood;

   7) in bark pockets and rind galls;

   8) fissures;

   9) ring and star shakes;

   10) ovality.

NOTE Recording of the strength-reducing characteristics is required for the purpose of later verification that the poles tested for the determination of characteristic values are representative of the true population.

C.3 Apparatus

C.3.1 Two pairs of clamps, capable of rigidly restraining the section of pole below the assumed position of ground line during testing. Each of these clamps shall be faced with a pair of timber shoes of at least 500 mm in length and shaped to fit approximately to the curvature of the pole under test. The clamping pressure applied to the pole shall allow it to be rigidly clamped, but shall not cause damage to the timber.

C.3.2 A loading mechanism, capable of applying a measured load at a position 150 mm from the tip of the pole in a direction perpendicular to the original centreline of the pole. The angle between the applied load and the original centreline of the poles shall be maintained at (90 ± 3)°. One means of achieving this is described in C.7.

C.3.3 A load-monitoring device, capable of measuring and continuously recording the load applied to an accuracy of ±1 % of actual reading.

C.3.4 A device for measuring and recording the deflection, at the point of load application, to an accuracy of ±1 % of actual reading.

C.3.5 A device for continuously measuring the distance between the clamping position (assumed ground line) and the load application point, in a direction parallel to the original axis of the pole to an accuracy of ±1 % of actual reading.

C.4 Procedure

C.4.1 The direction of test shall be determined before test by gently rolling the test pole on supports at the butt and tip to identify its “natural rest” position. The direction of test shall be such that the underside of the test pole in its “natural rest” position shall be in tension.

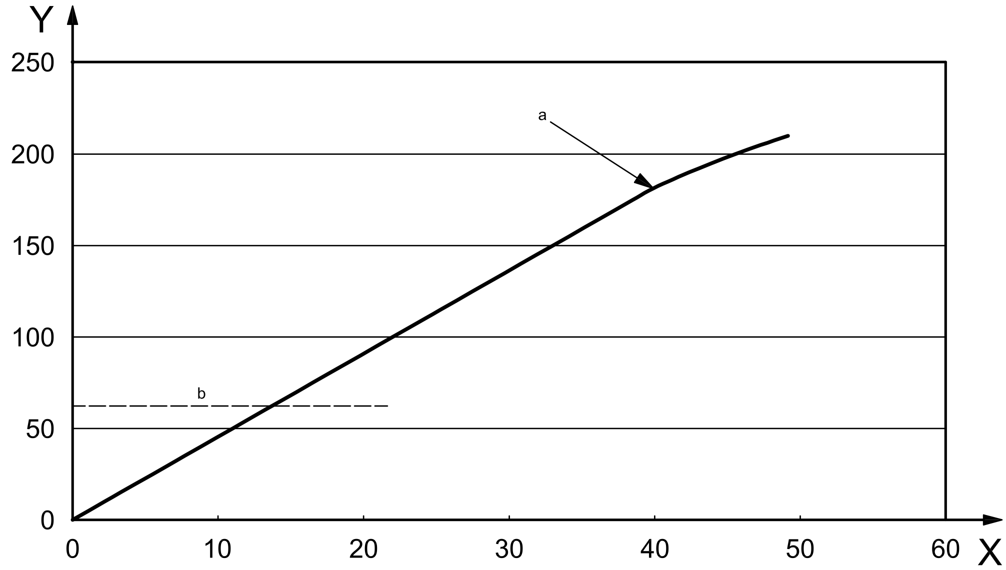
C.4.2 The test pole shall be positioned in the rig and clamped over the section of the test pole below the assumed ground line (see C.1). The clamping pressure applied to the pole shall allow it to be rigidly clamped, but shall not cause damage to the timber.

C.4.3 The load shall be applied to a point near the tip of the test pole and a series of at least 30 pairs of load and corresponding deflection measurements shall be obtained at a constant rate of increase of load up to a load level of approximately 30 % of the predicted maximum load capacity of the pole, as indicated schematically in Figure C.1. This load shall be reached within (90 ± 30) s. If this load level exceeds the linear section of the load versus deflection curve, that test pole shall be rejected and the load level shall be reduced for subsequent tests.

C.4.4 Load may be removed and reapplied at a constant rate of increase, such that failure occurs within (300 ± 120) s or loading may continue to failure within the same total time period. The position and type of failure shall be recorded.

C.4.5 Maximum stress points are calculated at the ground line cross-section or at the cross-section where the diameter is 1,5 times the diameter of the cross-section at the load application point, subject to that cross-section being above the ground line.

C.4.6 After testing, the moisture content shall be determined for samples cut from close to the position of failure and values determined in accordance with 6.8. The location, type of specimens and method used shall be recorded.



