

Eurocode 5: Design of timber structures —

Part 1-1: General — Common rules and rules for buildings

ICS 91.010.30; 91.080.20

National foreword

This British Standard is the UK implementation of EN 1995-1-1:2004+A2:2014, incorporating corrigendum June 2006. It supersedes BS EN 1995-1-1:2004+A1:2008, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by A1 A1.

The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/5, Structural use of timber.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Where a normative part of this EN allows for a choice to be made at the national level, the range and possible choice will be given in the normative text, and a note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

To enable BS EN 1995-1-1:2004+A2:2014 to be used in the UK the latest version of the NA to this Standard containing these NDPs should also be used. At the time of publication, it is NA to BS EN 1995-1-1:2004+A1:2008.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Eurocode 5: Design of timber structures - Part 1-1: General - Common rules and rules for buildings

Eurocode 5: Conception et calcul des structures en bois -
Partie 1-1 : Généralités - Règles communes et règles pour
les bâtiments

Eurocode 5: Bemessung und Konstruktion von Holzbauten
- Teil 1-1: Allgemeines - Allgemeine Regeln und Regeln für
den Hochbau

This European Standard was approved by CEN on 16 April 2004.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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Foreword

This European Standard EN 1995-1-1 has been prepared by Technical Committee CEN/TC250 "Structural Eurocodes", the Secretariat of which is held by BSI.

This European Standard shall be given the status of a National Standard, either by publication of an identical text or by endorsement, at the latest by May 2005, and conflicting national standards shall be withdrawn at the latest by March 2010.

This European Standard supersedes ENV 1995-1-1:1993.

CEN/TC250 is responsible for all Structural Eurocodes.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement¹ between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links de facto the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products – CPD – and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN 1990:2002	Eurocode: Basis of Structural Design
EN 1991	Eurocode 1: Actions on structures
EN 1992	Eurocode 2: Design of concrete structures
EN 1993	Eurocode 3: Design of steel structures
EN 1994	Eurocode 4: Design of composite steel and concrete structures
EN 1995	Eurocode 5: Design of timber structures
EN 1996	Eurocode 6: Design of masonry structures
EN 1997	Eurocode 7: Geotechnical design

¹ Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

EN 1998	Eurocode 8: Design of structures for earthquake resistance
EN 1999	Eurocode 9: Design of aluminium structures

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognise that Eurocodes serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 – Mechanical resistance and stability – and Essential Requirement N°2 – Safety in case of fire ;
- as a basis for specifying contracts for construction works and related engineering services ;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents² referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standards³. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex.

The National annex may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e.:

- values and/or classes where alternatives are given in the Eurocode;
- values to be used where a symbol only is given in the Eurocode;
- country specific data (geographical, climatic, etc.), e.g. snow map;

² According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for harmonised ENs and ETAGs/ETAs.

³ According to Art. 12 of the CPD the interpretative documents shall:
give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;
indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc. ;
serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.

The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

- the procedure to be used where alternative procedures are given in the Eurocode;
- decisions on the application of informative annexes;
- references to non-contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and harmonised technical specifications (ENs and ETAs) for products

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works⁴. Furthermore, all the information accompanying the CE Marking of the construction products which refer to Eurocodes shall clearly mention which Nationally Determined Parameters have been taken into account.

Additional information specific to EN 1995-1-1

EN 1995 describes the Principles and requirements for safety, serviceability and durability of timber structures. It is based on the limit state concept used in conjunction with a partial factor method.

For the design of new structures, EN 1995 is intended to be used, for direct application, together with EN 1990:2002 and relevant Parts of EN 1991.

Numerical values for partial factors and other reliability parameters are recommended as basic values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and of quality management applies. When EN 1995-1-1 is used as a base document by other CEN/TCs the same values need to be taken.

National annex for EN 1995-1-1

This standard gives alternative procedures, values and recommendations with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1995-1-1 should have a National annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

National choice is allowed in EN 1995-1-1 through clauses:

2.3.1.2(2)P	Assignment of loads to load-duration classes;
2.3.1.3(1)P	Assignment of structures to service classes;
2.4.1(1)P	Partial factors for material properties;
6.1.7(2)	Shear;
6.4.3(8)	Double tapered, curved and pitched cambered beams;
7.2(2)	Limiting values for deflections;
7.3.3(2)	Limiting values for vibrations;
8.3.1.2(4)	Nailed timber-to-timber connections: Rules for nails in end grain;
8.3.1.2(7)	Nailed timber-to-timber connections: Species sensitive to splitting;
9.2.4.1(7)	Design method for wall diaphragms;
9.2.5.3(1)	Bracing modification factors for beam or truss systems;
10.9.2(3)	Erection of trusses with punched metal plate fasteners: Maximum bow;
10.9.2(4)	Erection of trusses with punched metal plate fasteners: Maximum deviation.

Foreword to amendment A1

This document (EN 1995-1-1:2004/A1:2008) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", the secretariat of which is held by BSI.

This Amendment to the European Standard EN 1995-1-1:2004 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2008, and conflicting national standards shall be withdrawn at the latest by March 2010.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

⁴ see Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

Foreword to amendment A2

This document (EN 1995-1-1:2004/A2:2014) has been prepared by Technical Committee CEN/TC 250, "Structural Eurocodes", the secretariat of which is held by BSI.

This Amendment to the European Standard EN 1995-1-1:2004 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by May 2015, and conflicting national standards shall be withdrawn at the latest by May 2015.

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

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

According to the CEN-CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Section 1 General

1.1 Scope

1.1.1 Scope of EN 1995

(1)P EN 1995 applies to the design of buildings and civil engineering works in timber (solid timber, sawn, planed or in pole form, glued laminated timber or wood-based structural products, e.g. LVL) or wood-based panels jointed together with adhesives or mechanical fasteners. It complies with the principles and requirements for the safety and serviceability of structures and the basis of design and verification given in EN 1990:2002.

(2)P EN 1995 is only concerned with requirements for mechanical resistance, serviceability, durability and fire resistance of timber structures. Other requirements, e.g concerning thermal or sound insulation, are not considered.

(3) EN 1995 is intended to be used in conjunction with:
EN 1990:2002 Eurocode – Basis of design
EN 1991 “Actions on structures”
EN’s for construction products relevant to timber structures
EN 1998 “Design of structures for earthquake resistance”, when timber structures are built in seismic regions

(4) EN 1995 is subdivided into various parts:
EN 1995-1 General
EN 1995-2 Bridges

(5) EN 1995-1 “General” comprises:
EN 1995-1-1 General – Common rules and rules for buildings
EN 1995-1-2 General rules – Structural Fire Design

(6) EN 1995-2 refers to the common rules in EN 1995-1-1. The clauses in EN 1995-2 supplement the clauses in EN 1995-1.

1.1.2 Scope of EN 1995-1-1

(1) EN 1995-1-1 gives general design rules for timber structures together with specific design rules for buildings.

(2) The following subjects are dealt with in EN 1995-1-1:

Section 1: General
Section 2: Basis of design
Section 3: Material properties
Section 4: Durability

- Section 5: Basis of structural analysis
- Section 6: Ultimate limit states
- Section 7: Serviceability limit states
- Section 8: Connections with metal fasteners
- Section 9: Components and assemblies
- Section 10: Structural detailing and control.

(3)P EN 1995-1-1 does not cover the design of structures subject to prolonged exposure to temperatures over 60°C.

