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Timber structures — Structural classification for sawn timber

Structures en bois — Classification structurelle pour bois sciés

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Foreword

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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).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 165, *Timber structures.*

Introduction

The production of many different combinations of species and grades complicates timber specification and structural design. Structural classification groups together species and grades of similar properties, to make them interchangeable for structural purposes. The development of this International Standard is intended to benefit industry, consumers, governments and distributors, by balancing the principles of simplicity, product utility and structural reliability.

One of the key reasons for developing this International Standard is to provide a framework for understanding and working on compatibility between approaches used in different regions, through standardization of the basic elements of structural classes, including underlying assumptions and the general method for setting up classes. An example table is presented in Annex B for illustration purposes.

This International Standard provides a model or template that may be modified before adoption and it does not present final design values and adjustment factors. The scope includes evaluation of structural properties; it does not cover suitability with regard to durability, fire resistance and other timber properties.

Timber structures — Structural classification for sawn timber

1 Scope

This International Standard provides a basic international framework for establishing structural classes for sawn timber.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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*

3 Terms and definitions

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

3.1
characteristic value
standard estimate of a structural property of a *timber population* (3.11) corresponding to a fractile, tolerance limit or mean of sample test data after being adjusted to accepted reference conditions

3.2
derived property
structural property for which characteristic values are determined by correlation with one or more primary properties, and not typically used in deciding how to classify a population

3.3
design value
numerical quantity assigned to a timber population for use in structural design, calculated from the characteristic value and modified to suit provisions in the appropriate building code and standards

Note 1 to entry: Design values are not used directly in structural classes.

3.4
full-size specimen
timber test piece that is similar in size and characteristics to typical structural timbers and is prepared and tested in a way similar to use in construction

Note 1 to entry: See also *small clear specimen* (3.7).

3.5
normalization
adjustment of data, beyond basic data breakdown and moisture and size corrections, to be on a compatible basis with other data for evaluation in the same structural class system

3.6
primary property
structural property that is used to set criteria for allocating a timber population to a structural class system, based on the characteristic value for that property

3.7
small clear specimen
timber test piece that is much smaller than typical structural timbers and normally prepared to be free of visible defects

Note 1 to entry: See also *full-size specimen* (3.4).

3.8
species combination
two or more species or multiple data sets of the same species from different growth or production regions, combined into a single marketing group on the basis of similar properties and property relationships, or other applicable criteria

3.9
grade
solid sawn timber population produced with standardized rules that maintain well-defined limits on strength-controlling characteristics or properties

3.10
structural classification
system for assigning shared structural properties to timber populations of similar capacities, for the purpose of structural design and specification

3.11
timber population
solid sawn timber product of a grade and species or species combination intended for use in structural applications

4 Timber population and structural property data

This International Standard is based on the timber population and structural property data estimates conforming to those identified in ISO 12122-1 and ISO 12122-2.

NOTE See Annex A for additional information.

5 Primary properties

5.1 Framework

Primary properties shall be established on a standardized basis to ensure compatibility between different sets of test data from accepted sampling and testing programs. Primary characteristic properties include the following:

— bending strength: the modulus of rupture at the 5th percentile, with specified level of confidence;

— bending stiffness: the modulus of elasticity at the mean and 5th percentile levels;

— density: the density at the mean and 5th percentile levels.

NOTE 1 Strength properties are typically estimated as tolerance limits at the 5th percentile level with confidence specified at 75 %. Stiffness and density properties are typically estimated as either means or percentiles without a confidence statement, or as tolerance limits with confidence specified at 75 %.

NOTE 2 An alternative approach is to use axial (tension) strength instead of bending strength as a primary property. Some representative testing standards for primary properties are identified in the Bibliography.

5.2 Bending or tension property evaluation

5.2.1 General

Primary bending property data or, where applicable, tension property data shall be evaluated as characteristic values determined on the basis of standardized full-size specimen testing, except as permitted in 5.2.2.

5.2.2 Exception

Where it is necessary to evaluate bending or tension property data on a basis other than full-size testing, the data shall be supported by but not combined or interchanged with full-size testing results.

