



DPC: 23 / 30462500 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 28 June 2023

Origin: European

Latest date for receipt of comments: 15 August 2023

Project No. 2022/02082

Responsible committee: B/525/5 Structural use of timber

Interested committees:

Title: BS EN 1995-1-2 Eurocode 5 - Design of timber structures

Part 1-2: General - Structural fire design

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 15 August 2023**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: **Mr Christopher Starr (BSI)**

Direct tel:

E-mail: christopher.starr@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

English Version

Eurocode 5 - Design of timber structures - Part 1-2: Structural fire design

Eurocode 5 - Calcul des structures en bois - Part 1-2:
Calcul du comportement au feu

Eurocode 5 - Bemessung und Konstruktion von
Holzbauten - Teil 1-2: Tragwerksbemessung für den
Brandfall

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CEN 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 CEN-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Contents

Page

European foreword	6
0 Introduction.....	7
1 Scope.....	10
1.1 Scope of EN 1995-1-2	10
1.2 Assumptions	10
2 Normative references.....	10
3 Terms, definitions and symbols	12
3.1 Terms and definitions	12
3.2 Symbols and abbreviations	15
3.2.1 Latin upper case letters	15
3.2.2 Latin lower case letters.....	16
3.2.3 Greek upper case letters	20
3.2.4 Greek lower case letters.....	21
4 Basis of design.....	22
4.1 General.....	22
4.2 Nominal fire exposure.....	22
4.3 Physically based fire exposure	23
4.4 Actions	23
4.5 Design values of material properties	23
4.6 Verification methods	24
4.7 Member analysis	25
4.8 Analysis of parts of the structure.....	25
4.9 Global structural analysis	25
5 Material properties.....	26
5.1 General.....	26
5.2 Thermal properties.....	29
5.3 Mechanical properties	29
5.4 Charring.....	29
5.4.1 General.....	29
5.4.2 The European charring model	30
5.5 Adhesives.....	40
5.5.1 General.....	40
5.5.2 Bond line integrity of face bonds	41
6 Tabulated design data.....	41
6.1 General.....	41
6.2 Time limits for charring phases	41
6.3 Initially protected timber members	44
6.4 Plane timber members made of CLT.....	46
6.4.1 General.....	46
6.4.2 CLT with bond line integrity maintained	46
6.4.3 CLT with bond line integrity not maintained.....	47
7 Simplified design methods	49
7.1 General.....	49
7.1.1 Materials and products covered.....	49

7.1.2	Timber members	50
7.1.3	Mechanically jointed members	51
7.2	Effective cross-section method	51
7.2.1	General	51
7.2.2	Design of linear timber members	53
7.2.3	Design of plane timber members	56
7.2.4	Design of timber frame assemblies	60
7.2.5	Design of timber-concrete-composite members	69
7.3	Separating function method	70
7.3.1	General	70
7.3.2	Protection time	72
7.3.3	Insulation time	75
7.3.4	Position coefficients	76
7.3.5	Joint coefficients	79
7.3.6	Correction times	80
8	Advanced design methods	83
8.1	General	83
8.2	Thermal analysis	83
8.3	Mechanical analysis	83
8.4	Validation of advanced design methods	84
8.5	Thermal properties	84
8.5.1	General	84
8.5.2	Timber and wood-based materials	85
8.5.3	Gypsum plasterboard and gypsum fibreboard	88
8.5.4	Insulation materials	89
8.6	Mechanical properties	90
9	Connections	92
9.1	General	92
9.2	Initially unprotected connections with timber side members	92
9.2.1	General	92
9.2.2	Minimum fire resistance	93
9.2.3	Geometric requirements for a specific fire resistance	93
9.2.4	Exponential reduction method for connections with dowels or bolts	102
9.2.5	Exponential reduction method for connections with nails or screws	105
9.3	Connections with axially loaded mechanical fasteners	107
9.4	Protected connections	109
9.5	Connections with external steel plates	110
9.5.1	Unprotected connections	110
9.5.2	Protected connections	111
9.6	Carpentry connections	111
10	Detailing	111
10.1	General	111
10.2	Panels	112
10.2.1	Dimensions and spacings	112
10.2.2	Fixing and joints of panels	113
10.3	Insulation	116
10.4	Joints in and between elements and to other adjacent components	118
10.5	Penetrations and openings	120

Annex A (informative) Design of timber structures exposed to physically based design fires	123
A.1 Use of this Annex	123
A.2 Scope and field of application	123
A.3 Structural fire load by the timber members	123
A.4 Design models	124
Annex B (normative) Assessment of the bond line integrity in fire	132
B.1 Use of this Annex	132
B.2 Scope and field of application	132
B.3 Bond line integrity of face bonds	132
B.4 Bond line integrity of finger joints in I-shaped timber members	137
Annex C (normative) Determination of the basic charring rate	141
C.1 Use of this Annex	141
C.2 Scope and field of application	141
C.3 Test equipment	141
C.4 Test conditions	141
C.5 Test specimen	141
C.6 Installation of the test specimen	143
C.7 Application of instrumentation	143
C.8 Test procedure	145
C.9 Test results	146
C.10 Assessment	146
C.11 Application range of results	148
Annex D (normative) Assessment of Protection Level (PL) of the cavity insulation	149
D.1 Use of this Annex	149
D.2 Scope and field of application	149
D.3 Test equipment	149
D.4 Test conditions	149
D.5 Test specimen	149
D.6 Installation of the test specimen	151
D.7 Application of instrumentation	151
D.8 Test procedure	152
D.9 Test results	152
D.10 Assessment	152
Annex E (informative) Assessment of external flaming	153
E.1 Use of this annex	153
E.2 Scope and field of application	153

E.3	External flaming.....	153
Annex F (informative) Assessment of the failure time of fire protection systems		155
F.1	Use of this annex	155
F.2	Scope and field of application	155
F.3	Failure times.....	155
Annex G (normative) Implementation rules for the Separating Function Method.....		157
G.1	Use of this Annex.....	157
G.2	Scope and field of application	157
G.3	General	157
G.4	Fire testing	157
G.5	Determination of the design equations.....	159
G.6	Determination of the design equations.....	160
G.7	Verification of the developed design equations.....	163
Annex I (normative) Design model for timber frame assemblies with I-shaped linear timber members		164
I.1	Use of this annex	164
I.2	Scope and field of application	165
I.3	Design model.....	166
Annex M (normative) Material and product properties for the design with EN 1995-1-2		176
M.1	Use of this Annex.....	176
M.2	Timber members	176
M.3	Panels.....	176
M.4	Cavity insulation	176
Annex T (informative) Determination of temperature in timber members		177
T.1	Use of this Annex.....	177
T.2	Temperature determination	177
Bibliography		179

European foreword

This document (prEN 1995-1-2:2023) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognise the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

The main changes compared to the previous edition are listed below:

- improvement of the charring model (Clause 5.4);
- introduction of tabulated design data (Clause 6);
- improvement of the Effective cross-section method (Clause 7.2);
- addition of design rules for cross-laminated timber (Clause 7.2.3);
- improvement of design rules for timber frame assemblies (Clause 7.2.4);
- addition of design rules for timber-concrete composite members (Clause 7.2.5);
- introduction of the Separating function method (Clause 7.2.3);
- improvement of design rules for connections (Clause 9);
- improvement of rules for detailing (Clause 10);
- addition of normative and informative annexes.

0 Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

- EN 1990 Eurocode: Basis of structural and geotechnical 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
- EN 1998 Eurocode 8: Design of structures for earthquake resistance
- EN 1999 Eurocode 9: Design of aluminium structures
- New parts are under development, e.g. Eurocode for design of structural glass.

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1995 (all parts)

(1) EN 1995 (all parts) applies to the design of buildings and civil engineering works in timber (solid timber, sawn, planed or in pole form, structural finger jointed timber, glued solid timber, glued laminated timber, cross laminated timber and structural laminated veneer lumber), wood-based panels and softboards as sheeting of timber frame members jointed together with adhesives or mechanical fasteners. The design rules given in the standard are valid for softwoods and hardwoods of all species. Special limitations are given in relevant Clauses. It complies with the principles and requirements for the safety and serviceability of structures and the basis of their design and verification given in EN 1990 – Basis of structural and geotechnical design.

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

EN 1995 is intended to be used in conjunction with:

- EN 1990 “Basis of structural and geotechnical design”
- EN 1991 “Actions on structures”

- ENs for construction products relevant to timber structures
- EN 1998 “Design of structures for earthquake resistance”, when timber structures are built in seismic regions

(3) EN 1995 is subdivided in various parts:

- EN 1995-1 Design of timber structures — Part 1: General rules and rules for buildings
- EN 1995-2 Design of timber structures — Part 2: Bridges
- EN 1995-3 Design of timber structures — Part 3: Execution

EN 1995-1 in itself does not exist as a physical document, but comprises the following 3 separate parts:

- EN 1995-1-1 Design of timber structures — Part 1-1 General rules and rules for buildings
- EN 1995-1-2 Design of timber structures — Part 1-2: Structural fire design
- CEN/TS 19103 Eurocode 5 — Design of Timber Structures — Structural design of timber-concrete composite structures — Common rules and rules for buildings

EN 1995-2 “Bridges” refers to the common rules in EN 1995-1-1 and supplements, modifies or supersedes them, where relevant.

EN 1995-3 “Execution” refers to the common rules in EN 1995-1-1 and supplements, modifies or supersedes them, where relevant.

0.3 Introduction to EN 1995-1-2

This document provides rules for the structural fire design of timber structures and civil engineering timber works.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National Annex for EN 1995-1-2

National choice is allowed in this document where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1995-1-2 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this document is to be used.

When no national choice is made and no default is given in this document, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in prEN 1995-1-2 through notes to the following clauses:

4.5(1)

6.1(3)

9.2.3(1)

National choice is allowed in prEN 1995-1-2 on the application of the following Informative annexes:

Annex A

Annex E

Annex F

Annex T

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1995-1-2

(1) This document deals with the design of timber structures for the accidental situation of fire exposure and it is intended to be used in conjunction with prEN 1995-1-1 and prEN 1991-1-2.

This document only identifies differences from, or supplements to, normal temperature design.

(2) This document applies to timber structures required to fulfil a loadbearing function, separating function or both.

(3) This document gives principles and application rules for the design of structures for specified requirements in respect of the aforementioned functions and the levels of performance.

(4) This document applies to structures, or parts of structures, that are within the scope of prEN 1995-1-1 and are designed accordingly.

(5) The methods given in this document are applicable to all products covered by harmonized technical specifications made reference to in this document.