1.2 Normative references

[A1] (1) This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ISO standards:

- | | |
|-----------------|---|
| ISO 2081 | Metallic coatings. Electroplated coatings of zinc on iron or steel |
| ISO 2631-2:1989 | Evaluation of human exposure to whole-body vibration. Part 2: Continuous and shock-induced vibrations in buildings (1 to 80 Hz) |

European Standards:

- | | |
|----------|---|
| EN 300 | Oriented Strand Board (OSB) – Definition, classification and specifications |
| EN 301 | Adhesives, phenolic and aminoplastic for load-bearing timber structures; Classification and performance requirements |
| EN 312 | Particleboards – Specifications |
| EN 335-1 | Durability of wood and wood-based products – definition of hazard classes of biological attack – Part 1: General |
| EN 335-2 | Durability of wood and wood-based products – definition of hazard classes of biological attack – Part 2: Application to solid wood |
| EN 335-3 | Durability of wood and wood-based products – Definition of hazard classes of biological attack – Part 3: Application to wood-based panels |
| EN 350-2 | Durability of wood and wood-based products – Natural durability of solid wood – Part 2: Guide to natural durability and treatability of selected wood species of importance in Europe |
| EN 351-1 | Durability of wood and wood-based products – Preservative treated solid wood – Part 1: Classification of preservative penetration and retention |
| EN 383 | Timber structures – Test methods – Determination of embedding strength and foundation values for dowel type fasteners |
| EN 385 | Finger jointed structural timber – Performance requirements and minimum production requirements |
| EN 387 | Glued laminated timber – Large finger joints – Performance requirements and minimum production requirements |
| EN 409 | Timber structures – Test methods. Determination of the yield moment of dowel type fasteners – Nails [A1] |

EN 460	Durability of wood and wood-based products – Natural durability of solid wood – Guide of the durability requirements for wood to be used in hazard classes
EN 594	Timber structures – Test methods – Racking strength and stiffness of timber frame wall panels
EN 622-2	Fibreboards – Specifications. Part 2: Requirements for hardboards
EN 622-3	Fibreboards – Specifications. Part 3: Requirements for medium boards
EN 622-4	Fibreboards – Specifications. Part 4: Requirements for softboards
EN 622-5	Fibreboards – Specifications. Part 5: Requirements for dry process boards (MDF)
EN 636	Plywood – Specifications
EN 912	Timber fasteners – Specifications for connectors for timber
EN 1075	Timber structures – Test methods – Testing of joints made with punched metal plate fasteners
EN 1380	Timber structures – Test methods – Load bearing nailed joints
EN 1381	Timber structures – Test methods – Load bearing stapled joints
EN 1382	Timber structures – Test methods – Withdrawal capacity of timber fasteners
EN 1383	Timber structures – Test methods – Pull through testing of timber fasteners
EN 1990:2002	Eurocode – Basis of structural design
EN 1991-1-1	Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight and imposed loads
EN 1991-1-3	Eurocode 1: Actions on structures – Part 1-3: General actions – Snow loads
EN 1991-1-4	Eurocode 1: Actions on structures – Part 1-4: General actions – Wind loads
EN 1991-1-5	Eurocode 1: Actions on structures – Part 1-5: General actions – Thermal actions
EN 1991-1-6	Eurocode 1: Actions on structures – Part 1-6: General actions – Actions during execution
EN 1991-1-7	Eurocode 1: Actions on structures – Part 1-7: General actions – Accidental actions due to impact and explosions
EN 10346	Continuously hot-dip coated steel flat products – Technical delivery conditions
EN 13271	Timber fasteners – Characteristic load-carrying capacities and slip moduli for connector joints
EN 13986	Wood-based panels for use in construction – Characteristics, evaluation of conformity and marking
EN 14080	Timber structures – Glued laminated timber – Requirements
EN 14081-1	Timber structures – Strength graded structural timber with rectangular cross-section – Part 1, General requirements
EN 14250	Timber structures – Production requirements for fabricated trusses using punched metal plate fasteners
EN 14279	Laminated veneer lumber (LVL) – Specifications, definitions, classification and requirements

EN 14358	Timber structures – Fasteners and wood-based products – Calculation of characteristic 5-percentile value and acceptance criteria for a sample
EN 14374	Timber structures – Structural laminated veneer lumber – Requirements
EN 14545	Timber structures – Connectors – Requirements
EN 14592	Timber structures – Fasteners – Requirements
EN 26891	Timber structures – Joints made with mechanical fasteners – General principles for the determination of strength and deformation characteristics
EN 28970	Timber structures – Testing of joints made with mechanical fasteners; Requirements for wood density (ISO 8970:1989)
EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods (ISO 1461)

NOTE: As long as EN 14545 and EN 14592 are not available as European standards, more information may be given in the National annex.

1.3 Assumptions

(1)P The general assumptions of EN 1990:2002 apply.

(2) Additional requirements for structural detailing and control are given in section 10.

1.4 Distinction between Principles and Application Rules

(1)P The rules in EN 1990:2002 clause 1.4 apply.

1.5 Terms and definitions

1.5.1 General

(1)P The terms and definitions of EN 1990:2002 clause 1.5 apply.

1.5.2 Additional terms and definitions used in this present standard

1.5.2.1

Characteristic value

Refer to EN 1990:2002 subclause 1.5.4.1.

1.5.2.2

Dowelled connection

Connection made with a circular cylindrical rod usually of steel, with or without a head, fitting tightly in prebored holes and used for transferring loads perpendicular to the dowel axis.

1.5.2.3

Equilibrium moisture content

The moisture content at which wood neither gains nor loses moisture to the surrounding air.

1.5.2.4

Fibre saturation point

Moisture content at which the wood cells are completely saturated.

1.5.2.5

LVL

Laminated veneer lumber, defined according to EN 14279 and EN 14374

1.5.2.6

Laminated timber deck

A plate made of abutting parallel and solid laminations connected together by nails or screws or prestressing or gluing.

1.5.2.7

Moisture content

The mass of water in wood expressed as a proportion of its oven-dry mass.

1.5.2.8

Racking

Effect caused by horizontal actions in the plane of a wall.

1.5.2.9

Stiffness property

A property used in the calculation of the deformation of the structure, such as modulus of elasticity, shear modulus, slip modulus.

1.5.2.10

Slip modulus

A property used in the calculation of the deformation between two members of a structure.

1.6 Symbols used in EN 1995-1-1

For the purpose of EN 1995-1-1, the following symbols apply.

Latin upper case letters

A	Cross-sectional area
$\langle A_1 \rangle A_{ef}$	Effective area of the total contact surface between a punched metal plate fastener and the timber; Effective contact area in compression perpendicular to the grain $\langle A_1 \rangle$
A_f	Cross-sectional area of flange
$A_{net,t}$	Net cross-sectional area perpendicular to the grain
$A_{net,v}$	Net shear area parallel to the grain
C	Spring stiffness
$E_{0,05}$	Fifth percentile value of modulus of elasticity;
E_d	Design value of modulus of elasticity;
E_{mean}	Mean value of modulus of elasticity;
$E_{mean,fin}$	Final mean value of modulus of elasticity;
F	Force
$F_{A,Ed}$	Design force acting on a punched metal plate fastener at the centroid of the effective area
$F_{A,min,d}$	Minimum design force acting on a punched metal plate fastener at the centroid of the effective area
$F_{ax,Ed}$	Design axial force on fastener;
$F_{ax,Rd}$	Design value of axial withdrawal capacity of the fastener;
$F_{ax,Rk}$	Characteristic axial withdrawal capacity of the fastener;
F_c	Compressive force

