Overview of the Evolution of EN 1995: Design of timber structures

21 August 2020

Issue 1
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Structure of this slide deck

- General overview of the evolution of EN 1995
- Specific overview of the evolution of EN 1995 parts:
  - EN 1995-1-1: General – Common rules and rules for buildings
  - EN 1995-1-2: General – Structural fire design
  - EN 1995-2: Bridges

General overview of the Evolution of EN 1995: Design of timber structures

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Agenda – Evolution of EN 1995

- Key changes to EN 1995
- New content included in the scope of EN 1995
- How ease of use has been enhanced

The following slides provide a general overview of the evolution of EN 1995. Complementary slides provide greater details for individual Eurocode Parts.

Key changes to EN 1995

→ Extension to current state of the art i.e.:

- Implementation of new materials
- Extension and revision of several design procedures
- Extension and revision on the rules for fire design

→ Material properties needed for Eurocode design – Annex M

New content included in scope of EN 1995

- CEN Technical Specification for timber-concrete composite
- CEN Technical Report for bonded-in rods

How ease of use has been enhanced

- Harmonization with the whole Eurocode family (i.e. general structure and symbols)
- Reduction of NDPs
- Restructuring of key clauses
- Outsourcing of minor design issues to normative Annexes

Overview of the Evolution of EN 1995-1-1: General – Common rules and rules for buildings

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Agenda – Evolution of EN 1995-1-1: General – Common rules and rules for buildings

- Key changes to EN 1995-1-1
- New content included in the scope of EN 1995-1-1
- How ease of use has been enhanced

Key changes to EN 1995-1-1

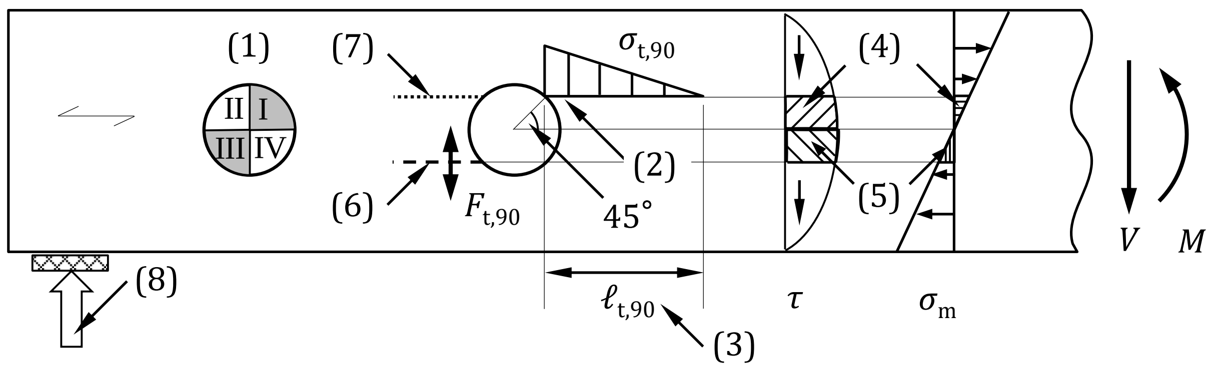
→ Extension of design rules for:
- Laminated veneer lumber
- Floor vibrations
- Connections (i.e. bonded-in rods, modern carpentry connections)

→ Revision of design rules for:
- Compression perpendicular to grain
- Stability and bracing
- Racking resistance of walls
- Connections (i.e. lateral load-carrying capacity, corrosion protection)

New content included in scope of EN 1995-1-1

- Materials i.e.:
  - Cross laminated timber
  - Multi-layered solid wood panels
  - Glued laminated veneer lumber
- Brittle failure
- Unreinforced and reinforced holes in beams
- Reinforcement of timber structures
- Carpentry connections
- Wooden foundation piles