NOTE Although full-size timber testing is preferred, small clear specimen testing is used in cases where full-size bending or tension testing is not feasible or practical, with modification factors to partially calibrate the data in accordance with characteristic value standards, and subject to a review of consistency in the level of safety between small clear and full-size testing approaches (see Annex C).

5.3 Density evaluation

Density property data shall be evaluated as characteristic values determined on the basis of standardized small clear wood specimen testing.

NOTE ISO 13910 provides a standardized approach to evaluating density properties.

5.4 Class boundaries

Class boundaries for primary bending or tension strength properties shall be set at intervals of no less than 2 MPa.

6 Derived properties

6.1 Framework

Derived properties shall be established on the basis of standardized relationships to one or more of the primary properties provided that it can be demonstrated that these relationships are generally applicable to the timber population.

Derived strength and stiffness properties for structural classes shall include properties other than the primary strength and stiffness properties and shall be expressed on the same basis as primary properties (See NOTES to 5.1).

6.2 Evaluation

6.2.1 General

Derived properties shall be assigned as characteristic values determined on the basis of standardized relationships identified in 6.1 or, where further evidence of compliance is required, evaluated in accordance with the alternative method in 6.2.2.

6.2.2 Exception

Where derived properties are to be evaluated or corroborated by testing, they shall be evaluated on a standardized basis to ensure compatibility between different sets of test data from accepted sampling and test programs. Bending or tension property data used to evaluate derived properties shall be determined as characteristic values on the basis of standardized full-size specimen testing, except as permitted in 5.2.2.

NOTE Ongoing monitoring or quality control testing is sometimes used to demonstrate suitability for cases involving new or modified products or grading systems.

7 Allocation to a class

7.1 Framework

7.1.1 General

A timber population shall be qualified to be allocated to a class if the characteristic values for the primary properties equal or exceed the tabulated class values. In addition, where derived properties are to be evaluated or corroborated by testing, the population shall be qualified to be allocated to a class only if its characteristic values for such properties also equal or exceed the tabulated class values, except as provided in 7.1.2.

7.1.2 Normalization of characteristic values

Prior to allocation to a class, characteristic values for data sets derived following standard methods for sampling the timber population and evaluating the primary properties shall be permitted to be normalized to account for documented differences in property estimation as well as the dispersion in data sets around the characteristic value.

NOTE 1 This requirement is based on the assumption that a uniform approach will be applied to structural property modification for each or all structural classes to achieve a desired level of safety. Timber from grading systems or processes that are very different can require the use of normalization factors to calibrate characteristic values (see Annex C) to ensure that products allocated to a class demonstrate a consistent level of structural performance in end use.

NOTE 2 A different basis for sampling and deriving characteristic values (such as the use of small clear specimens versus samples of full-size commercial production) will yield different levels of dispersion in the data set as well as characteristic values. These differences require the development of different data set adjustments; for example, see Annex C for a comparison between the small clear and full-size specimen approach.

7.2 Grading systems

7.2.1 General

Structural classes shall be permitted to include timber populations from different grading systems provided that these populations fit within the established framework of structural property relationships.

NOTE An example of a structural classification framework appears in Annex B.

7.2.2 Exception

Where timber populations from different grading systems have significantly different structural property relationships or levels of variability, they shall be allocated either under separate classification systems, or in accordance with rules addressing these differences through appropriate adjustments to properties or grading processes.

7.3 Design values

This International Standard is based on the assumption that any structural property modifications made to establish design values in building codes and design standards will be consistent with the data and assumptions used to allocate populations to structural classes.

NOTE The body adopting a structural class system can also decide to incorporate individual species-grade design values in appropriate codes or standards as an alternative approach to structural class design values.

8 Reporting

Timber population and data estimates, sampling, test procedures and adjustments to data and structural class allocation shall be recorded and included in a report.

NOTE Other factors to be considered in setting up and implementing a structural classification system are identified in Annex C.

Annex A
(normative)

Timber population and structural property data

A.1 Resource

This International Standard is applicable only to timber populations with the following characteristics.

— The population is a defined forest region managed with a goal of maintaining similar or improved characteristics in the future. Where properties or property relationships differ substantively from the resource in other regions, i.e. resource of the same species or from other members of the classification system, this is noted and represented appropriately in the sample data.

