Cross Laminated Timber (CLT) in Europe: Resistance against Fire




Cross Laminated Timber (CLT) Fire Performance Workshop

Canadian Wood Councils

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Competence Centre holz.bau forschungs gmbh Graz | AT

CONTENT

- „TIMBER“ at the Graz University of Technology
  - Institute for Timber Engineering and Wood Technology (TEWT)
  - Competence Centre holz.bau forschungs gmbh (hbf)
  - R&D Areas
- Cross Laminated Timber and Fire
  - Motivation for Research on Fire-resistance of CLT
  - Introduction | History
  - Research Project hbf – TUG – ETHZ
  - Future Developments
- Summary

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GRAZ UNIVERSITY OF TECHNOLOGY

Austria / Europe

7 faculties | 11,264 students | staff 2,222
budget: **€ 150 Mill.** (1/3 3rd party budget)

Faculty of Civil Engineering Sciences

17 institutes | about 1,140 students
[207 “diploma”, 693 “Bachelor”, 146 “Master”, 93 “PhD”]

Institute for Timber Engineering and Wood Technology

1991: Chair for Timber Engineering

10|2004: **Institute Timber Engineering and Wood Technology**

Scientific staff: **7.0 FTE** | third-party-budget: **€ 250.000** (2008)

Competence Centre holz.bau forschungs gmbh

09|2002 Acceptance of 4-year-fundings: Competence Center Timber Engineering and Wood Technology

12|2002 **Competence Centre holz.bau forschungs gmbh**

09|2007 Acceptance of 5-year-fundings: K-Project “timber.engineering” | COMET-Programme

Scientific staff: **7.1 FTE** | budget: **€ 1.000.000** (2008)

AREA 1

Timber Engineering (TE) – Design and Construction Sciences (DCS)

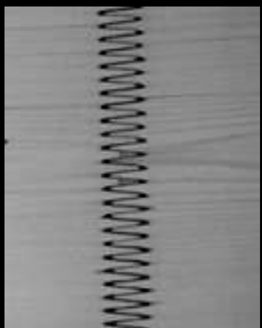
1.1 Shell and Spatial Timber Constructions (SSTC)

1.2 Innovative and Intelligent Connection Systems (IICS)

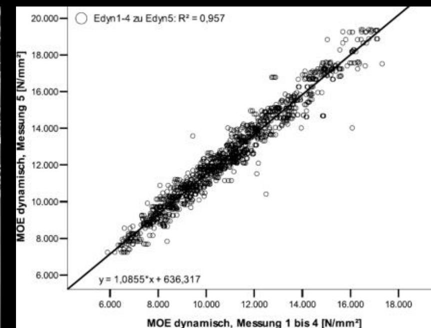
AREA 2

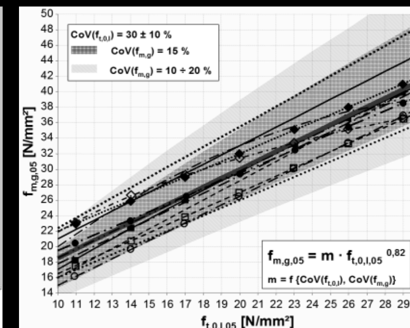
Wood Technology (WT) – Material and Structure Sciences (MSS)

2.1 Advanced Products and Test Methods (APTM)

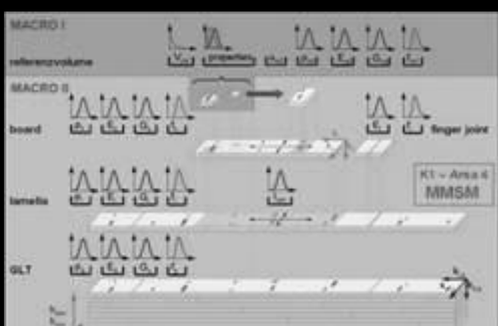
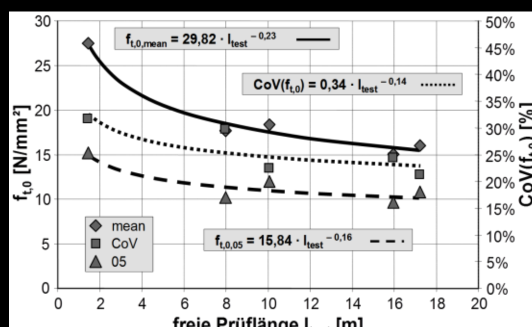


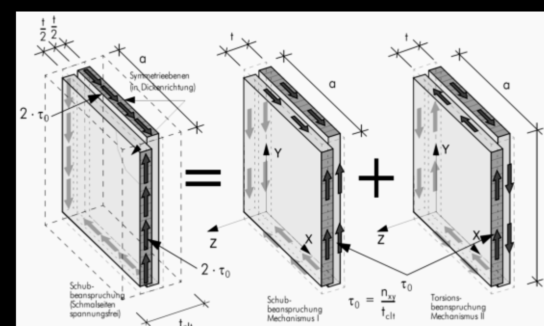


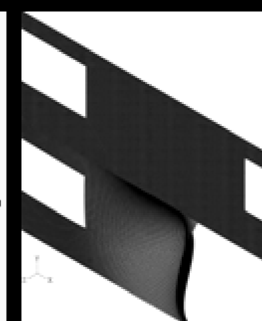




2.2 Material Modelling and Simulation Methods (MMSM)





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EN 1995-1-2:2006

Design of timber structures - Part 1-2_General - Structural fire design.pdf

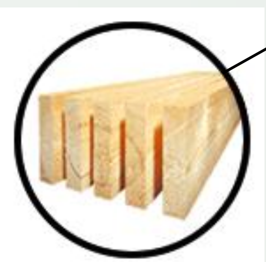


Table 3.1 – Design charring rates β_0 and β_n of timber, LVL, wood panelling and wood-based panels

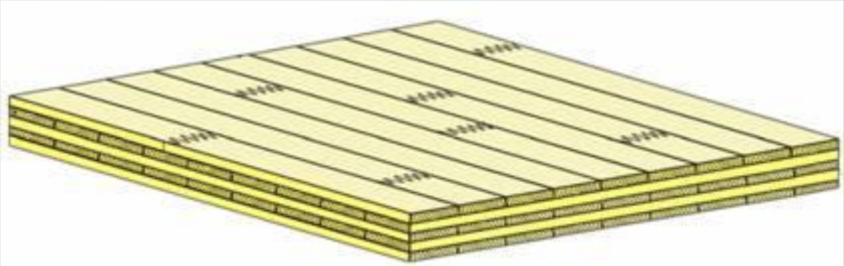
	β_0 mm/min	β_n mm/min
a) Softwood and beech		
Glued laminated timber with a characteristic density of ≥ 290 kg/m^3	0,65	0,7
Solid timber with a characteristic density of ≥ 290 kg/m^3	0,65	0,8 because of cracks

β_0 … design charring rate for one-dimensional under standard fire exposure

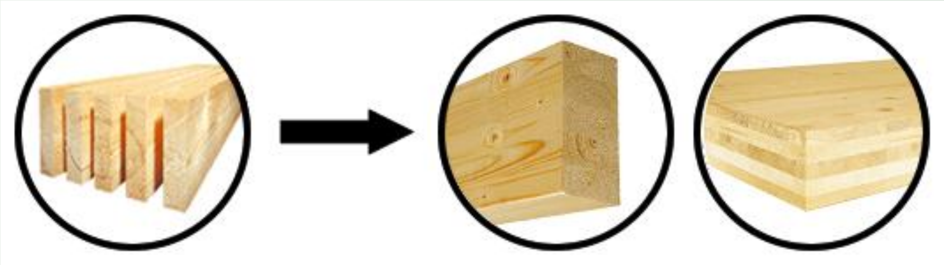
β_n … is the notional design charring rate, the magnitude of which includes the effect of corner roundings and fissures