New design rules for unreinforced and reinforced holes in beams



Key

(1) Hole in member, may be divided into quadrants I-IV; the quadrant with possible crack development is dependent on the type of loading and the location in the beam, see clause 8.4.5.2(5)

(2) possible crack line and (simplified) distribution of tensile stresses perpendicular to the grain $\sigma_{t,90}$

(3) distribution length, see clause 8.4.5.2(2)

(4) portion of shear and bending stresses to be transferred around the upper edge of the hole

(5) portion of shear and bending stresses to be transferred around the lower edge of the hole

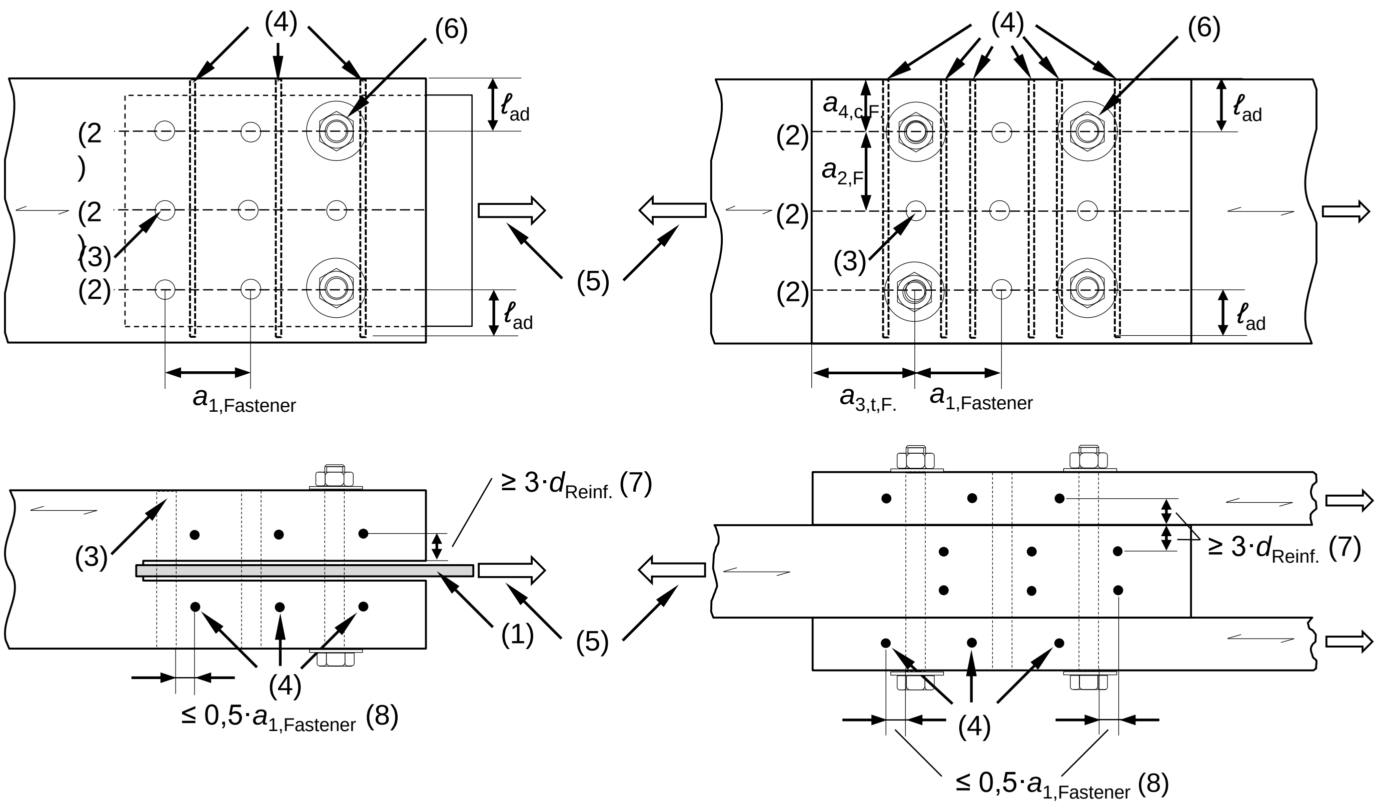
(6) possible crack line in locations with high shear stresses ($F_{t,V,d} \geq F_{t,M,d}$) and tensile force perpendicular to the grain Ft,90

