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2018-10

Structural timber — Visual strength grading — Basic principles

Bois de structure — Classement visuelle selon la résistance — Principes de base

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by ISO/TC 165, *Timber structures*.

This second edition cancels and replaces the first edition (ISO 9709:2005), which has been technically revised. The main changes compared to the previous edition are as follows:

— general grading provisions have been moved to the main body from the annexes;

— Clause 7 has been technically revised;

— Annexes C and E have been added to provide additional guidance on the grading framework;

— a new Annex D on grading tropical hardwood timber has been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The general principle of this document is that any type of visual strength-grading procedure is acceptable, provided it is defined, controlled, and documented to the extent required to reflect the degree of certainty of structural properties intended for the structural application of the product. The body of this document specifies the essential features common to all visual strength-grading operations. The requirements are minimal so as to ensure maximum scope and flexibility in the application of a standard to the visual strength-grading process for timber. The annexes provide a detailed example of a conformance standard resulting in strength properties having a high degree of engineering reliability and a simple standard resulting in strength properties where a high degree of engineering reliability is not required, as well as a tropical timber example.

This document was based initially on the European Standard EN 518 and modified to bring it into conformance with ISO procedures and requirements.

The bibliography lists a number of additional standards referenced during the development of this document.

Structural timber — Visual strength grading — Basic principles

1 Scope

This document establishes the basic principles for rules and procedures governing the visual sorting of timber for use in structural applications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

ISO 24294, *Timber — Round and sawn timber — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13910 and ISO 24294 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
air dried timber
timber that has been dried by exposure to air without any artificial heating above 50 °C and has a moisture content in approximate equilibrium with the surrounding natural atmospheric conditions

3.2
compression wood
abnormal wood that forms on the underside of leaning and crooked coniferous trees

3.3
density
mass per unit volume expressed as kg/m^3 at a moisture content of 12 %

3.4
fissure
separation of the wood occurring at various locations in a piece of timber, classified in terms of its type, size and location

EXAMPLE Shake, check or split.

3.5
fungal decay
disintegration of the wood substance due to action of wood-destroying fungi

3.6
grade
population of timber derived from a specified resource and by applying a specified sorting procedure

3.7
heartwood
inner core of the tree, in some species with a different colour from the sapwood

Note 1 to entry: Boxed heart means heartwood is enclosed within the four surfaces of a piece of sawn timber at both ends.

3.8
insect damage
damage including pinholes and larger bore holes caused by insects

3.9
kiln dried timber
sawn timber that has been dried in a closed chamber in which the required moisture content is obtained by artificial heat and humidity control

3.10
knot
portion of a branch or limb that has become incorporated in a piece of timber, classified in terms of its type, size and location

EXAMPLE Sound, unsound or other types.

3.11
moisture condition
classification of timber wetness, based on measurement of the weight of water in wood expressed as a percentage of the weight of the oven-dry wood

3.12
pith
small soft core in the structural centre of a log

3.13
pocket
well-defined opening between the rings of annual growth which develops during the growth of the tree and typically contains resin or bark

3.14
rate of growth
classification of timber growth rings, expressed as the number of rings per unit width

3.15
sapstain
natural variation from the colour of the sapwood

3.16
sapwood
outer layer of wood between the bark and the heartwood

3.17
seasoned timber
dry timber
timber with moisture content of 19 % or less

3.18
slope of grain
deviation of the wood fibre direction from a line parallel to the edges of a piece of timber, expressed as the ratio of unit deviation to the unit of length over which it occurs

3.19
sound wood
wood that is free of decay

3.20
strength group
strength class
classification of timber based on particular characteristic values such as bending strength, density and mean modulus of elasticity parallel to the grain

3.21
structural requirements
grade requirements that affect the structural properties of the timber

Note 1 to entry: Structural features are: knots, slope of grain, fissures, and any other features that may cause a decrease in strength properties to an amount which threatens the serviceability of the piece.

3.22
thickness
lesser dimension perpendicular to the longitudinal axis of a piece of timber

3.23
unseasoned timber
timber with moisture content greater than 19 %

3.24
utility requirements
grade requirements that do not affect the structural properties of the timber to an extent that jeopardizes the serviceability of the piece

3.25
visual graded timber
sawn wood that has been sorted into structural or non-structural grades according to visual criteria

Note 1 to entry: The visual criteria identify visible physical features that affect timber strength, utility of the product and/or the visual quality of the product.

3.26
wane
lack of wood on any face or edge of a piece of sawn timber, including or not including bark

3.27
warping
any deviation from a true or plane surface including bow, crook, cupping or spring, twisting, or any combination thereof

EXAMPLE Bow, crook, cup or spring, twist.

3.28
white speck
white or brown pit or spot in wood caused by the "Fomes Pini" fungus that only develops in the living tree and does not develop further in service

3.29
width
greater dimension perpendicular to the longitudinal axis of a piece of timber

4 Symbols and abbreviated terms

For the purposes of this document, the symbols and abbreviated terms given in ISO 13910 apply.

5 General

5.1 Visual strength-graded timber

Visual strength-graded timber is sawn wood that has been sorted into structural or non-structural grades according to visual criteria. The visual criteria identify physical features that can affect timber strength.

5.2 Visual strength-grading operations

A typical visual strength-grading operation shall be comprised of a visual grader who sorts an input resource into one or more output grades (see Figure 1). A visual-grading machine shall be permitted to be used in place of the visual grader.

In addition to the structural requirements, any relevant non-structural or utility requirements shall also be specified.

NOTE Some of the timber might not meet the requirements of the minimum specified grade.

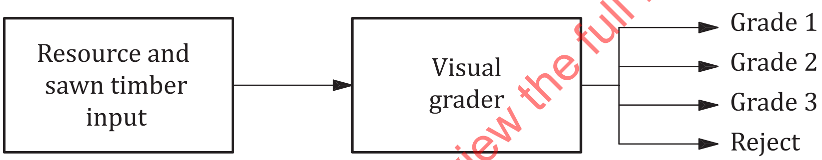


Figure 1 — Schematic of visual strength-grading operation

5.3 Visual strength-grading principles of quality control

Visual grading is one element of quality control operations. This document requires that the quality control related to the visual grading operation is undertaken by placing checks on the three components of the grading operation: 1) the resource and sawn timber inputs; 2) the visual sorting process; and 3) the graded timber output (see Figure 1).

NOTE In theory it is possible to control quality either

a) by control on the resource input and the visual sorting operation, or

b) by checks of the visual sorting operation and of the quality of the output grades.

However, in practice it is not feasible to rely solely on the checks on the output grades because of the high variability and complexity of timber, and because of the large sample sizes that are required to reliably measure the 5-percentile strength values.

6 Resource and sawn timber input requirements

6.1 General

The input resources shall be identified in terms of all parameters that can affect the output of the visual grade sorting operation.

6.2 Input requirements

6.2.1 Resource

The parameter that shall be identified is the timber species or mixture of species.