Cross Laminated Timber CLT

- Wide spanned, multi-layered wood based product
- Strength graded board as base product
- Orthogonally glued layers



- Up to now CLT is not regulated within the design standard!
- Assumption: if the base-material „board" and the board-based product GLT have the same charring rate β_0
  $\Rightarrow$ than the board-based product CLT also has the same charring rate



β_0 = 0,65 mm/min (Softwood)

Signs of need for research

1. Research Project ETH Zürich (Technical Report published 2007)

   „…single layers of 3-layer-boards fell off after burn-through … it can be assumed that claddings with layered cross sections, e.g. 3-layer-boards, have an disadvantageous behaviour compared to solid timber boards.“

2. European Technical Approval ETA from a producer (2007)

Resistance to fire		
Charring rate, see Annex 4 – Charring of cover layer only. – The cross section of the remaining wood shall be reduced by 10 %. – At least 3 mm of the cover layer shall remain uncharred.	EN 1995-1-2	0,67 mm/min
– Charring of more layers than the cover layer.		0,76 mm/min

Research on Fire behaviour of CLT

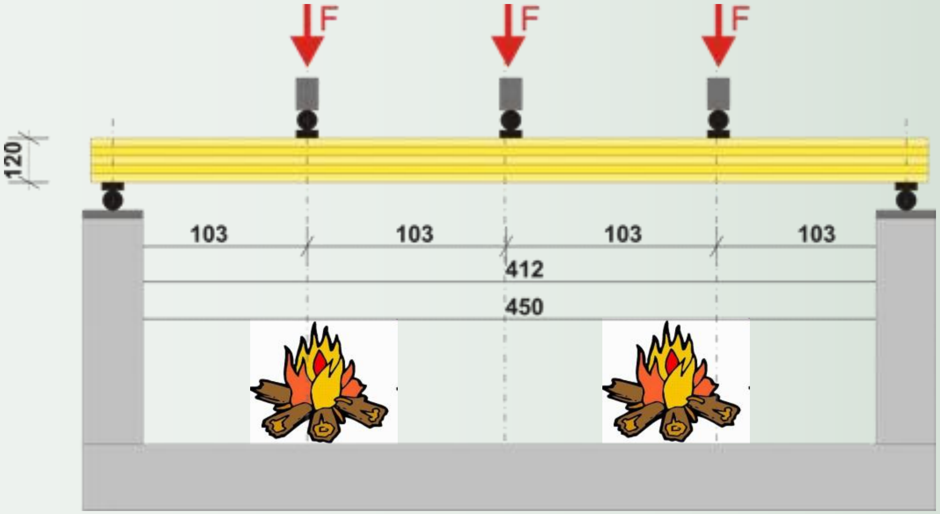
1. Bresta H – KLH (1998): fire-bending tests on loaded 5-layer CLT
2. HAAS (2006): full scale fire tests on timber-houses with a light-weight-roof and with a timber solid construction roof (CLT)
3. SOFIE (2007): full scale fire test on a 3-storey-building (see A. Ceccotti)
4. CLT-FIRE hbf-TUG-ETHZ (2009): first parameter studies during fire-tests on CLT

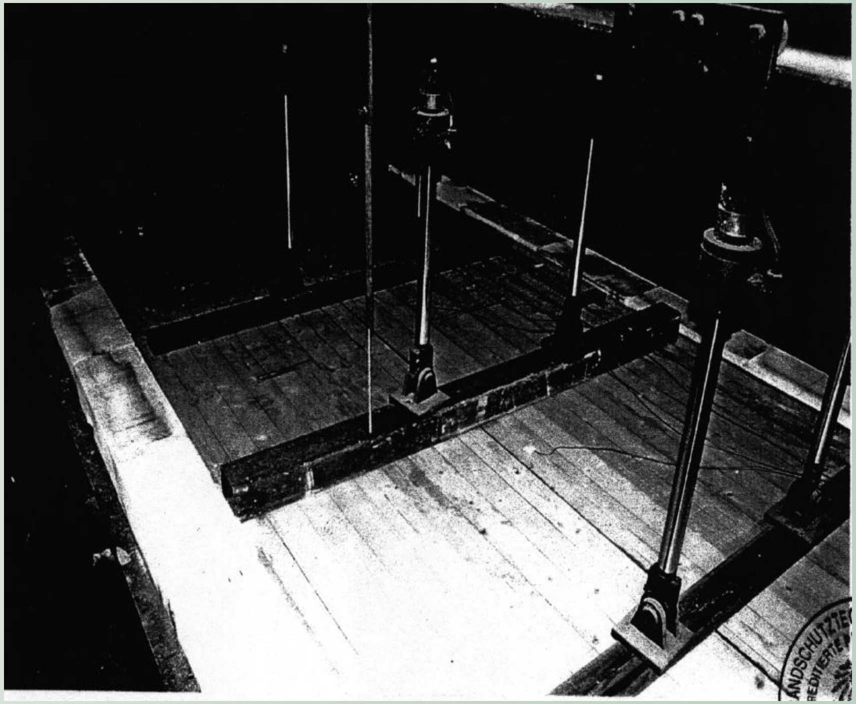
Current: Fire tests in Sweden/SP Trätek

PhD work startet at ETH

Fire Research on CLT

1. Bresta H – KLH (1998): fire-bending tests on loaded 5-layer CLT





Fire Research on CLT

2. HAAS (2006): full scale fire tests

Timber Light-weight Construction **TLC**

Timber Solid Construction **TSC**

Fire Research on CLT

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Timber Light-weight Construction **TLC**

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Fire Research on CLT

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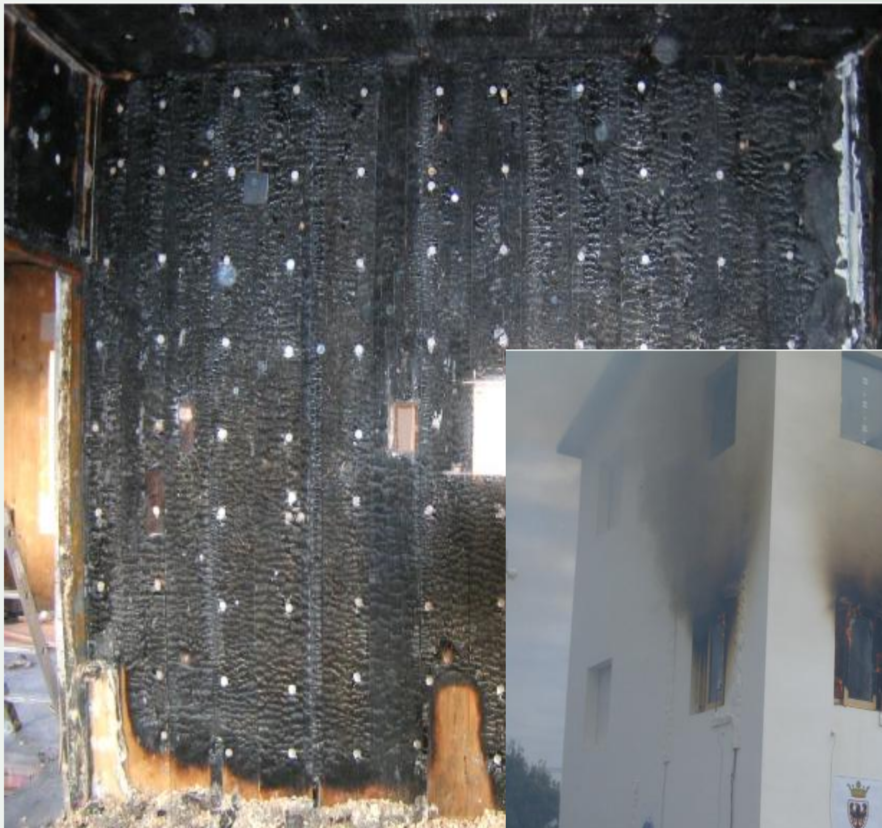
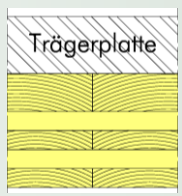
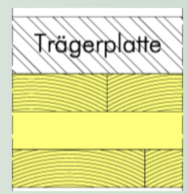
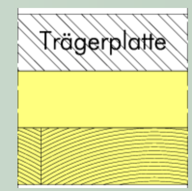