Key

X deflection, in millimetres

Y load, in kilonewtons

[a] Limit of linearity.

[b] 30 % load.

Figure C.1 — Typical load vs. deflection plot

C.5 Results

C.5.1 A value of modulus of elasticity, E, shall be calculated using Equation (C.1):

$$E = \frac{Q\left[l - l_g - l_q - (s_a - s_0)\right]^3 d_q^{\ 3}}{3I_q(t_a - t_0)d_g^{\ 3}} \tag{C.1}$$

Where Q is the tip load and the other variables in Equation (C.1) are shown in Figure C.2.

NOTE 1 For Equation (1) to apply, the following assumptions have been made:

a) the pole is circular in cross-section along its length;

b) the pole has a linear taper between the ground line and the point of load application;

c) the magnitude of deflection is small relative to the pole geometry, such that second order effects can be ignored;

d) the pole has a constant and uniform modulus of elasticity.

NOTE 2 The calculations are carried out, using the theory of linear elasticity as a basis.

C.5.2 Calculate the bending strength of the pole, f_m, using Equation (C.2):

$$f_m = \frac{32Q\left[l - l_{max} - l_q - (s_a - s_0)\right]}{\pi d_{max}^{\ 3}} \tag{C.2}$$

NOTE For Equation (C.2), the calculations are carried out, using the theory of linear elasticity as a basis.

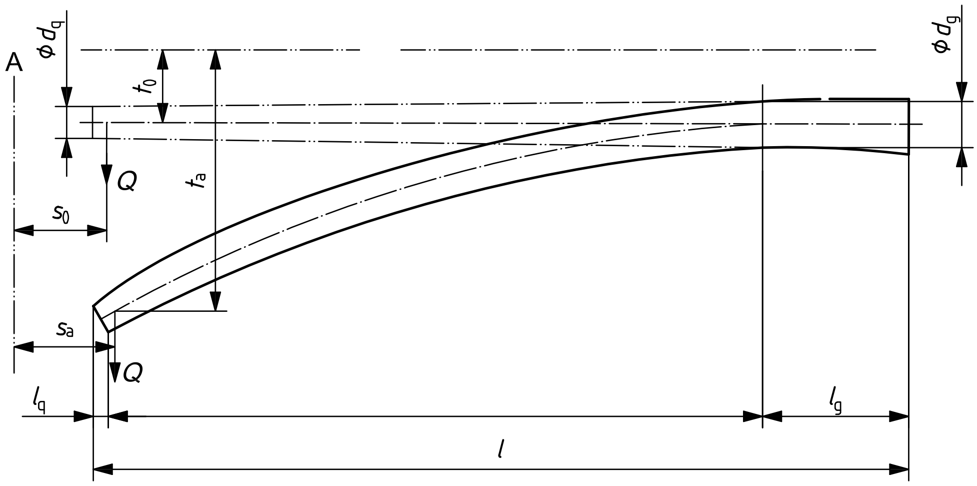


Figure C.2 — Notation used in bending strength and modulus of elasticity calculations

C.6 Test report

C.6.1 General

The test report shall specify at least the following:

a) the details of the test material;

b) the test procedure;

c) the test results, as described in C.6.2 to C.6.4.

C.6.2 Test material

The following information shall be reported:

a) the species;

b) the length;

c) the butt nominal diameter;

d) the nominal diameter 1,5 m from butt, or at the assumed ground line;

e) the nominal diameter at load point;

f) the tip nominal diameter;

g) the assumed ground-line position;

h) the moisture content;

i) the type of preservation, the process used and penetration, where applicable;

j) the sampling procedure;

k) the location and size of strength-reducing characteristics within 300 mm either side of the failure zone;

l) the geographical region of pole population tested;

m) the maximum growth rate (i.e. minimum number of rings per 25 mm);

n) the ovality at points of nominal diameter measurement.

C.6.3 Test procedure

The following information shall be recorded:

a) the equipment used;

b) any other information that could have influenced the test results.