Other relevant parameters shall be identified, such as the following:

a) silvicultural practices used;

b) log source;

c) log size;

d) cutting pattern used to manufacture sawn timber from logs;

e) any other parameters deemed to be important.

6.2.2 Sawn timber

Parameters that shall be specified are:

a) condition (such as seasoned, unseasoned, etc.);

b) moisture content and moisture content range;

c) any other parameters deemed to be important.

6.3 Control of inputs

A periodic check on the resource and sawn timber inputs shall be defined and specified.

NOTE See ISO 12122-1 and ISO 12122-2 for information about the determination of structural properties.

6.4 Reprocessing of previously graded material

If major reprocessing of previously graded material is permitted, then any requirements for re-grading of the material shall be specified.

7 Visual strength-grading requirements

7.1 Grader requirements

The grader shall be qualified to grade timber accurately at the necessary operational speeds and to evaluate the visual quality of all grades and sizes that the grader will encounter in commercial visual grading operations.

7.2 Grading process

7.2.1 General

The grading process shall be specified. During grading, methods shall be in place to ensure that the timber species and the timber moisture content comply with the requirements specified.

The framework for the grading system shall be supported by evidence that it can provide a stable basis for delivering graded products that achieve key characteristic properties.

NOTE The detail required in the standard is directly related to the reliability of the stated structural properties. Annex A provides a detailed example of a conformance standard resulting in strength properties having a moderate to high degree of engineering reliability. Annex B provides an example of a conformance standard resulting in strength properties where a high degree of engineering reliability is not required. Annex D provides an example for tropical hardwoods.

7.3 Grading to satisfy structural requirements

7.3.1 Structural features

To ensure adequate structural properties, limitations shall be specified on one or more of the following features:

a) knots (type, size and location);

b) slope of grain;

c) rate of growth;

d) fissures (shake, checks, and/or splits);

e) moisture condition;

f) any other features that are deemed to be important.

7.3.2 Measurement of structural features

7.3.2.1 Knots

Knots shall be measured in a manner consistent with grading provisions.

NOTE Examples of knot measurement are shown in Annexes A, B and D.

7.3.2.2 Slope of grain

The slope of grain (see Figure 2) is assessed over a distance sufficiently great so as to avoid the influence of local deviations.

7.3.2.3 Rate of growth

To assess rate of growth, measurements shall be made on one end of the piece, and expressed as the average ring width in millimetres along a straight line 75 mm long normal to the growth rings, passing through the centre of the end of the pieces [see Figure 3 a]; or commencing 25 mm from the pith when it is present [see Figure 3 b]. When a line 75 mm in length is unobtainable, the measurements are to be made on the longest possible line normal to the growth rings and passing through the centre of the piece.

7.3.2.4 Fissures

Fissures shall be measured as illustrated in Figure 4.

7.3.2.5 Moisture condition

Moisture condition shall be determined in accordance with a specified standard.

7.3.2.6 Combinations of defects

Each of the defects listed will reduce the strength of a piece to the lowest permissible if present to the maximum extent allowed, even if no other type of defects is present. Where two or more defects, each of a size smaller than the maximum permitted, are present at the same place in a piece, the timber grader shall use his discretion to reject any piece that he believes will be weakened to a greater extent than would be caused by a single defect of the maximum size.

7.3.3 Framework for structural requirements

The provisions identified in 7.3.1 and 7.3.2 shall be supported by testing of samples from at least two reference grades containing a random selection of the permitted features, resulting in data on the mean modulus of elasticity and the 5th percentile of at least one strength property. This data shall be permitted to be used to formulate the structural grade model including other grades and sizes, provided it shows a consistent relationship for the reference grades.

NOTE The intent is to select reference grades and sample sizes that will serve best to represent the grades in the system, reflecting both the range and frequency of features that could appear in these grades and demonstrating that the grading system is robust enough to differentiate properties for the timber population. Annex C provides an example of a framework to support structural requirements.

7.4 Grading to satisfy the utility requirements

7.4.1 Utility features

To ensure adequate visual quality, limitations shall be specified on all relevant features, such as:

a) crookedness;

b) dimensions and tolerances;

c) fungal decay;

d) insect damage;

e) sapstain;

f) squareness;

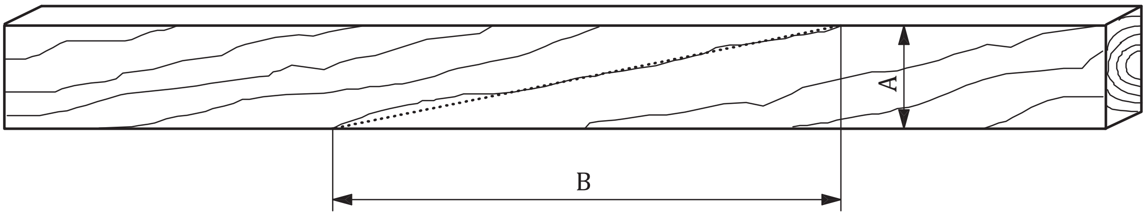
g) white speck;

h) any other features that are deemed to be important.

7.4.2 Measurement of utility features

7.4.2.1 Crookedness

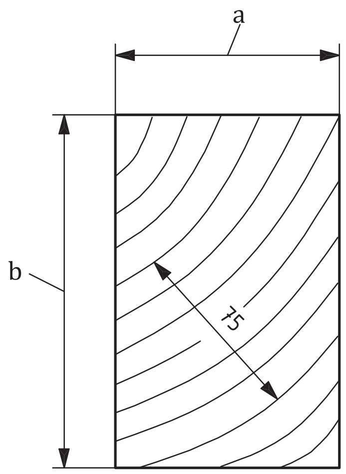
Bow, spring (or crook) and twist shall be assessed the entire length (see Figure 6). Longitudinal curvature in square section pieces shall be assessed using the limits for bow. Measurement shall be taken at the time of grading. Cupping shall be assessed across the width (see Figure 7).



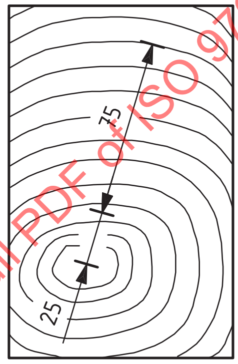
Key

1 slope of grain is A/B

Figure 2 — Measurement of slope of grain



a) Average ring width measurement, passing through the centre of the end of the piece