Fire Research on CLT

4. CLT-FIRE hbf-TUG-ETHZ (2009): first parameter studies during fire-tests on CLT

Parameters - glue, thickness of layers, orientation

	10/10/10/10/20 	20/20/20 	30/30 
PUR-1	X		X
PUR-2	X		
PUR-3	X	X	
PUR-4	X	X	
PUR-5		X	
MUF	X		X

1 specimen with 5-layered uni-directional cross section and PUR

Fire Research on CLT

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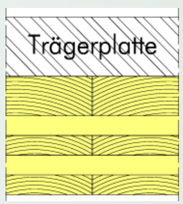
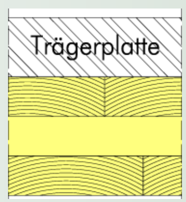
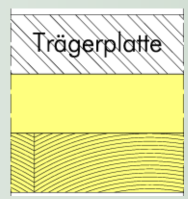
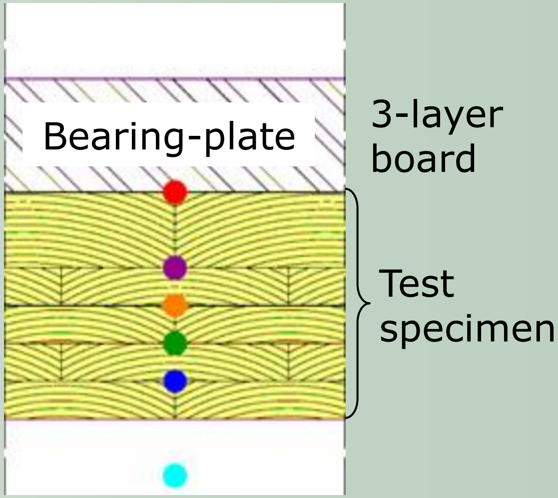
Parameters - glue, thickness of layers, orientation

			
PUR-1	X		X
PUR-2	X		
PUR-3	X	X	
PUR-4	X	X	
PUR-5		X	
MUF	X		X

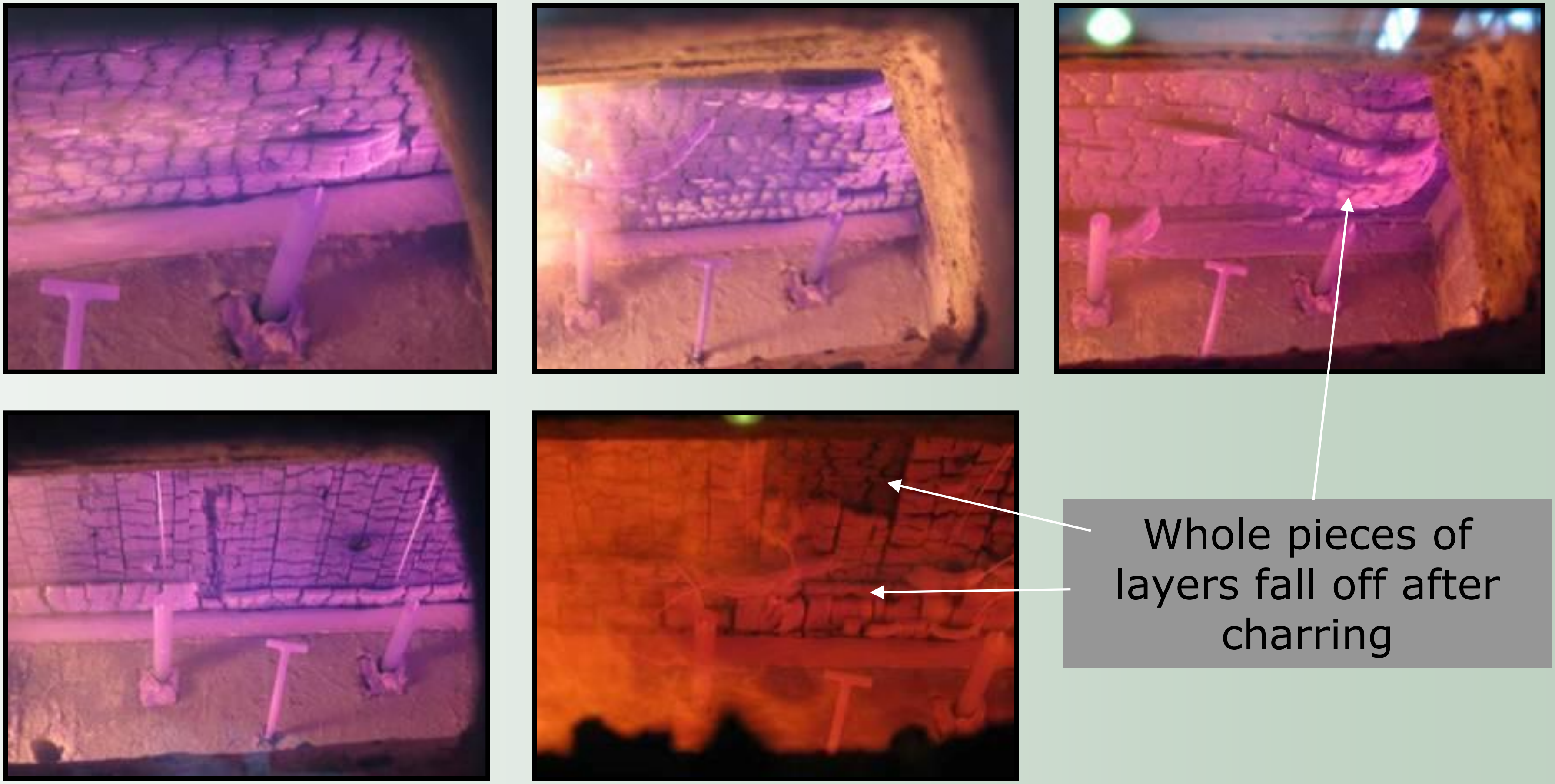
1 specimen with 5-layered uni-directional cross section and PUR

Determination of charring rate and charring depth via temperature with thermocouples placed between the single layers