— The population is defined in terms of species or combination of species, geographical origin and other relevant traits. Geographical origin means the overall growth region supplying all included mills in the broadest sense, except where the source is explicitly restricted. Where subdivisions of the same species or species combination have been identified, all relevant boundaries or differences between these subdivisions are defined.

— Long experience of a grading system is desired for the population, and any significant changes in the resource or production process will be reviewed prior to data evaluation. Grading systems may produce significantly different property relationships or variability in relationships, requiring special review: to show them to be compatible or to be treated differently from other grading systems.

— Test samples are representative of the population following the selected sampling strategy that either a) includes as much variation as possible or b) focuses on the lower end of the structural property distribution, and the selected approach is carried forward to analysis.

A.2 Test data

This International Standard is applicable only to data sets with the following characteristics.

— All major property data are based on standardized full-size testing of graded timber, with exceptions for cases where consideration of small clear wood test data are necessary and supported by evidence from experience in relationship to structural performance, and this data are kept separate from data from full-size in-grade sampling and testing programs.

— Data sets for size-grade categories are made as stable and consistent as possible by means of a comprehensive strategy considering natural variation, grading provisions, the sampling plan and quality control procedures.

— A representative sample matrix of sizes and grades, unless shown to be unnecessary, is used to ensure a stable data set (an exception may be ongoing testing through quality control procedures). Stratified sampling plans are another way of approaching data stability. Sample sizes are selected to match the data strategy.

— Each individual sample (e.g. of a timber size) is adequate to achieve precision targets. Pooling of data are done following a standardized approach, not to make up for deficiencies in individual cell sample sizes. Improper representation at the cell level is not compensated for by pooling from different test programs.

— Data are adjusted to a reference moisture content, size and other appropriate conditions using standardized procedures (see Bibliography).

— Where data are fit to parametric distributions, the test data show a reasonable fit in the distributional region of interest.

A.3 Species and species combinations

This International Standard is applicable only to structural classes with the following provisions for species.

— The population consists of species and grades of designated products with structural applications. Separate structural class tables are permitted to be used for species that differ significantly in properties or property relationships, such as softwoods—hardwoods. Species with similar properties and property relationships are permitted to be grouped into combinations for marketing purposes.

— All relevant boundaries or differences (e.g. geographic, topological, climatic or by provenance) are defined and recorded, particularly where subdivisions of the same species or species combination have been identified.

— In cases where there is limited experience with species, species varieties or specific resource subgroups, evidence is gathered on compatibility of properties and property relationships with the classification framework.

— Where the resource consists largely of plantation timber, or where the resource is immature or substantively different from other members of the class system or from other resource of the same species, this is noted as a minimum and represented appropriately in the sample data. Alternatively, if the database is limited, the application of the structural class is also limited.

A.4 Size

This International Standard is applicable only to structural classes with the following provisions for member size.

— The system is formulated on the basis of a specific characteristic value size.

— Adjustment factors are used to modify values for different timber sizes. These adjustment factors are comparable to factors used to evaluate raw data in the development of characteristic values, or steps are taken to ensure compatibility.

— The effects of moisture content on timber size and capacity are accommodated in a manner comparable to how they are accommodated with raw data in the development of characteristic values, or steps are taken to ensure compatibility.

— In cases where the sample matrix does not incorporate sizes that could be produced or that are implied in the structural class system, further review is undertaken before the population is allocated to a class.

— Ongoing quality control testing is permitted to be used to demonstrate consistency for a given size-grade, particularly for machine grading systems.

A.5 Grading systems

This International Standard is applicable only to structural classes with the following provisions for grading systems.

— The population is produced using a well-defined and stable grading system.

— For visual grading systems, grade characteristics are standardized and interpreted in a consistent manner. Any significant change in grading provisions or interpretations is examined as to potential impacts on properties or property relationships.

— For other cases, such as machine-graded timber systems, the properties and property relationships may be maintained through a standardized process and quality system, or there are specified steps to ensure that the critical properties stay in control.

— For cases involving new or modified grading systems, further review is undertaken before the population is allocated to a class. Ongoing monitoring or quality control testing may be used to demonstrate suitability for a given population.