C.6.4 Test results

The following information shall be recorded:

a) the maximum load applied;

b) the bending strength;

c) the position of section of maximum stress;

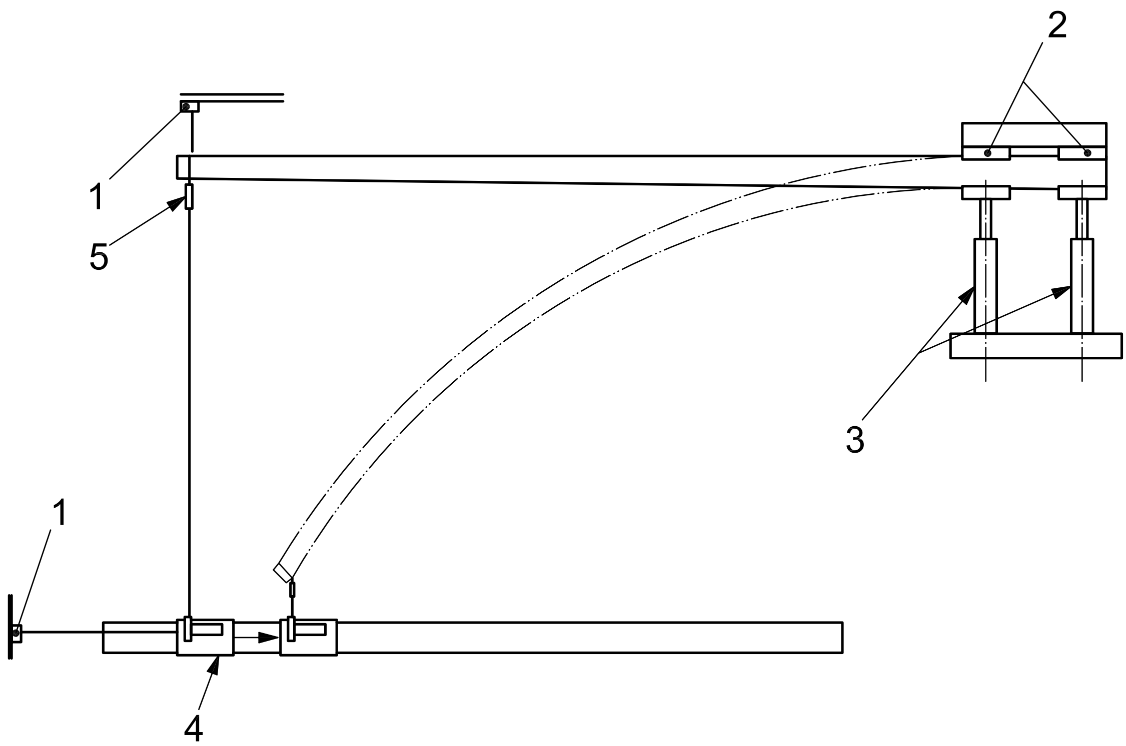
d) the mode of failure,

e) the modulus of elasticity;

f) any other relevant information that could have influenced the results.

C.7 Example of suitable cantilever bending test method

One means of performing this test is by using a cable and winch system with the winch mounted on a low-friction trolley, such that it is free to move as the pole deflects. A typical arrangement is shown diagrammatically in Figure C.3.



Key

1 deflection measuring device

2 contoured shoes

3 clamping cylinders

4 trolley-mounted winch

5 load measuring device

Figure C.3 — Principle of bending test procedure

Annex D
(normative)

Test method for bending properties — Four-point method

D.1 Principle

The butt and tip of the pole under test are attached to the reaction frame. Two loads are applied about the ground line as shown in Figure D.1, which is nominally located between 1 500 mm and 2 000 mm above the butt. The loads are applied at a uniform distance from the ground line in a direction perpendicular to the original axis of the pole.

NOTE As the direction of loading imposed on the pole in practice is not known, it is important that the value of f_m determined relates to the apparent weakest direction of the pole. A procedure for determining the direction of test is given in D.4.

D.2 Preparation

Prior to testing, the following data shall be measured and recorded:

a) the length of the pole in accordance with 5.3;

b) the circumference is measured to an accuracy of ±1 %, at the following positions:

  1) the butt;

  2) both points of application of the test load;

  3) the assumed ground line;

  4) the mid-length of the pole;

  5) the tip;

c) the location and size of any strength-affecting characteristics, as defined in 5.5, including:

  1) decay and insects;

  2) straightness;

  3) knots;

  4) mechanical damage;

  5) slope of grain;

  6) thickness of sapwood;

  7) barks and rind galls;

  8) fissures;

  9) ring and star shakes;

  10) ovality.

NOTE Recording of the strength-reducing characteristics is required for the purpose of later verification that the poles tested for the determination of characteristic values are representative of the true population.

D.3 Apparatus

D.3.1 Two reaction frame yokes, at each end of the pole, capable of both supporting the pole under its own weight (downwards load) and restraining the pole when loaded by the two loading jacks in an upwards direction. The ends of the pole shall be restrained by wooden packing material and the reaction frame yokes at each end of the pole shall be capable of rotation to allow for the curvature of the pole as it is loaded. The clamping pressure applied to the pole shall allow it to be rigidly clamped to the yokes, but shall not cause damage to the timber.