(7) possible crack line in locations with dominating bending stresses ($F_{t,V,d} << F_{t,M,d}$)

(8) external force direction

Figure 8.2 – Holes in beams

New design rules for reinforcement of timber structures



Key

(1) slotted-in steel plate

(2) possible crack line

(3) dowel; bolt

(4) reinforcement

(5) direction of force

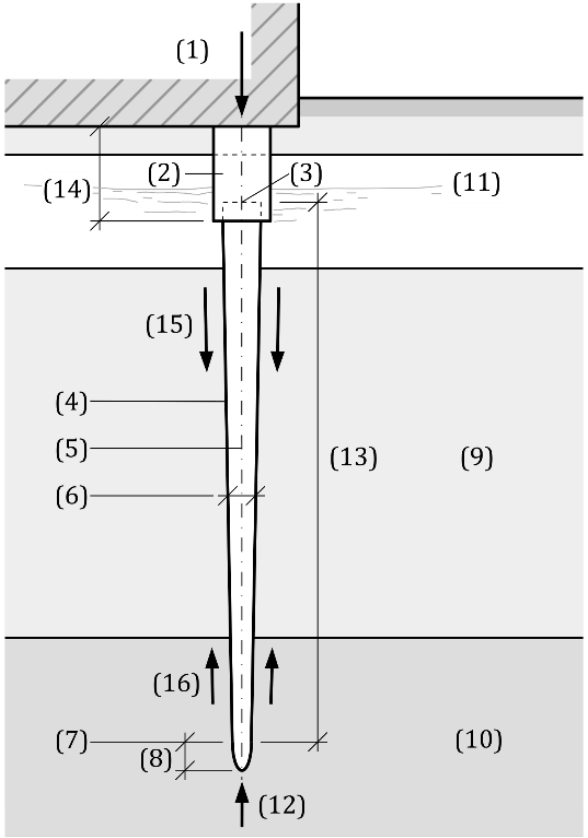
(6) tight-fitting bolts to reduce moment from eccentricity

(7) recommended: $3d_{Reinf.}$

(8) recommended: $2d_{Reinf.}$

Figure 10.11 – Reinforcement of bolted and dowelled connections

New design rules for wooden foundation piles



Key

(1) Supported structure

(2) Extension pile made of material exhibiting sufficient durability when exposed to varying ground water levels (e.g. concrete pile extension, see [14.3 (3) and (4)])

(3) Pile head

(4) Timber pile (tapered), pile shaft

(5) Pile axis

(6) Pile diameter

(7) Pile toe

(8) Pile tip (pile base, tapered end of the pile or of the log, respectively)

(9) Weak soil

(10) Load bearing (compact) soil layer

(11) Ground water table

(12) Base resistance, resistance at pile toe

(13) Pile length

(14) Length of concrete pile-extension (see Figure 14.2)

(15) Down drag (negative skin friction)

(16) Positive skin friction

Figure 14.1 – Timber foundation pile with acting forces

How ease of use has been enhanced

- Improving clarity:
  - Restructuring of Clause:
    4. *Basis of design*
    7. *Structural analysis*
    8. *Ultimate limit states*

  - Reinforcement draft clauses following the design sequence:
    i. General requirements
    ii. Design of the unreinforced detail
    iii. Design of the reinforced detail (if necessary)

How ease of use has been enhanced

→ Improving clarity:

- Improved definition of service classes in clause 4
- Stiffness values to be used to calculate the design stiffness in ultimate limit states (ULS) in clause 4

Improved definition of service classes

Relative humidity	Service class			
	SC 1	SC 2	SC 3	SC 4
Upper limit [(a)]	65%	85%	95%	[(c)]
Corresponding moisture content	12%	20%	24%	saturated
Yearly average [(b)]	50%	75%	85%	[(c)]
Corresponding moisture content	10%	16%	18%	saturated

(a) The upper limit of relative humidity should not be exceeded for more than a period of a few consecutive weeks per year (see [Key (4) in Figure 4.1]).