F_d	Design force
$F_{d,ser}$	Design force at the serviceability limit state
$F_{f,Rd}$	Design load-carrying capacity per fastener in wall diaphragm
$F_{i,c,Ed}$	Design compressive reaction force at end of shear wall
$F_{i,t,Ed}$	Design tensile reaction force at end of shear wall
$F_{i,vert,Ed}$	Vertical load on wall
$F_{i,v,Rd}$	Design racking resistance of panel i (in 9.2.4.2) or wall i (in 9.2.4.3)
F_{la}	Lateral load
$F_{M,Ed}$	Design force from a design moment
F_t	Tensile force
$\overline{A_1} F_{t,Rk}$	Characteristic tensile resistance of connection $\overline{A_1}$
$F_{v,0,Rk}$	Characteristic load-carrying capacity of a connector along the grain;
$F_{v,Ed}$	Design shear force per shear plane of fastener; Horizontal design effect on wall diaphragm
$F_{v,Rd}$	Design load-carrying capacity per shear plane per fastener; Design racking load capacity
$F_{v,Rk}$	Characteristic load-carrying capacity per shear plane per fastener
$F_{v,w,Ed}$	Design shear force acting on web;
$F_{x,Ed}$	Design value of a force in x-direction
$F_{y,Ed}$	Design value of a force in y-direction
$F_{x,Rd}$	Design value of plate capacity in x-direction;
$F_{y,Rd}$	Design value of plate capacity in y-direction;
$F_{x,Rk}$	Characteristic plate capacity in x-direction;
$F_{y,Rk}$	Characteristic plate capacity in y-direction;
$G_{0,05}$	Fifth percentile value of shear modulus
G_d	Design value of shear modulus
G_{mean}	Mean value of shear modulus
H	Overall rise of a truss
I_f	Second moment of area of flange
I_{tor}	Torsional moment of inertia
I_z	Second moment of area about the weak axis
K_{ser}	Slip modulus
$K_{ser,fin}$	Final slip modulus
K_u	Instantaneous slip modulus for ultimate limit states
$L_{net,t}$	Net width of the cross-section perpendicular to the grain
$L_{net,v}$	Net length of the fracture area in shear
$M_{A,Ed}$	Design moment acting on a punched metal plate fastener
$M_{ap,d}$	Design moment at apex zone
M_d	Design moment
$M_{y,Rk}$	Characteristic yield moment of fastener
N	Axial force
$R_{90,d}$	Design splitting capacity
$R_{90,k}$	Characteristic splitting capacity
$R_{ax,d}$	Design load-carrying capacity of an axially loaded connection
$R_{ax,k}$	Characteristic load-carrying capacity of an axially loaded connection
$R_{ax,\alpha,k}$	Characteristic load-carrying capacity at an angle to grain
R_d	Design value of a load-carrying capacity
$R_{ef,k}$	Effective characteristic load-carrying capacity of a connection
$R_{iv,d}$	Design racking capacity of a wall
R_k	Characteristic load-carrying capacity
$R_{sp,k}$	Characteristic splitting capacity
$R_{to,k}$	Characteristic load-carrying capacity of a toothed plate connector
$R_{v,d}$	Design racking capacity of a wall diaphragm
V	Shear force; Volume
V_u, V_1	Shear forces in upper and lower part of beam with a hole
W_y	Section modulus about axis y
X_d	Design value of a strength property
X_k	Characteristic value of a strength property

Latin lower case letters

a	Distance
a_1	Spacing, parallel to grain, of fasteners within one row
$\boxed{A_1} a_{1,CG}$	End distance of centre of gravity of the threaded part of screw in the member $\boxed{A_1}$
a_2	Spacing, perpendicular to grain, between rows of fasteners
$\boxed{A_1} a_{2,CG}$	Edge distance of centre of gravity of the threaded part of screw in the member $\boxed{A_1}$
$a_{3,c}$	Distance between fastener and unloaded end
$a_{3,t}$	Distance between fastener and loaded end
$a_{4,c}$	Distance between fastener and unloaded edge
$a_{4,t}$	Distance between fastener and loaded edge
a_{bow}	Maximum bow of truss member
$a_{bow,perm}$	Maximum permitted bow of truss member
a_{dev}	Maximum deviation of truss
$a_{dev,perm}$	Maximum permitted deviation of truss
b	Width
b_i	Width of panel i (in 9.2.4.2) or wall i (in 9.2.4.3)
b_{net}	Clear distance between studs
b_w	Web width
$\boxed{A_1} d$	Diameter; Outer thread diameter
d_1	Inner thread diameter $\boxed{A_1}$
d_c	Connector diameter
d_{ef}	Effective diameter
$\boxed{A_1} d_h$	Head diameter of screws $\boxed{A_1}$
$f_{h,i,k}$	Characteristic embedment strength of timber member i
$f_{a,0,0}$	Characteristic anchorage capacity per unit area for $\alpha = 0^\circ$ and $\beta = 0^\circ$
$f_{a,90,90}$	Characteristic anchorage capacity per unit area for $\alpha = 90^\circ$ and $\beta = 90^\circ$
$f_{a,\alpha,\beta,k}$	Characteristic anchorage strength
$\boxed{A_1} f_{ax,k}$	Characteristic pointside withdrawal strength for nails; Characteristic withdrawal strength $\boxed{A_1}$
$f_{c,0,d}$	Design compressive strength along the grain
$f_{c,w,d}$	Design compressive strength of web
$f_{f,c,d}$	Design compressive strength of flange
$f_{c,90,k}$	Characteristic compressive strength perpendicular to grain
$f_{t,t,d}$	Design tensile strength of flange
$f_{h,k}$	Characteristic embedment strength
$f_{head,k}$	Characteristic pull through parameter for nails
f_1	Fundamental frequency
$f_{m,k}$	Characteristic bending strength
$f_{m,y,d}$	Design bending strength about the principal y-axis
$f_{m,z,d}$	Design bending strength about the principal z-axis
$f_{m,\alpha,d}$	Design bending strength at an angle α to the grain
$f_{t,0,d}$	Design tensile strength along the grain
$f_{t,0,k}$	Characteristic tensile strength along the grain
$f_{t,90,d}$	Design tensile strength perpendicular to the grain
$f_{t,w,d}$	Design tensile strength of the web
$f_{u,k}$	Characteristic tensile strength of bolts
$f_{v,0,d}$	Design panel shear strength
$f_{v,ax,\alpha,k}$	Characteristic withdrawal strength at an angle to grain
$f_{v,ax,90,k}$	Characteristic withdrawal strength perpendicular to grain
$f_{v,d}$	Design shear strength
h	Depth; Height of wall
h_{ap}	Depth of the apex zone
h_d	Hole depth
h_e	Embedment depth
h	Loaded edge distance
h_{ef}	Effective depth
$h_{f,c}$	Depth of compression flange

$h_{f,t}$	Depth of tension flange
~~A_2~~ text deleted A_2	
h_w	Web depth
i	Notch inclination
$k_{c,y}$ or $k_{c,z}$	Instability factor
A_1 k_{cr}	Crack factor for shear resistance A_1
k_{crit}	Factor used for lateral buckling
k_d	Dimension factor for panel
k_{def}	Deformation factor
k_{dis}	Factor taking into account the distribution of stresses in an apex zone
$k_{f,1}, k_{f,2}, k_{f,3}$	Modification factors for bracing resistance
k_h	Depth factor
$k_{i,q}$	Uniformly distributed load factor
k_m	Factor considering re-distribution of bending stresses in a cross-section
k_{mod}	Modification factor for duration of load and moisture content
k_n	Sheathing material factor
k_r	Reduction factor
$k_{R,red}$	Reduction factor for load-carrying capacity
k_s	Fastener spacing factor; Modification factor for spring stiffness
$k_{s,red}$	Reduction factor for spacing
k_{shape}	Factor depending on the shape of the cross-section
k_{sys}	System strength factor
k_v	Reduction factor for notched beams
k_{vol}	Volume factor
k_y or k_z	Instability factor
$\ell_{a,min}$	Minimum anchorage length for a glued-in rod
ℓ	Span; contact length
ℓ_A	Support distance of a hole
ℓ_{ef}	Effective length; Effective length of distribution
ℓ_V	Distance from a hole to the end of the member
ℓ_Z	Spacing between holes
m	Mass per unit area
n_{40}	Number of frequencies below 40 Hz
n_{ef}	Effective number of fasteners
p_d	Distributed load
q_i	Equivalent uniformly distributed load
r	Radius of curvature
s	Spacing
s_0	Basic fastener spacing
r_{in}	Inner radius
t	Thickness
t_{pen}	Penetration depth
u_{creep}	Creep deformation
u_{fin}	Final deformation
$u_{fin,G}$	Final deformation for a permanent action G
$u_{fin,Q,1}$	Final deformation for the leading variable action Q_1
$u_{fin,Q,i}$	Final deformation for accompanying variable actions Q_i
u_{inst}	Instantaneous deformation
$u_{inst,G}$	Instantaneous deformation for a permanent action G
$u_{inst,Q,1}$	Instantaneous deformation for the leading variable action Q_1
$u_{inst,Q,i}$	Instantaneous deformation for accompanying variable actions Q_i
w_c	Precamber
w_{creep}	Creep deflection
w_{fin}	Final deflection
w_{inst}	Instantaneous deflection
$w_{net,fin}$	Net final deflection
v	Unit impulse velocity response