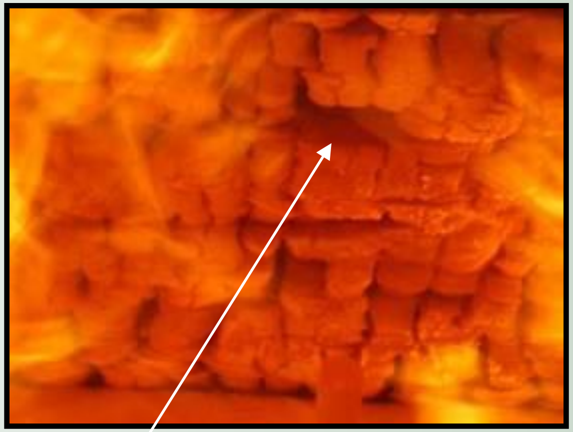
Fire Research on CLT

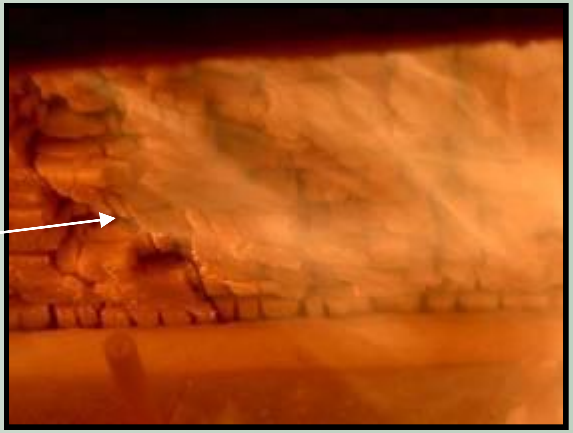
1K-PUR: Oberservations during fire tests



Fire Research on CLT

MUF: Oberservations during fire tests

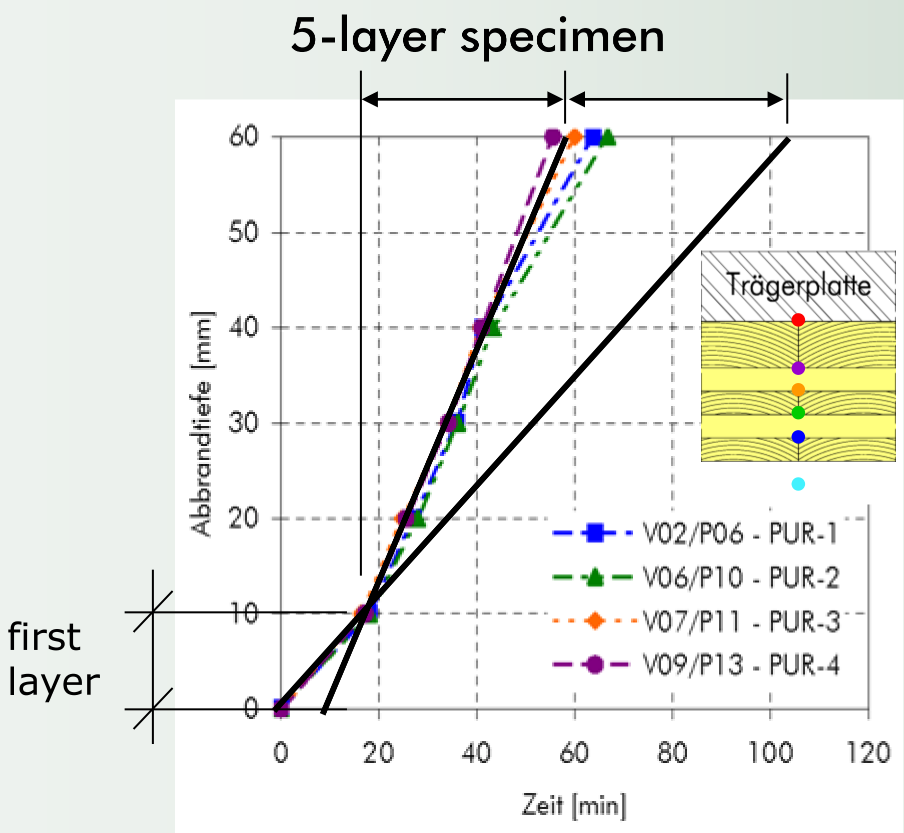


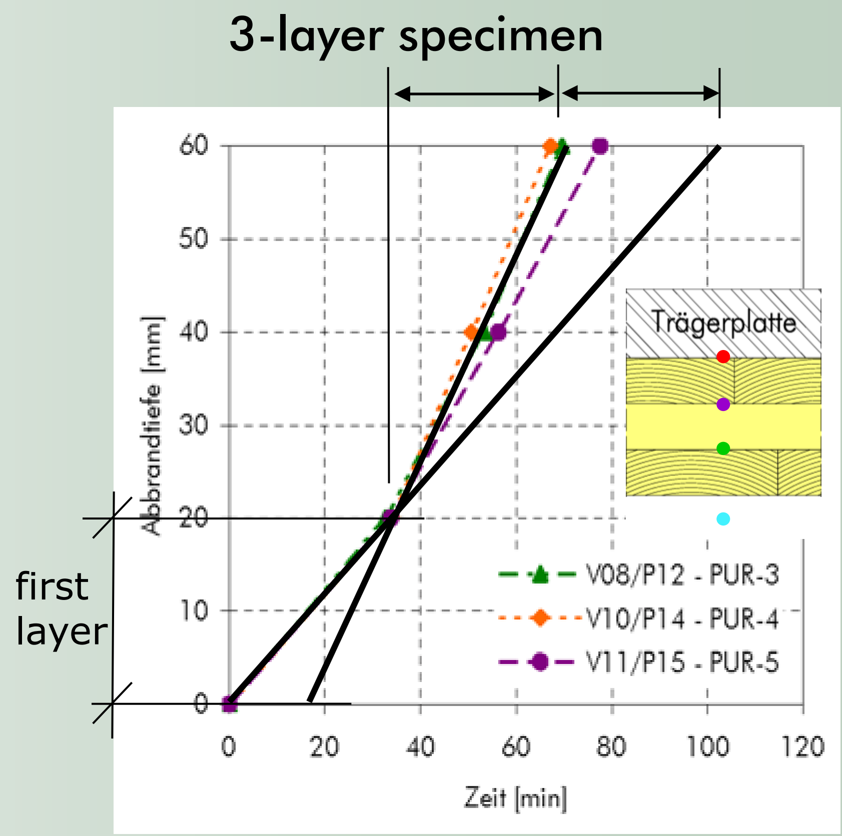


Charred layers do not fall off – thermal insulation as known from sawn timber and GLT is given

Fire Research on CLT

1K-PUR: charring depth



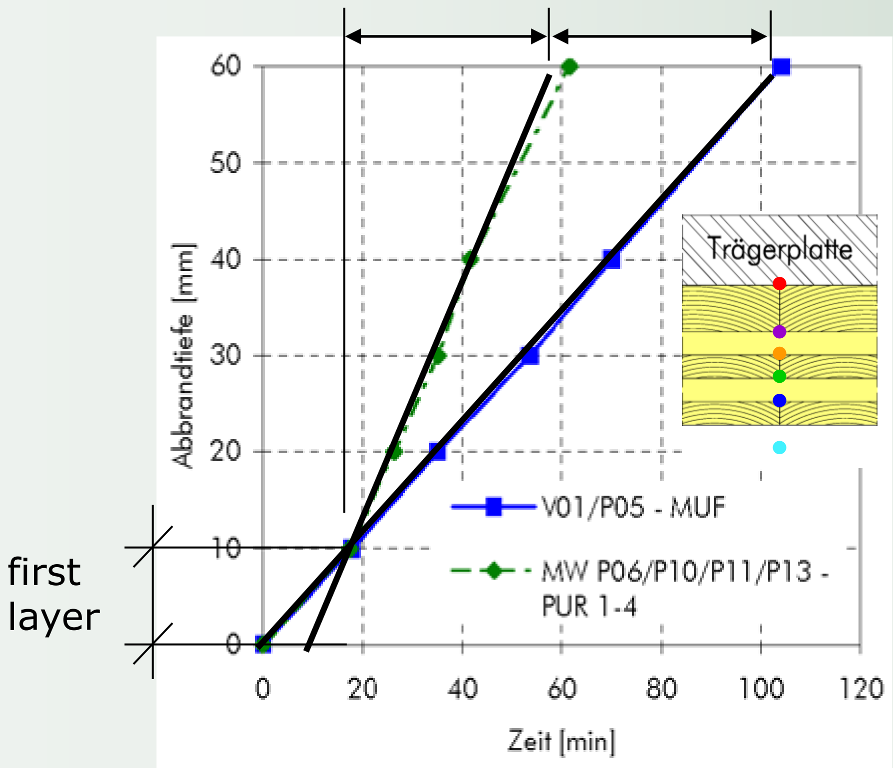


⇒ Effect due to different 1K-PUR glues regarding charring rates may be neglected.