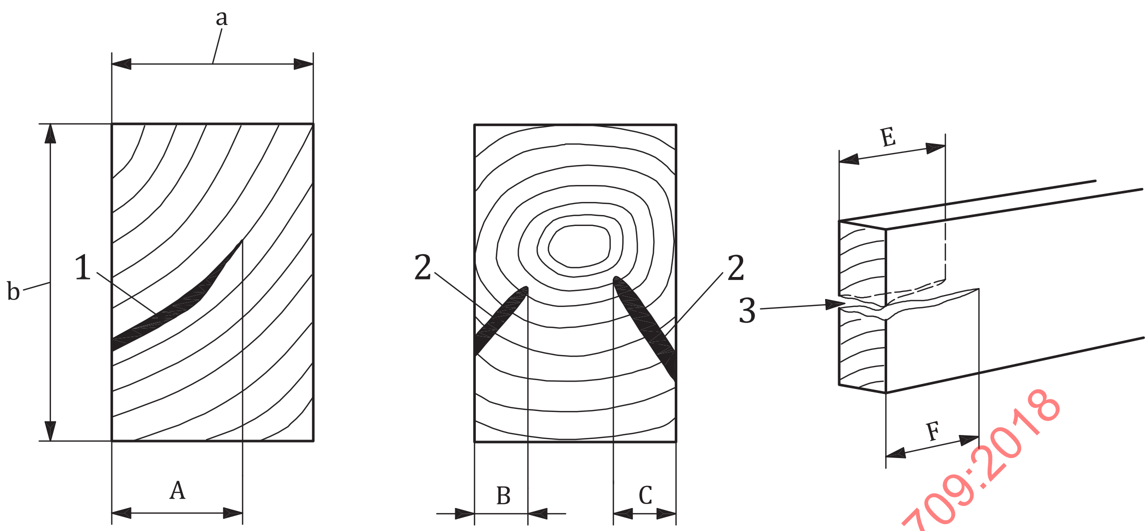


b) Average ring width measurement, commencing 25 mm from the pith when this is present

a Thickness.

b Width.

Figure 3 — Measurement of rate of growth



Key

1 shake; the length of the shake is A

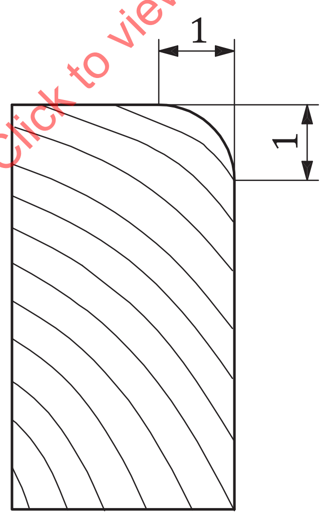
2 check; the length of the check is B + C

3 split; the length of the split is (E + F)/2

a Thickness.

b Width.

Figure 4 — Measurement of fissures



Key

1 wane

Figure 5 — Measurement of wane

7.4.2.2 Dimension and tolerances

The dimensions shall be measured in accordance with grading provisions. Wane shall be measured in relationship to affected timber faces (see Figure 5).

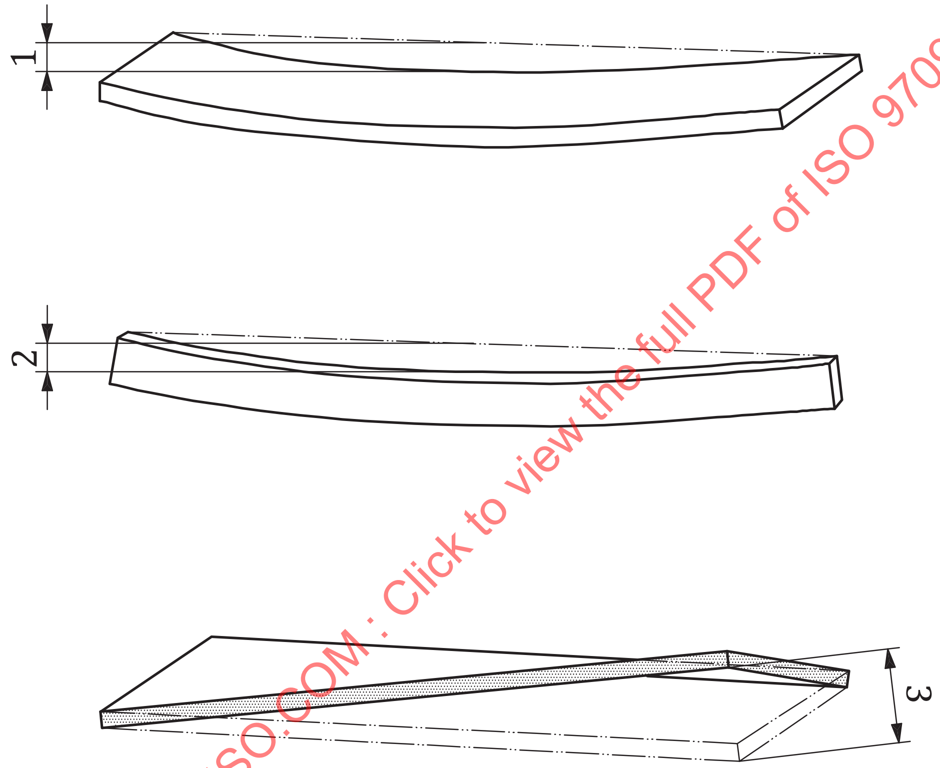
7.4.2.3 Other features

Other features shall be measured in accordance with grading provisions; however, any piece which contains defects that can cause a decrease in strength properties to an amount that threatens the serviceability of the piece, shall be excluded from the grades.

7.5 Check on visual grading process

A periodic check shall be required to assess the accuracy of the grading process. If a check indicates that the process is inadequate, then appropriate measures shall be specified to modify the process so that the process is adequate.

NOTE Annex E provides background information on training, supervision and oversight of grading.



Key

1 bow

2 spring (or crook)

3 twist

Figure 6 — Measurement of bow, spring (or crook) and twist

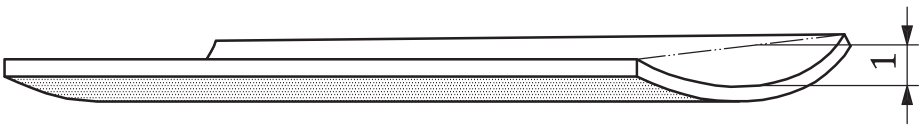


Figure 7 — Measurement of cupping

8 Visual graded timber structural properties

8.1 General

The structural properties of strength-graded timber shall be as defined and measured in the test methods in ISO 13910.

The structural design properties shall be determined from tests on timber having a defined moisture content. If the tests are conducted on timber having a moisture content that differs from that specified by the procedure conforming to this document, the properties resulting from the tests shall be adjusted (using sound engineering principles) so that the structural design properties reflect the intent of these basic requirements and/or the applicable associated design codes.

NOTE These structural properties could be incorporated in the visual strength-grading standard or could be in other appropriate standards referencing the grades determined using the criteria of the visual strength-grading standard.

8.2 Initial evaluation

Once the grading operation has been selected, evidence shall be provided that the resultant output grades have the structural properties stated for the material. The requirements for this test program shall be based on sound sampling principles as specified in ISO 12122-1 and ISO 12122-2, and the tests for the structural properties shall be based on the test procedures specified in 8.1.

For cases where such evidence is not available or it is not appropriate to link the evidence to other mills, an initial test program shall be specified.