Greek lower case letters

α	Angle between the x-direction and the force for a punched metal plate; Angle between a force and the direction of grain; Angle between the direction of the load and the loaded edge (or end)
β	Angle between the grain direction and the force for a punched metal plate
β_c	Straightness factor
γ	Angle between the x-direction and the timber connection line for a punched metal plate
γ_M	Partial factor for material properties, also accounting for model uncertainties and dimensional variations
λ_y	Slenderness ratio corresponding to bending about the y-axis
λ_z	Slenderness ratio corresponding to bending about the z-axis
$\lambda_{rel,y}$	Relative slenderness ratio corresponding to bending about the y-axis
$\lambda_{rel,z}$	Relative slenderness ratio corresponding to bending about the z-axis
$\langle A_1 \rangle \rho_a$	Associated density $\langle A_1 \rangle$
ρ_k	Characteristic density
ρ_m	Mean density
$\sigma_{c,0,d}$	Design compressive stress along the grain
$\sigma_{c,\alpha,d}$	Design compressive stress at an angle α to the grain
$\sigma_{f,c,d}$	Mean design compressive stress of flange
$\sigma_{f,c,max,d}$	Design compressive stress of extreme fibres of flange
$\sigma_{f,t,d}$	Mean design tensile stress of flange
$\sigma_{f,t,max,d}$	Design tensile stress of extreme fibres of flange
$\sigma_{m,crit}$	Critical bending stress
$\sigma_{m,y,d}$	Design bending stress about the principal y-axis
$\sigma_{m,z,d}$	Design bending stress about the principal z-axis
$\sigma_{m,\alpha,d}$	Design bending stress at an angle α to the grain
σ_N	Axial stress
$\sigma_{t,0,d}$	Design tensile stress along the grain
$\sigma_{t,90,d}$	Design tensile stress perpendicular to the grain
$\sigma_{w,c,d}$	Design compressive stress of web
$\sigma_{w,t,d}$	Design tensile stress of web
τ_d	Design shear stress
$\tau_{F,d}$	Design anchorage stress from axial force
$\tau_{M,d}$	Design anchorage stress from moment
$\tau_{tor,d}$	Design shear stress from torsion
ψ_0	Factor for combination value of a variable action
ψ_2	Factor for quasi-permanent value of a variable action
ζ	Modal damping ratio

Section 2 Basis of design

2.1 Requirements

2.1.1 Basic requirements

(1)P The design of timber structures shall be in accordance with EN 1990:2002.

(2)P The supplementary provisions for timber structures given in this section shall also be applied.

(3) The basic requirements of EN 1990:2002 section 2 are deemed to be satisfied for timber structures when limit state design, in conjunction with the partial factor method using EN 1990:2002 and EN 1991 for actions and their combinations and EN 1995 for resistances, rules for serviceability and durability, is applied.

2.1.2 Reliability management

(1) When different levels of reliability are required, these levels should be preferably achieved by an appropriate choice of quality management in design and execution, according to EN 1990:2002 Annex C.

2.1.3 Design working life and durability

 (1) EN 1990:2002 clauses 2.3 and 2.4 apply. 

2.2 Principles of limit state design

2.2.1 General

(1)P The design models for the different limit states shall, as appropriate, take into account the following:

- different material properties (e.g. strength and stiffness);
- different time-dependent behaviour of the materials (duration of load, creep);
- different climatic conditions (temperature, moisture variations);
- different design situations (stages of construction, change of support conditions).

2.2.2 Ultimate limit states

(1)P The analysis of structures shall be carried out using the following values for stiffness properties:

- for a first order linear elastic analysis of a structure, whose distribution of internal forces is not affected by the stiffness distribution within the structure (eg. all members have the same time-dependent properties), mean values shall be used;
- for a first order linear elastic analysis of a structure, whose distribution of internal forces is affected by the stiffness distribution within the structure (eg. composite members containing materials having different time-dependent properties), final mean values adjusted to the load component causing the largest stress in relation to strength shall be used;
- for a second order linear elastic analysis of a structure, design values, not adjusted for duration of load, shall be used.

NOTE 1: For final mean values adjusted to the duration of load, see 2.3.2.2(2).

NOTE 2: For design values of stiffness properties, see 2.4.1(2)P.

(2) The slip modulus of a connection for the ultimate limit state, $K_{u,}$ should be taken as:

$$K_u = \frac{2}{3} K_{ser} \quad (2.1)$$

Ⓐ where K_{ser} is the slip modulus, see 7.1(1). Ⓐ

2.2.3 Serviceability limit states

(1)P The deformation of a structure which results from the effects of actions (such as axial and shear forces, bending moments and joint slip) and from moisture shall remain within appropriate limits, having regard to the possibility of damage to surfacing materials, ceilings, floors, partitions and finishes, and to the functional needs as well as any appearance requirements.

(2) The instantaneous deformation, u_{inst} , see figure 7.1, should be calculated for the characteristic combination of actions, see EN 1990, clause 6.5.3(2) a), using mean values of the appropriate moduli of elasticity, shear moduli and slip moduli.

Ⓐ (3) The final deformation u_{fin} , see e.g. w_{fin} in Figure 7.1, should be calculated by superimposing the creep deformation u_{creep} calculated using the quasi-permanent combination of actions, see EN 1990:2002, 6.5.3(2)(c), on the instantaneous deformation u_{inst} calculated from 2.2.3(2). The creep deformation should be calculated using mean values of the appropriate moduli of elasticity, shear moduli and slip moduli and the relevant values of k_{def} given in Table 3.2.

(4) If the structure consists of members or components having different creep behaviour, the long-term deformation due to the quasi-permanent combination of actions should be calculated using the final mean values of the appropriate moduli of elasticity, shear moduli and slip moduli according to 2.3.2.2 (1). The final deformation u_{fin} is then calculated by superimposing the instantaneous deformation, due to the difference between the characteristic and the quasi-permanent combination of actions on the long-term deformation. Ⓐ

(5) For structures consisting of members, components and connections with the same creep behaviour and under the assumption of a linear relationship between the actions and the corresponding deformations, as a simplification of 2.2.3(3), the final deformation, u_{fin} , may be taken as:

$$\text{Ⓐ } u_{fin} = u_{fin,G} + u_{fin,Q_1} + \sum u_{fin,Q_i} \quad \text{Ⓐ} \quad (2.2)$$

where:

$$u_{fin,G} = u_{inst,G} (1 + k_{def}) \quad \text{for a permanent action, G} \quad (2.3)$$

$$u_{fin,Q,1} = u_{inst,Q,1} (1 + \psi_{2,1} k_{def}) \quad \text{for the leading variable action, } Q_1 \quad (2.4)$$

$$u_{fin,Q,i} = u_{inst,Q,i} (\psi_{0,i} + \psi_{2,i} k_{def}) \quad \text{for accompanying variable actions, } Q_i \text{ (} i > 1 \text{)} \quad (2.5)$$

$u_{inst,G}$, $u_{inst,Q,1}$, $u_{inst,Q,i}$ are the instantaneous deformations for action G, Q_1 , Q_i respectively;

$\psi_{2,1}$, $\psi_{2,i}$ are the factors for the quasi-permanent value of variable actions;

$\psi_{0,i}$ are the factors for the combination value of variable actions;

k_{def} is given in table 3.2 for timber and wood-based materials, and in 2.3.2.2 (3) and 2.3.2.2 (4) for connections.

When expressions (2.3) to (2.5) are used, the ψ_2 factors should be omitted from expressions (6.16a) and (6.16b) of EN1990:2002.

Note: In most cases, it will be appropriate to apply the simplified method.

(6) For serviceability limit states with respect to vibrations, mean values of the appropriate stiffness moduli should be used.

2.3 Basic variables

2.3.1 Actions and environmental influences

2.3.1.1 General

(1) Actions to be used in design may be obtained from the relevant parts of EN 1991.

Note 1: The relevant parts of EN 1991 for use in design include:

EN 1991-1-1	Densities, self-weight and imposed loads
EN 1991-1-3	Snow loads
EN 1991-1-4	Wind actions
EN 1991-1-5	Thermal actions
EN 1991-1-6	Actions during execution
EN 1991-1-7	Accidental actions

(2)P Duration of load and moisture content affect the strength and stiffness properties of timber and wood-based elements and shall be taken into account in the design for mechanical resistance and serviceability.