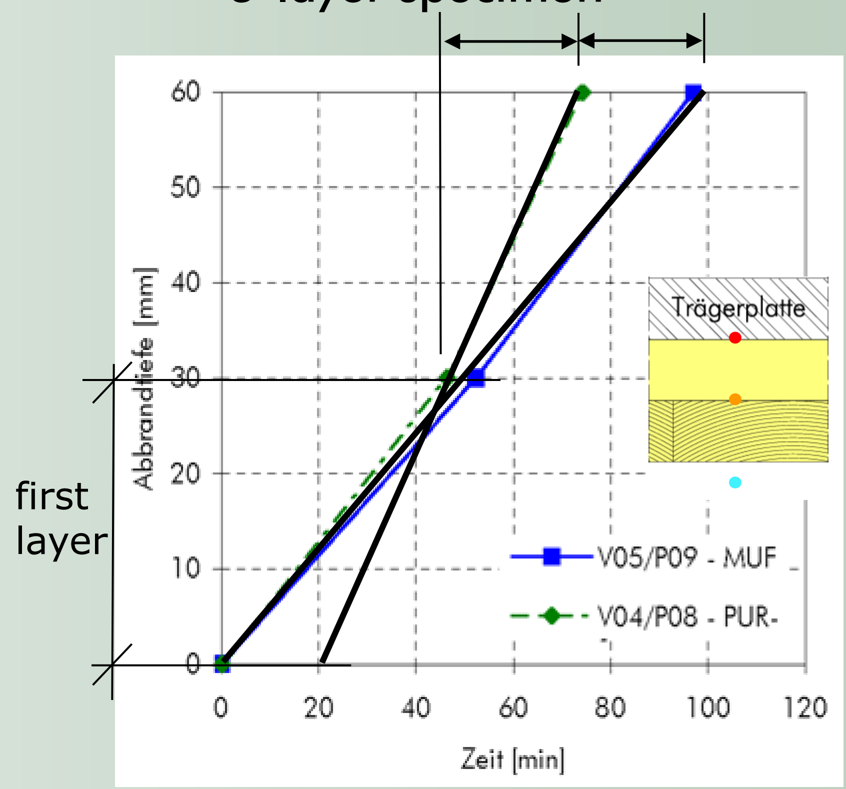
Fire Research on CLT

Charring – Parameter GLUE – 1K-PUR / MUF

5-layer specimen



3-layer specimen



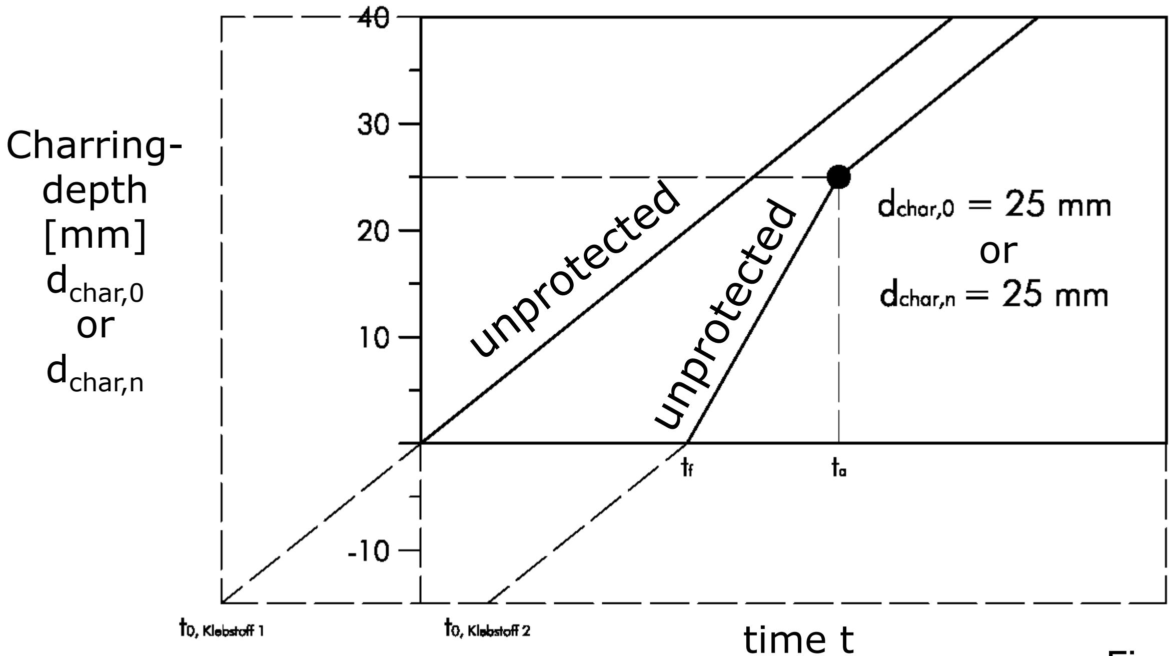
⇒ Type of glue (PUR – MUF) has a significant influence on the charring behaviour

Fire Research on CLT

EN 1995-1-2:

Difference between unprotected

and initial protected timber cross sections.



Based on scientific work

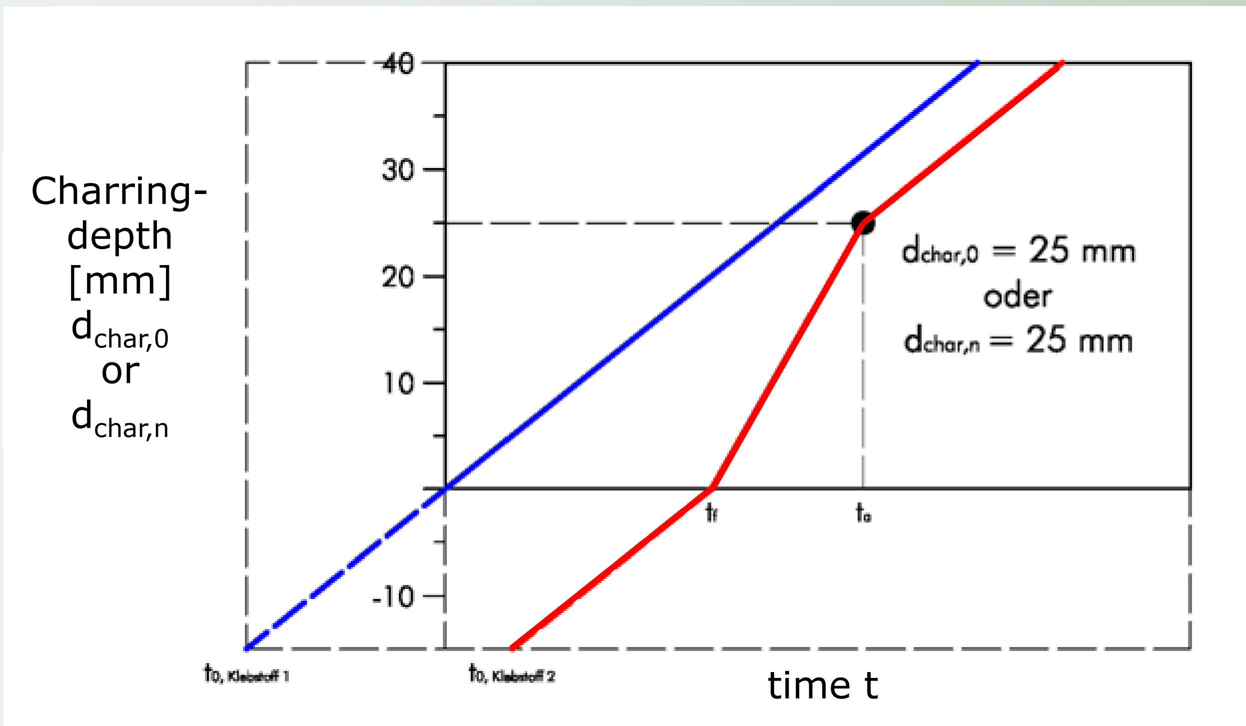
(Fontana, König, Frangi, ...)

