TECHNICAL REPORT

ISO/TR 18267

First edition
2013-04-01

Timber structures — Review of design standards

Structures en bois — Revue des normes de calculs

Reference number
ISO/TR 18267:2013(E)

Contents

Page

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. 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. 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.

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

Introduction

In the 1980s ISO Technical Committee 165 prepared and circulated a draft International Standard based on a Structural Timber Design Code that was put together by a Working Group of CIB (International Council for Building Research Studies and Documentation). The stated purpose of the ISO/TC 165 draft and the CIB code was to "provide an agreed background for the national committees and international bodies responsible for formulating timber design standards, to ensure a reasonable and consistent quality of timber structures." Neither document included safety factors, partial coefficients, or loads, since they were considered to be the responsibility of national authorities.

Engineering material design standards demonstrate compliance with the structural requirements of building codes; therefore, they have a special relationship to national codes and related legal considerations and are even called "codes" in many places. Design standards provide regulatory bodies with information needed to protect public safety.

The standards also provide a mechanism for adopting advances in structural modelling, material behaviour science, reliability and other subjects. They are vehicles for introducing research into practice. They are also a means for receiving feedback and modifying design requirements based on practical experiences.

Beyond this, design standards also create a framework for specifications of construction products. This provides a context for recognition and approval of structural initiatives using referenced products.

In 2006 ISO/TC 165 prepared a business plan that identified "standards to support harmonization of design and building codes internationally" as a Committee priority. Around the same time, an ISO/TC 165 Framework document included design requirements on the list of work areas, although it did not specify what those requirements might include.

ISO/TC 165, at its 25th meeting in 2011, reviewed a report on current national design standards for timber and international design standards for other construction materials. The committee concluded that, at this time, there was not sufficient interest to undertake development of a structural timber design standard. However, the information provided was deemed to be a valuable resource that should be formally retained for use by ISO/TC 165 and member bodies in future development of timber design standards.

Timber structures — Review of design standards

1 Scope

This Technical Report documents the findings of a review of design standards undertaken by ISO/TC 165 to assess how an ISO International Standard for the design of timber structures might be developed and whether development of such an International Standard should be initiated.

NOTE Annex A summarizes the factors considered and the activity of the TC leading to the preparation of this Technical Report.

2 Current and draft ISO design standards

The five structural design standards and technical reports shown in the following table are published ISO structural design documents. They provide a selection of different approaches for review to help understand what is involved in preparing an international design standard and what the end product might look like.

Designation	Title
ISO/TR 11069:1995	*Aluminium structures — Material and design — Ultimate limit state under static loading*
ISO 10721-1:1997	*Steel structures — Part 1: Materials and design*
ISO 9652-2:2000	*Masonry — Part 2: Unreinforced masonry design by simple rules*
ISO 15673:2005	*Guidelines for the simplified design of structural reinforced concrete for buildings* (ISO/TC 71)
ISO 22156:2004	*Bamboo — Structural Design* (ISO/TC 165)

2.1 Basis for design

All structural design standards are based on a design philosophy that defines the relationship between load requirements and material resistances. International standard committees make basic choices on ground rules, leading to different design approaches in these standards.

Most of the reviewed ISO documents are established in Limit States Design format. It is instructive to see how the limit states are defined in each document, influenced to some extent by material-specific considerations. Limit States Design format also includes partial coefficients in the calculation of loading and resistance, and these factors are handled differently (or are unspecified) in the documents.

Although quantified reliability is implied by Limit States Design philosophy, none of the documents quantify reliability targets or indices. The overall view is that the subject is too dependent on regional conditions and applications to be defined in an international standard and so is left to the discretion of the adopting country or region.

Serviceability Limit States are even more dependent on regional cases and conditions than Strength or Ultimate Limit States, and are largely left out of these documents.

Annex B of this report provides a short summary for the reviewed documents.

2.2 Scope and limitations

In each of the reviewed ISO documents, the scope and limitations give an indication of intended purpose and audience. Since the general aim of material design standards is to facilitate engineering design of structures, the target audience is taken to be the professional community qualified in this practice.