NOTE In some cases, the evidence could be linked to other mills carrying out equivalent sorting procedures. For cases where a high degree of certainty of the structural properties is not required, then the structural properties of the material could be based on other mechanical or physical properties representative of the grade being evaluated, provided these properties have been defined and related to the test procedures as specified in 8.1 and continue to be used as the basis of the sorting process.

9 Product identification

A product identification mark on the timber shall be specified to indicate the document conforming to this document on which the sorting is based, the grade and/or strength class, and the producer responsible. The product identification mark shall also include any other relevant information required to show suitability for end use.

Each piece of timber shall be marked except for high quality strength-graded timber intended for appearance as well as structural purposes. For this high quality appearance timber, each shipment shall be accompanied by documentation containing the product identification requirements specified in the standard.

10 Documentation

Documentation requirements shall include:

a) the standard on which the visual strength-grading process is based;

b) specifications of the resource input;

c) specifications of the visual grade sorting process;

d) specifications for the timber grade criteria;

e) methods for assigning and confirming a grade;

f) specifications for the identification of the product.

Documentation requirements shall also include, where relevant to the process and product:

g) control checks of the resource input;

h) control checks of the visual grade sorting process;

i) specifications and control checks of the structural properties;

j) materials identifying the allocation of responsibilities for quality control operations;

k) other specifications or materials deemed to be important.

Annex A
(informative)

Example of a visual strength-grading timber standard — based on the need for design values where a degree of certainty of structural properties is required

This is one of a number of possible systems provided as an example only – not a system proposed for universal usage. This example is a practical implementation of the visual strength-grading principles defined in the main body of this document, as applied to the following case:

— rectangular cross-section timber;

— for structural applications;

— requiring strength characteristic values with a moderate to high degree of engineering reliability.

The layout corresponds to that of an International Standard to clearly show how an International Standard in this domain should look. It includes both

— structural elements (scope, normative references, terms and definitions, symbols and abbreviated terms, requirements, sampling, test methods), and

— supplementary informative elements (bibliography).

Informative annexes (like this Annex A) and normative annexes may also form part of an International Standard. Although some of this Annex is written in mandatory language for illustration purposes, it is not a normative part of this document.

A.1 Scope

This annex provides an example of the grading procedures for producing visually sorted strength and stiffness graded rectangular timber for structural applications requiring strength characteristic values with a moderate to high degree of engineering reliability.

It is applicable for timber that is graded in the seasoned state.

It could be applicable for timber that is graded in the unseasoned state providing the structural design properties for the timber are modified to reflect the intent of this standard and/or to the associated design codes.

A.2 Normative references

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

ISO 9709, *Structural timber — Visual strength grading — Basic principles*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

A.3 Terms and definitions

For the purposes of this annex, the terms and definitions in Clause 3 and the following apply.

A.3.1
knot area ratio
KAR
ratio of the sum of the cross-sectional knots to the cross-sectional area of a piece of timber

A.3.2
margin knot area ratio
MKAR
ratio of the projected cross-sectional area of all knots intersected by the margin areas of the piece

A.3.3
total knot area ratio
TKAR
ratio of the projected cross-sectional areas of all knots intersected by the total cross-sectional area of the piece

Other features such as bow, cup, fissures, knots, rate of growth, slope of grain, spring (or crook), twist and wane should be defined in the appropriate subclauses and by referencing the features to an illustration.

A.4 Symbols

E modulus of elasticity

f strength

N sample size

CV coefficient of variation

A.5 General

A.5.1 Visual strength-grading operations

The visual strength-grading operation shall be comprised of one or more visual graders who sort an input resource into two output grades. Some of the timber may not meet the requirements of the minimum grade.

Structural and utility requirements are specified for the visual strength-graded timber.

A.5.2 Principles of quality control

The visual strength-grading is one element of the quality control operations. This standard requires that the quality control be undertaken by placing checks on the three components of the strength-grading operation: the resource input, the visual grade sorting, and the graded timber output.

A.6 Resource input requirements

The input resource shall be defined in terms of all parameters that may affect the output of the visual grade sorting operation.

Parameters that shall be defined are

a) timber species or mixture of species,

b) log source,

c) log size,

d) silvicultural practices used,

e) cutting pattern used to manufacture sawn timber from logs,

f) seasoning condition at the time of visual grade sorting, and

g) moisture content.

Limits on resource parameters shall be stated in a quality manual.

A.7 Visual properties

A.7.1 Grader requirements

The grader shall be qualified to grade timber to the requirements of this standard at the necessary operational speeds and to evaluate the visual quality and sizes being manufactured.

A.7.2 Visual grading requirements

A.7.2.1 Definitions of features

In addition to the features defined in Clauses 3 and 7, the size of a knot is assessed by the knot area ratio (KAR) (see A.3.1 and Figure A.1). In addition, the location of a knot is defined in terms of edge, face and margin areas (see Figure A.2).

Two types of knot area ratios are defined:

— the margin knot area ratio (MKAR) (see A.3.2);

— the total knot area ratio (TKAR) (see A.3.3).

Fissures are measured as illustrated in Figure 4.

The slope of grain (see Figure 2) is assessed over a distance sufficiently great so as to avoid the influence of local deviations.

To assess rate of growth, measurements are made on one end of the piece, and expressed as the average ring width in millimetres along a straight line 75 mm long normal to the growth rings, passing through the centre of the end of the pieces [see Figure 3 a]; or commencing 25 mm from the pith when it is present [see Figure 3 b]. When a line 75 mm in length is unobtainable, the measurements are to be made on the longest possible line normal to the growth rings and passing through the centre of the piece.

A.7.2.2 Limits for structural features

The following limitations shall be applied so as to meet the visual grade structural requirements.

Table A.1 provides the limits for ensuring adequate structural properties. Two visual strength grades, denoted by G1 and G2, are specified. To qualify for a grade, a piece shall not contain characteristics which exceed the limits given in Table A.1.

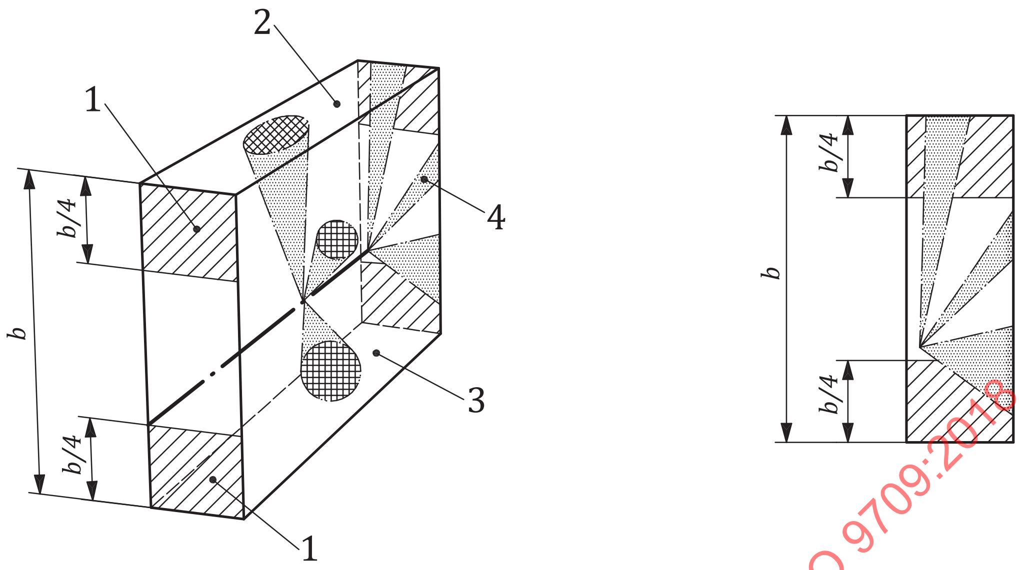
Sapstain is not a structural defect and shall be acceptable without limitation.