Figure 3.4 (EN 1995-1-2)

Fire Research on CLT

Proposal to EN 1995-1-2 for the design of CLT

- Cross sections with 1-K PUR → initial protected timber
- Cross sections with MUF → unprotected timber



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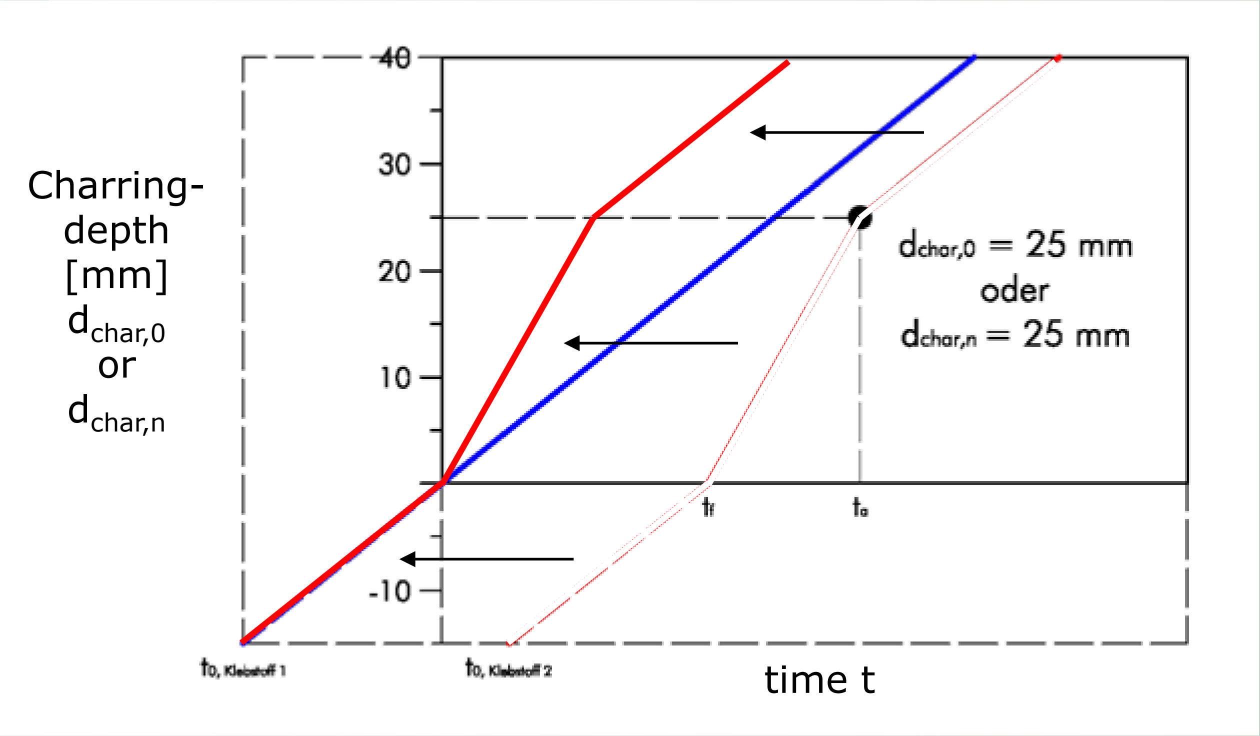
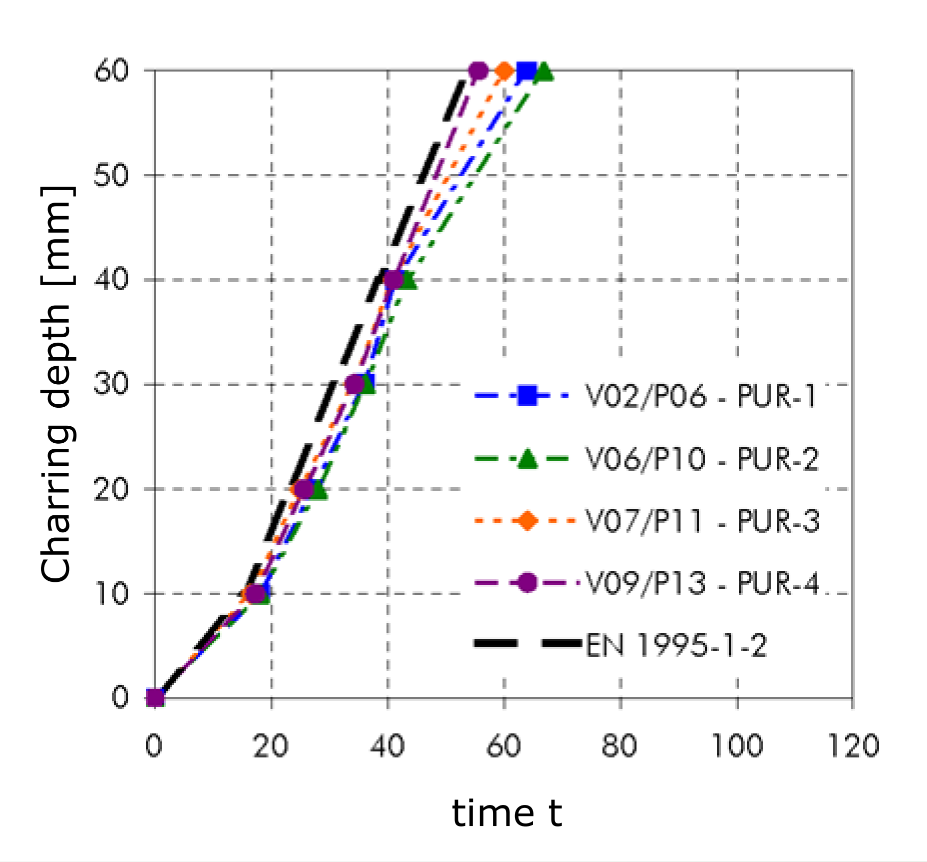