In some cases, the scope of a standard is limited to make the task more manageable, or to make room for design aids such as rules-of-thumb or other tools for the purpose of design simplification. Simplification can be a particular priority where the primary audience is very diverse or is located in countries that do not have existing national standards for the purpose at hand.

It should be noted, however, that simplifying assumptions or design aids do not necessarily result in “simple” standards. There is always a need for professional engineering knowledge and interpretation of design requirements. In other words, scope limitations do not necessarily diminish the need for complete structural design.

In some cases, the limitations may be defined in terms of the geometry or layout of structures; in other cases, limitations are defined by the extent or application of design requirements (see Annex B for examples).

2.3 Standard or guide

Some of the ISO documents under review are written to guide as well as to standardize design requirements. Some put more emphasis on the guidance, others on the normative function.

Design shortcuts are provided in some cases where a more comprehensive design procedure would result in smaller sections. This is generally the role of a handbook or guide rather than a Standard; however, in the case of an international standard, there may be no handbook or guide to consult. Design shortcuts are included to simplify or facilitate the presentation, or to ensure that a requirement is not overlooked or misinterpreted.

Terminology used in the documents to express mandatory or non-mandatory actions can provide a clue as to which provisions are intended to “advise” or “guide” practice rather than “regulate” it. From an implementation standpoint, standards written in mandatory language with specific quantifiable requirements are easier to enforce. But this is difficult to achieve in a standard that is intended to be applied across national boundaries (see Annex B for examples).

2.4 Rules-based or engineered approach

The reviewed ISO documents, like most material design standards, are intended for use by engineers and are typically formulated on the basis of principles and assumptions that lead to calculated design solutions.

Prescriptive rules-based standards, on the other hand, are sometimes written for a non-engineering audience and are formulated to be carried out without further structural analysis or calculations. In the process, rules-based standards can yield more conservative solutions than would result from a fully engineered approach. Also, rules-based approaches are limited in applicability due to assumptions that don’t fit all cases.

From time to time, a rules-based engineering standard is developed for one of a number of reasons, such as: a) to illustrate a particular type of structural design problem and solution, b) to provide a readily-enforceable document for building regulators, or c) to provide a baseline for acceptable solutions.

Most standards combine elements of prescriptive and performance-based standards writing, and some include provision for interpolating or extrapolating beyond the scope of rules-based provisions. Standards can be placed on a scale ranging from fully-engineered to rules-based provisions (see Annex B for examples).

2.5 Material specifications

Before a product can be utilized in design, it must be clearly defined and the structural performance characteristics of the product defined. Product definition is generally done through material specifications and performance characteristics established by testing and evaluation protocols.

Design standards provide a framework for referencing standards for construction products because it is preferable to make normative references to specification or testing standards for this purpose. International standards have special challenges in this area.

Although ISO material specification and testing standards are referenced where available, the general trend in the reviewed documents seems to be to recognize that national material standards are at least as likely to be used and are referenced as well. This is done even though the specifications and the related properties may be based on standard dimensions and grade qualities that may not be recognized in all countries (see Annex B).

A further complication is the number of proprietary structural products that have emerged in recent years. Proprietary products can play a significant role in current design practice, which can vary regionally and over time. Generally such products have not been addressed specifically in the reviewed ISO standards.

Unless the design standard is to become an omnibus standard addressing many different subjects, it is preferable to have a separate referenceable standard to deal with basic material properties and the development of characteristic values. This helps to relieve the design standard from the need to address many material specification issues.

2.6 Load provisions

Load requirements are the domain of national building codes and standards, and it seems counterproductive for an international ISO design standard to specify load provisions incompatible with those that are already in use in interested countries. Complete load requirements include the factors or coefficients that are used to calculate load actions, as well as parameters or references for specified loads.

Nevertheless, some aspects of load requirements are inseparable from the design provisions in these standards. Examples include the limitations to application of a standard, load interaction effects. In the case of timber or timber-based products, there is also the special duration of load effect that ties load and resistance effects together.

Lateral load design complicates design standards significantly, and some standards avoid the topic entirely. Others provide partial lateral load design requirements (Annex B).

The ISO TC responsible for Bases of Design, TC 98, has developed a number of load standards, some of which are referenced in the design standards as listed below.