Any piece which contains defects such as compression wood, insect damage, fungal decay (not sapstain), physical damage, combinations of knots and/or other characteristics, which can cause a decrease in strength properties to an amount which threatens the serviceability of the piece, shall be excluded from the grades.

It shall be permissible for pieces to be accepted, where the reduction in strength caused by the abnormal defect or damage is obviously less than that caused by the defects admitted by the grade, subject to the provision that these abnormal defects are of a type which will not progress after conversion and drying, e.g. white speck derived from the standing tree.

Table A.1 — Grade limits for ensuring structural properties for G1 and G2 grades

Feature	Feature limit	
	Grade G1	Grade G2
Limitation on knot sizes	Either MKAR > 1/2 TKAR ≤ 1/2 or MKAR ≤ 1/2 TKAR ≤ 1/2	Either MKAR ≤ 1/2 TKAR ≤ 1/3 or MKAR > 1/2 TKAR ≤ 1/4
Slope of grain	1 in 6	1 in 10
Average width of annual rings (rate of growth)	≤10 mm	≤6 mm
Fissures — not through thickness	unlimited	$L/2$
Fissures — through thickness	≤600 mm	$2b$
Pockets (resin pockets and bark pockets)	Unlimited if shorter than half width of piece, otherwise same limits as for size of fissures	
NOTE L is the length of piece b s the width of piece TKAR is the total knot area ratio MKAR is the margin knot area ratio		



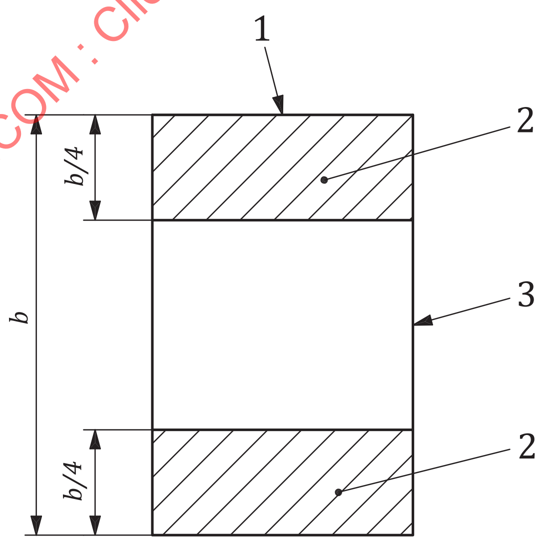
a) Axonometric view, showing a group of knots and their projection on a cross-section plane

b) Front view of projection plane showing projection of knots

Key

1 margin
2 edge
3 face
4 plane of projection

Figure A.1 — Illustration of knot projection area



Key

1 edge
2 margin area
3 face

Figure A.2 — Illustration of edge, face and margin areas

A.7.2.3 Limits for utility features

The following limitations shall be applied to meet the visual grade utility requirements:

a) knot on wide face — maximum 1/2 width;

b) thickness and width — 0 mm to +2 mm;

c) squareness — ±2 degrees;

d) wane (see Figure 5) — maximum 1/3 of width of either face;

e) bow (see Figure 6) — maximum 5 mm per meter of length;

f) spring (or crook) (see Figure 6) — maximum 4 mm per metre of length;

g) twist (see Figure 6) — maximum 1 mm per 25 mm of width per metre of length;

h) cupping (see Figure 7) — maximum 1 mm per 50 mm of width.

A.7.3 Check on visual grading process

During each production shift a check shall be made to assess the accuracy of the grading process. This shall be done by visually regrading a sample of graded timber. The pass criterion is that not more than 5 % of the pieces fall below grade and that not more than 20 % of the pieces fail the utility limitations.

If the checks indicate that the process is inadequate, then appropriate measures shall be undertaken to modify the process.

A.8 Structural properties

A.8.1 General

The critical properties of visual strength-graded timber are structural properties. These properties are defined and measured as specified in ISO 13910, in accordance with the principles of ISO 12122-1 and ISO 12122-2.

NOTE ISO 9709 principles identify that the structural properties could be incorporated in the visual strength-grading standard or could be in other appropriate standards referencing the grades determined using the criteria of the visual strength-grading standard. This annex incorporates structural properties in its grade criteria.

A.8.2 Initial evaluation

Once the visual grading operation has been selected, evidence shall be provided that the resultant output grades have the required structural properties. This evidence shall be through direct measurement of structural properties of full-size timber (see A.8.1) or through the equivalent data from other equivalent grading operations.

Initial evaluation procedures by case are given below.

a) For the case where a strength-grading operation in a mill commences with a grade-sorting procedure and input resource that are equivalent to those already existing in other mills, no special initial evaluation is required as the evaluation data obtained from the other mills may be cited as initial evidence of properties of the graded timber.

b) For the case where an existing grade-sorting procedure is applied to a new species and/or a new mixture of species, then measurements of the graded material shall be made at least for bending and tension strength and modulus of elasticity.

   1) All grades and at least two sizes spanning the range of commercial material to be produced should be evaluated.

   2) Other structural properties may be deduced from relationships observed in other similar species or mixtures of species.

c) For the case of a new grade-sorting procedure, all specified grade properties and all grades shall be assessed.

   1) For material having a limited range of sizes, then all sizes shall be evaluated.

   2) For material having three or more widths and/or two or more thicknesses, then it shall be sufficient to limit the evaluation to three widths and two thicknesses providing the widths and thicknesses evaluated are representative of the overall range of sizes available.

A.9 Product identification

Except for exceptional circumstances where the end use of the timber may require marking to be omitted for aesthetic reasons and where the customer specifically requests/orders timber to be free of marks, timber shall be marked to identify:

a) reference to this standard;

b) producer responsible;

c) grade;

d) certification body;

e) timber condition (moisture content at the time of grading);

f) species or species mixture (group) and origin (growth range).

Figure A.3 provides a visual reference of a mark providing this required information.