Annex B
(informative)

Structural class example table

B.1 Structural class example 1: Softwood species (150 mm width basis)

Table B.1 — Structural class example for softwood species (150 mm width basis)

	S10	S16	S20	S24	S28	S32	S36	S40
Bending (MPa) $F_{m,k}$	**10**	**16**	**20**	**24**	**28**	**32**	**36**	**40**
Tension parallel (MPa) $F_{t,0,k}$	5	8	11	13	15	17	19	21
Tension perp. (MPa) $F_{t,90,k}$	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Compression parallel (MPa) $F_{c,0,k}$	13	17	19	21	22	22	23	24
Compression perp. (MPa) $F_{c,90,k}$	2	2,5	3	3,5	3,5	4	4,5	5
Shear parallel (MPa) $F_{v,k}$	1,5	2,5	2,5	3	3	3,5	3,5	3,5
Mean MOE parallel (GPa) $E_{0,mean}$	**7**	**8,5**	**9,5**	**10,5**	**11,5**	**12,5**	**13,5**	**14,5**
Density (g/cm^3) $\rho_{mean, oven-dry}$	**0,33**	**0,36**	**0,39**	**0,41**	**0,44**	**0,46**	**0,49**	**0,51**

NOTE This softwood timber example is for illustration purposes only, and structural classes can be added or removed to adjust to standardization requirements.

B.2 Derivation assumptions

Any example will be based on some method of establishing properties, and the selected method influences the relationship between properties as well as the allocation of species and grades to classes. Properties in Table B.1 are based largely on ASTM standards and related technical documents; however, the properties and relationships can be compared to other standards as well.

Primary properties appear in bold print in the table. The table is based on the assumption that bending strength, modulus of elasticity and density will be designated as primary properties. Property divisions are spaced to sustain distinct end uses and reproducibility in class allocation.

The bending properties are based on random location of defects in the test span for determining both strength and MOE, in accordance with the ASTM approach. Density is determined on the basis of specific gravity, i.e. oven-dry mass and volume, and is expressed as a mean value. Conversion information is shown in B.3.

Mean MOE is correlated linearly to the bending strength characteristic value, $F_{m,k}$, as follows:

$$MOE = 250\ (F_{m,k}) + 4\ 500 \qquad \text{[units in MPa]}$$

This is an average relationship for a timber population of mid-range dimension for typical grades, sampled and tested with the maximum strength-reducing characteristics located randomly in the test span.

Density is based on relationships in North American and EN standards following the form:

$$\rho_{\ mean} = 0{,}025\ (\text{MOE in GPa}) + 0{,}15 \qquad \text{[units in g/cm}^3\text{]}$$

This is density calculated on the basis of oven-dry moisture content for mass and volume (specific gravity), but it can be converted to other moisture content bases where required. Also, where required, a 5th percentile value can be calculated assuming a normal distribution and a specified coefficient of variation.

Other properties are derived from the primary properties. Tension and compression parallel to grain properties are based on trends found in North American timber data, similar to trends found elsewhere (see ISO TC 165 report N632). The formulae have been reduced slightly from mean trends to accommodate variation in the relationship. For tension parallel to grain, the formula is as follows:

$$F_{t,0,k} = 0{,}53\ (F_{m,k}) \qquad \text{[units in MPa]}$$

For compression parallel to grain, the formula is as follows:

$$F_{c,0,k} = F_{m,k}\ (1{,}7 - 4{,}6 \times 10^{-2}\ (F_{m,k}) + 4{,}6 \times 10^{-4}\ (F_{m,k})^2) \qquad \text{[units in MPa]}$$

These relationships are representative for most softwood species. If full-size data are judged to justify a higher value, this data can also be used.

Testing and analysis methods for other properties can vary significantly in different standards, so these properties are more difficult to assess. The compression perpendicular property in the table is used in typical applications such as bearing at the ends of bending members, based on the approach used in ASTM standards for mean stress at 1 mm deformation. Shear values in the table are comparable to those determined in ASTM standards for typical softwood species, and tension perpendicular values are based on shear values in accordance with practice in several North American timber standards.