1.2 Assumptions

(1) In addition to the general assumptions of EN 1990, the following assumptions apply:

- the choice of the relevant design fire scenario is made by appropriate qualified and experienced personnel, or is given by the relevant national regulation;
- any fire protection measure taken into account in the design will be adequately maintained.

2 Normative references

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

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in 'should' clauses), permissions ('may' clauses), possibilities ('can' clauses), and in notes.

EN 300, *Oriented strand boards (OSB) — Definitions, classification and specifications*

EN 301, *Adhesives, phenolic and aminoplastic, for load-bearing timber structures — Classification and performance requirements*

EN 312, *Particleboards — Specifications*

EN 520, *Gypsum plasterboards — Definitions, requirements and test methods*

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 998-1, *Specification for mortar for masonry — Part 1: Rendering and plastering mortar*
- EN 1363-1, *Fire resistance tests — Part 1: General requirements*
- EN 1990:2023, *Eurocode — Basis of structural and geotechnical design*
- EN 1991 (all parts), *Eurocode 1 — Actions on structures*
- prEN 1991-1-2:2021, *Eurocode 1 — Actions on structures — Part 1-2: Actions on structures exposed to fire*
- FprEN 1992-1-2, *Eurocode 2 — Design of concrete structures — Part 1-2: Structural fire design*
- prEN 1993-1-2, *Eurocode 3 — Design of steel structures — Part 1-2: Structural fire design*
- prEN 1995-1-1:2023, *Eurocode 5 — Design of timber structures — Part 1-1: General rules and rules for buildings*
- ISO 5660-1, *Reaction-to-fire tests — Heat release, smoke production and mass loss rate — Part 1: Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)*
- EN 13162, *Thermal insulation products for buildings — Factory made mineral wool (MW) products — Specification*
- EN 13171, *Thermal insulation products for buildings — Factory made wood fibre (WF) products. Specification*
- EN 13353, *Solid wood panels (SWP) — Requirements*
- EN 13914-2, *Design, preparation and application of external rendering and internal plastering — Part 2: Internal plastering*
- EN 13986, *Wood-based panels for use in construction — Characteristics, evaluation of conformity and marking*
- EN 14080, *Timber structures — Glued laminated timber and glued solid timber — Requirements*
- EN 14081-1, *Timber structures — Strength graded structural timber with rectangular cross section — Part 1: General requirements*
- EN 14279, *Laminated Veneer Lumber (LVL) — Definitions, classification and specifications*
- EN 14374, *Timber structures — Structural laminated veneer lumber — Requirements*
- EN 14915, *Solid wood panelling and cladding — Characteristics, requirements and marking*
- EN 15101-1, *Thermal insulation products for buildings — In-situ formed loose fill cellulose (LFCI) products — Part 1: Specification for the products before installation*
- EN 15283-2, *Gypsum boards with fibrous reinforcement — Definitions, requirements and test methods — Part 2: Gypsum fibre boards*
- EN 15425, *Adhesives — One component polyurethane (PUR) for load-bearing timber structures — Classification and performance requirements*

EN 15497, *Structural finger jointed solid timber — Performance requirements and minimum production requirements*

EN 16351, *Timber structures — Cross laminated timber — Requirements*

3 Terms, definitions and symbols

3.1 Terms and definitions

(1) For the purposes of this document, the terms and definitions given in EN 1990, prEN 1991-1-2 and prEN 1995-1-1 and the following apply.

3.1.1

assembly

composition of elements

[SOURCE: prEN 1995-1-1]

3.1.2

basic design charring rate

charring rate of wood species of initially unprotected members or charring rate of initially unprotected panels exposed to fire from one side without considering effects of *gaps* (3.1.16), joints, etc.

3.1.3

bond line integrity in fire

ability of the bond line for face bonds to provide stickability between layers in the fire situation

3.1.4

char-line

border-line between char layer and the *residual cross-section* (3.1.25), assumed to be equal with the position of the 300 °C isotherm

3.1.5

charring depth

distance from the original surface of the timber member to the *char-line* (3.1.4)

3.1.6

charring phase

initially unprotected, protected, post-protected or consolidated phase within the European charring model, defined as a time period

3.1.7

cladding

lining

external or internal covering formed by panels

3.1.8

coating

surface treatment applied on timber member

3.1.9**component**

part of an *assembly* (3.1.1) or element

[SOURCE: prEN 1995-1-1]

3.1.10**effective cross-section**

cross-section of the original timber member reduced by the *charring depth* (3.1.5) and the zero-strength layer at heated sides of the timber member

3.1.11**failure time of fire protection system**

time at which the fall-off of the fire protection system occurs

3.1.12**fire protection material**

material applied for the purpose of increasing fire resistance

3.1.13**fire protection system**

kit of *fire protection material(s)* (3.1.12) together with a defined method of fixing and mounting

3.1.14**foil**

thin layer applied on and in an *assembly* (3.1.1) or element for example a vapour barrier

3.1.15**fully developed char layer**

layer of charred material insulating the substrate

3.1.16**gap**

distance between or within adjacent assemblies, elements or *components* (3.1.9) in a joint

3.1.17**I-shaped member**

glued thin-webbed beam or stud consisting of wood-based flanges and symmetrically placed thin web between the flanges, for example I-joist or I-stud

3.1.18**insulation time**

time from the start of fire to reach the temperature rise of 140 K on the unexposed side of the *assembly* (3.1.1) used for the separating function method

3.1.19**notional charring depth**

charring depth (3.1.5) considering *notional design charring rates* (3.1.20) for all relevant charring phases (3.1.6)

3.1.20**notional design charring rate**

charring rate within one *charring phase* (3.1.6) considering effects of dimensions, *gaps* (3.1.16), joints, etc. according to the European charring model

3.1.21

normal temperature design

design for ambient temperature according to Part 1-1 of EN 1992 to EN 1996 or EN 1999

3.1.22

protected member

member with applied fire protection systems

3.1.23

protection time

time to reach the charring of entire thickness or temperature rise of 250 K behind the considered material or product

3.1.24

protection level

PL

level describing the ability of cavity insulation to protect timber members in case of fire

3.1.25

residual cross-section

cross-section of the original timber member reduced by the *charring depth* (3.1.5) at heated sides of the timber member

3.1.26

start time of charring

time at the beginning of the fire exposure for initially unprotected sides of timber members, or time when the surface temperature for initially protected sides of timber members reaches 300 °C

3.1.27

span direction

direction of the member between two supports

3.1.28

tongue-groove joint

joint between *wood-based panels* (3.1.30) or panelling which have edges profiled to tongue and groove geometry

3.1.29

vertical member

member not deviating more than 15° from the vertical

3.1.30

wood-based panel

panel according to EN 13986

3.1.31

solid wood panelling

layers of solid wood boards according to EN 14915

3.1.32

zero strength layer

depth of cross-section taking into account the stiffness or strength reduction of timber member when exposed to fire and the uncertainty of charring rate

3.2 Symbols and abbreviations

(1) For the purposes of this document, the following symbols apply:

3.2.1 Latin upper case letters

E	Integrity criterion
E	Cumulative radiant energy
$E_{d,fi}$	design effect of actions for the fire situation
E_{web}	modulus of elasticity of the web
I	insulation criterion
$I_{web,ef}$	moment of inertia of the web
K	slip modulus at normal temperature
K_{fi}	slip modulus in the fire situation
L_p	span of the panel
L_{wall}	height of the wall including sole and head plates
$L_{y,ef}$	buckling length with respect to out of plane buckling
$L_{z,ef}$	buckling length with respect to in plane buckling
O	opening factor of the fire compartment
R	loadbearing criterion
R_k	loadbearing capacity of the connection at the normal condition
$R_{k,fi}$	characteristic loadbearing capacity of the connection at the required fire resistance time
$R_{d,fi,t}$	design resistance in the fire situation
$RHR_{ext,ef}$	effective external time dependent rate of heat release
$RHR_{f,ef}$	effective time dependent rate of heat release by the movable fuel
$RHR_{int,ef}$	effective internal time dependent rate of heat release
RHR_{st}	time dependent rate of heat release per square meter combusting timber members surface as function of the time dependent design charring rate
$RHR_{st,ef}$	effective time dependent rate of heat release by the structural fuel
$RHR_{tot,ef}$	effective total time dependent rate of heat release
T	temperature
$T_{mean,45}$	temperature after 45 minutes of fire exposure
$T_{mean,60}$	temperature after 60 minutes of fire exposure
$X_{d,fi}$	design value of a strength or stiffness property for fire temperature design

X_k	characteristic value of a strength or stiffness property for normal temperature design
X_θ	effective value of a strength or stiffness property for the fire situation

3.2.2 Latin lower case letters

a_3	end distance
a_4	edge distance
a_{fi}	increase of end or edge distance required for the fire situation
a_{edge}	distance of the panel edge
a_{min}	minimum end or edge distance
a_p	minimum distance from the exposed side
$a_{p,i}$	distance from the exposed side i
$a_{fi,t1}$	increase of the thickness of the timber side member required for the fire situation
b	width of the initial cross-section
b_{ef}	width of the effective cross-section
b_{fi}	width of the cross-section of the timber member required for fire situation
b_f	initial cross-section width of the flange
$b_{f,ef}$	effective cross-section width of the flange
b_w	initial cross-section width of the web
$b_{w,ef}$	effective cross-section width of the web
c	specific heat capacity
c_i	coefficient
d	thickness
d_0	zero-strength layer depth
$d_{char,i,j}$	measured charring depth at the cross-section i at the point j
$d_{char,n}$	notional charring depth
$d_{char,n,1}$	notional charring depth for the fire-exposed side
$d_{char,n,2}$	notional charring depth for the lateral side
$d_{char,n,w}$	notional charring depth of the web
$d_{char,t}$	design charring depth, charring depth to determine the structural fire load
d_{ef}	effective charring depth

d_i	depth at measurement point i from the initial fire exposed surface of the timber member
d_{i+1}	depth of the subsequent measurement point $i+1$ from initial fire exposed surface of the timber member
f	joint width
h	depth of the initial cross-section
h_1	thickness of the gypsum plasterboard or gypsum fibreboard on the fire exposed side
h_{ef}	depth of the effective cross-section
h_{fi}	depth of the cross-section of the timber member required for the fire situation
h_i	thickness of the layer i
h_{ins}	thickness of the cavity insulation
h_f	initial cross-section depth of the flange
$h_{f,ef}$	effective cross-section depth of the flange
h_n	thickness of the last layer n
h_p	panel thickness
$h_{p,j}$	average initial thickness of the wooden panel j under investigation
$h_{p,min}$	minimum thickness of the panel
$h_{res,i}$	uncharred thickness of the layer i
h_w	cross-section depth of the web
i	number of the layer i
k	coefficient for connections; web stiffness
k_2	protection factor for Phase 2
k_3	post-protection factor for Phase 3
$k_{3,1}$	post-protection factor for Phase 3 for the fire exposed side
$k_{3,2}$	post-protection factor for Phase 3 for the lateral side
k_4	consolidation factor for Phase 4
k_{con}	connection factor
k_{fi}	modification factor for a strength or stiffness property for the fire situation
k_g	gap factor
k_{gd}	grain direction factor
k_h	thickness factor