D.3.2 Loading mechanisms, capable of applying measured loads at the two positions indicated in Figure D.1 and loading the pole in a direction perpendicular to the original centreline of the pole. The angle between the applied load and the original centreline of the poles shall be maintained at (90 ± 3)°.

D.3.3 Load-monitoring devices, capable of measuring and continuously recording the load applied to an accuracy of ±1 % of the actual reading.

D.3.4 Device for measuring and recording the deflection, to an accuracy of ±1 % of actual reading, installed at one of the following locations: a) the point of load application nearest the centre of the pole (load Q_2 in Figure D.1); b) the midpoint of the pole length.

D.4 Procedure

D.4.1 The direction of test shall be determined before test by gently rolling the test pole on supports at the butt and tip to identify its “natural rest” position. The direction of test shall be such that the underside of the test pole in its “natural rest” position shall be in tension.

D.4.2 The test pole shall be positioned in the rig and clamped over the section of the test pole below the assumed ground line, as noted in D.1. The clamping pressure applied to the pole shall allow it to be rigidly clamped within the reaction yokes, without impeding the ability of the yokes to rotate or causing damage to the timber.

D.4.3 The loads shall be applied at the points on either side of the ground-line section of the pole and a series of at least three full cycles of loading and unloading and corresponding deflection measurements shall be obtained at a constant rate of increase of load up to a load level of approximately 30 % of the predicted maximum load capacity of the pole, which can be considered to be the nominal service load for the purpose of the test. This load shall be reached within (90 ± 30) s. If this load level exceeds the linear section of the load versus deflection curve, then that test pole shall be rejected and the load level shall be reduced for subsequent tests.

D.4.4 On the third loading cycle, the deflection measuring devices may be removed once the load reaches the nominal service load. The loading is then continued at a constant rate of increase, such that failure occurs within (300 ± 120) s or loading may continue to failure within the same total time period. The position and type of failure shall be recorded.

D.4.5 Maximum stress points are calculated at the ground-line cross-section and the cross-section where load Q_2 is applied.

D.4.6 After testing, the moisture content shall be determined for samples cut from close to the position of failure and values determined in accordance with 6.8. The location, type of specimens and method used shall be recorded.

D.5 Results

D.5.1 A value of modulus of elasticity shall be calculated using the following equation:

NOTE 1 The calculations are carried out using the theory of linear elasticity as a basis.

a) when the deflection is measured at the loading point Q_2, using Equation (D.1):

$$E = \frac{m_2 \times l_3}{3lI}\left[\left(l_1 + l_2\right)^2 l_3 + \left(l_1 \times l^2\right) - \left(l_1^3 \times l_3^2\right)\right] \quad \text{(D.1)}$$

where

$m_2 =$ the slope obtained from a linear regression of $\frac{Q_2}{s_2}$, and s_2 is the deflection at point Q_2.

b) when the deflection is measured at the mid-span of the pole, using Equation (D.2):

$$E = \frac{1}{48I \times s_{\text{mid}}}\left[\left(3l^2 a_1^2 - 4a_1^3\right) \times Q_1 + \left(3l^2 a_2^2 - 4a_2^3\right) \times Q_2\right] \quad \text{(D.2)}$$

where

s_{mid} = the deflection at the mid-span of the pole

$a_1 = l - l_1$

$a_2 = l - l_2 - l_1$

The variables in Equation (D.2) are shown in Figure D.1.

NOTE 2 For Equation (D.2) to apply, the following assumptions have been made:

a) the pole is circular in cross-section along its length;

b) the pole has a linear taper between the ground line and the point of load application;

c) the magnitude of deflection is small relative to the pole geometry, such that second-order effects can be ignored;

d) the pole has a constant and uniform modulus of elasticity.

D.5.2 Calculate the bending strength of the pole, f_{m}, using the following equation:

NOTE The calculations are carried out using the theory of linear elasticity as a basis.

a) when the stress is calculated at the loading point Q_2, using Equation (D.3):