ISO 15673 (concrete) references:

- ISO 4354, *Wind actions on structures*
- ISO 2103, *Loads due to use and occupancy in residential and public buildings*
- ISO 2633, *Determination of imposed floor loads in production buildings and warehouses*
- ISO 3010, *Basis for design of structures — Seismic actions on structures*
- ISO 4355, *Bases for design of structures — Determination of snow loads on roofs*

ISO/TR 11069 (aluminium) references:

- ISO 2394, *General principles on reliability for structures*
- ISO 3898, *Bases for design of structures — Notations — General symbols*
- ISO 8930, *General principles on reliability for structures — List of equivalent terms*

ISO 10721-1 (steel) references:

- ISO 2394, *General principles on reliability of structures*
- ISO 3898, *Bases for design of structures — Notations — General symbols*

2.7 Assemblies or components

Most of the reviewed ISO documents address structural members and typical connections, focusing on the most basic and generally applicable design cases. The material behaviour formulae are based on generally accepted models, and some of these are specific to material types and connections. In general, the standards do not address more complex structural assemblies or components.

Connection design can be quite involved and complicates even a limited-scope standard. Today's practice also includes proprietary types of connections and designs, which have not been included specifically in the reviewed documents.

Although a few of the standards address specific types of applications, or assembly design procedures, none of them go into detail (Annex B).

2.8 Construction practice

The reviewed ISO documents include general comments on construction and workmanship, without going into much detail. Construction practice requirements are not always included in national design standards, and it is even more difficult to develop construction requirements that would be applicable across different countries or regions.

In some cases, the reviewed standards refer to other documents that cover construction and fabrication details (Annex B).

2.9 Commentary

The reviewed ISO documents include varying amounts of commentary, ranging from very little to more than half of the document. In general, commentary is an important part of any structural design standard because the user needs to understand the principles behind the requirements, and standards are written to be enforceable rather than easy to understand. In the case of an international standard, however, the need for commentary may be overlooked (Annex B).

2.10 Relationship of the draft laminated bamboo structural design standard

The Draft design code for laminated bamboo submitted by INBAR in 2010 is in most cases identical to the existing bamboo standard (ISO 22156). A few differences of note in the laminated bamboo draft are as follows:

- Terms and definitions are added for glubam, plybamboo and lamination joint.
- Design by "concepts based otherwise" are permitted in lieu of calculations, as in the bamboo standard, although design based on "experience from appropriate timber construction requirements" has been substituted for design based on "previous generations."
- The formula for calculating characteristic values from test data are retained, with the suggestion that a smaller sample size is possible for glubam.
- The factor of safety and duration of load factors are retained, including the same assumption about standard deviation.
- The design assumptions have been amended with respect to joints, initial curvature in shape, and shear stresses.
- A new section on "shear walls," defined as panels formed with framing elements and sheathing panels, has been added.

3 Adoption or use of these design standards

As discussed in the Introduction, a draft International Standard (designated N95) was prepared in the 1980s based on the CIB Structural Timber Design Code. The CIB document received input from both ISO and CIB committees, and a revised version was eventually adopted as the European Structural Timber Code (Eurocode 5). Later in the 1990s, ISO TC 165 agreed that work on the draft (N95) should be suspended until Eurocode 5 was finished. No further activity has been recorded.

The most recent "systematic review" of current ISO material design standards resulted in two positive responses on the question of whether they had been adopted: Austria for ISO/TR 11069 (aluminium) and Colombia for ISO 15673 (concrete). A few of the other countries indicated that they made use of one or more of the design standards in some way, without adoption.

In the ballot responses, there were a few comments coming mainly from European countries, indicating lack of interest at the national level or suggesting the standards be modelled after Eurocodes. A lengthy comment from Germany noted the intensive effort required by Eurocodes to reconcile national differences, and indicated that ISO work had been put on "standby" due to priorities. This comment went on to say: "Now this work is complete and it is time to think about the next step in the internationalization of masonry construction and about applying the experience gathered by others. It is also an opportunity to streamline the work on and for masonry and its worldwide application."

4 Relationship to selected national timber standards

The next step is to compare and contrast the nature of some current national timber design standards in the same terms that have been discussed for the ISO standards. The timber design documents shown in the following table are all long-established standards that have been adopted and used widely in design practice. These standards are referred to here as "national" standards even though the Eurocodes are applied beyond national boundaries.