k_i	modification factors for charring
k_j	joint coefficient
$k_{j,i}$	joint coefficient of the layer i
$k_{j,n}$	joint coefficient of the last layer n
k_{mod}	modification factor
k_n	conversion factor
$k_{pos,exp,i}$	position coefficient for the fire exposed side of the layer i
$k_{pos,exp,n}$	position coefficient for the fire exposed side of the last layer n
$k_{pos,exp,sim}$	position coefficient for the fire exposed side from simulation
$k_{pos,unexp,i}$	position coefficient for the unexposed side of the layer i
$k_{pos,unexp,sim}$	position coefficient for the unexposed side from simulation
$k_{s,n,1}$	combined section and conversion factor for the fire exposed side
$k_{s,n,2}$	combined section and conversion factor for the lateral side
k_{side}	number of respective sides exposed to fire
k_{sys}	system strength factor
kT	cumulative thermal impact described by the temperature
k_w	factor for reduction of buckling length
k_θ	temperature-dependent reduction factor for a strength or stiffness property
k_ρ	density factor
$l_{a,min}$	minimum anchorage length of the fastener into the uncharred timber member
l_s	depth of the residual bearing area required for loadbearing in the case of fire
l_x	penetration length of the fastener
$l_{x,min}$	minimum penetration length of the fastener
m	combustion factor
n	number; number of the last layer; number of the measurement points
p	projection of steel dowels above the timber surface
$q_{t,d}$	design fire load density
s_{10}	charring rate related to the rate of heat release of timber members per unit area
	heat release of structural timber

t	time
t_0	time until a constant charring rate is assumed
$t_{300,\text{furnace}}$	time when the temperature of 300 °C in the furnace is reached
$t_{300,i}$	time when the temperature of 300 °C in measurement point i is reached
$t_{300,p,j}$	time when the temperature of 300 °C behind the wooden panel j is reached
$t_{300,i+1}$	time when the temperature of 300 °C in the subsequent measurement point $i+1$ is reached
$t_{1,fi}$	thickness of the timber side member required for the fire situation
$t_{1,\text{sim}}$	time from simulation until the temperature between the preceding layer and the investigated layer reaches 270 °C
t_2	thickness of the timber internal member
$t_{2,\text{sim}}$	time from simulation until the temperature behind the investigated layer reaches 270 °C
$t_{3,\text{sim}}$	time from simulation until the temperature behind the investigated layer which is baked by mineral wool reaches 270 °C
t_a	consolidation time
$t_{a,i}$	consolidation time of layer i
t_{ch}	start time of charring on the fire exposed side
$t_{\text{ch},2}$	start time of charring for the lateral side
t_{end}	time when the parametric fire temperature reaches 20 °C
t_f	failure time of panels initially exposed to fire
t_{fi}	fire resistance time
$t_{f,i}$	failure time of layer i
$t_{f,\text{pr}}$	failure time of the fire protection system
$t_{f,\text{test}}$	failure time of the fire protection system determined from the tests
$t_{f,\text{test},i}$	failure time of the fire protection system determined from the test i
t_g	thickness of the slot
t_{ins}	insulation time of the assembly
$t_{\text{ins},0,n}$	basic insulation time of the last layer n
$t_{\text{ins},n}$	insulation time of the last layer n
$t_{\text{ins,max},n}$	maximum insulation time of the last layer n
t_j	time until the mean value of the temperature measurements reaches 270 °C
$t_{fi,\text{min}}$	minimum fire resistance time

$t_{\max}$	time when the maximum temperature is reached
$t_{\text{mean},100}$	average time when the char-line has reached the depth of 100 mm on the surface of the timber member
t_{peak}	time for maximum values of zero-strength layer depths
$t_{\text{prot},0,i}$	basic protection time of the layer i
$t_{\text{prot},0,\text{sim}}$	basic protection time from simulation
$t_{\text{prot},i}$	protection time of the layer i
$t_{\text{prot},\max,i}$	maximum protection time of the layer i
$t_{\text{prot},n}$	protection time of the last layer n
t_{req}	required fire resistance time
t_s	depth of the residual bearing area required for loadbearing in the case of fire
$v_{\text{fi},c}$	absolute value of the time dependent cooling rate
v_{rec}	recession speed
w	dimension as width / length
x	scaling factor
y	distance from the fire exposed side in y-direction
z	distance from the fire exposed side in x-direction

3.2.3 Greek upper case letters

Γ	factor accounting for the thermal properties of the boundaries of the enclosure of the compartment given
Δt_i	correction time of the layer i
$\Delta t_{i,c}$	time difference in the cooling phase
$\Delta t_{\max,i}$	maximum correction time of the layer i
$\Delta t_{\max,n}$	maximum correction time of the last layer n
Δt_n	correction time for the last layer n
$\Delta T_{i,c}$	temperature difference in the cooling phase
θ	time dependent temperature
$\theta_{\max}$	maximum temperature in the fire compartment
$\prod k_i$	product of applicable modification factors for charring
Σt_{prot}	sum of protection times
$\Sigma t_{\text{prot},i}$	sum of the protection times of the insulation layer i and the layers preceding the insulation layer i

$\Sigma t_{\text{prot},i-1}$ sum of the protection times of the layers preceding the layer i

3.2.4 Greek lower case letters

α	time dependent parameter
α_{fi}	modification factor for the zero-strength layer depth
α_{st}	modification factor to consider the combustion behaviour of structural timber members
β_0	basic design charring rate
$\beta_{i,j}$	charring rate between two consecutive in depth measurement points i and $i+1$ at an individual measurement station j
$\beta_{i,j,\text{aver}}$	average charring rate in a specific depth at point i considering the preceding measurement points in a measurement station j ,
$\beta_{\text{mean,specimen}}$	mean charring rate of the test specimen
$\beta_{\text{mean,reference}}$	mean charring rate of the reference specimen
β_{n}	notional design charring rate within one charring phase
$\beta_{\text{n,Phase2}}$	notional design charring rate during Phase 2
$\beta_{\text{n,Phase3}}$	notional design charring rate during Phase 3
β_{par}	design charring rate for the parametric fire
β_{st}	time dependent design charring rate
$\gamma_{\text{M,fi}}$	partial factor for the relevant mechanical material property for the fire situation
ε	emissivity
η_{fi}	ratio between the design effect of actions for the fire situation and the characteristic loadbearing capacity of the connection at normal temperature
$\eta_{\text{K,fi}}$	modification factor for the slip modulus for connections for the fire situation
$\eta_{\text{R,fi}}$	modification factor for the strength for connections for fire situation
λ	thermal conductivity
λ_{p}	density dependent conductivity
ρ	density
ρ_{20}	density at normal temperature of 20 °C
ρ_i	density of the layer i
ρ_{k}	characteristic density
σ	Stefan-Boltzmann constant

4 Basis of design

4.1 General

(1) The structural fire design shall be in accordance with the general rules given in EN 1990 and EN 1991 (all parts) and the specific design provisions for timber structures given in EN 1995-1-1.

(2) Where mechanical resistance in the case of fire is required, timber structures shall be designed and constructed in such a way that they maintain their loadbearing function during the relevant fire exposure.

(3) Where compartmentation is required, the elements forming the boundaries of the fire compartment, including joints, shall be designed and constructed in such a way that they maintain their separating function during the relevant fire exposure to ensure that integrity and insulation failures do not occur.

NOTE For non-loadbearing elements, the loadbearing function under self-weight is expected to be maintained in order to fulfil the separating function.

(4) Deformation criteria shall be applied where the means of protection require consideration of the deformation of the loadbearing structure.

(5) Consideration of the deformation of the loadbearing structure may be omitted, when the efficiency of the means of protection has been evaluated according to 5.4.2.3 or 7.3.

(6) Deformation criteria shall be applied where the design criteria for separating elements require taking into account of the deformation of the loadbearing structure.

(7) Consideration of the deformation of the loadbearing structure may be neglected when the separating elements fulfil requirements of a nominal fire exposure.

4.2 Nominal fire exposure

(1) For standard fire exposure, elements shall comply with one of the following functions or combinations of function during the required time of fire exposure:

- loadbearing function: loadbearing capacity (R);
- separating function: integrity (E) and, when requested, insulation (I);
- separating and loadbearing functions: (R, E) and, when requested, (I).

(2) The loadbearing function (R) is assumed to be satisfied when loadbearing capacity is maintained.

(3) The separating function is assumed to be satisfied when integrity (E) and, when requested, insulation (I) is maintained.

(4) Integrity (E) is assumed to be maintained when a separating element of building construction, exposed to fire on one side, prevents the passage through it of flames and hot gases and the occurrence of flames on the unexposed side.

(5) Insulation (I) is assumed to be maintained when the average temperature rise over the whole of the unexposed surface is limited to 140 K, and the maximum temperature rise at any point of that surface does not exceed 180 K.

(6) With the external fire exposure curve the same functions (R, E, I) shall apply. However, the reference to this specific curve shall be identified by the letters "ef".

(7) With the hydrocarbon fire exposure curve the same functions (R, E, I) shall apply. However, the reference to this specific curve shall be identified by the letters "HC".

4.3 Physically based fire exposure

(1) The loadbearing function shall be maintained during the complete duration of the fire, including the cooling phase or during a required period of time according to prEN 1991-1-2:2021, 4.4 (4).

NOTE 1 A method for the design of timber structures exposed to physically based design fires is given in Annex A (informative).

NOTE 2 A method for the assessment of external flaming of fire compartments with exposed structural timber is given in Annex E (informative).

(2) For the verification of the separating function the following applies, assuming that the normal temperature is 20 °C:

- the average temperature rise of the unexposed side of the construction should be limited to 140 K and the maximum temperature rise of the unexposed side should not exceed 180 K during the heating phase until the maximum temperature in the fire compartment is reached;
- the average temperature rise of the unexposed side of the construction should be limited to 200 K and the maximum temperature rise of the unexposed side should not exceed 240 K during the cooling phase.