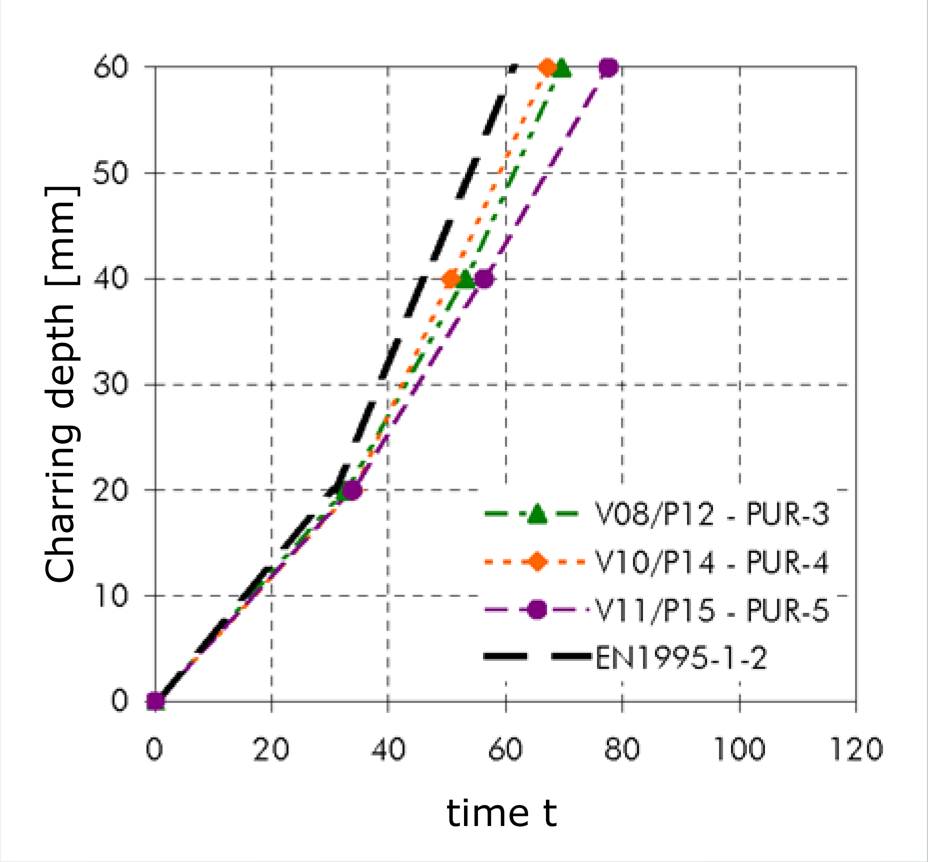
Fire Research on CLT

Comparison between proposal and test results

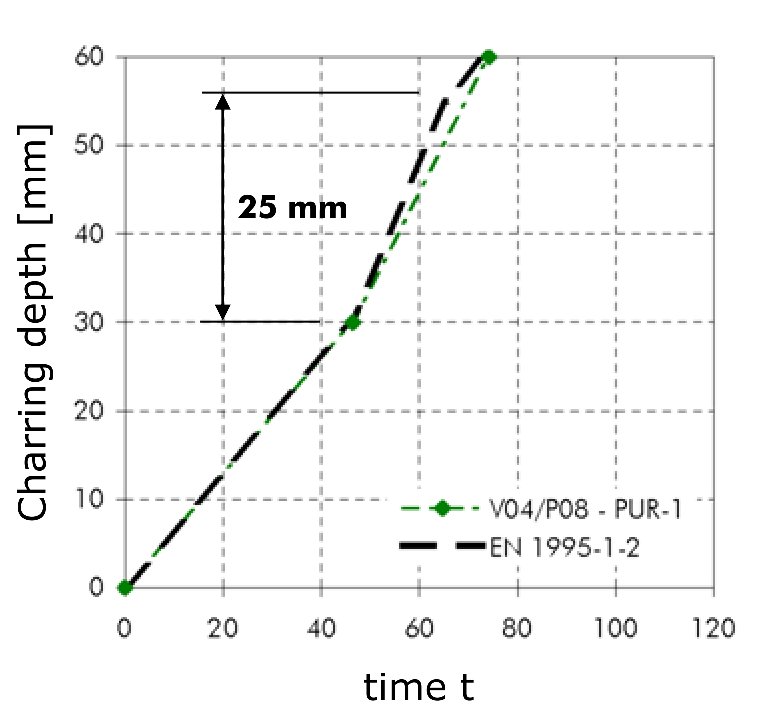
5-layer specimen PUR

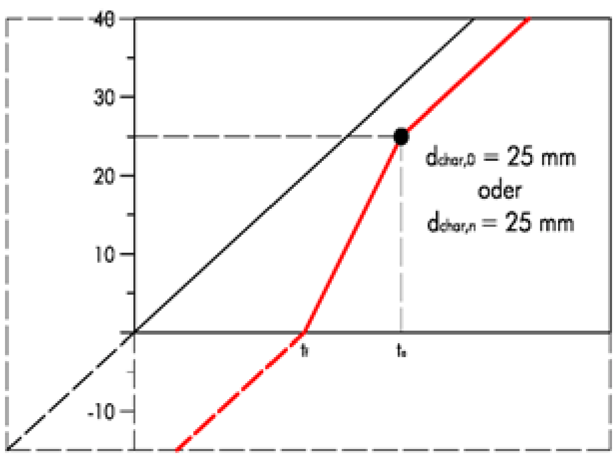


3-layer specimen PUR

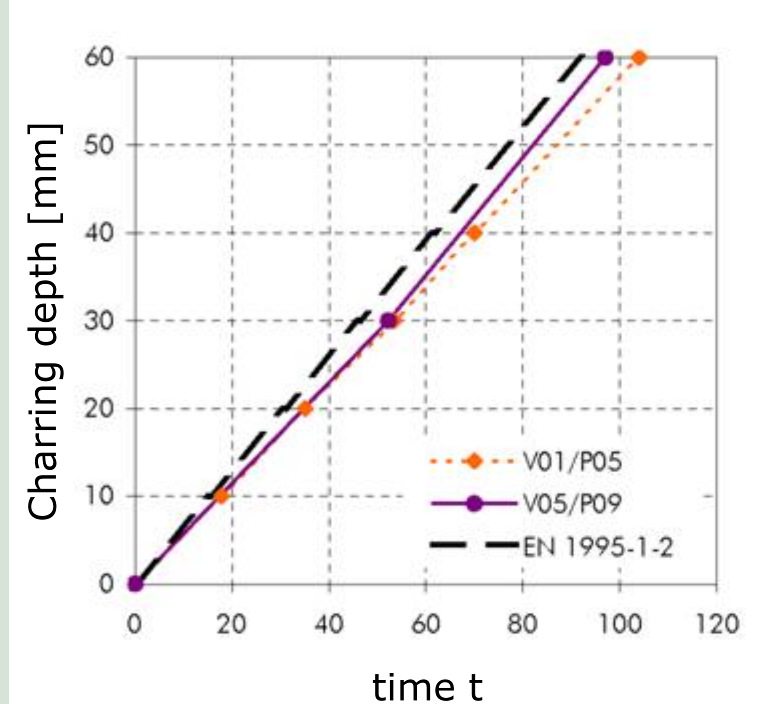


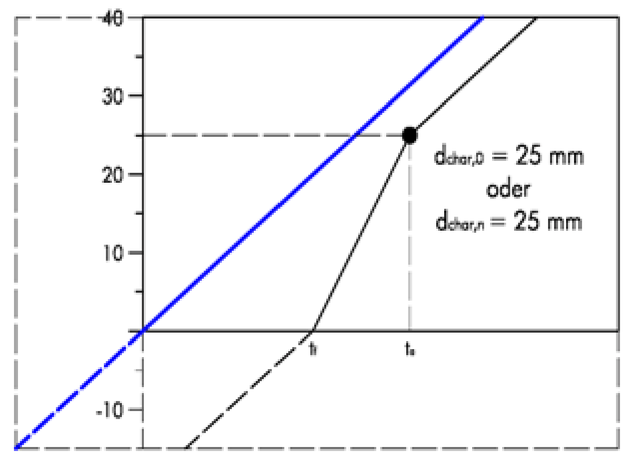
2-layer specimen PUR