The values shown in the table for compression perpendicular have been derived from density values, a common practice in this case using the following ASTM relationship:

$$F_{c,90,mean} = 1{,}7\ (15\ (\rho_{\ mean}\ \text{in g/cm}^3) - 3{,}3) \qquad \text{[units in MPa]}$$

The 5th percentile is calculated assuming a normal distribution and 20 % coefficient of variation. The resulting value was rounded to the nearest 0,5 MPa to express the degree of precision.

The shear values are based on a relationship to bending values (see ISO TC 165 N632) and are then rounded to the nearest 0,5 MPa to express the degree of precision. The relationship is as follows:

$$F_{v,k} = F_{m,k}\ (0{,}20 - 4{,}3 \times 10^{-3}\ (F_{m,k}) + 4{,}0 \times 10^{-5}\ (F_{m,k})^2) \qquad \text{[units in MPa]}$$

Tension perpendicular to grain is based on one-third of the lowest shear value in the table, in accordance with provisions in North American timber design standards.

In summary, the resulting structural class Table B.1 is built on principles of distinct end uses, reasonable class allocation and reproducibility in property assessment. The bending classes differ generally by 4 MPa, tension by 2 MPa to 3 MPa, and MOE by 1 GPa. Structural capacities that are higher or modified in some way are also possible and can be dealt with separately. The lowest class is provided to be inclusive of lower-strength or lower-grade timbers that are in occasional use in construction.

Any example of a SC table will require some adjustment before adoption to ensure appropriate safety and consideration of the variables discussed above. The table is an example of the principles and assumptions provided to ISO TC 165 in developing the Structural Class Standard.

B.3 Relationship to other standards

Table B.1 is based on B.2 derivation assumptions associated with ASTM standards and related documents. The following information is provided to assist in conversions between this approach and other structural class standards such as EN 338.

— Bending strength:

The ASTM random location of maximum strength-reducing defects in the test span results in a higher strength estimate compared to the EN testing method of placing these defects in the central third of the span, and the bending strength difference is estimated to range from 5 % for high strength timbers to about 15 % for lower strength timbers. On the other hand, the EN statistical method of calculating characteristic values results in higher strength property estimates. A review by Rouger in 2004 (ISO TC 165 N418) suggested that these counterbalancing differences are approximately equal.

Note that different characteristic sizes in the EN and ASTM approaches (150 mm vs. 184 mm) and target moisture contents (12 % vs. 15 %) are further potential sources of difference, but they can be accounted for by appropriate data adjustments.

— Modulus of Elasticity:

Bending test differences also influence MOE properties, so MOE tends to be somewhat lower in EN standards compared to ASTM standards (Note that the different target moisture contents have the opposite effect.). Test reports suggest that the magnitude of the test method difference is in the range of 5 % for lower stiffness material and insignificant for higher stiffness material.

— Tension Parallel to Grain:

Relationships between tension and bending strength are generally expressed as a constant ratio although it can vary for different timber species. The ratio in EN 338 is 0,6, while ASTM D1990 provides 0,45 as a lower boundary for untested species. The ratio used in this example for softwoods is 0,53, i.e. lower than the mean trend but higher than the absolute lower limit.

— Compression Parallel to Grain:

The relationship between compression and bending strength is expressed as a polynomial equation in ASTM D1990. In EN 338 it is expressed as a power equation with an exponent of 0,45. The polynomial formula used in Table B.1 in this International Standard gives results that are somewhat higher than the ASTM D1990 equation, which serves as a lower boundary for untested species. On average, the resulting compression values in the table are the same as in EN 338, although individual values can vary by 2 % to 3 %.

— Compression Perpendicular to Grain:

Compared to compression perpendicular strength results determined by an ASTM standard deformation limit, results based on the EN standard method tend to be about 30 % lower for softwoods (ISO 13910). This is due primarily to the test method that provides for partial bearing contact in ASTM and full bearing contact in EN standards. The properties may be modified further in published values.

— Shear:

Compared to shear strength results determined by the ASTM standard method, results based on the EN standard method are estimated to be one-third higher for softwoods (ISO 13910). This is due primarily to differences in test specimens and methodology. The properties may be modified in published values.

— Tension Perpendicular to Grain:

Although derived from different test methods, tension perpendicular to grain strength values in most timber standards are lower bound limits and so the characteristic properties are not significantly different from an end use perspective. This lower bound approach is taken due to the weak and brittle nature of the property.