4.4 Actions

(1) Thermal and mechanical actions shall be taken from prEN 1991-1-2.

4.5 Design values of material properties

(1) Design values of mechanical (strength and stiffness) properties for the fire situation $X_{d,fi}$ should be determined as follows:

$$X_{d,fi} = k_{\theta} \cdot k_{fi} \cdot X_k / \gamma_{M,fi} \quad (4.1)$$

where

- | | |
|-----------------|---|
| $X_{d,fi}$ | is the design value of a strength or stiffness property (generally f_k or E_k) for fire temperature design; |
| k_{θ} | is the temperature-dependent reduction factor for a strength or stiffness property according to 7.2 or 8.6; |
| k_{fi} | is the modification factor for a strength or stiffness property for the fire situation according to Table 4.1; |
| X_k | is the characteristic value of a strength or stiffness property (generally f_k or E_k) for normal temperature design according to prEN 1995-1-1; |
| $\gamma_{M,fi}$ | is the partial factor for the relevant mechanical property for the fire situation. |

NOTE The value of $\gamma_{M,fi}$ is 1,0 unless the National Annex gives a different value.

(2) The modification factor k_{fi} for a strength or stiffness property for the fire situation should be taken from Table 4.1.

Table 4.1 — Modification factor for strength and stiffness property for the fire situation

Material	k_{fi}
Structural timber, structural finger jointed solid timber, glued solid timber	1,25
Glued laminated timber, block glued glulam, CLT	1,15
Wood-based panels	1,15
LVL, GLVL	1,10

(3) For products not included in Table 4.1, the modification factor k_{fi} should be taken equal to 1,0.

(4) The modification factor k_{mod} , the system strength factor k_{sys} , the adjustment factor k_v for shear strength and the factor $k_{c,1}$ considering the effect on the compressive strength by different moisture contents in SC 1 and SC 2 according to prEN 1995-1-1 shall be taken equal to 1,0.

(5) The design values of thermal properties for the fire situation should be taken equal to their characteristic values.

4.6 Verification methods

(1) The model of the structural system adopted for design shall reflect the performance of the structure in the fire situation.

(2) Mechanical resistance shall be verified for the required duration of fire exposure t as follows:

$$E_{d,fi} \leq R_{d,fi,t} \quad (4.2)$$

where

$E_{d,fi}$ is the design effect of actions for the fire situation, determined in accordance with prEN 1991-1-2, including effects of thermal expansions of materials and deformations;

$R_{d,fi,t}$ is the corresponding design resistance in the fire situation.

(3) The thermal expansion of timber may be neglected.

(4) The structural analysis for the fire situation should be carried out according to 7.1.5 of EN 1990:2023.

NOTE For verifying resistance requirements based on the standard fire curve, unless otherwise specified, a member analysis is typically undertaken.

(5) If not specified in the relevant clauses, the verification methods given in this document may be applied for all types of fire exposure.

(6) The following design methods may be used in order to satisfy 4.6 (2):

- use of tabulated design data for specific types of members, see Clause 6;
- use of simplified design methods for specific types of members, see Clause 7 and Clause 10;
- use of advanced design methods for the analysis of members and connections, parts of the structure or the entire structure, see Clause 8.

(7) As an alternative to design by calculation, fire design may be based on the results of fire tests, or on fire tests in combination with calculations.

(8) Fire resistance calculated according to design methods given in this document may be used for the classification according to EN 13501-2.

4.7 Member analysis

(1) The design effect of actions should be determined for time $t = 0$ using combination factors according to 6.3 of prEN 1991-1-2:2021.

(2) As a simplification, the value of $\eta_{fi} = 0,6$ should be used, except for imposed loads according to category E as given in prEN 1991-1-1 (areas susceptible to accumulation of goods, including access areas) where the value should be $\eta_{fi} = 0,7$.

NOTE As indicated in prEN 1991-1-2:2021, 6.3, different values for the reduction factor η_{fi} can be given in the National Annex.

(3) The effects of thermal deformations resulting from thermal gradients across the cross-section of materials other than timber shall be considered in the design.

(4) The effects of axial or in-plane thermal expansions may be neglected.

(5) The kinematic boundary conditions at supports and ends of members, applicable at time $t = 0$, may be assumed to remain unchanged throughout the fire exposure.

(6) Tabulated design data, simplified or advanced design methods given in Clause 6, Clause 7 and Clause 8 respectively may be used for verifying members under fire conditions.

4.8 Analysis of parts of the structure

(1) The effect of actions should be determined for time $t = 0$ using combination factors according to 6.3 of prEN 1991-1-2:2021.

(2) As an alternative to 4.8 (1), the reactions at supports and internal forces and moments at boundaries of part of the structure may be obtained from structural analysis for normal temperature design as given in 4.7.

(3) Within the part of the structure to be analysed, the relevant failure mode in fire, the temperature-dependent material properties and member stiffness, and the effects of thermal expansions of materials other than timber and deformations (indirect fire actions) shall be taken into account.

(4) The part of the structure to be analysed should be specified on the basis of the potential thermal expansions of materials other than timber and deformations such that their interaction with other parts of the structure can be approximated by time-independent support and boundary conditions during fire exposure.

4.9 Global structural analysis

(1) A global structural analysis for the fire situation shall take into account:

- the relevant failure mode in fire exposure;
- the temperature-dependent material properties and member stiffness;
- effects of thermal expansions of materials other than timber and deformations (indirect fire actions).

5 Material properties

5.1 General

(1) Products used for the design according to this document shall fulfil the minimum requirements in Table 5.1.

Table 5.1 — Minimum requirements for products

Timber members	Abbreviation	EN	EAD ^a	Requirements
Structural timber		EN 14081-1		$\rho_k \geq 290 \text{ kg/m}^3$
Structural finger jointed solid timber		EN 15497		$\rho_k \geq 290 \text{ kg/m}^3$
Glued laminated timber	GLT	EN 14080		$\rho_k \geq 290 \text{ kg/m}^3$
Glued solid timber				
Glulam with large finger joints				
Block glued glulam				
Glued laminated timber made of solid hardwood	GLT		EAD 130320-00-0304	$\rho_k \geq 600 \text{ kg/m}^3$
Cross laminated timber	CLT	EN 16351	EAD 130005-00-0304	$\rho_k \geq 290 \text{ kg/m}^3$
Laminated Veneer Lumber	LVL	EN 14374		$\rho_k \geq 480 \text{ kg/m}^3$
Glued Laminated LVL	GLVL		EAD 130337-00-0304 or EAD 130010-01-0304	$\rho_k \geq 480 \text{ kg/m}^3$
where ρ_k is the characteristic density, in kg/m^3 .				
^a The column has the status of a NOTE (informative) and is not exhaustive.				

Table 5.1 — Minimum requirements for products (continuation)

Panels	Abbreviation	EN	Requirements
Solid wood panelling and claddings		EN 14915	$\rho_k \geq 290 \text{ kg/m}^3$
Solid wood panels	SWP	EN 13353 and EN 13986	$\rho_k \geq 290 \text{ kg/m}^3$
Oriented Strand Board	OSB	EN 300 and EN 13986	$\rho_k \geq 550 \text{ kg/m}^3$
Particleboards		EN 312 and EN 13986	$\rho_k \geq 500 \text{ kg/m}^3$
Fibreboards		EN 622-2, EN 622-3 or EN 622-5 and EN 13986	$\rho_k \geq 500 \text{ kg/m}^3$
LVL panels		EN 14374 and EN 14279	$\rho_k \geq 480 \text{ kg/m}^3$
Plywood		EN 636 and EN 13986	$\rho_k \geq 400 \text{ kg/m}^3$
Gypsum plasterboards Type A, H and F		EN 520	$\rho \geq 700 \text{ kg/m}^3$
Gypsum fibreboards		EN 15283-2	$\rho \geq 1000 \text{ kg/m}^3$
Clay plaster		EN 13914-2	$1610 \leq \rho \leq 1800 \text{ kg/m}^3$
Clay boards			$1610 \leq \rho \leq 1800 \text{ kg/m}^3$
Lime plaster		EN 998-1 and EN 13914-2	$\rho = 1700 \pm 100 \text{ kg/m}^3$
Mineral wool insulation panels		EN 13162	Protection level PL1 $\rho \geq 100 \text{ kg/m}^3$
Wood fibre insulation board		EN 13171 or EN 622-4 and EN 13986	$110 \leq \rho \leq 270 \text{ kg/m}^3$
where ρ_k is the characteristic density, in kg/m^3; ρ is the density, in kg/m^3.			

Table 5.1 — Minimum requirements for products (continuation)

Screed	Abbreviation	EN	Requirements
Floor screed (cement, anhydride)		EN 13813	$\rho \geq 1500 \text{ kg/m}^3$
where ρ is the density, in kg/m^3 .			

Table 5.1 — Minimum requirements for products (continuation)

Cavity insulation	EN	EAD ^a	Requirements
Mineral wool insulation	EN 13162		Protection level PL1 $\rho \geq 20 \text{ kg/m}^3$
			Protection level PL2 $\rho \geq 14 \text{ kg/m}^3$
Wood fibre cavity insulation	EN 13171		Min. protection level PL2 $\rho \geq 50 \text{ kg/m}^3$
Loose-fill cellulose fibre cavity insulation made from paper	EN 15101-1	EAD 040138-00-1201	Min. protection level PL2 $\rho \geq 50 \text{ kg/m}^3$
Loose-fill wood fibre cavity insulation			Min. protection level PL2 $\rho \geq 35 \text{ kg/m}^3$
where ρ is the density, in kg/m ³ .			
^a The column has the status of a NOTE (informative) and is not exhaustive.			

(2) The protection level PL shall be assessed as specified in Annex D or shall be taken from Table 5.2.

Table 5.2 — Protection level PL for cavity insulation materials

Protection level PL	Insulation material	Requirement
PL1	Stone wool	$\rho \geq 26 \text{ kg/m}^3$
PL2	Glass wool	$\rho \geq 14 \text{ kg/m}^3$
	Wood fibre	$\rho \geq 50 \text{ kg/m}^3$
	Loose-fill cellulose fibre	$\rho \geq 50 \text{ kg/m}^3$
	Loose-fill wood fibre	$\rho \geq 35 \text{ kg/m}^3$
PL3	XPS, EPS, PUR, PIR	-
	Not assessed insulation materials	-
where ρ is the density, in kg/m ³ .		

(3) Unless given as design values, the values of thermal and mechanical properties given in Clause 5 and Clause 8 shall be treated as characteristic values.