(3)P Actions caused by the effects of moisture content changes in the timber shall be taken into account.

2.3.1.2 Load-duration classes

(1)P The load-duration classes are characterised by the effect of a constant load acting for a certain period of time in the life of the structure. For a variable action the appropriate class shall be determined on the basis of an estimate of the typical variation of the load with time.

(2)P Actions shall be assigned to one of the load-duration classes given in Table 2.1 for strength and stiffness calculations.

Table 2.1 – Load-duration classes

Load-duration class	Order of accumulated duration of characteristic load
Permanent	more than 10 years
Long-term	6 months – 10 years
Medium-term	1 week – 6 months
Short-term	less than one week
Instantaneous	

NOTE: Examples of load-duration assignment are given in Table 2.2. Since climatic loads (snow, wind) vary between countries, the assignment of load-duration classes may be specified in the National annex.

Table 2.2 – Examples of load-duration assignment

Load-duration class	Examples of loading
Permanent	self-weight
Long-term	storage
Medium-term	imposed floor load, snow
Short-term	snow, wind
Instantaneous	wind, accidental load

2.3.1.3 Service classes

(1)P Structures shall be assigned to one of the service classes given below:

NOTE 1: The service class system is mainly aimed at assigning strength values and for calculating deformations under defined environmental conditions.

NOTE 2: Information on the assignment of structures to service classes given in (2)P, (3)P and (4)P may be given in the National annex.

(2)P Service class 1 is characterised by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air only exceeding 65 % for a few weeks per year.

NOTE: In service class 1 the average moisture content in most softwoods will not exceed 12 %.

(3)P Service class 2 is characterised by a moisture content in the materials corresponding to a temperature of 20°C and the relative humidity of the surrounding air only exceeding 85 % for a few weeks per year.

NOTE: In service class 2 the average moisture content in most softwoods will not exceed 20 %.

(4)P Service class 3 is characterised by climatic conditions leading to higher moisture contents than in service class 2.

2.3.2 Materials and product properties

2.3.2.1 Load-duration and moisture influences on strength

(1) Modification factors for the influence of load-duration and moisture content on strength, see 2.4.1, are given in 3.1.3.

(2) Where a connection is constituted of two timber elements having different time-dependent behaviour, the calculation of the design load-carrying capacity should be made with the following modification factor k_{mod} :

$$k_{\text{mod}} = \sqrt{k_{\text{mod},1} k_{\text{mod},2}} \quad (2.6)$$

where $k_{\text{mod},1}$ and $k_{\text{mod},2}$ are the modification factors for the two timber elements.

2.3.2.2 Load-duration and moisture influences on deformations

A2 (1) For serviceability limit states, if the structure consists of members or components having different time-dependent properties, the final mean value of modulus of elasticity $E_{\text{mean,fin}}$, shear modulus $G_{\text{mean,fin}}$ and slip modulus $K_{\text{ser,fin}}$ which are used to calculate the long-term deformation due to the quasi-permanent combination of actions (see EN 1990:2002, 6.5.3(2)(c)) should be taken from the following expressions: **A2**

$$E_{\text{mean,fin}} = \frac{E_{\text{mean}}}{(1 + k_{\text{def}})} \quad (2.7)$$

$$G_{\text{mean,fin}} = \frac{G_{\text{mean}}}{(1 + k_{\text{def}})} \quad (2.8)$$

$$K_{\text{ser,fin}} = \frac{K_{\text{ser}}}{(1 + k_{\text{def}})} \quad (2.9)$$

(2) For ultimate limit states, where the distribution of member forces and moments is affected by the stiffness distribution in the structure, the final mean value of modulus of elasticity, $E_{\text{mean,fin}}$, shear modulus $G_{\text{mean,fin}}$, and slip modulus, $K_{\text{ser,fin}}$, should be calculated from the following expressions :

$$E_{\text{mean,fin}} = \frac{E_{\text{mean}}}{(1 + \psi_2 k_{\text{def}})} \quad (2.10)$$

$$G_{\text{mean,fin}} = \frac{G_{\text{mean}}}{(1 + \psi_2 k_{\text{def}})} \quad (2.11)$$

$$K_{\text{ser,fin}} = \frac{K_{\text{ser}}}{(1 + \psi_2 k_{\text{def}})} \quad (2.12)$$

where:

E_{mean} is the mean value of modulus of elasticity;

G_{mean} is the mean value of shear modulus;

K_{ser} is the slip modulus;

k_{def} is a factor for the evaluation of creep deformation taking into account the relevant service class;

ψ_2 is the factor for the quasi-permanent value of the action causing the largest stress in relation to the strength (if this action is a permanent action, ψ_2 should be replaced by 1).

NOTE 1: Values of k_{def} are given in 3.1.4.

NOTE 2: Values of ψ_2 are given in EN 1990:2002.

(3) Where a connection is constituted of timber elements with the same time-dependent behaviour, the value of k_{def} should be doubled.

(4) Where a connection is constituted of two wood-based elements having different time-dependent behaviour, the calculation of the final deformation should be made with the following deformation factor k_{def} :

$$k_{\text{def}} = 2 \sqrt{k_{\text{def},1} k_{\text{def},2}} \quad (2.13)$$

where $k_{\text{def},1}$ and $k_{\text{def},2}$ are the deformation factors for the two timber elements.

2.4 Verification by the partial factor method

2.4.1 Design value of material property

(1)P The design value X_d of a strength property shall be calculated as:

$$X_d = k_{\text{mod}} \frac{X_k}{\gamma_M} \quad (2.14)$$

where:

X_k is the characteristic value of a strength property;

γ_M is the partial factor for a material property;

k_{mod} is a modification factor taking into account the effect of the duration of load and moisture content.

NOTE 1: Values of k_{mod} are given in 3.1.3.

NOTE 2: The recommended partial factors for material properties (γ_M) are given in Table 2.3. Information on the National choice may be found in the National annex.

Table 2.3 – Recommended partial factors γ_M for material properties and resistances

Fundamental combinations:	
Solid timber	1,3
Glued laminated timber	1,25
LVL, plywood, OSB,	1,2
Particleboards	1,3
Fibreboards, hard	1,3
Fibreboards, medium	1,3
Fibreboards, MDF	1,3
Fibreboards, soft	1,3
Connections	1,3
Punched metal plate fasteners	1,25
Accidental combinations	1,0

(2)P The design member stiffness property E_d or G_d shall be calculated as:

$$E_d = \frac{E_{\text{mean}}}{\gamma_M} \quad (2.15)$$

$$G_d = \frac{G_{\text{mean}}}{\gamma_M} \quad (2.16)$$

where:

E_{mean} is the mean value of modulus of elasticity;

G_{mean} is the mean value of shear modulus.

2.4.2 Design value of geometrical data

(1) Geometrical data for cross-sections and systems may be taken as nominal values from product standards hEN or drawings for the execution.

(2) Design values of geometrical imperfections specified in this standard comprise the effects of

- geometrical imperfections of members;
- the effects of structural imperfections from fabrication and erection;
- inhomogeneity of materials (e.g. due to knots).

2.4.3 Design resistances

(1)P The design value R_d of a resistance (load-carrying capacity) shall be calculated as:

$$R_d = k_{\text{mod}} \frac{R_k}{\gamma_M} \quad (2.17)$$

where:

R_k is the characteristic value of load-carrying capacity;

γ_M is the partial factor for a material property,

k_{mod} is a modification factor taking into account the effect of the duration of load and moisture content.

NOTE 1: Values of k_{mod} are given in 3.1.3.

NOTE 2: For partial factors, see 2.4.1.

2.4.4 Verification of equilibrium (EQU)

(1) The reliability format for the verification of static equilibrium given in Table A1.2 (A) in Annex A1 of EN 1990:2002 applies, where appropriate, to the design of timber structures, e.g. for the design of holding-down anchors or the verification of bearings subject to uplift from continuous beams.

Section 3 Material properties

3.1 General

3.1.1 Strength and stiffness parameters

(1)P Strength and stiffness parameters shall be determined on the basis of tests for the types of action effects to which the material will be subjected in the structure, or on the basis of comparisons with similar timber species and grades or wood-based materials, or on well-established relations between the different properties.