(b) The yearly average relative humidity over a ten-year period is used to assign timber members to corrosivity classes for steel dowel-type fasteners (see [Key (5) in Figure 4.1]).

(c) The moisture content of members in service class SC 4 (mostly fully saturated) is affected by the surrounding element (e.g. soil or water).

NOTE 1: The moisture content in a structure is dependent on the building type, building use, location of the building. The following are examples of structures assigned to different service classes:

— SC 1: structures inside insulated and heated buildings;

— SC 2: structures under shelter (i.e. not exposed to rain), in non-insulated and unheated conditions;

— SC 3: structures exposed to rain, if water will run off and end grain is protected from splashing (e.g. facades);

— SC 4: structures submerged in soil or water (e.g. foundation piles and marine structures).

Table 4.2 – Service classes

How ease of use has been enhanced

→ Simplified methods for:
- Verification of deflections (harmonization with prEN 1990:2019)
- European yield model (EYM) for the design of wood connections
- Simplified formulas for the buckling of screws in the wood
- Symmetric arrangement of reinforcement

→ Reduction of NDPs:
- Bracing
- Design of the racking resistance of walls

Overview of the Evolution of EN 1995-1-2: General – Structural fire design

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Agenda – Evolution of EN 1995-1-2 : General – Structural fire design

- Key changes to EN 1995-1-2
- New content included in the scope of EN 1995-1-2
- How ease of use has been enhanced

Key changes to EN 1995-1-2

→ **Extension of design rules for:**

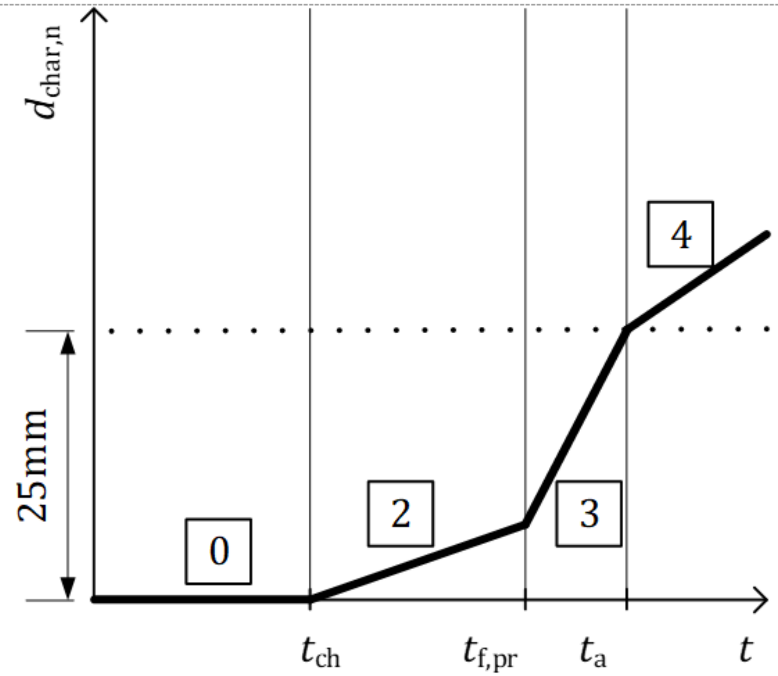
- Effective cross-section method (application i.e. on timber I-joists, cross laminated timber, timber-concrete composite elements, etc.)
- Design model for the verification of the separating function of wall and floor assemblies
- Failure time (falling off) of the fire protection system