— Density:

The ASTM density value (i.e. specific gravity) is based on both mass and volume at oven-dry moisture content, whereas the EN density value is based on mass and volume at 12 % moisture content. Therefore, the EN values are 6 % higher than the ASTM values. Also, EN 338 also uses a 5th percentile estimate of density as the characteristic value; while the values in Table B.1 are mean values, they can be converted to comparable 5th percentile values by dividing by 1,2.

B.4 Structural class example 2: Hardwood species (150 mm width basis)

Table B.2 is based on the same guiding principles as the softwood table, with some adjustments to account for the different range of properties and property relationships.

Table B.2 — Structural class example for hardwood species (150 mm width basis)

	H14	**H18**	**H24**	**H30**	**H40**	**H50**	**H60**	**H70**
Bending (MPa) $F_{m,k}$	**14**	**18**	**24**	**30**	**40**	**50**	**60**	**70**
Tension parallel (MPa) $F_{t,0,k}$	7	9	12	15	20	25	30	35
Tension perp. (MPa) $F_{t,90,k}$	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6
Compression parallel (MPa) $F_{c,0,k}$	16	18	21	22	24	28	35	41
Compression perp. (MPa) $F_{c,90,k}$	4	4,5	5,5	6,5	8	9,5	11	12,5
Shear parallel (MPa) $F_{v,k}$	2	2,5	3	3	3,5	4,5	5	6,5
Mean MOE parallel (GPa) $E_{0,mean}$	**8**	**8,5**	**10**	**11**	**13**	**15**	**17**	**19**
Density (g/cm^3) $\rho_{mean, oven-dry}$	**0,46**	**0,48**	**0,55**	**0,60**	**0,69**	**0,78**	**0,87**	**0,96**

NOTE 1 This hardwood timber example is for illustration purposes only, and structural classes can be added or removed to adjust to standardization requirements.

NOTE 2

— MOE = 200 ($F_{m,k}$) + 5 000 [units in MPa]

— ρ_{mean} = 0,045 (MOE in GPa) + 0,1 [units in g/cm^3]

— $F_{t,0,k} = 0{,}5\ (F_{m,k})$ [units in MPa]

— $F_{c,0,k} = F_{m,k}\ (1{,}7 - 4{,}6 \times 10^{-2}\ (F_{m,k}) + 4{,}6 \times 10^{-4}\ (F_{m,k})^2)$[a] [units in MPa]

— $F_{c,90,mean} = 1{,}7\ (15\ (\rho_{mean}$ in g/cm$^3) - 3{,}3)$ [units in MPa]

— $F_{v,k} = F_{m,k}\ (0{,}20 - 4{,}3 \times 10^{-3}\ (F_{m,k}) + 4{,}0 \times 10^{-5}\ (F_{m,k})^2)$ [units in MPa]

— $F_{t,90,k} = 0{,}6$ [units in MPa]

[a] $F_{c,0,k}$ not permitted to be greater than 0,59 ($F_{m,k}$).

Annex C
(informative)

Commentary

C.1 Scope

The overall goal of Structural classification is to simplify the design process. This International Standard is intended to provide a general framework for setting up a classification system, highlighting choices that influence the overall balance of simplification, product utility and structural reliability in the system. The choices will depend on how the system is to be used, with conditions to maintain integrity of the system.

This International Standard does not attempt to standardize or harmonize characteristic properties, since that is an initiative of another Working Group and beyond the scope of this effort; however, it makes assumptions about the way characteristic values are determined and related to each other. Additional information about the application of this International Standard appears in the Introduction.

C.2 References

This International Standard references the ISO characteristic value standard for timber structural property estimates. In addition, Annex A and the Bibliography includes some background information and key national or regional standards on the subject.

C.3 Terms and definitions

The definition of timber is intended to reflect international usage, although in North America, "timber" refers to larger members. The focus of this International Standard is primarily on members with a thickness no less than 30 mm and no greater than 105 mm ("dimension lumber" in North American terms); however, this does not exclude application to other appropriate sizes. Where this International Standard is applied to large timbers based on small clear-wood testing, the database is not directly comparable to full-size specimen testing databases. Where this International Standard is applied to thinner pieces (less than 30 mm), it may be necessary to determine whether the failure modes for test specimens remain consistent, or if bending strength is limited by cross-grain rolling shear failures.