For those cases where the customer specifically requests/orders timber free of marks, each parcel/package of timber of a single grade/strength class shall be dispatched under the cover of a certificate of compliance stating the following information:

g) serial name and date of the certificate;

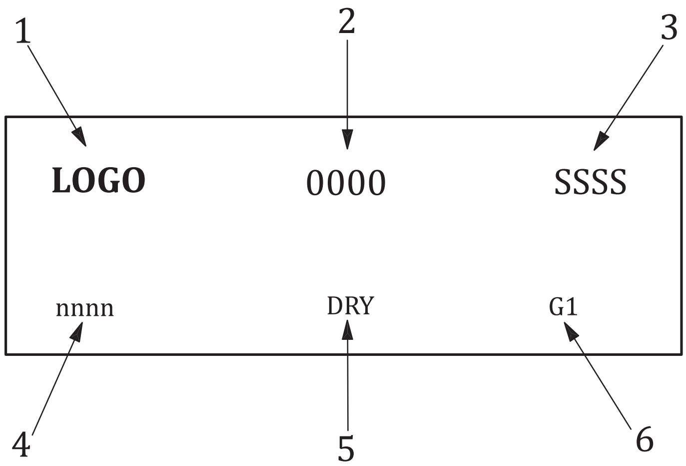
h) customer's name and address;

i) customer's purchase or order number;

j) species or species mixture (species group), grade, and dimensions and quantities, grade;

k) reference to this document, timber condition (moisture content at the time of grading, and date the timber was graded);

l) signature of the operator or of the grader.



Key

1 certification body LOGO or MARK
2 grader and/or company reference
3 species or species group
4 standard reference (a reference to this example standard)
5 timber condition (as defined in this example standard, i.e. seasoned, dry, or unseasoned)
6 grade (see Table A.1, i.e. G1 or G2)

Figure A.3 — Example of a mark on visually strength-graded timber

A.10 Documentation

A quality manual shall include the following:

a) specifications of the resource input;

b) this document, i.e. ISO XXXX;

c) definition of the grade sorting process;

d) specifications of the structural and utility requirements;

e) specifications on controls for the grade sorting process;

f) specifications on the methods used to initially and periodically evaluate the properties of the timber;

g) specifications on control checks of graded timber;

h) specifications of the information marked on the timber, or where applicable for timber ordered free of marks specifications for the certificate of compliance accompanying each parcel/package of timber;

i) allocation of responsibilities for quality control operations;

j) specifications used by the certification body.

Annex B
(informative)

Example of a visual strength-grading timber standard based on the need for design values where a high degree of certainty of structural properties is *not* required

This is one of a number of possible systems provided as an example only – not a system proposed for universal usage. This example is a practical implementation of the visual strength-grading principles defined in the main body of this document, as applied to the following case:

— rectangular timber;

— for structural applications;

— where a high degree of engineering reliability is not required.

The layout corresponds to that of an International Standard to clearly show how an International Standard in this domain should look. It includes both

— structural elements (scope, terms and definitions, symbols and abbreviated terms, requirements, sampling, test methods), and

— supplementary informative elements (bibliography).

Informative annexes (like this Annex B) and normative annexes may also form part of an International Standard. Although some of this Annex is written in mandatory language for illustration purposes, it is not a normative part of this document.

B.1 Scope

This annex specifies the grading procedures for producing visually sorted strength and stiffness graded rectangular timber for structural applications where a high degree of engineering reliability is not required.

B.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this annex. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 9709, *Structural timber — Visual strength grading — Basic principles*

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

B.3 Terms and definitions

For the purposes of this annex, the terms and definitions in Clause 3 apply.

B.4 General

B.4.1 Visual strength-grading operations

The visual strength-grading operation shall be comprised of a visual grader who sorts an input resource into four output grades. Some of the timber may not meet the requirements of the minimum grade.

B.4.2 Principles of quality control

This standard requires that the quality control be undertaken by placing checks on the resource input, the visual grade sorting, and the graded timber output.

B.5 Resource input requirements

The input resource shall be defined in terms of timber species or mixture of species, log size, log source and the sawn timber's moisture condition and content.

B.6 Strength-grading requirements

B.6.1 Limits for grade sorting

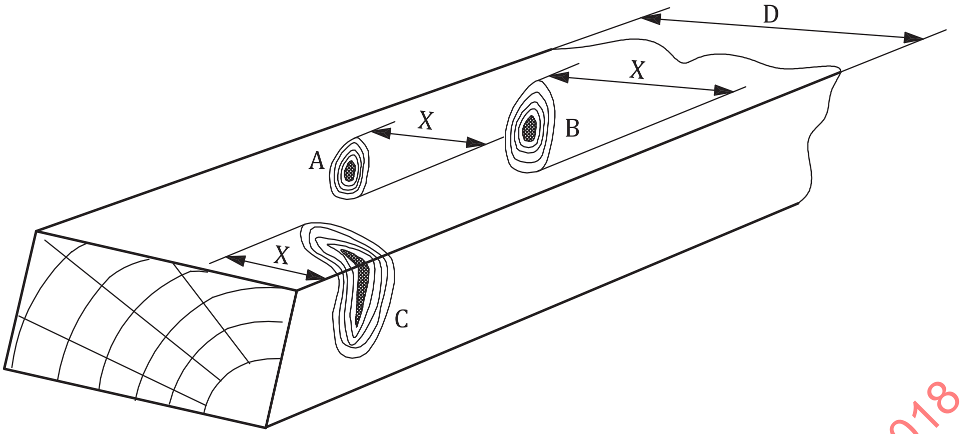
B.6.1.1 For structural purposes

The acceptable limits on features for grade GG−3, are given in Table B.1 and illustrated in Figure B.1.

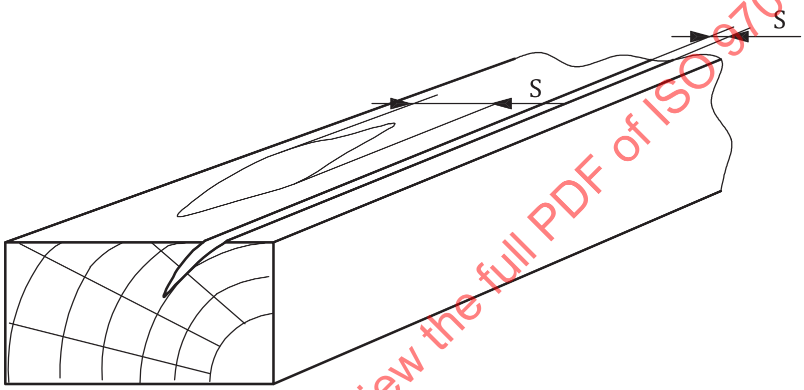
Table B.1 — Sorting limits for structural grade GG-3

Sorting feature	Feature limit Grade GG−3
Width of knot size and pockets[a]	1/2 surface
Slope of grain	1 in 5
Length of splits and resin veins	3 times width of timber
Pith	none