→ **Revision of design rules for:**

- Charring
- Timber-frame assemblies
- Connections in fire
- Detailing
- Design of timber structures exposed to physically based design fires

Key changes to EN 1995-1-2

→ The European charring model



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

Key:	
1	Normal charring phase (Phase 1)
0	Encapsulated phase (Phase 0)
2	Protected charring phase (Phase 2)
3	Post-protected charring phase (Phase 3)
4	Consolidated charring phase (Phase 4)

Key changes to EN 1995-1-2

→ Failure time (falling off) of the fire protection system

Fire protection system		Wall $t_{f,degr}$ [min]	Wall h_p [mm]	Floor $t_{f,degr}$ [min]	Floor h_p [mm]
Gypsum plasterboards	Type F, one layer	$t_{f,degr} = 3,9 \cdot h_p - 16$ (5.9)	$9 \leq h_p \leq 18$	$t_{f,degr} = 1,6 \cdot h_p + 3$ (5.10)	$12.5 \leq h_p \leq 16$
		58	$h_p > 18$	29	$h_p > 16$
	Type F, two layers	$t_{f,degr} = 3,1 \cdot h_p - 19$ (5.11)	$25 \leq h_p \leq 31$	$t_{f,degr} = 0,7 \cdot h_p + 31$ (5.12)	$25 \leq h_p \leq 31$
		77	$h_p > 31$	53	$h_p > 31$
	Type F, three layers			68	$h_p = 45$
	Type A, one layer	$t_{f,degr} = 1,8 \cdot h_p - 4,8$ (5.13)	$9 \leq h_p \leq 15$	14	$h_p = 12,5$
		22,5	$h_p > 15$		
	Type A, two layers	40	$h_p = 25$	28	$h_p = 25$
Gypsum fibreboards		$t_{f,degr} = 2,5 \cdot h_p - 11$ (5.14)	$9 \leq h_p \leq 18$		

where:

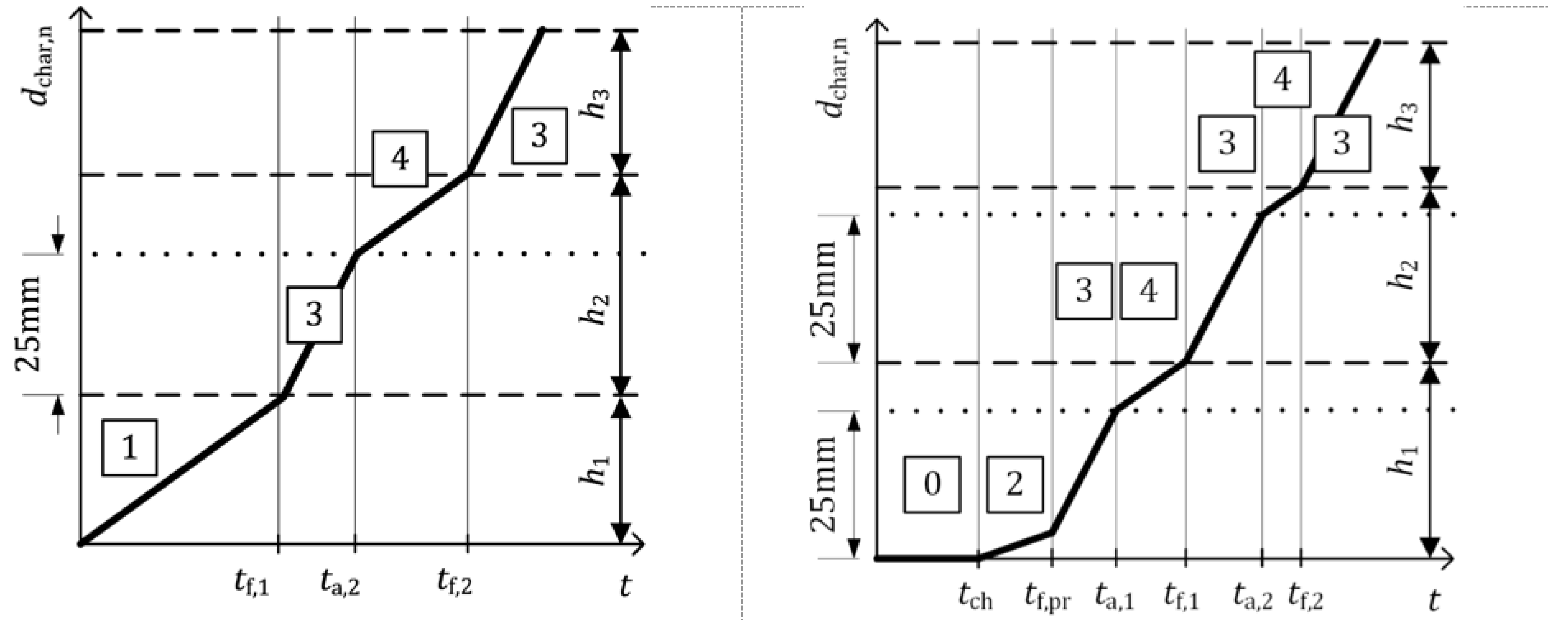
h_p is the thickness of the fire protection system, in mm