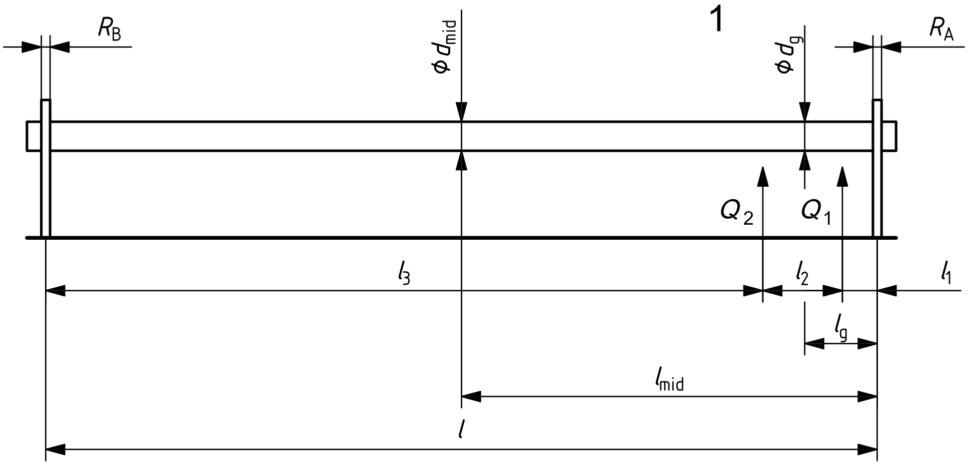
$$f_{\text{m}} = \frac{32\left[\left(l_1 + l_2\right) \times R_{\text{A}} - Q_1 \times l_2\right]}{\pi d_{Q2}{}^3} \quad \text{(D.3)}$$

where R_{A} is the reaction at the butt end of the pole = $Q_2 \times l_3 + Q_1 \times \frac{\left(l_2 + l_3\right)}{l}$

b) when the stress is calculated at the ground line of the pole, using Equation (D.4):

$$f_{\text{m}} = \frac{32\left[\left(l - l_{\text{g}}\right) \times R_{\text{B}} - \left(l_{\text{g}} - l_1\right) \times Q_2\right]}{\pi d_{Q,\text{mid}}{}^3} \quad \text{(D.4)}$$

where R_B is the reaction at the butt end of the pole = $Q_2 + Q_1 - R_A$



Key

1 normal ground line

Figure D.1 — Notation used in bending strength and modulus of elasticity calculations

D.6 Test report

D.6.1 General

The test report shall specify at least the following:

a) the details of the test material;

b) the test procedure;

c) the test results, as described in D.6.2 to D.6.4.

D.6.2 Test material

The following information shall be reported:

a) the species;

b) the length;

c) the butt nominal diameter;

d) the nominal diameter 1,5 m from butt, or at the assumed ground line;

e) the nominal diameter at load point;

f) the tip nominal diameter;

g) the assumed ground-line position;

h) the moisture content;

i) the type of preservation, the process used and penetration, where applicable;

j) the sampling procedure;

k) the location and size of strength-reducing characteristics within 300 mm either side of the failure zone;

l) the geographical region of pole population tested;

m) the maximum growth rate (i.e. minimum number of rings per 25 mm);

n) the ovality at points of nominal diameter measurement.

D.6.3 Test procedure

The following information shall be recorded:

a) the equipment used;

b) any other information that could have influenced the test results.

D.6.4 Test results

The following information shall be recorded:

a) the maximum load applied;

b) the bending strength;

c) the position of section of maximum stress;

d) the mode of failure;

e) the modulus of elasticity;

f) any other relevant information that could have influenced the results.

D.7 Example of suitable four-point bending test method

One means of performing this test is using a cable and winch system with the winch mounted on a low-friction trolley, such that it is free to move as the pole deflects. A typical arrangement is shown photographically in Figure D.2.

Figure D.2 — Example of four-point bending test procedure

Annex E
(normative)

Test method for bending properties — Three-point method proof test

E.1 Principle

E.1.1 The butt and tip of the pole under test are attached to the reaction frame. A single load is applied at mid-span, as shown in Figure E.1 as a proof load. The load is applied in a direction perpendicular to the original axis of the pole.

NOTE 1 As the direction of loading imposed on the pole in practice is not known, it is important that the value of f_m determined relates to the apparent weakest direction of the pole. A procedure for determining the direction of test is given in E.4.

NOTE 2 The test method is derived from SABS 754.

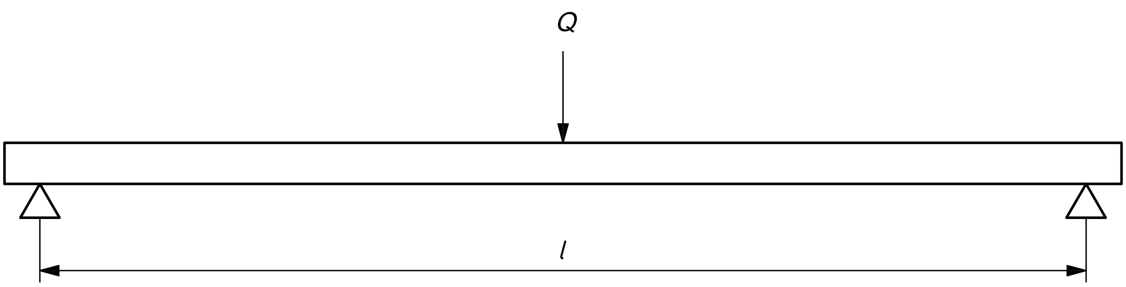


Figure E.1 — Example of three-point bending proof test procedure

E.2 Preparation

E.2.1 Prior to testing, the following data shall be measured and recorded:

a) the length of the pole in accordance with 5.3;

b) the circumference, measured to an accuracy of ±1 %, at the following positions:

   1) the butt;

   2) the mid-length of the pole;

   3) the tip;

c) the location and size of any strength-affecting characteristics, as defined in 5.5, including:

   1) decay and insects;

   2) straightness;

   3) knots;

4) mechanical damage;

5) slope of grain;

6) thickness of sapwood;

7) in barks and rind galls;

8) fissures;

9) ring and star shakes;

10) ovality.

NOTE Recording of the strength-reducing characteristics is required for the purpose of later verification that the poles tested for the determination of characteristic values are representative of the true population.

E.3 Apparatus

E.3.1 Two suitable anchorages, not capable of damaging the pole during the test and such that the distance between them can be adjusted to the appropriate test span, i.e. the length of the pole under test, less 600 mm or less 200 mm, as relevant (see E.5).

E.3.2 Suitable force applicator, positioned centrally between the anchorages, for example,

a) either a hydraulic or a pneumatic ram of adequate capacity and stroke, with a pressure foot of radius such as to fit the diameter at mid-length of the pole under test and not capable of damaging the pole during the test, or

b) a suitable winch and cable.

E.3.3 Force indicator or **recorder**, calibrated to indicate or record (as relevant), to within 2,5 %, the actual force applied to the pole.

E.3.4 Device for measuring and recording deflection (optional), to an accuracy of ±1 % of actual reading, installed at the midpoint of the pole length, if there is a requirement to determine the modulus of elasticity in accordance with E.5.2.

E.4 Procedure

E.4.1 The direction of test shall be determined before test by gently rolling the test pole on supports at the butt and tip to identify its “natural rest” position. The direction of test shall be such that the underside of the test pole in its “natural rest” position shall be in tension.

E.4.2 Position the pole under test in the apparatus such that the anchorages secure the pole at positions (300 ± 25) mm or (100 ± 25) mm (as relevant) from its ends and that, if the pole displays crook or sweep, the concave side of the crook or sweep faces towards the ram or the convex side of the crook/sweep faces towards the winch, as appropriate.

E.4.3 If a winch and cable is used, take up the slack and, without jerking the pole, apply force to the mid-length point of the pole. If a ram is used, extend the ram (without impacting the pole) until it touches the mid-length point of the pole. In each case, increase the force (gradually and at as uniform a rate as possible) until it reaches the appropriate value of f, calculated using the equation given in E.5.1. Then stop the test and release the force.

E.4.4 The pole is considered to be defective if any visible sign of failure is noted during the test.

E.5 Results

E.5.1 Proof strength

NOTE The calculations are carried out, using the theory of linear elasticity as a basis.

Calculate the proof load bending strength of the pole using Equation (E.1):

$$Q = \frac{f_m \times \pi \, d_{Q,mid}^3}{8 \times L} \tag{E.1}$$

where

Q is the force, in newtons, applied at mid-span required to cause the relevant proof fibre stress in midpoint loading;

f_m is the relevant fibre stress at mid-span, for example softwood can require a proof stress of 25 MPa, whereas hardwoods can require 75 MPa;

$d_{Q,mid}$ is the diameter of the pole at mid-length point, in millimetres, based on the specified minimum top diameter and a taper of 5 mm per metre of length;

L is the test span distance, in millimetres.

E.5.2 Modulus of elasticity

A value of modulus of elasticity, E, shall be calculated using Equation (E.2), when the deflection is measured at the mid-span of the pole:

$$E = \frac{Q}{s_{mid}} \times \frac{L^3}{48 \times I} \tag{E.2}$$

where

s_{mid} is the deflection at the mid-span of the pole;

L is the test span;

Q is the applied load at mid-span.

NOTE For Equation (E.2) to apply, the following assumptions have been made:

a) the pole is circular in cross-section along its length;

b) the pole has a linear taper between the ground line and the point of load application;

c) the magnitude of deflection is small relative to the pole geometry, such that second-order effects can be ignored;

d) the pole has a constant and uniform modulus of elasticity.

E.6 Test report

E.6.1 General

The test report shall specify at least the following:

a) the details of the test material;

b) the test procedure;

c) the test results, as described in D.6.2 to D.6.4.