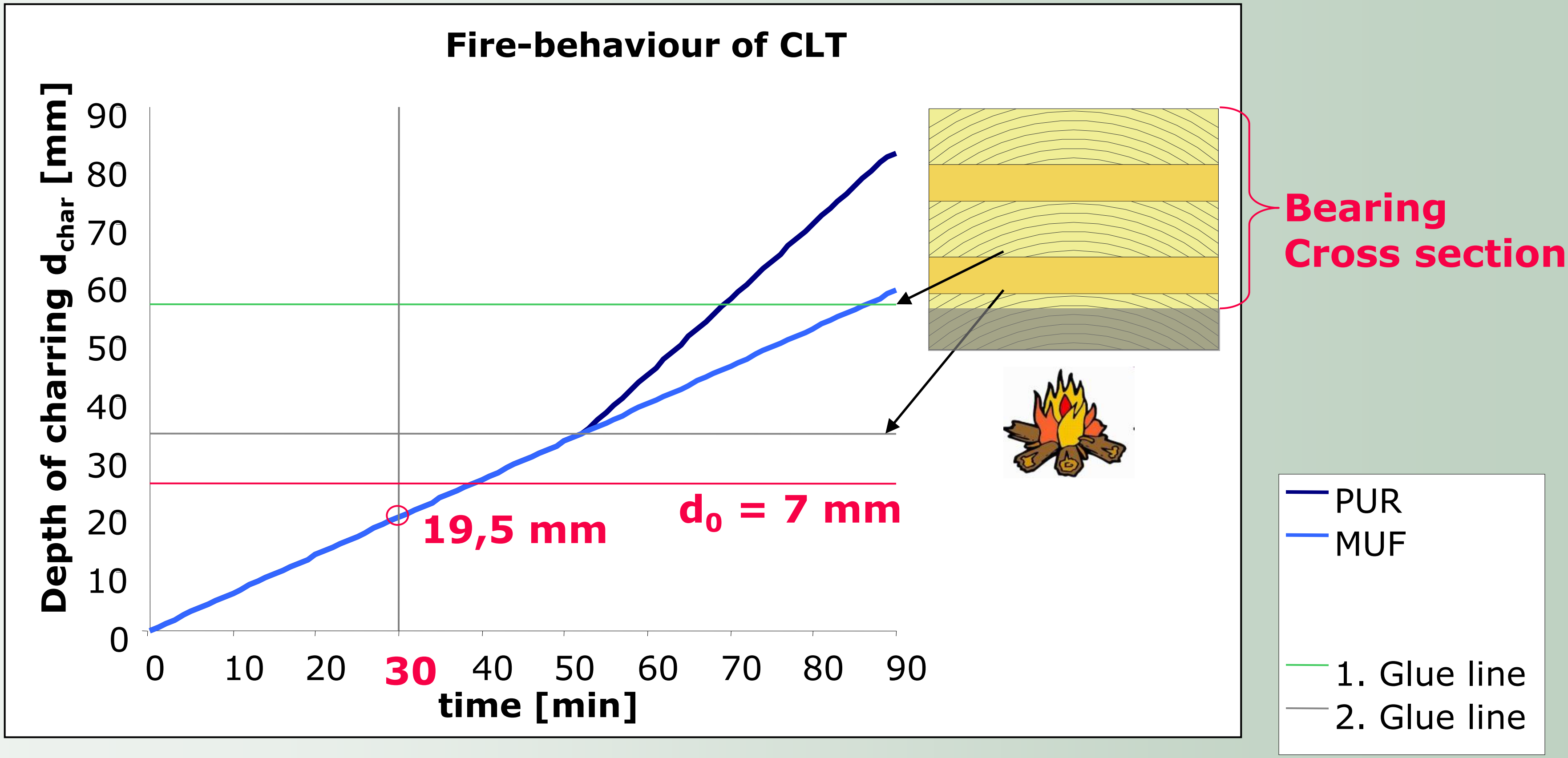


2-layer specimen MUF



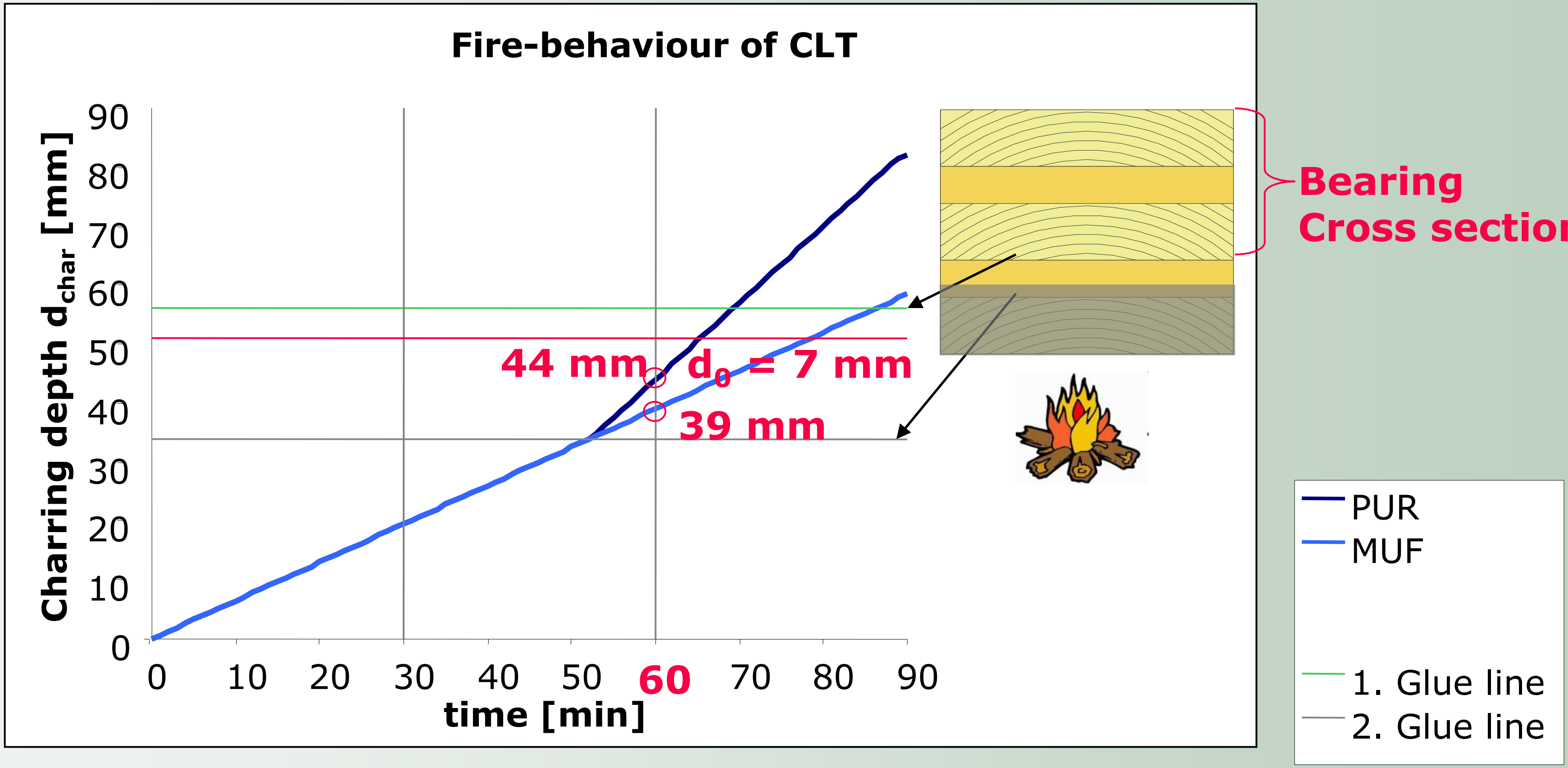


Proposal for design: Difference between PUR an MUF for R30



No difference between PUR and MUF!

Proposal for design: Difference between PUR an MUF for R60



Difference between PUR and MUF 5 mm!

Contact:

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