C.4 Timber population and property data estimates

The timber population is generally defined in terms of species or species combination and grade. Estimates for strength determination are defined as characteristic values, on a basis that needs to be compatible with the classification system.

The work on structural classification systems can be divided into two steps: forming a structural class system, and allocating entries to the system. The evaluation and comparability of test data from different sources is assessed before both steps. Ongoing work on determining characteristic values is critical to this effort. Characteristic values define the basis for placing data on a common scale. However, both formation and allocation may present data challenges even when starting from characteristic values.

Some sampling strategies focus on selecting maximum strength-reducing characteristics, while others seek a random selection of the full range of characteristics. Sampling should be conducted in accordance with standard practices and the resulting data assessed accordingly, as summarized in the appropriate characteristic value standard. Test method requirements and test variables need to be reviewed in setting up and allocating populations to classes.

Population data estimates are based on the assumption of standardized approaches not only for sampling and testing a population, but also for review of resulting data. Data modelling, for example, involves many decisions that can affect the evaluation of properties. Nonparametric statistics are often used to characterize timber data where timber populations are represented by large samples of a matrix of sizes and grades. Sometimes it is preferable to use parametric statistics to model test data. It is essential that the distribution is a good fit to the relevant part of the distribution, particularly at the characteristic value level.

Timber grading systems can influence relationships between grades, sizes and properties. That is why structural class systems are based on the assumption of long experience of use. While ISO 9709:2005, Annex A identifies examples of grading and evaluation provisions where a high degree of certainty about structural properties is required, and ISO 13912 provides features of machine grading systems that are common to all operations, there is not enough detail in these product standards to fully specify the prerequisites of grading systems. National or regional product standards are key supports for class systems.

A sample matrix is recommended for the purpose of detecting, and if necessary, correcting for relationship anomalies. This is also why it is preferable to have full-size test data for all major properties: i.e. bending, tension and compression parallel to grain. In the context of this International Standard, full-size specimen testing (see definition in 3.4) refers to a comprehensive program that evaluates property relationships between timber sizes and grades, as well as species. This involves testing large representative samples of several size-grade categories. For this reason, full-size data are not directly comparable to small clear-wood specimen data (see also C.7).

Current structural class systems are formulated for a specific size, typically the characteristic value size. Adjustment factors are used to modify values for different timber sizes. This makes it possible to determine properties for a range of sizes and grades, provided the test samples representative range of sizes for each grade. The final adjustment factors are typically derived from evaluation of a range of data sets, each based on test samples graded according to various commercial timber grading systems.

Some of the variation in size relationships for different species and grading systems is disregarded in the interest of simplifying the design and specification process. It may need to be revisited, however, for new or modified grading systems. The suitability of combining data from different studies, also known as data pooling, is a potential source of error without review of program and data compatibility.

Machine-graded timber processes have inherent structural class systems that are typically based on a size-grade category of interest rather than a matrix of sizes and grades. This may be addressed in a machine grading process through quality control testing to augment and strengthen the online process. Although machine grading is often specific to a given mill process, it may be possible to assess and manage the overall production of a machine-graded population for purposes of design value assignment.

C.5 Primary properties

The relationship between bending strength (MOR) and stiffness (MOE) is fundamental to structural classes. The relationship is not only used to lay out primary properties but also serves as the basis for other relationships with derived properties, to quantify the rest of the values for the class system.

The MOE-MOR relationship is typically assumed to be a function of a measured correlation but each distribution can be very different; and while MOE is characterized by both a mean and a lower fractile, MOR is characterized by a lower fractile only. Therefore, database and distribution assumptions can influence the relationship.

Because MOR varies with size and MOE is assumed to be size-independent, the relationship is typically assessed by bringing all MOR data to a common dimension (usually characteristic size) basis, using size adjustment factors. These adjustment factors are not always the same as the size factors that are used in design, since the former can be derived from a more selective sampling of species and grades from the source database; however, the two approaches need to be compatible in a structural class system.