E.6.2 Test material

The following information shall be reported:

a) the species;

b) the length;

c) the butt nominal diameter;

d) the nominal diameter at mid-span (load point);

e) the tip nominal diameter;

f) the assumed ground-line position;

g) the moisture content;

h) the type of preservation, the process used and penetration, where applicable;

i) the sampling procedure;

j) the location and size of strength-reducing characteristics within 300 mm either side of the failure zone;

k) the geographical region of pole population tested;

l) the maximum growth rate (i.e. minimum number of rings per 25 mm);

m) the ovality at points of nominal diameter measurement.

E.6.3 Test procedure

The following information shall be recorded:

a) the equipment used;

b) any other information that could have influenced the test results.

E.6.4 Test results

The following information shall be recorded:

a) the maximum load applied;

b) the bending stress at the proof load;

c) whether or not the pole passed or failed the proof load;

d) the modulus of elasticity (if required);

e) any other relevant information that could have influenced the results.

Annex F
(normative)

Determination of characteristic values

F.1 General

Characteristic values for poles shall be determined for moisture content levels exceeding the fibre saturation point (FSP) for each species. Poles for testing shall be conditioned to the FSP or greater. However, tests may be carried out at other levels of moisture content if sufficient data exist to adjust the results to the FSP.

NOTE Results from tests on poles with moisture contents higher than the FSP are similar and are acceptable.

Characteristic values for poles shall be determined after any mechanical processing prior to treatment (e.g. incising). Poles to be tested for characteristic values shall be tested in their final condition prior to preservation. Durable poles, used without preservative treatment, shall be tested in their ready-to-use condition.

The characteristic values shall be determined for poles of a stated population (species, source and grade) and of the standard size.

If it is evident from tests that mechanical properties vary with pole size, then mechanical properties for sizes of pole other than standard size may be determined by applying factors, supported by test evidence, to the characteristic values.

Sampling, testing and the calculation of characteristic values shall be repeated for each population if there is evidence to suggest that the characteristic values for the population are lower.

F.2 Sampling

Several samples of poles shall be selected from the population to represent the range of strength-reducing characteristics permitted by the grade and variations within the growth region. The number of samples shall depend on the size of the growth region and any known or suspected differences in the mechanical properties of poles obtained from different areas of that growth region. In particular, the pole taper shall be representative of the range used in service.

For the purposes of determining characteristic values, all poles in a sample shall be of the same size in accordance with 5.3 and of the same species in accordance with 5.2.

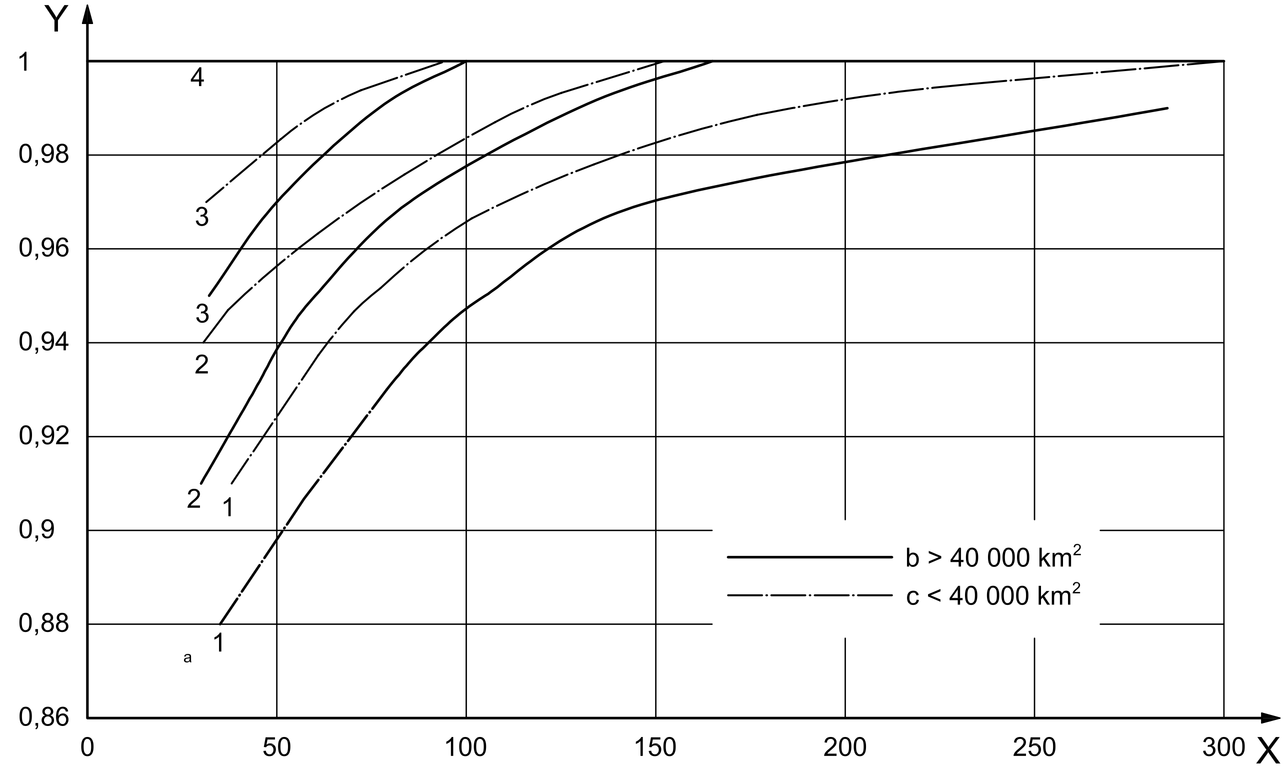
The number of poles in each sample shall be not less than 40.