3.1.2 Stress-strain relations

(1)P Since the characteristic values are determined on the assumption of a linear relation between stress and strain until failure, the strength verification of individual members shall also be based on such a linear relation.

(2) For members or parts of members subjected to compression, a non-linear relationship (elastic-plastic) may be used.

3.1.3 Strength modification factors for service classes and load-duration classes

(1) The values of the modification factor k_{mod} given in Table 3.1 should be used.

(2) If a load combination consists of actions belonging to different load-duration classes a value of k_{mod} should be chosen which corresponds to the action with the shortest duration, e.g. for a combination of dead load and a short-term load, a value of k_{mod} corresponding to the short-term load should be used.

3.1.4 Deformation modification factors for service classes

(1) The values of the deformation factors k_{def} given in Table 3.2 should be used.

3.2 Solid timber

A1 (1)P Timber members shall comply with EN 14081-1.

NOTE: Strength classes for timber are given in EN 338. **A1**

(2) The effect of member size on strength may be taken into account.

(3) For rectangular solid timber with a characteristic timber density $\rho_k \leq 700 \text{ kg/m}^3$, the reference depth in bending or width (maximum cross-sectional dimension) in tension is 150 mm. For depths in bending or widths in tension of solid timber less than 150 mm the characteristic values for $f_{\text{m,k}}$ and $f_{\text{t,0,k}}$ may be increased by the factor k_{h} , given by:

$$k_{\text{h}} = \min \left\{ \left(\frac{150}{h} \right)^{0,2} \right. \\ \left. 1,3 \right. \quad (3.1)$$

where h is the depth for bending members or width for tension members, in mm.

Table 3.1 – Values of k_{mod}

Material	Standard	Service class	Load-duration class				
			Permanent action	Long term action	Medium term action	Short term action	Instantaneous action
Solid timber	EN 14081-1	1	0,60	0,70	0,80	0,90	1,10
		2	0,60	0,70	0,80	0,90	1,10
		3	0,50	0,55	0,65	0,70	0,90
Glued laminated timber	EN 14080	1	0,60	0,70	0,80	0,90	1,10
		2	0,60	0,70	0,80	0,90	1,10
		3	0,50	0,55	0,65	0,70	0,90
LVL	EN 14374, EN 14279	1	0,60	0,70	0,80	0,90	1,10
		2	0,60	0,70	0,80	0,90	1,10
		3	0,50	0,55	0,65	0,70	0,90
Plywood	EN 636 Type EN 636-1 Type EN 636-2 Type EN 636-3	1	0,60	0,70	0,80	0,90	1,10
		2	0,60	0,70	0,80	0,90	1,10
		3	0,50	0,55	0,65	0,70	0,90
OSB	EN 300 OSB/2 OSB/3, OSB/4 OSB/3, OSB/4	1	0,30	0,45	0,65	0,85	1,10
		1	0,40	0,50	0,70	0,90	1,10
		2	0,30	0,40	0,55	0,70	0,90
Particle-board	EN 312 Type P4, Type P5 Type P5 Type P6, Type P7 Type P7	1	0,30	0,45	0,65	0,85	1,10
		2	0,20	0,30	0,45	0,60	0,80
		1	0,40	0,50	0,70	0,90	1,10
		2	0,30	0,40	0,55	0,70	0,90
Fibreboard, hard	EN 622-2 HB.LA, HB.HLA 1 or 2 HB.HLA1 or 2	1	0,30	0,45	0,65	0,85	1,10
		2	0,20	0,30	0,45	0,60	0,80
Fibreboard, medium	EN 622-3 MBH.LA1 or 2 MBH.HLS1 or 2 MBH.HLS1 or 2	1	0,20	0,40	0,60	0,80	1,10
		1	0,20	0,40	0,60	0,80	1,10
		2	–	–	–	0,45	0,80
Fibreboard, MDF	EN 622-5 MDF.LA, MDF.HLS MDF.HLS	1	0,20	0,40	0,60	0,80	1,10
		2	–	–	–	0,45	0,80

A1

(4) For timber which is installed at or near its fibre saturation point, and which is likely to dry out under load, the values of k_{def} , given in Table 3.2, should be increased by 1,0.

(5)P Finger joints shall comply with EN 385.

3.3 Glued laminated timber

(1)P Glued laminated timber members shall comply with EN 14080.

NOTE: In EN 1194 values of strength and stiffness properties are given for glued laminated timber allocated to strength classes, see annex D (Informative).

(2) The effect of member size on strength may be taken into account.

(3) For rectangular glued laminated timber, the reference depth in bending or width in tension is 600 mm. For depths in bending or widths in tension of glued laminated timber less than 600 mm

the characteristic values for $f_{m,k}$ and $f_{t,0,k}$ may be increased by the factor k_h , given by

$$k_h = \min \left\{ \left(\frac{600}{h} \right)^{0,1} \right. \\ \left. 1,1 \right\} \quad (3.2)$$

where h is the depth for bending members or width for tensile members, in mm.

[A1] (4)P Large finger joints complying with the requirements of EN 387 shall not be used for products to be installed in service class 3, where the direction of grain changes at the joint. **[A1]**

(5)P The effect of member size on the tensile strength perpendicular to the grain shall be taken into account.

[A1] Table 3.2 – Values of k_{def} for timber and wood-based materials

Material	Standard	Service class		
		1	2	3
Solid timber	EN 14081-1	0,60	0,80	2,00
Glued Laminated timber	EN 14080	0,60	0,80	2,00
LVL	EN 14374, EN 14279	0,60	0,80	2,00
Plywood	EN 636			
	Type EN 636-1	0,80	–	–
	Type EN 636-2	0,80	1,00	–
	Type EN 636-3	0,80	1,00	2,50
OSB	EN 300			
	OSB/2	2,25	–	–
	OSB/3, OSB/4	1,50	2,25	–
Particleboard	EN 312			
	Type P4	2,25	–	–
	Type P5	2,25	3,00	–
	Type P6	1,50	–	–
	Type P7	1,50	2,25	–
Fibreboard, hard	EN 622-2			
	HB.LA	2,25	–	–
	HB.HLA1, HB.HLA2	2,25	3,00	–
Fibreboard, medium	EN 622-3			
	MBH.LA1, MBH.LA2	3,00	–	–
	MBH.HLS1, MBH.HLS2	3,00	4,00	–
Fibreboard, MDF	EN 622-5			
	MDF.LA	2,25	–	–
	MDF.HLS	2,25	3,00	–

[A1]

3.4 Laminated veneer lumber (LVL)

(1)P LVL structural members shall comply with EN 14374.

(2)P For rectangular LVL with the grain of all veneers running essentially in one direction, the effect of member size on bending and tensile strength shall be taken into account.

(3) The reference depth in bending is 300 mm. For depths in bending not equal to 300 mm the characteristic value for $f_{m,k}$ should be multiplied by the factor k_h , given by

$$k_h = \min \left\{ \left(\frac{300}{h} \right)^s, 1,2 \right\} \quad (3.3)$$

where:

h is the depth of the member, in mm;

s is the size effect exponent, refer to 3.4(5)P.

(4) The reference length in tension is 3000 mm. For lengths in tension not equal to 3000 mm the characteristic value for $f_{t,0,k}$ should be multiplied by the factor k_ℓ given by

$$k_\ell = \min \left\{ \left(\frac{3000}{\ell} \right)^{s/2}, 1,1 \right\} \quad (3.4)$$

where ℓ is the length, in mm.

(5)P The size effect exponent s for LVL shall be taken as declared in accordance with EN 14374.

A1 (6)P Large finger joints complying with the requirements of EN 387 shall not be used for products to be installed in service class 3, where the direction of grain changes at the joint. **A1**

(7)P For LVL with the grain of all veneers running essentially in one direction, the effect of member size on the tensile strength perpendicular to the grain shall be taken into account.

3.5 Wood-based panels

(1)P Wood-based panels shall comply with EN 13986 and LVL used as panels shall comply with EN 14279.

(2) The use of softboards according to EN 622-4 should be restricted to wind bracing and should be designed by testing.

3.6 Adhesives

(1)P Adhesives for structural purposes shall produce joints of such strength and durability that the integrity of the bond is maintained in the assigned service class throughout the expected life of the structure.