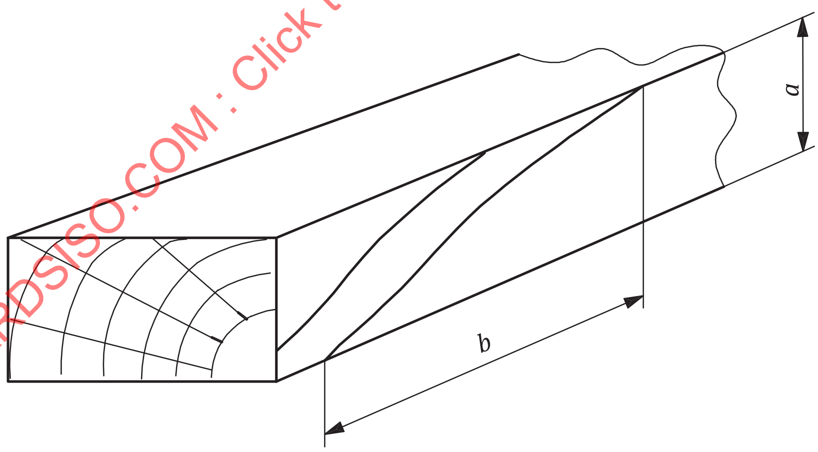
[a] Check all four surfaces.



a) Knot size



b) Width of pocket



c) Slope of grain

Key

X knot size

S width of pocket

a/b slope of grain

Figure B.1 — Method of measurement of structural features

B.6.1.2 For utility purposes

No pith is permitted.

The spring (or crook) of the timber shall be measured as indicated in Figure 6 and shall not exceed 10 mm per meter of length of the timber.

B.6.2 Check on grading process

During each production shift some check shall be made to assess the accuracy of the grade sorting process.

B.7 Structural properties

B.7.1 General

The structural properties are defined and measured as specified in ISO 13910.

NOTE ISO 9709 principles identify that the structural properties may be incorporated in the visual strength-grading standard or may be in other appropriate standards referencing the grades determined using the criteria of the visual strength-grading standard. This annex incorporates the criteria used to define characteristic values of the structural properties but does not list the properties.

B.7.2 Initial evaluation

The timber species (or species mixture) shall be classified according to its density as stated in Table B.2. Density shall be measured on pieces of full cross-section cut from clear wood from the structural timber. A minimum sample of 10 specimens shall be used. The specimens shall be selected at random. The average value shall be used for classification purposes.

Table B.2 — Classification limits for clear wood density

Mean density at 12 % moisture content (kg/m^3)	Species class
400	IC – 1
600	IC – 2
800	IC – 3
1 000	IC – 4

B.8 Product identification

Timber shall be marked to indicate reference to this standard, the grade (GG-3) and the species class (IC-1, IC-2, IC-3, or IC-4), and the producer responsible.

B.9 Documentation

A quality manual shall include:

a) specifications of the resource;

b) this standard;

c) the grade sorting process;

d) timber grade specifications;

e) mark specifications.

Annex C
(informative)

Example of a framework for structural grading provisions

C.1 General

This Annex illustrates a framework for standardizing the development of grading rules for producing visually sorted and graded rectangular timber for structural applications. This is an example of a practical implementation of the visual strength-grading principles defined in the main body of ISO 9709 including evidence that the grading rules are appropriate for producing structural timbers.

C.2 Framework example

One way of standardizing the grading of wood features that affect structural properties is as follows:

1) Determine the proportion of solid wood displaced by the feature (see knot area ratio in Annex A);

2) Use a mathematical model to calculate the effect the displacement has on a structural property;

3) Apply displacement limitations to a grade to achieve a targeted level of structural performance.

This approach has helped to define equivalency for different types of wood features (e.g., edge and centreline knots). It has also provided a rationale for allowing larger sizes of knots in wider timbers without compromising the grade definition; this is an important practical consideration due to the frequency of larger knot sizes in bigger timbers.

The framework has also offered a basis for evaluating the actual wood features in comparison with the grade limits. Knowledge of how the features affect timber strength can guide the application of the grading rule.

C.3 Model considerations

The mathematical model used to calculate the effect of wood features on a property is usually based on a "strength ratio," which is defined in various sources as the ratio of the capacity of a piece with features to the capacity of a piece without features. This has been a useful concept because it not only provides a framework for the limitations placed on grades of timber, but also provides the basis for determination of structural properties using test data on small, clear pieces of wood.

In-grade testing has raised some issues with applications of the strength ratio concept. The strength ratio method combined with using small clear wood data is less precise than using tests of commercially graded timber to establish structural properties, and property relationships between grades and sizes need further correction to match data from tests of commercially graded timber.

But problems associated with applying the strength ratio concept to structural properties do not invalidate the use of strength ratios in setting up a grading framework. The question of whether the model is anchored firmly in the clear wood database is not overly important because the strength ratio concept can still provide a useful scale for setting grade limitations. The effects on property relationships of grade definitions for different sizes of timber are more concerning; however, it is still possible to modify property relationships in design procedures (e.g., using size or grade factors).

The correlation between strength ratios and structural properties is apparent but weak in overall populations of graded timber. This is due partly to the nature of wood: the location of features along a piece of timber, the variability of hidden features like density. It's also due partly to grading and manufacturing factors: how closely the grade limitations are followed, and what other limitations are placed on production and sorting.

If the strength ratio model is to form the basis for the grading system, then it needs to be supported by evidence that it can provide a stable framework for maintaining key characteristic properties in spite of the challenges identified above. The key characteristic properties are the 5^{th} percentile value (for strength) and mean value (for stiffness) for a grade.

C.4 Implementation

The model can be implemented in different ways to achieve a desired level of structural performance. For example,

— Option A: The model is used to apply identical grade limitations (knot sizes, slope of grain) to all populations of species, grades and sizes.

— Option B: The model is used to apply varying grade limitations to different populations of species, grades and sizes.

Option A has the advantage of being a practical approach for administering a grade rule system across species and regions. A disadvantage is that it may result in many different structural design values, which can be confusing to end users. Also, not all species and/or grades will exhibit the same wood features, so there needs to be some flexibility in applying the grading rule to all populations.

Option B has the advantage of being an efficient way to establish common structural design values for a structural class system covering a wide range of species and grades. A disadvantage is that it is difficult to administer from the point of view of inspection and enforcement, which could be a concern for the stability of the grading system. It may be possible for Option B to evolve from Option A for selected grades and species groups.

Grading rules will result in grades that include pieces with a wide variation of features. Some populations will be strongly affected by features in the wood, whereas others may be less affected by these features. Some timber may require special rules limiting features such as growth rate and percentage of summerwood. Also, some features may not affect properties at all. The grading rules and production practices, including combinations of grades or species, will dictate how many subpopulations of timber with similar wood features need to be checked.

The test of the example described in C.2 is in applying the framework to a matrix of timber species, grades and sizes, then comparing the strength property relationships between benchmark cells of the matrix. (see Table C.1). The benchmark cells are key grades with clearly differentiated structural features, facilitating the setting up of a grade model that can include other grades for practical purposes and a size model that can include other sizes as well.

Table C.1 — Example of Relationships for 5^{th} percentile bending strength

Timber size	Grade 1 (Select Structural)	Grade 2 (No.2 Grade)
	Ratio[1]	Ratio[1]
38 mm × 89 mm	1,00	0,64
38 mm × 184 mm	0,71	0,46
38 mm × 235 mm	0,66	0,42

NOTE 1 Ratios are expressed relative to the value at Size 1 of Grade 1.