F.3 Testing

F.3.1 General

Testing shall be carried out on standard-sized poles in accordance with Annex C, D or E, with the ground line at 1,5 m from the butt end. The characteristic values of bending strength and modulus of elasticity are calculated from the test results using a statistical factor "k" found from Figure F.1. This factor takes into account the size of the smallest sample, the number of samples and the nominal area of the forest from which the samples have been selected.

The use of alternative non-destructive test techniques is allowed, where sufficient test data exist to prove a satisfactory correlation to the results of the destructive test techniques described in Annex C, D or E.



Key

X size of smallest sample

Y value of *k*

[a] Number of samples.

[b] Large forest.

[c] Small forest.

Figure F.1 — The effect of the number of poles and samples on *k*

F.3.2 Bending strength

For each sample (based on a normal distribution) a 5-percentile value $f_{m,05}$ shall be obtained from Equation (F.1):

$$f_{m,05} = m(f_m) - 1,65\, s(f_m) \quad \text{(F.1)}$$

where

$m(f_m)$ is the mean value of the test results;

$s(f_m)$ is the standard deviation of the test results.

Alternatively, a log normal distribution can be analysed using the following equations:

The characteristic value, f_k, of a strength property shall be computed from Equation (F.2), namely,

$$f_k = k_s\, f_{05} \quad \text{(F.2)}$$

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The values of k_s and f_{05} shall be computed from the following Equations:

$$k_s = \left(1 - 1{,}1 V_R / \sqrt{n}\right) \quad \text{(F.3)}$$

$$f_{05} = \exp\left(\bar{y} - 1{,}645 S_y\right) \quad \text{(F.4)}$$

and

$$V_R = \sqrt{\exp\left(S_y^2\right) - 1} \quad \text{(F.5)}$$

$$S_y = \sqrt{\frac{1}{(n-1)} \sum_{i=1}^{n} \left[\ln\left(f_i\right) - \bar{y}\right]^2} \quad \text{(F.6)}$$

$$\bar{y} = \frac{1}{n} \sum_{i=1}^{n} \ln\left(f_i\right) \quad \text{(F.7)}$$

where

V_R is the co-efficient of variation of the complete test data;

n is the sample size;

S_Y is the standard deviation of the natural logarithms of the complete test data;

$\bar{y}$ is the arithmetic mean of the natural logarithms of the complete test data;

f_i is the i^{th} ranked strength value in the test data, in megapascals.

NOTE The computation of the sampling factor, k_s, is only valid for sample size, $n \geqslant 30$ where the confidence coefficient k_z = 1,1.

The characteristic value $f_{m,k}$ is then found from Equation (F.8):

$$f_{m,k} = k \times m(f_{m,05}) \quad \text{(F.8)}$$

where

$m(f_{m,05})$ is the mean, weighted according to sample size of the $f_{m,05}$ values for each sample;

k is defined by the C_V and the sample size.

F.3.3 Modulus of elasticity

The sample mean value of modulus of elasticity, $m(E)$, shall be calculated using Equation (F.9):

$$m(E) = \frac{\sum E_i}{n} \quad \text{(F.9)}$$

where E_i is the value of modulus of elasticity of sample "i" (in N/mm^2).

The characteristic value, E_{mean}, shall be calculated from Equation (F.10):

$$E_{mean} = \frac{\sum m(E)_j n_j}{\sum n_j} \quad (F.10)$$

where

n_j is the number of specimens in sample j;

$m(E)_j$ is the mean value of modulus of elasticity for sample j (in N/mm^2).

F.3.4 Test report

A written report giving details of the population, sampling, testing, analytical procedure and calculations shall be prepared for consideration for inclusion of each population.

Bibliography

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