(2) Adhesives which comply with Type I specification as defined in EN 301 may be used in all service classes.

(3) Adhesives which comply with Type II specification as defined in EN 301 should only be used in service classes 1 or 2 and not under prolonged exposure to temperatures in excess of 50°C.

3.7 Metal fasteners

(1)P Metal fasteners shall comply with EN 14592 and metal connectors shall comply with EN 14545.

Section 4 Durability

4.1 Resistance to biological organisms

(1)P Timber and wood-based materials shall either have adequate natural durability in accordance with EN 350-2 for the particular hazard class (defined in EN 335-1, EN 335-2 and EN 335-3), or be given a preservative treatment selected in accordance with EN 351-1 and EN 460.

NOTE 1: Preservative treatment may affect the strength and stiffness properties.

NOTE 2: Rules for specification of preservation treatments are given in EN 350-2 and EN 335.

4.2 Resistance to corrosion

(1)P Metal fasteners and other structural connections shall, where necessary, either be inherently corrosion-resistant or be protected against corrosion.

(2) Examples of minimum corrosion protection or material specifications for different service classes (see 2.3.1.3) are given in Table 4.1.

Table 4.1 – Examples of minimum specifications for material protection against corrosion for fasteners (related to ISO 2081)

Fastener	Service Class ^b		
	1	2	3
Nails and screws with $d \leq 4$ mm	None	Fe/Zn 12c ^a	Fe/Zn 25c ^a
Bolts, dowels, nails and screws with $d > 4$ mm	None	None	Fe/Zn 25c ^a
Staples	Fe/Zn 12c ^a	Fe/Zn 12c ^a	Stainless steel
Punched metal plate fasteners and steel plates up to 3 mm thickness	Fe/Zn 12c ^a	Fe/Zn 12c ^a	Stainless steel
Steel plates from 3 mm up to 5 mm in thickness	None	Fe/Zn 12c ^a	Fe/Zn 25c ^a
Steel plates over 5 mm thickness	None	None	Fe/Zn 25c ^a
^a If hot dip zinc coating is used on steel plates, Fe/Zn 12C shall be replaced by Z275 and Fe/Zn 25C by Z350 in accordance with EN 10346. If hot dip coating is used on dowel type fasteners, Fe/Zn 12C shall be replaced by a layer of zinc of minimum 39 µm and Fe/Zn 25C by a layer of zinc of minimum 49 µm in accordance with EN ISO 1461.			
^b For especially corrosive conditions consideration should be given to heavier hot dip coatings or stainless steel.			

Section 5 Basis of structural analysis

5.1 General

(1)P Calculations shall be performed using appropriate design models (supplemented, if necessary, by tests) involving all relevant variables. The models shall be sufficiently precise to predict the structural behaviour, commensurate with the standard of workmanship likely to be achieved, and with the reliability of the information on which the design is based.

(2) The global structural behaviour should be assessed by calculating the action effects with a linear material model (elastic behaviour).

(3) For structures able to redistribute the internal forces via connections of adequate ductility, elastic-plastic methods may be used for the calculation of the internal forces in the members.

(4)P The model for the calculation of internal forces in the structure or in part of it shall take into account the effects of deformations of the connections.

(5) In general, the influence of deformations in the connections should be taken into account through their stiffness (rotational or translational for instance) or through prescribed slip values as a function of the load level in the connection.

5.2 Members

(1)P The following shall be taken into account by the structural analysis:

- deviations from straightness;
- inhomogeneities of the material.

NOTE: Deviations from straightness and inhomogeneities are taken into account implicitly by the design methods given in this standard.

(2)P Reductions in the cross-sectional area shall be taken into account in the member strength verification.

(3) Reductions in the cross-sectional area may be ignored for the following cases:

- nails and screws with a diameter of 6 mm or less, driven without pre-drilling;
- holes in the compression area of members, if the holes are filled with a material of higher stiffness than the wood.

(4) When assessing the effective cross-section at a joint with multiple fasteners, all holes within a distance of half the minimum fastener spacing measured parallel to the grain from a given cross-section should be considered as occurring at that cross-section.

5.3 Connections

(1)P The load-carrying-capacity of the connections shall be verified taking into account the forces and the moments between the members determined by the global structural analysis.

(2)P The deformation of the connection shall be compatible with that assumed in the global analysis.

(3)P The analysis of a connection shall take into account the behaviour of all the elements which constitute the connection.

5.4 Assemblies

5.4.1 General

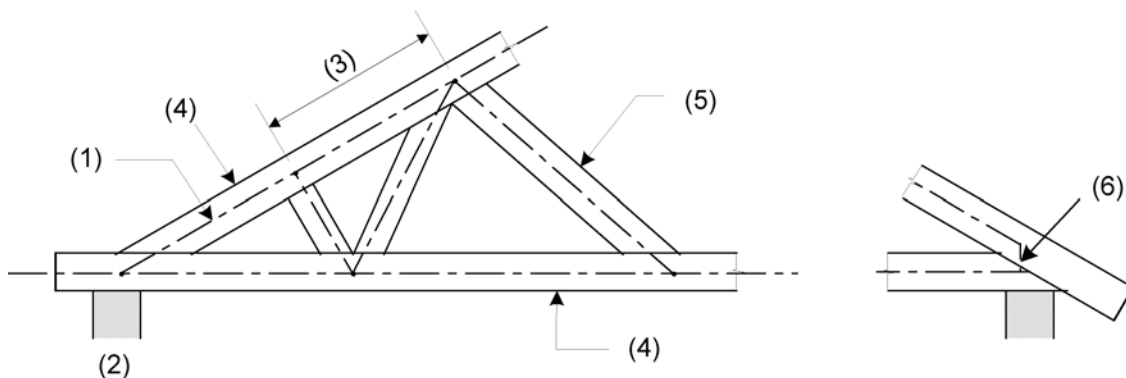
(1)P The analysis of structures shall be carried out using static models which consider to an acceptable level of accuracy the behaviour of the structure and of the supports.

(2) The analysis should be performed by frame models in accordance with 5.4.2 or by a simplified analysis in accordance with 5.4.3 for trusses with punched metal plate fasteners.

(3) Second order analysis of plane frames or arches should be performed in accordance with 5.4.4.

5.4.2 Frame structures

(1)P Frame structures shall be analysed such that the deformations of the members and joints, the influence of support eccentricities and the stiffness of the supporting structure are taken into account in the determination of the member forces and moments, see Figure 5.1 for definitions of structure configurations and model elements.



Key:

- (1) System line
- (2) Support
- (3) Bay
- (4) External member
- (5) Internal member
- (6) Fictitious beam element

Figure 5.1 – Examples of frame analysis model elements

(2)P In a frame analysis, the system lines for all members shall lie within the member profile. For the main members, e.g. the external members of a truss, the system lines shall coincide with the member centre-line.

(3)P If the system lines for internal members do not coincide with the centre lines, the influence of the eccentricity shall be taken into account in the strength verification of these members.

(4) Fictitious beam elements and spring elements may be used to model eccentric connections or supports. The orientation of fictitious beam elements and the location of the spring elements should coincide as closely as possible with the actual joint configuration.

(5) In a first order linear elastic analysis, the effect of initial deformations and induced deflections may be disregarded if taken into account by the strength verification of the member.

(6) The frame analysis should be carried out using the appropriate values of member stiffness defined in 2.2.2. Fictitious beam elements should be assumed to have a stiffness corresponding to that of the actual connections.

(7) Connections may be assumed to be rotationally stiff, if their deformation has no significant effect upon the distribution of member forces and moments. Otherwise, connections may be generally assumed to be rotationally pinned.

(8) Translational slip at the joints may be disregarded for the strength verification unless it significantly affects the distribution of internal forces and moments.

(9) Splice connections used in lattice structures may be modelled as rotationally stiff if the actual rotation under load would have no significant effect upon member forces. This requirement is fulfilled if one of the following conditions is satisfied:

- The splice connection has a load-carrying capacity which corresponds to at least 1,5 times the combination of applied force and moment
- The splice connection has a load-carrying capacity which corresponds to at least the combination of applied force and moment, provided that the timber members are not subject to bending stresses which are greater than 0,3 times the member bending strength, and the assembly would be stable if all such connections acted as pins.