NOTE The characteristic values of thermal properties correspond to mean values.

5.2 Thermal properties

(1) Thermal properties should be taken as given in 8.5.

NOTE Thermal properties are used for advanced design methods (Clause 8). For simplified design methods (Clause 7 and Clause 9) thermal properties are considered in the methods.

5.3 Mechanical properties

(1) The influence of temperature on the mechanical properties should be taken as given in 8.6.

NOTE Temperature-dependent mechanical properties are used for advanced design methods (Clause 8). For simplified design methods (Clause 7 and Clause 9) the influence of temperature on the mechanical properties is considered in the methods.

5.4 Charring

5.4.1 General

(1) Charring shall be taken into account for all sides of timber members directly exposed to fire, and, where relevant, for initially protected sides, where charring occurs during the relevant time of fire exposure.

(2) The position of the char-line in timber members should be assumed as the position of the 300 °C–isotherm.

NOTE Determination of temperature in timber members for specific situations (e.g. glued composite timber members or connections with bonded-in rods) can be calculated using Annex T.

(3) The charring depth should be calculated using appropriate charring rate(s).

(4) It should be taken into account that the charring rates are normally different for

- initially unprotected sides of timber members;
- initially protected sides of timber members prior to failure of the protection;
- sides of timber members directly exposed to fire after failure of the protection.

(5) The calculation of the residual cross-section should consider the geometrical and material characteristics of the member or the assembly, and, where appropriate, the overlay of heat flux into the residual cross-section.

NOTE 1 Components with deviating heat conduction compared to wood (e.g. steel plates or fasteners) influence the charring rate.

NOTE 2 The overlay of heat flux is e.g. due to fire exposure from several sides or to the influence of steel plates or fasteners.

(6) The radius of the corner roundings of the residual cross-section due to the overlay of heat flux may be taken equal to the charring depth.

(7) The residual cross-section shall be calculated using either the European charring model (see 5.4.2) or advanced calculations (see Clause 8).

NOTE The European charring model is a simplified model for the calculation of the residual cross-section of a timber member assuming linear charring rates during different charring phases.

5.4.2 The European charring model

5.4.2.1 General

(1) The European charring model should be applied to standard fire exposure.

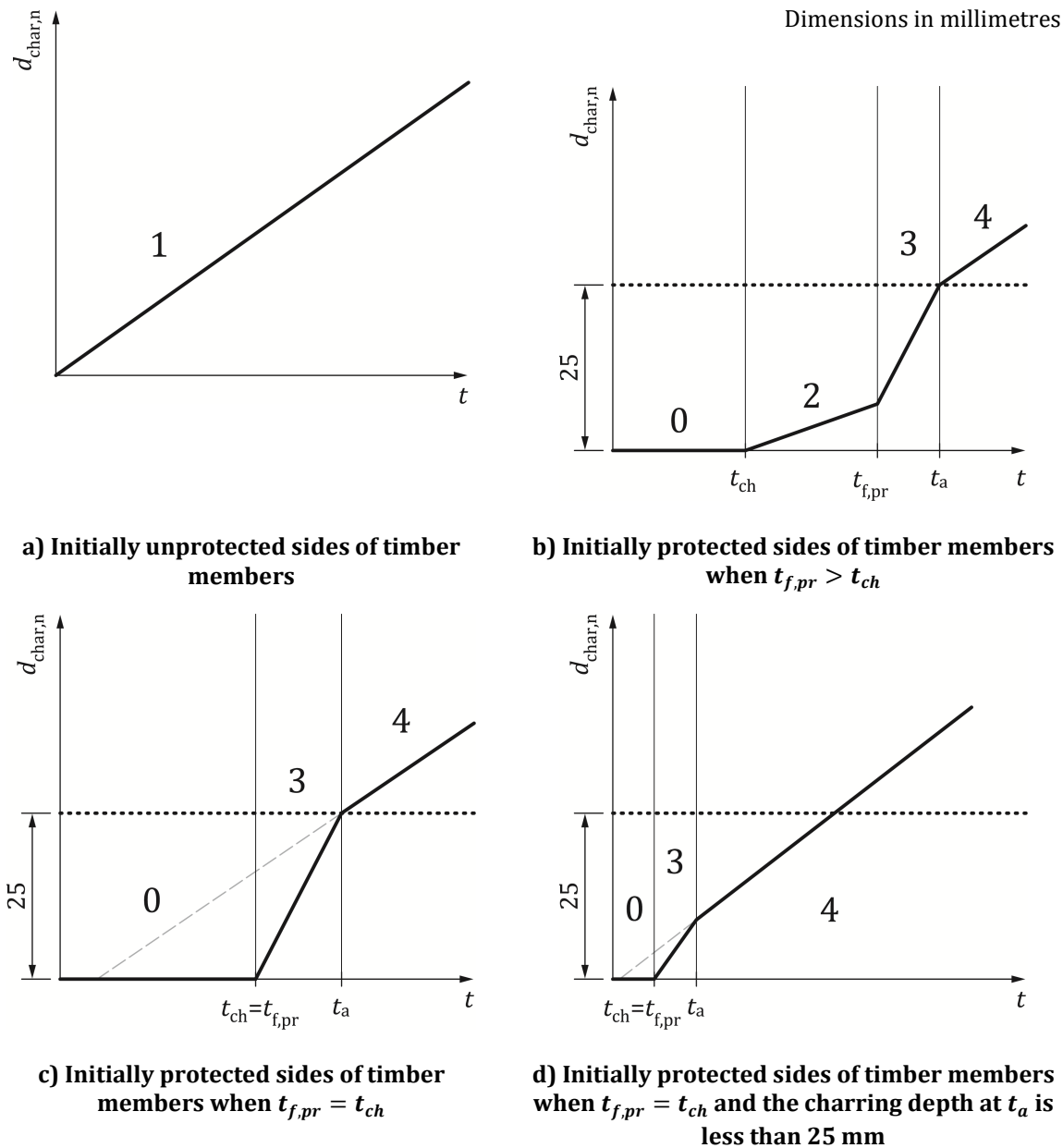
(2) The following phases should be taken into account where relevant (see Figure 5.1 and Figure 5.2):

For initially unprotected sides of timber members:

- **Normal charring phase (Phase 1).**

For initially protected sides of timber members:

- **Encapsulated phase (Phase 0)** is the phase when no charring occurs behind the fire protection system;
- **Protected charring phase (Phase 2)** is the phase when charring occurs behind the fire protection system while this system is still in place;
- **Post-protected charring phase (Phase 3)** is the phase after the failure of the fire protection system before a fully developed char layer has been formed;
- **Consolidated charring phase (Phase 4)** is the phase with fully developed char layer.



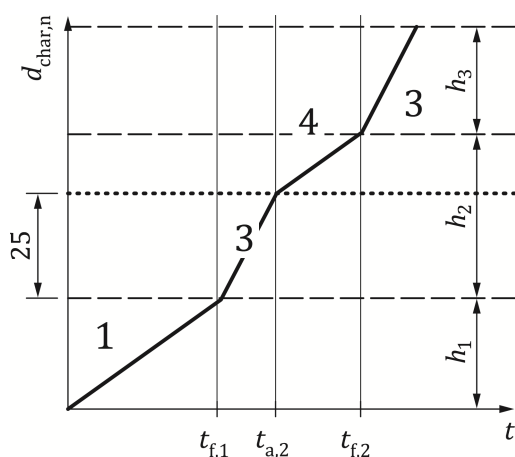
Key

0	encapsulated phase (Phase 0)	$d_{char,n}$	notional charring depth
1	normal charring phase (Phase 1)	t	time
2	protected charring phase (Phase 2)	t_a	consolidation time; see 5.4.2.3 (1)
3	post-protected charring phase (Phase 3)	t_{ch}	start time of charring; see 5.4.2.3 (3)
4	consolidated charring phase (Phase 4)	$t_{f,pr}$	failure time of the fire protection system; see 5.4.2.3. (6) to (10)

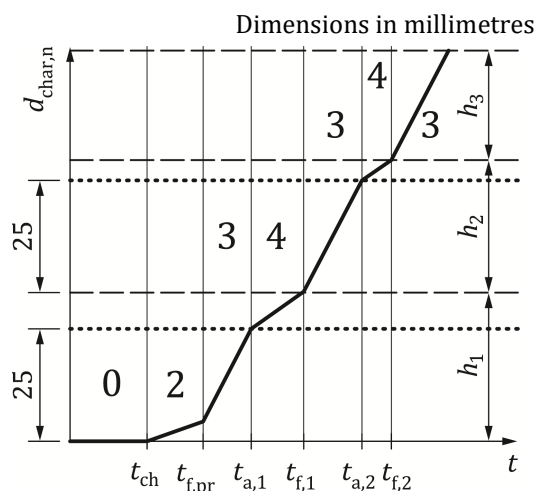
NOTE 1 In Figure 5.1 (b) and (c), the Phase 4 illustrates that a char layer of 25 mm gives sufficient protection to reduce the charring rate to the value for initially unprotected sides of timber members (Phase 1).

NOTE 2 Information on bond line integrity in fire of face bonds is given in 5.5.

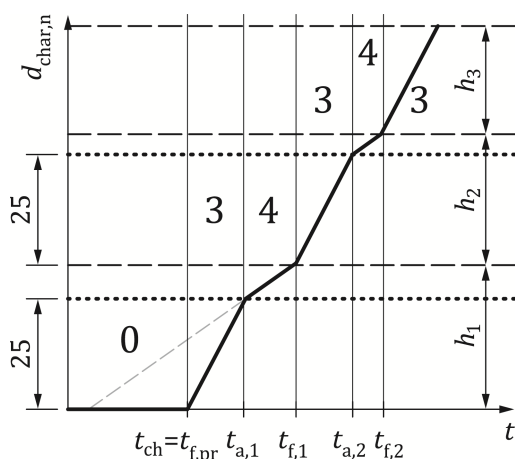
Figure 5.1 — Phases for sides of timber members when the bond line integrity of face bonds is maintained during the fire exposure



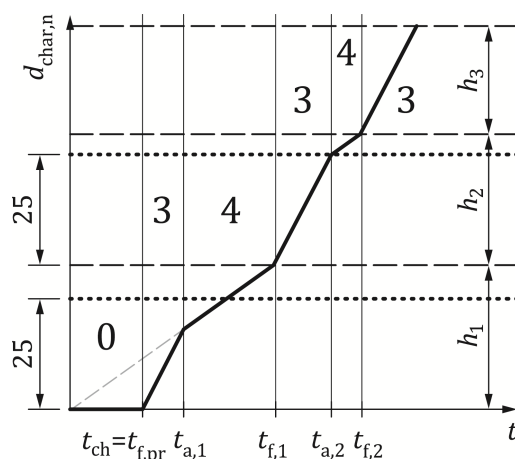
a) Initially unprotected sides of timber members



b) Initially protected sides of timber members when $t_{f,pr} > t_{ch}$



c) Initially protected sides of timber members when $t_{f,pr} = t_{ch}$



d) Initially protected sides of timber members when $t_{f,pr} = t_{ch}$ and the charring depth at t_a is less than 25 mm

Key

- 0 encapsulated phase (Phase 0)
- 1 normal charring phase (Phase 1)
- 2 protected charring phase (Phase 2)
- 3 post-protected charring phase (Phase 3)
- 4 consolidated charring phase (Phase 4)

- $d_{char,n}$ notional charring depth, in mm
- h_1, h_2, h_3 thickness of layers $i = 1, i = 2$ and $i = 3$, in mm
- t time
- $t_{f,i}$ failure time of layer i
- $t_{a,i}$ consolidation time of layer i .