New content included in scope of EN 1995-1-2

- Fire design rules for:
  - Cross laminated timber
  - Timber-concrete composite elements
- Fire design rules for timber frame assemblies:
  - With fully filled cavities with different insulation materials
  - With partly filled cavities with different insulation materials
  - With I-joists
- Design procedures for fire protective system

New content included in scope of EN 1995-1-2

→ Fire design rules for cross laminated timber:



a) Initially unprotected sides	b) Initially protected sides

Key:	
0, 1, 2, 3, 4	Phase 0, Phase 1, Phase 2, Phase 3 and Phase 4;

How ease of use has been enhanced

- Improving clarity:
  - Deletion of the reduced properties method
- Simplified methods for:
  - Calculation of the mechanical resistance of timber members (i.e. effective cross-section method)
  - Calculation of the mechanical resistance of connections (i.e. exponential reduction method)
  - Calculation of the failure time of fire protective systems
- Reduction of NDPs:
  - Only safety relevant NDPs

Overview of the Evolution of EN 1995-2: Bridges

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Agenda – Evolution of EN 1995-2: Bridges

- Key changes to EN 1995-2
- How ease of use has been enhanced

Key changes to EN 1995-2

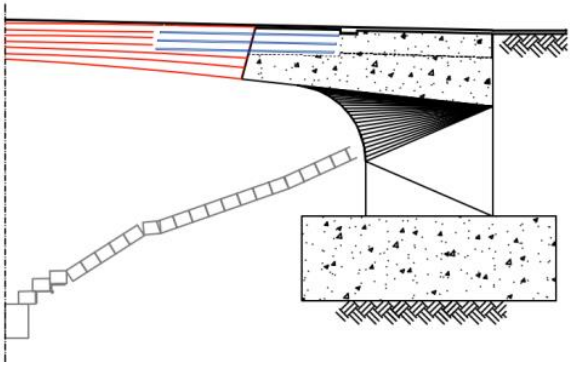
→ Extension of design rules for:
- Durability and Detailing, Sealing
- Deck plates
- Integral bridges
- Seismic design

→ Revision of design rules for:
- Timber-concrete composites (TCC)
- Laminated veneer lumber (LVL)
- Vibrations and damping
- Fatigue

Key changes to EN 1995-2

→ Timber-concrete composites

→ Fatigue



→ Integral bridges

How ease of use has been enhanced

→ Improving clarity:

- Harmonization of EN 1995-1-1 and EN 1995-2 regarding:
  - Durability
  - Fatigue

→ Simplified methods for:

- Fatigue of notches under dynamic loads

→ Reduction of NDPs:

- Only safety relevant NDPs (and 1 SLS NDP on damping)