5.4.3 Simplified analysis of trusses with punched metal plate fasteners

(1) A simplified analysis of fully triangulated trusses should comply with the following conditions:

- there are no re-entrant angles in the external profile;
- the bearing width is situated within the length a_1 , and the distance a_2 in Figure 5.2 is not greater than $a_1/3$ or 100 mm, whichever is the greater;
- the truss height is greater than 0,15 times the span and 10 times the maximum external member depth.

(2) The axial forces in the members should be determined on the basis that every node is pin-jointed.

(3) The bending moments in single-bay members should be determined on the basis that the end nodes are pin-jointed. Bending moments in members that are continuous over several bays should be determined on the basis that the member is a beam with a simple support at each node. The effect of deflection at the nodes and partial fixity at the connections should be taken into account by a reduction of 10 % of the moments at the inner supports of the member. The inner support moments should be used to calculate the span bending moments.

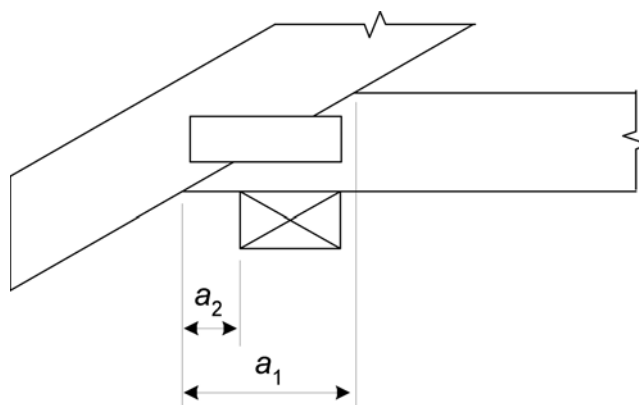


Figure 5.2 – Geometry of support

5.4.4 Plane frames and arches

(1)P The requirements of 5.2 apply. The effects of induced deflection on internal forces and moments shall be taken into account.

(2) The effects of induced deflection on internal forces and moments may be taken into account by carrying out a second order linear analysis with the following assumptions:

- the imperfect shape of the structure should be assumed to correspond to an initial deformation which is found by applying an angle ϕ of inclination to the structure or relevant parts, together with an initial sinusoidal curvature between the nodes of the structure corresponding to a maximum eccentricity e .
- the value of ϕ in radians should as a minimum be taken as

$$\begin{aligned} \phi &= 0,005 & \text{for } h \leq 5 \text{ m} \\ \phi &= 0,005 \sqrt{5/h} & \text{for } h > 5 \text{ m} \end{aligned} \quad (5.1)$$

where h is the height of the structure or the length of the member, in m.

- the value of e should as a minimum be taken as:

$$e = 0,0025 \ell \quad (5.2)$$

Examples of assumed initial deviations in the geometry and the definition of ℓ are given in Figure 5.3.

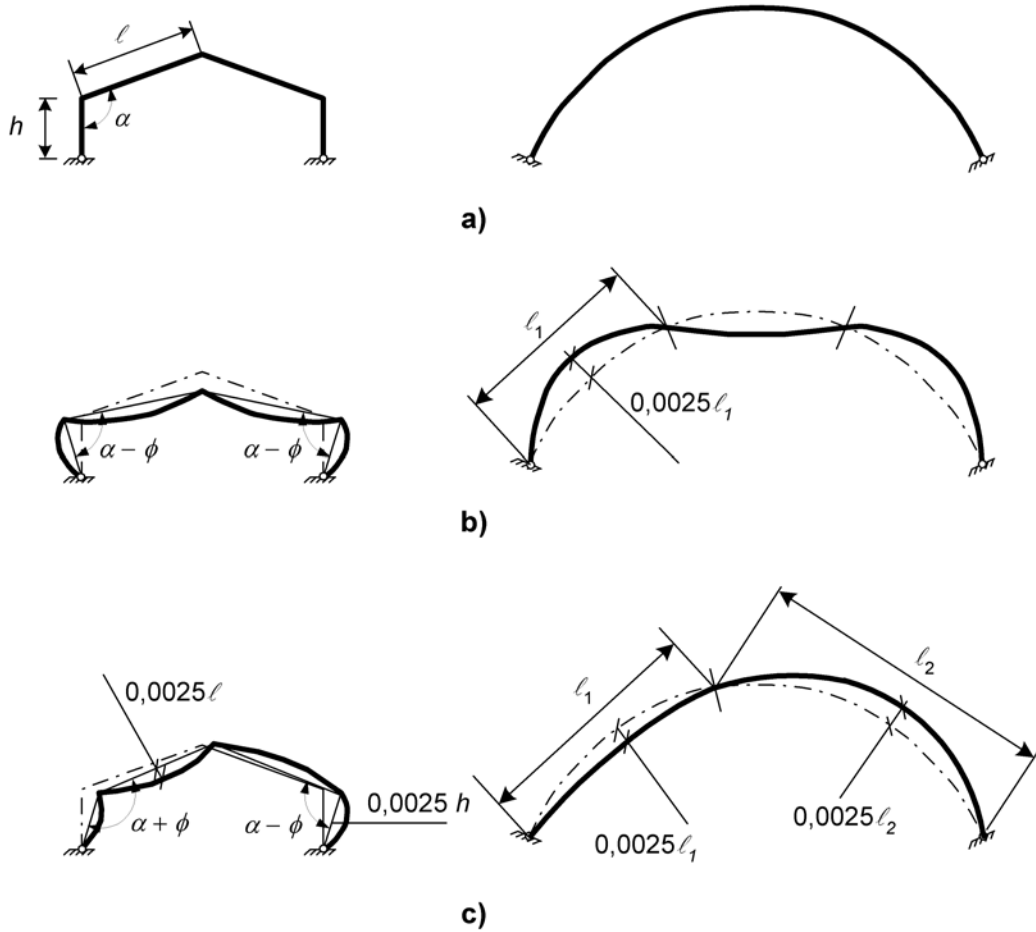


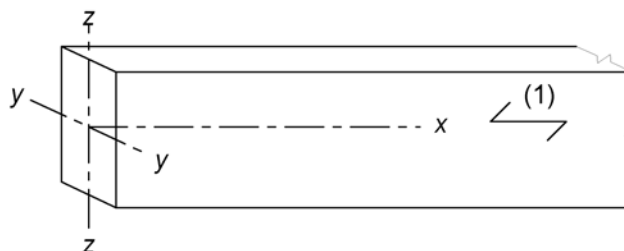
Figure 5.3 – Examples of assumed initial deviations in the geometry for a frame (a), corresponding to a symmetrical load (b) and non-symmetrical load (c)

Section 6 Ultimate limit states

6.1 Design of cross-sections subjected to stress in one principal direction

6.1.1 General

(1) Clause 6.1 applies to straight solid timber, glued laminated timber or wood-based structural products of constant cross-section, whose grain runs essentially parallel to the length of the member. The member is assumed to be subjected to stresses in the direction of only one of its principal axes (see Figure 6.1).



Key:
(1) direction of grain

Figure 6.1 – Member Axes

6.1.2 Tension parallel to the grain

(1)P The following expression shall be satisfied:

$$\sigma_{t,0,d} \leq f_{t,0,d} \quad (6.1)$$

where:

$\sigma_{t,0,d}$ is the design tensile stress along the grain;
 $f_{t,0,d}$ is the design tensile strength along the grain.

6.1.3 Tension perpendicular to the grain

(1)P The effect of member size shall be taken into account.

6.1.4 Compression parallel to the grain

(1)P The following expression shall be satisfied:

$$\sigma_{c,0,d} \leq f_{c,0,d} \quad (6.2)$$

where:

$\sigma_{c,0,d}$ is the design compressive stress along the grain;
 $f_{c,0,d}$ is the design compressive strength along the grain.

NOTE: Rules for the instability of members are given in 6.3.

6.1.5 Compression perpendicular to the grain

$\langle A_1 \rangle$ (1)P The following expression shall be satisfied:

$$\sigma_{c,90,d} \leq k_{c,90} f_{c,90,d} \quad (6.3)$$

with: $\langle A_1 \rangle$