NOTE 2 Based on In-Grade data for major North American timber species, tested at a constant span-to-depth ratio (17:1).

Where Option A is chosen for the implementation strategy, all included species should be shown to share comparable grade and size relationships within acceptable bounds. The resulting grade and/or size models need to be consistent or they cannot be implemented in a meaningful way in design standards. If the ratios shown in Table C.1 are average values, they can be expected to vary across species, but if this variation is too great the grade rule framework may need to be reassessed.

Where Option B is chosen, the grade and size relationships are defined *a priori* to be identical, so the implementation task becomes a matter of demonstrating that common structural properties are achievable across the range of included species.

A comprehensive set of grading rules (e.g., Annex A) will need a larger sample size to achieve an acceptable result in terms of support for implementation. If the rules are targeting square edge produce with a fairly narrow range of a particular defect (e.g., Annex B) a smaller sample size may be sufficient. The latter might be possible if the objective is to develop a grade model for specific knot configurations. The results of this testing will help confirm that later testing of commercially graded timber is representative for the grading system.

C.5 Variability and the grading rule

The structural property data that is used to put a grading rule framework in place is assumed to be representative of the timber population as a whole. To validate this assumption, it is important to look into the sources and magnitude of variability in sample data.

For stiffness properties like the modulus of elasticity, the stability of the mean property over time is of greatest importance. This is relatively easy to check because the assumption of normality is generally found to be appropriate and there are statistical tools to evaluate its consistency.

For strength properties like bending or tension strength, the influence of the grading rule on the lower tail of the property distribution is of the greatest significance. Observations from large scale in-grade studies confirm that assumptions of normality may not be appropriate for estimating strength properties, and that assuming an underlying distribution and relying on small sample estimates of the mean and variability around the mean may not always be a reliable predictor of the lower tail statistics.

The strengths of the weaker pieces in a distribution depend also on the sampling of strength-related and non-strength-related wood features defined in the grading rule; for example, their frequency of occurrence within and between pieces, and their potential for reducing strength or stiffness. How the population is generated and sampled will influence the types of wood features present in the sample. This should be carefully considered when judging whether or not the sample contains a sufficiently representative cross-section of wood features to adequately assess a grading rule.

From a reliability perspective, the important test is whether an appropriate coefficient of variation on the lower part of the strength distribution can be achieved, so that there will be some stability in the property relationships between benchmark grades and sizes. A statistical distribution fitted to the data from the lower tails should be used; a distribution such as 2-parameter Weibull can be used to represent the subpopulation. C. Other distributions may not be appropriate as they can be shown to go beyond the data.

The most important question for a structural product is whether future random samples will have consistent properties given the normal temporal variation in the input. This is why multiple independent samples are better than a large sample from a single source to characterize a population.

C.6 Periodic review

If there is a reason to expect that the initial grading rule framework may no longer be representative of current production (e.g. due to changes to the forest resource, production practices, or marketing practices) there will be a need for direct measurement of the structural properties of full-size timber. Ongoing monitoring and evaluation are an essential parts of structural timber production but are beyond the scope of this document.

In any case, the grading rules will need to be reviewed and updated periodically. Some circumstances can change the frequency of wood features that influence structural properties in the overall population.

Examples of such circumstances are resource changes due to disease or restriction, or widespread selection of timber for new market destinations. The result of such changes can be non-conformance in either product utility or structural capacity, or both.

To respond to a condition of non-conformance, it may be necessary to alter grade specifications, change the method of processing or restrict the resource that can be processed. Where the evaluation indicates the need for an adjustment to some or all structural properties, reassessment of the timber population should be in accordance with ISO 12122-1 and ISO 12122-2.

Annex D
(informative)

Example of visual strength grading for tropical hardwood timber

This is one of a number of possible systems provided as an example only – not a system proposed for universal usage. This example is a practical implementation of the visual strength-grading principles defined in the main body of this document, as applied to the following case:

— rectangular timber;

— for structural applications;

— applicable to tropical hardwoods.

The layout corresponds to that of an International Standard to clearly show how an International Standard in this domain should look. It includes both

— structural elements (scope, terms and definitions, symbols and abbreviated terms, requirements, sampling, test methods), and

— supplementary informative elements (bibliography).

Informative annexes (like this Annex D) and normative annexes may also form part of an International Standard. Although some of this annex is written in mandatory language for illustration purposes, it is not a normative part of this document.

D.1 Scope

This annex provides an example of grading tropical hardwood timber visually for structural use. The timber shall at least be surface dry. For tropical hardwoods, the permissible limits of characteristics for a single visual strength grade of timber are specified, designated Select Structural Grade, Standard Structural Grade, Common Building Grade and Hardwood Structural Grade.

D.2 Normative reference

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this annex. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13910, *Timber structures — Strength graded timber — Test methods for structural properties*

ISO 12122-1, *Timber structures — Determination of characteristic values — Part 1: Basic requirements*

ISO 12122-2, *Timber structures — Determination of characteristic values — Part 2: Sawn timber*

D.3 Terms and definition

For the purposes of this annex, the terms and definitions in Clause 3 and the following apply.

D.3.1
bare sawn
sawn timber that measures, at the time of inspection, the same as the dimensions specified

D.3.2
brittle heart
defective core of a log, characterised by abnormal brittleness

D.3.3
compression failure
fractures across the grain in which the fibres are broken transversely or are crushed by compression

D.3.4
included phloem
strands or zones of abnormal and often very hard tissue occurring in some timbers caused by abnormal development of the cambium

D.3.5
surface dry
condition of sawn timber which has been partially air dried so that the surfaces appear and feel dry, also known as skin dry

D.4 Strength graded timber

D.4.1 Visual strength-grading operations

The visual strength-grading operation shall be comprised of a visual grader who sorts an input resource into four output grades. Some of the timber may not meet the requirements of the minimum grade.

D.4.2 Principles of quality control

This standard requires that the quality control be undertaken by placing checks on the resource input, the visual grade sorting, and the graded timber output.

D.4.3 Resource input requirements

D.4.3.1 General

The input resource shall be defined in terms of timber species or mixture of species, log size, log source and the sawn timber's moisture condition and content.

D.4.3.2 Seasoning

Timber shall be on stickers, under covers for a period of time sufficient to reach a surface dry condition.

D.4.3.3 Sizes

Unless otherwise specified, timber graded to this standard shall conform to a specified standard with respect to permissible deviations and processing reductions applicable to construction timber. It shall have a minimum cross-sectional area of 600 mm^2.

D.4.4 Processed timber

If the grading has been carried out before processing, provided the processing reduction from the target size is not greater than 3 mm on sizes less than or equal to 100 mm, or not greater than 5 mm on sizes greater than 100 mm, the grade shall not be considered to have been changed. The standard timber sizes for structural use shall be specified.