NOTE 1 Figure 5.2 illustrates a combination of sequenced charring phases for each layer using individual notional charring rates.

NOTE 2 In Figure 5.2 Phase 3 illustrates that fall-off of the charring layer occurs when the charring depth reaches the bond line leading to an increased charring rate for the following layer.

NOTE 3 In Figure 5.2 (a), (b) and (c), Phase 4 illustrates that a char layer of 25 mm gives sufficient protection to reduce the charring rate as for initially unprotected sides of timber members (Phase 1).

NOTE 4 Information on bond line integrity in fire of face bonds is given in 5.5.

Figure 5.2 — Phases for sides of timber members when the bond line integrity of face bonds is not maintained during the fire exposure

(3) If the timber member undergoes charring in different charring phases the European charring model shall be individually applied for the individual charring phases (see Figure 5.1 and Figure 5.2).

(4) The notional charring depth $d_{char,n}$ (see Figure 5.3) should be calculated as follows:

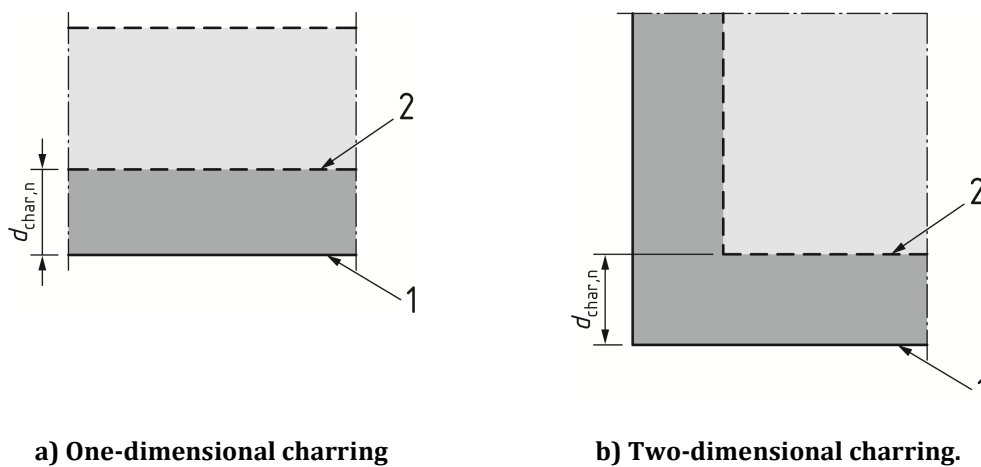
$$d_{char,n} = \sum_{Phases} (\beta_n \cdot t) \quad (5.1)$$

where

$d_{char,n}$ is the notional charring depth in mm;

β_n is the notional design charring rate within one charring phase in mm/min
(see 5.4.2.2);

t is the time for the charring phase considered in min (see 5.4.2.1).



Key

- 1 fire exposed side
- 2 border-line of the residual cross-section
- $d_{char,n}$ notional charring depth in mm

NOTE The notional charring depth is the sum of the charring depths considering the individual charring phases where relevant.

Figure 5.3 — Notional charring depth $d_{char,n}$

5.4.2.2 Notional design charring rate

(1) The notional design charring rate β_n should be calculated in accordance with Formula (5.2) using the applicable modification factors for charring k_i given in Table 5.3 and the basic design charring rate β_0 given in Table 5.4:

$$\beta_n = \prod k_i \cdot \beta_0 \quad (5.2)$$

where

β_n is the notional design charring rate within one charring phase, in mm/min;

β_0 is the basic design charring rate, in mm/min given in Table 5.4;

$\prod k_i$ is the product of applicable modification factors for charring k_i given Table 5.3.

Table 5.3 — Modification factors for charring

Modification factor	Designation	Description	Reference
k_{con}	connection factor	It considers the effect of increased charring due to the fasteners	5.4.2.2 (3) and (4)
k_{gd}	grain direction factor	It considers the effect of the increased charring parallel to the grain	5.4.2.2 (5) and (5)
k_{g}	gap factor	For plane timber members, it considers the effect of increased charring of the member with the gap	7.2.3(2) and (3)
k_{h}	thickness factor	For wood panelling and wood-based panels, it considers the effect of the limited thickness	5.4.2.2 (7)
k_{n}	conversion factor	For linear timber members, it considers the effect of corner roundings and the effect of cracks and fissures on the surface, and allows the conversion into a rectangular residual cross-section.	7.2.2 (2) and (3)
$k_{\text{s},\text{n},1}$	combined section and conversion factor for the fire exposed side	For timber frame assemblies, they consider the effect of corner roundings as well as the superposition of heat flux, they allow the conversion into a rectangular residual cross-section.	7.2.4(14)
$k_{\text{s},\text{n},2}$	combined section and conversion factor for the lateral side		0 (14)
k_{p}	density factor	For wood-based panels, it considers the effect of the density.	5.4.2.2 (8)
k_2	protection factor		5.4.2.2 (9) and (10)
k_3	post-protection factor		5.4.2.2 (11)
$k_{3,1}$	post-protection factor		7.2.4 Table 7.6
$k_{3,2}$	post-protection factor		7.2.4 Table 7.6
k_4	consolidation factor		5.4.2.2 (12)

Table 5.4 — Basic design charring rate β_0

Timber member or panel	β_0 [mm/min]
Timber member made of softwood ^{a, c, d}	0,65
Timber member made of hardwood ^a	
Beech ^e	0,70
Beech ^e LVL	0,65
Ash ^f	0,60
Oak ^g	0,50
Panel ^b	
Solid wood panelling and cladding, solid wood panel with only one layer	0,65
LVL panel ^c	0,65
Particleboard, fibreboard	0,72
OSB, solid wood panel with multiple layers	0,9
Plywood	1,0
^a Timber members according to 5.1(1), subgroup timber members. ^b Panels according to 5.1(1), subgroup panels. ^c LVL and GLVL with a characteristic density of $\geq 480 \text{ kg/m}^3$ ^d Table B.2 in EN 14081-1 ^e FASY in EN 14081-1 ^f FXEX in EN 14081-1 ^g QCXA, QCXE, QCXR in EN 14081-1	

(2) For products made of materials not included in Table 5.4, the basic design charring rate shall be determined by testing as specified in Annex C.

(3) The connection factor k_{con} should be taken from Table 9.6 for connections with dowels or bolts and from Table 9.11 for connections with nails or screws.

(4) For screws used as reinforcement the connection factor k_{con} may be

$$k_{con} = 1$$

(5) The grain direction factor k_{gd} should be:

$$k_{gd} = \begin{cases} 1 & \text{for charring perpendicular to the grain} \\ 2 & \text{for charring parallel to the grain} \end{cases}$$

(6) For sides of members exposed to charring both perpendicular and parallel to the grain (e.g. narrow face of CLT), a weighted average for the grain direction factor may be used.

(7) For wood panelling and wood-based panels the thickness factor k_h should be calculated as follows:

$$k_h = \begin{cases} 1 & \text{for } h_p \geq 20\text{mm} \\ \sqrt{\frac{20}{h_p}} & \text{for } h_p < 20\text{mm} \end{cases} \quad (5.3)$$

where

h_p is the panel thickness in mm.

(8) For OSB, plywood, particleboards and fibreboards the density factor k_ρ should be calculated as follows:

$$k_\rho = \sqrt{\frac{450}{\rho_k}} \quad (5.4)$$

where

ρ_k is the characteristic density in kg/m³.

NOTE For wood-based panels characteristic densities can be found in the declaration of performance of the product (DoP).

(9) The protection factor k_2 for Phase 2 should be taken as given in Table 5.5.

Table 5.5 — Protection factor k_2 for Phase 2

Panel	Protection factor k_2	
Gypsum plasterboard, gypsum fibreboard	$k_2 = 1 - \frac{h_p}{55}$	for $h_p \leq 50mm$
Clay plaster, clay board	$k_2 = 1 - \frac{h_p}{100}$	for $h_p \leq 40mm$
Mineral wool insulation panel	$k_2 = \begin{cases} 1 \\ 0,6 \end{cases}$	for $h_p < 20mm$
		for $h_p \geq 20mm$
where h_p is the thickness of the single panel or the total thickness of multiple panels of the same material, in mm		

(10) For other products not listed in Table 5.5, the protection factor k_2 for Phase 2 should be determined by testing according to EN 13381-7.

(11) Unless other rules are given in this document, the post-protection factor k_3 for Phase 3 should be

$$k_3 = 2$$

(12) Unless other rules are given in this document, the consolidation factor k_4 for Phase 4 should be

$$k_4 = 1$$

5.4.2.3 Time limits for charring phases

(1) The consolidation time t_a should be calculated as follows:

$$t_a = \min \left\{ t_{f,pr} + \frac{2t_{f,pr}}{25 - (t_{f,pr} - t_{ch})\beta_{n,Phase2}} \right. \quad (5.7)$$

where

- t_a is the consolidation time, in min;
- $t_{f,pr}$ is the failure time of the fire protection system, in min;
- t_{ch} is the start time of charring, in min;
- $\beta_{n,Phase2}$ is the notional design charring rate during Phase 2, in mm/min;
- $\beta_{n,Phase3}$ is the notional design charring rate during Phase 3, in mm/min.

(2) Unless other rules are given in this document, the following time limits (see Figure 5.1) should be assessed on the basis of tests according to EN 13381-7:

- the start time of charring t_{ch} ;
- the failure time $t_{f,pr}$ of the fire protection system.