Reference	Designation	Title
NDS	ANSI/AF&PA NDS (2005)	National Design Specification for Wood Construction ASD/LRFD
CSA O86	CSA O86-09 (2009)	Engineering Design in Wood
EC 5	Eurocode 5 (EN 1995-1-1:2004+A1)	Design of Timber Structures, Part 1-1: General, Common rules and rules for buildings

4.1 Basis for design

All of the above timber design standards include Limit States Design (or Load and Resistance Factored Design) requirements. The NDS also provides design requirements in Working Stress Design (or Allowable Stress Design) format, which is more commonly used in the US.

Target reliabilities and partial coefficients for loading and resistance in these standards are different, since they are determined by code bodies in various countries and are influenced by other engineering materials besides timber. The Foreword to Eurocode 5 notes that the same partial coefficients and reliability parameters have to be assigned when the standard is used as a base document by other TCs. CSA O86 states that any load requirements other than those given in the standard would necessitate review of the appropriateness of applicable factored resistance values. The NDS refers to the applicable building code or, in the absence of a governing code, the ASCE standard on minimum design loads.

Serviceability limit states are also very important for timber design, perhaps more than for other structural materials, and are treated in detail in these standards. EC 5 addresses serviceability criteria for beam deflection, floor vibration and joint slip; CSA O86 addresses beam deflection and floor vibration; NDS addresses beam deflection. Details of deflection provisions are significantly different in the three standards, although the overall goal of preventing unacceptable deformation is the same.

4.2 Scope and limitations

All of the national timber standards are designed to address fully engineered structures, regardless of occupancy or size. In general, the scope of these standards is not limited for purpose of design simplification, since there are many design tools like handbooks and software to aid in interpreting and applying the design requirements of each standard. Where limitations are imposed, they are typically related to material properties or environmental conditions.

In addition to purely structural concerns, the standards include some provisions for durability and fire resistance. While not the main subject of the standards, selected requirements have been included in recognition that structural integrity can be impacted by these issues. EC 5 has a separate section (1995-1-2) for structural fire design, and the NDS has a section on design procedures for exposed timber members.

From time to time, some timber committees have considered the possibility of creating a “two-level” standard: one level for a novice or occasional timber designer, and a higher level for an experienced timber designer. The typical reason for this suggestion is that novice designers find some aspects too complicated or unfamiliar for occasional use. A two-level approach could facilitate design at the basic or lower level, while enabling selection of smaller sections at the higher level. Although this is an appealing idea, it has not been acted upon at the national level, primarily because enforcement requires a single level of regulation.

4.3 Standard or guide

All of the listed timber documents are written to be enforced as regulatory standards, i.e. they are written in mandatory language with specific quantifiable requirements, and guidance is reserved for notes or informative appendices.

The Foreword to EC 5 identifies specific clauses where alterations may need to be made by a country in adopting the standard. Some of these clauses include: assignment of loads to load-duration classes, assignment of structures to service classes, and partial factors for material properties. This provision for national choice is a version of the “boxed” value concept noted earlier in some ISO standards.

Other more limited types of timber standards have been produced to address specific applications and are written more like a guide. Examples were reviewed in ISO/TR 12910. They are based on the parent engineering design standards and supplemented with selection tables and graphics to facilitate understanding and implementation for specific design cases.

The success of a guide document depends on a clear definition of the specific design application and the intended audience.

4.4 Rules-based or engineered approach

All of the national timber design standards are formulated as engineering documents rather than rules-based or prescriptive documents. On the other hand, light-frame construction standards are typically written as prescriptive documents.

This division between engineered and light-frame timber construction design arises partly from building code policy allowing relaxation of full engineering design in view of performance history and reduced consequences of failure, and/or other considerations for small buildings. Some examples are noted in ISO/TR 12910. Although an accepted tradition within countries, it is difficult to extrapolate beyond national boundaries since it depends on conditions and knowledge located at home.

4.5 Material specifications

Materials are specified in national timber design standards in accordance with product and test standards, grading rules and other specifications of the host country or region. Beyond these specific references, the design standards provide a framework for technical specifications of products. This is more difficult to achieve at the international level.