NOTE A procedure for the assessment of the failure time of fire protection systems based on reported results of full-scale fire tests other than EN 13381-7 is given in Annex F.

(3) The start time of charring t_{ch} behind the fire protection system should be calculated as follows:

$$t_{ch} = \sum t_{prot} \quad \text{for the fire protection system consisting only of timber and wood-based materials} \quad (5.8)$$

$$t_{ch} = \min \left\{ \sum_{t_{f,pr}} t_{prot} \right. \quad \text{for other fire protection systems} \quad (5.9)$$

where

- t_{ch} is the start time of charring behind the fire protection system, in min;
- $\sum t_{prot}$ is the sum of protection times of the fire protection system according to 7.3.2.
- $t_{f,pr}$ is the failure time of the fire protection system, in min;

(4) The failure time $t_{f,pr}$ of the fire protection system should be calculated as follows:

$$t_{f,pr} = \sum t_{prot} \quad \text{for the fire protection system consisting only of timber and wood-based materials} \quad (5.10)$$

$$t_{f,pr} = t_f \quad \text{for the fire protection system consisting only of panels according to Table 5.6} \quad (5.11)$$

$$t_{f,pr} = \max \left\{ \sum_{t_f} t_{prot} \right\} \quad \text{for all other fire protection systems consisting of combinations of panels according to Table 5.6 with other panels} \quad (5.12)$$

where

t_f is the failure time of panels initially exposed to fire according to Table 5.6, in min;

$\sum t_{prot}$ is the sum of protection times of the fire protection system according to 7.3.2.

NOTE In general, the failure time of the fire protection system is dependent on material degradation of the fire protection system or anchorage failure of the fasteners. Detailing rules for fasteners are given in 10.2.2.

(5) The failure time $t_{f,pr}$ of the fire protection system for linear timber members and walls may be calculated as follows:

$$t_{f,pr} = \sum t_{prot} \quad (5.13)$$

where

$t_{f,pr}$ is the failure time of the fire protection system, in min;

$\sum t_{prot}$ is the sum of protection times of the fire protection system according to 7.3.2.

NOTE In general, failure due to material degradation is dependent on temperature and size of the panels and their orientation. Normally, vertical orientation of the assembly e.g. walls is more favourable than horizontal orientation of the assembly, e.g. ceilings.

(6) The failure time t_f of panels initially exposed to fire should be taken from Table 5.6.

Table 5.6 — Failure time t_f of panels initially exposed to fire

Panels		Vertical		Horizontal	
		t_f [min]	h_p [mm]	t_f [min]	h_p [mm]
Gypsum plasterboards	Type F, one layer	$t_f = 4,6 \cdot h_p - 25$	$9 \leq h_p \leq 18$	$t_f = 1,3 \cdot h_p + 9$	$9 \leq h_p \leq 18$
	Type F, two layers or Type Fa + A	$t_f = 4,4 \cdot h_p - 50$	$25 \leq h_p \leq 36$	$t_f = 1,5 \cdot h_p + 15$	$25 \leq h_p \leq 36$
	Type A, one layer	$t_f = 2,1 \cdot h_p - 6$	$9 \leq h_p \leq 18$	$t_f = 2,1 \cdot h_p - 9$	$9 \leq h_p \leq 18$
	Type A, two layers	$t_f = 1,8 \cdot h_p - 4$	$25 \leq h_p \leq 36$	$t_f = 1,7 \cdot h_p - 13$	$25 \leq h_p \leq 36$
Gypsum fibreboards, one layer		$t_f = 3,8 \cdot h_p - 21$	$9 \leq h_p \leq 18$	$t_f = 1,3 \cdot h_p + 7$	$9 \leq h_p \leq 18$
Gypsum fibreboards, two layers		$t_f = 3,7 \cdot h_p - 42$	$25 \leq h_p \leq 36$	$t_f = 1,3 \cdot h_p + 14$	$25 \leq h_p \leq 36$
where h_p is the thickness of the single panel or the total thickness of multiple panels, in mm.					
^a Type F directly exposed to fire.					

(7) For fire protection systems with horizontal orientation (e.g. floors) and exposed to fire from above, the values according to Table 5.6 for vertical application may be used.

(8) For linear timber members (e.g. beams and columns, see 7.2.2) the values according to Table 5.6 for the vertical orientation may be used and the values may be increased by 10 %.

(9) For timber frame assemblies with void cavities the values according to Table 5.6 may be increased by 10 %.

(10) The failure time t_f according to Table 5.6 may be increased by 10 % when the fire protection system is applied to plane timber members (see 7.2.3), which are vertically oriented (e.g. walls).

(11) The failure time t_f according to Table 5.6 may be increased by 20 % when the fire protection system is applied to plane timber members (see 7.2.3), which are horizontally oriented (e.g. ceilings).

(12) The failure time $t_{f,pr}$ of the fire protection system made of clay plaster and clay boards on walls may be calculated as follows.

$$t_{f,pr} = t_{ch} + \frac{(l_x - 10)}{\beta_{n,Phase2}} \quad (5.14)$$

where

- $t_{f,pr}$ is the failure time of fire protection system, in min;
- t_{ch} is the start time of charring, in min;
- l_x is the penetration length of the fastener, in mm;
- $\beta_{n,Phase2}$ is the notional design charring rate during Phase 2, in mm/min.

5.5 Adhesives

5.5.1 General

(1) For structural glued members and glued connections the fire performance for the required time of fire resistance t_{req} shall be considered in the design.

(2) The design methods given in this document should be used to satisfy 5.5.1(1) assuming the following types of adhesives:

For structural glued members (bonds of wood to wood, wood to wood-based materials or wood-based materials to wood-based materials)

- phenol-formaldehyde Type I adhesives according to EN 301 aminoplastic Type I adhesives according to EN 301
- PUR Type I adhesives according to EN 15425
- EPI Type I adhesives according to EN 16254
- adhesives for structural LVL according to EN 14374 and plywood according to EN 636
- adhesives for structural solid wood panels according to EN 13353

For glued connections

- adhesives of 2-component PUR according to EN 17334
- epoxy adhesives according to EN 17334

(3) As an alternative to 5.5.1(2), the fire performance for the required time of fire resistance t_{req} for the particular member or connection may be assessed by testing.

NOTE The loadbearing capacity in fire of the particular member can be assessed by testing according to EN 1365 (all relevant parts).

5.5.2 Bond line integrity of face bonds

(1) For structural members with face bonds the bond line integrity in fire for the required time of fire resistance t_{req} shall be considered in the design.

NOTE The bond line integrity in fire can depend on the particular member, e.g. layup of the cross-section, thickness of the lamellae, etc.

(2) The European charring model given in 5.4.2 should be used to satisfy 5.5.2(1) when the bond line integrity in fire is maintained (see Figure 5.1) or not maintained (see Figure 5.2).

(3) Unless other rules are given in this document, the bond line integrity in fire of face bonds shall be verified using the test method given in Annex B.

(4) The bond line integrity in fire may be assumed as maintained for the following adhesives:

- phenolic Type I adhesives according to EN 301
- phenolic adhesives for structural LVL according to EN 14374 and plywood according to EN 636

6 Tabulated design data

6.1 General

(1) The tabulated design data refer to member analysis according to 4.7. They shall be used only for the standard fire exposure.

(2) The temperature distribution should be assumed to be the same along the length of the structural members.

(3) Tabulated design data shall give safe-sided results compared to relevant tests or simplified or advanced design methods. They shall be applied without extrapolation outside their range of application.

NOTE Tabulated data are derived from tests, calculation models or a combination of the two and are presented either in the form of a table or a formula.

(4) Tabulated design data may be used to obtain recognised design solutions generally in relation to member typology (dimensions) without recourse to any form of equilibrium equation.

NOTE Tabulated design data can be given in the National Annex.

(5) Tabulated design data given in Clause 6 may be used with materials and products according to 5.1(1).

6.2 Time limits for charring phases

(1) For common fire protection systems, the start time of charring t_{ch} and the failure time of the fire protection systems $t_{f,pr}$ may be taken from

Table 6.1 and Table 6.2 when:

- material and product requirements in 5.1(1) are satisfied;
- detailing requirements in 10 are satisfied.

NOTE The values given in Table 6.1 and Table 6.2 were calculated based on the rules in 5.4.

Table 6.1 — Start time of charring t_{ch} and failure time of the fire protection systems $t_{f,pr}$ on vertical and horizontal linear timber members, vertical timber frame assemblies, vertical plane timber members and horizontal timber frame assemblies or plane timber members exposed to fire from above

Panels	Thickness of the fire protection system h_p [mm] ^a		Layers backed by insulation ^b		Layers backed by panel ^c	
	layer 1 h_1	layer 2 h_2	Start of charring t_{ch} [min]	Failure time $t_{f,pr}$ [min]	Start of charring t_{ch} [min]	Failure time $t_{f,pr}$ [min]
Gypsum plasterboard Type A	12,5	-	17	20	22	22
	15	-	22	25	28	28
	18	-	29	32	35	35
	12,5	12,5	28	41	39	45
	15	15	36	50	49	55
	18	18	47	61	60	67
Gypsum plasterboard Type F	12,5	-	17	32	24	35
	15	-	22	44	30	48
	18	-	29	58	37	63
	12,5	12,5	39	60	49	66
	15	15	50	82	60	90
	18	18	63	108	75	119
Gypsum plasterboard Type F + Type A (Type F is layer 1)	12,5	12,5	39	60	49	66
	15	12,5	45	71	55	78
Gypsum fibreboard	12,5	-	17	26	24	29
	15	-	22	36	30	39
	18	-	29	47	37	52
	12,5	12,5	39	50	49	55
	15	15	50	69	60	76
	18	18	63	91	75	100
Particleboard	18	-	19	19	27	27
OSB	18	-	16	16	21	21
Softwood plywood	18	-	12	12	16	16
Solid wood panels	18	-	17	17	26	26
LVL	27	-	29	29	41	41
^a Layer 1 is at the fire exposed side. ^b When the layers are backed by a void cavity with a thickness of 40 mm or more, the values for layers backed by insulation should be used. ^c When the layers are backed by a vertically or horizontally oriented linear member, the values for layers backed by a panel should be used.						

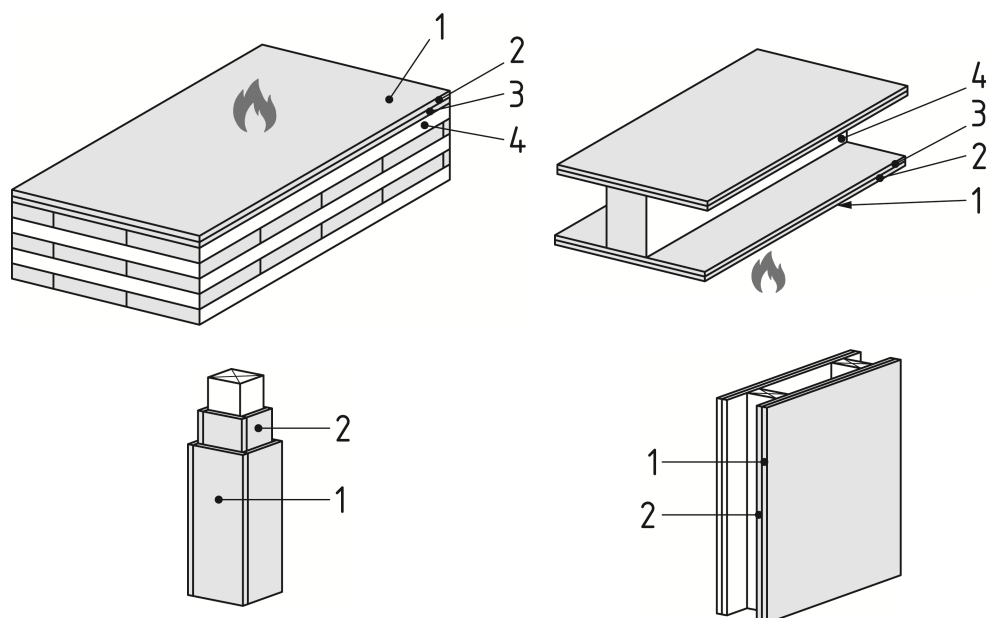
Table 6.2 — Start time of charring t_{ch} and failure time of the fire protection systems $t_{f,pr}$ on horizontal timber frame assemblies or plane timber members exposed to fire from below

Panels	Thickness of the fire protection system h_p [mm] ^a		Layers backed by insulation ^b		Layers backed by panel	
	layer 1 h_1	layer 2 h_2	Start of charring t_{ch} [min]	Failure time $t_{f,pr}$ [min]	Start of charring t_{ch} [min]	Failure time $t_{f,pr}$ [min]
Gypsum plasterboard Type A	12,5	-	17	17	20	20
	15	-	22	22	27	27
	18	-	29	29	34	34
	12,5	12,5	28	29	35	35
	15	15	36	39	45	45
	18	18	47	48	58	58
Gypsum plasterboard Type F	12,5	-	17	25	24	30
	15	-	22	28	30	34
	18	-	28	32	37	39
	12,5	12,5	39	52	49	63
	15	15	50	60	60	72
	18	18	63	69	75	83
Gypsum plasterboard Type F + Type A (Type F is layer 1)	12,5	12,5	39	52	49	63
	15	12,5	45	56	55	67
Gypsum fibreboard	12,5	-	17	23	24	28
	15	-	22	26	30	32
	18	-	29	30	36	36
	12,5	12,5	39	46	49	55
	15	15	50	53	60	63
	18	18	61	61	73	73
Particle board	18	-	19	19	27	27
OSB	18	-	16	16	21	21
Softwood plywood	18	-	12	12	16	16
Solid wood panels	18	-	17	17	26	26
LVL	27	-	29	29	41	41
^a Layer 1 is at the fire exposed side. ^b When the layers are backed by a void cavity with a thickness of 40 mm or more, the values for layers backed by insulation should be used.						

(2) For fire protection systems $t_{f,pr}$ with horizontal orientation (e.g. floors) and exposed to fire from above, values given in Table 6.1 may be used.

6.3 Initially protected timber members

(1) The rules given in 0 should be applied to initially protected timber members (see Figure 6.1).



Key

- 1 fire exposed surface
- 2 layer 1 of fire protection systems
- 3 layer 2 of fire protection systems
- 4 timber member

Figure 6.1 — Examples of initially protected timber members

(2) The fire resistance of the initially protected timber member may be satisfied when all of the following conditions are fulfilled:

- the timber member satisfies the design for normal temperature;
- material and product requirements in 5.1(1) are satisfied;
- detailing requirements in 10 are satisfied, and
- requirements for applied fire protection systems given in Table 6.3 and Table 6.4 are satisfied.

Table 6.3 — Fire protection systems satisfying the required fire resistance of 30 minutes of the timber members (R, EI, REI)

Layer 1	Layer 2
LVL with tongue and groove and $h_i \geq 25$ mm	not required
Particleboard with tongue and groove and $h_i \geq 25$ mm	not required
Plywood with tongue and groove and $h_i \geq 26$ mm	not required
Solid wood panel (SWP) with tongue and groove and $h_i \geq 26$ mm	not required
Solid wood panelling and cladding with tongue and groove and $h_i \geq 27$ mm	not required
Oriented Strand Board (OSB) with tongue and groove and $h_i \geq 30$ mm	not required
Gypsum plasterboards Type F with filled or tight butt joint and $h_i \geq 18$ mm	not required
Gypsum fibreboard (GF) with filled or tight butt joint and $h_i \geq 18$ mm	not required
Floor screed (cement, gypsum, anhydride) with $h_i \geq 35$ mm	not required
Floor screed (cement, gypsum, anhydride) with $h_i \geq 25$ mm	Mineral wool insulation with PL1 and $h_i \geq 15$ mm
h_i is the thickness of the layer i	

Table 6.4 — Fire protection systems satisfying the required fire resistance of 60 minutes of the timber members (R, EI, REI)

Layer 1	Layer 2
Solid wood panel (SWP) with tongue and groove and $h_i \geq 53$ mm	not required
Solid wood panel (SWP) with tongue and groove and $h_i \geq 27$ mm	Solid wood panel (SWP) with tongue and groove and $h_i \geq 27$ mm ^a
Gypsum plasterboards Type F with filled or tight butt joint and $h_i \geq 18$ mm	Gypsum plasterboards Type F with filled or tight butt joint and $h_i \geq 18$ mm
Gypsum fibreboard (GF) with filled or tight butt joint and $h_i \geq 18$ mm	Gypsum fibreboard (GF) with filled or tight butt joint and $h_i \geq 18$ mm
Floor screed (cement, gypsum, anhydride) with $h_i \geq 60$ mm	not required
Floor screed (cement, gypsum, anhydride) with $h_i \geq 45$ mm	Mineral wool insulation with PL1 and $h_i \geq 15$ mm
h_i is the thickness of the layer i	
^a The two layers mounted with the longitudinal direction perpendicular to each other.	

6.4 Plane timber members made of CLT

6.4.1 General

(1) The rules given in 6.4 should be applied to plane timber members made of CLT with specific layups for the x-direction and assuming that $k_g = 1$.

NOTE Tabulated values in Table 6.5 to Table 6.12 were derived from advanced design methods.

6.4.2 CLT with bond line integrity maintained

(1) For CLT with specific layups when the bond line integrity is maintained during the fire exposure or the charring depth does not exceed the first bond line, the depth of the effective cross-section h_{ef} for CLT should be taken from Table 6.5 to Table 6.8.

Table 6.5 — Values of the depth of the effective cross-section h_{ef} in mm for initially unprotected floors made of CLT with bond line integrity maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min	60 min	90 min
3	20-20-20	60	18	9	-
3	40-40-40	120	94	38	38
5	20-20-20-20-20	100	58	49	18
5	40-20-20-20-40	140	114	78	70
5	40-20-40-20-40	160	134	98	90
5	40-30-40-30-40	180	154	108	108
5	40-40-40-40-40	200	174	118	118

Table 6.6 — Values of the depth of the effective cross-section h_{ef} in mm for initially protected floors made of CLT with bond line integrity maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min with $t_{ch} \geq 20$ min	60 min with $t_{ch} \geq 30$ min	90 min with $t_{ch} \geq 60$ min
3	20-20-20	60	18	16	16
3	40-40-40	120	95	38	38
5	20-20-20-20-20	100	58	56	56
5	40-20-20-20-40	140	115	78	78
5	40-20-40-20-40	160	135	98	98
5	40-30-40-30-40	180	155	108	108
5	40-40-40-40-40	200	175	118	118

Table 6.7 — Values of the depth of the effective cross-section h_{ef} in mm for initially unprotected walls made of CLT with bond line integrity maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min	60 min	90 min
3	30-20-30	80	51	22	8
3	30-40-30	100	71	25	24
3	40-20-40	100	63	37	32
3	40-40-40	120	83	36	36
5	20-20-20-20-20	100	56	43	16
5	30-20-40-20-30	140	111	79	68

Table 6.8 — Values of the depth of the effective cross-section h_{ef} in mm for initially protected walls made of CLT with bond line integrity maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min with $t_{ch} \geq 20$ min	60 min with $t_{ch} \geq 30$ min	90 min with $t_{ch} \geq 60$ min
3	30-20-30	80	26	26	28
3	30-40-30	100	26	26	29
3	40-20-40	100	63	36	36
3	40-40-40	120	83	36	36
5	20-20-20-20-20	100	56	48	55
5	30-20-40-20-30	140	86	86	88

6.4.3 CLT with bond line integrity not maintained

(1) For CLT with specific layups when the bond line integrity is not maintained during the fire exposure, the depth of the effective cross-section h_{ef} for CLT should be taken from Table 6.9 to Table 6.12.

Table 6.9 — Values of the depth of the effective cross-section h_{ef} in mm for initially unprotected floors made of CLT with bond line integrity not maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min	60 min	90 min
3	20-20-20	60	18	-	-
3	40-40-40	120	94	38	37
5	20-20-20-20-20	100	58	18	-
5	40-20-20-20-40	140	114	78	38
5	40-20-40-20-40	160	134	98	71
5	40-30-40-30-40	180	154	108	96
5	40-40-40-40-40	200	174	118	117

Table 6.10 — Values of the depth of the effective cross-section h_{ef} in mm for initially protected floors made of CLT with bond line integrity not maintained

# of layers	Layup [mm]	Total thickness [mm]	h_{ef} [mm]		
			30 min with $t_{ch} \geq 20$ min	60 min with $t_{ch} \geq 30$ min	90 min with $t_{ch} \geq 60$ min
3	20-20-20	60	18	9	9
3	40-40-40	120	95	38	38
5	20-20-20-20-20	100	58	49	49
5	40-20-20-20-40	140	115	78	78
5	40-20-40-20-40	160	135	98	98
5	40-30-40-30-40	180	155	108	108
5	40-40-40-40-40	200	175	118	118