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Foundation FSE-WO2

- Consultants, industry, suppliers, industry associations
- Link between academic world and engineering world

www.fellowfse.nl

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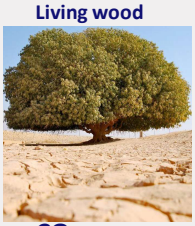
Popularity of wooden buildings

Living wood	Dead wood	Burnt wood
		
CO_2: -	CO_2: 0	CO_2: +

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What was the problem with wooden buildings?

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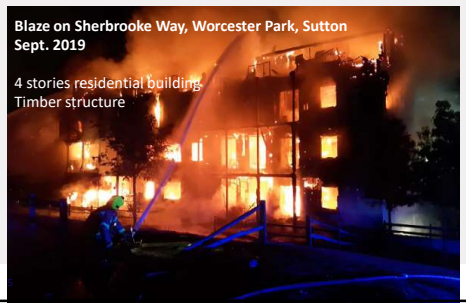
Can we handle this problem?



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Performance based: objectives

Risk subsystems:

- Safety of third party properties (neighbouring plots)
- Safety of building occupants and fire service (escape routes and attack routes)
- Safety of the building (load bearing structure) → LOD
- Limiting spread of fire (compartmentation) → LOD
- Limiting smoke propagation (sub compartmentation) → LOD
- Limiting fire development (reaction to fire) → LOD

LOD:

- Line of Defence

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Performance based: assessment criteria

For each risk subsystem, project specific assessment:

AST > RST x γ

γ = safety factor
AST = available safe time [min] / [min SFC]
RST = required safe time [min] / [min SFC]

LOD's with a large safety factor ensure fire resilience

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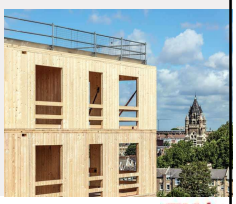
CLT in residential buildings

Walls and floors are load bearing structure
Walls and floors are separation constructions of (sub)compartments

Rule based:
- CLT exposed to fire can be sufficiently fire resistant (meets fire resistance criteria according to EN 13501-2)

Performance based:
- Does the fire stop after the standard fire duration? (self extinguishing effect)



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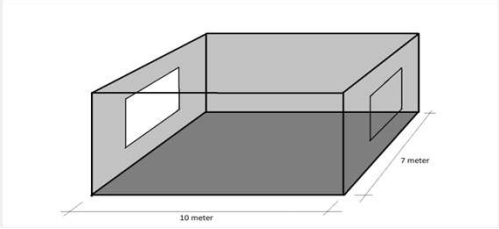
CLT in residential buildings

Simulation natural fire: Traditional vs. exposed CLT



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CLT in residential buildings

Simulation natural fire: Traditional vs. exposed CLT

Boundary condition		Traditional	CLT
Permanent fire load (average)	[MJ/m²]	-	400 (2)
Variable fire load (average)	[MJ/m²]	780 (1)	780 (1)
Rate of Heat Release density	[kW/m²]	250 (1)	250 (1)
Time constant fire development	[s]	300 (1)	300 (1)
Combustion value	[MJ/kg]	17,5 (3)	17,5 (3)
Stoichiometric constant	[kg/kg]	1,27 (3)	1,27 (3)
Combustion efficiency	[-]	0,8 (3)	0,8 (3)
Collapsed daylight openings h x b	[m]	1,5 x 8,2 (total)	1,5 x 8,4 (total)

(1) According to NEN-EN 1991-1-2/NB
(2) Assuming a characteristic permanent fire load of 500 MJ/m²
(3) According to NEN 6055

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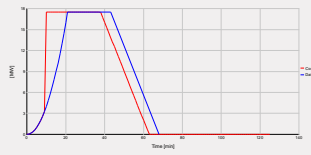
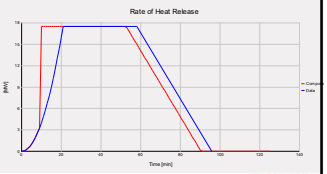
CLT in residential buildings

Thermal action caused by fire

Thermal action by fire (traditional)



Thermal action by fire (CLT)



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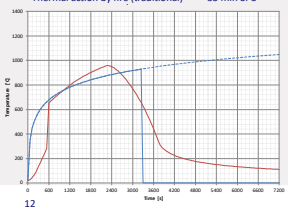
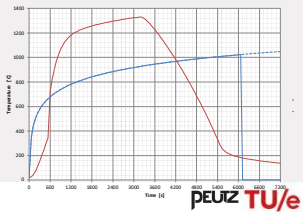
CLT in residential buildings

Thermal action caused by fire

Thermal action by fire (traditional) 55 min SFC



Thermal action by fire (CLT) 101 min SFC



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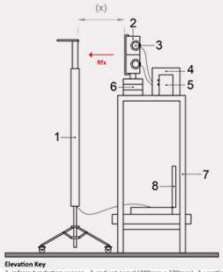
Lab research



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Lab research

Self extinguishing effect and delamination

Andrés Berdugo Calderon (Politecnico Torino)

Delamination: lamella falls off (ME glue)

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Lab research

Results:

- Q_{rad} = 100 kW/m² → no measurement possible
- Q_{rad} = 25 kW/m² → burn in speed: 0,3 mm/min (flaming/smouldering)
- Q_{rad} = 15 kW/m² → burn in speed: 0,15 mm/min (smouldering)
- Q_{rad} = 10 kW/m² → burn in speed: 0,15 mm/min (smouldering)
- Q_{rad} = 5 kW/m² → burn in speed: 0,15 mm/min (smouldering)

Transition from flaming to smouldering combustion (CLT):

- Burn in depth: 3 – 8 mm

All experiments (90 min): continuous smouldering combustion in CLT samples

- No self extinguishing effect was found!

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Adjusted simulation

Thermal action by fire

Modeled contribution of permanent fire load (CLT):

- Fully developed fire: 0.6 mm/min (assumption)
- Decay phase: 0.3 mm/min (flaming combustion)
- Variable fire load combusted: 0.15 mm/min (smouldering combustion)

Fully developed fire:

- RHR density: 250 kW/m^2
- Increases due to CLT to: 435 kW/m^2 (factor 1.74)
  (façade openings enlarged to full façade width)

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Adjusted simulation

Thermal action by fire

Modeled contribution of permanent fire load (CLT):

- Fully developed fire: 0.6 mm/min (assumption)
- Decay phase: 0.3 mm/min (flaming combustion)
- Variable fire load combusted: 0.15 mm/min (smouldering combustion)

After 2 hours natural fire (Ozone simulation):

- Burn-in depth: 34 mm
- Corresponds to permanent fire load density 530 MJ/m^2 floor area

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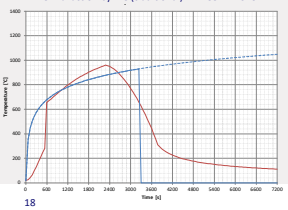
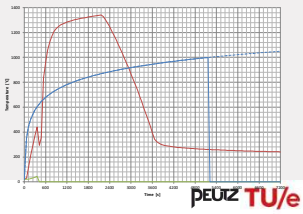
Adjusted simulation

Thermal action by fire

Thermal action by fire (traditional) 55 min SFC



Thermal action by fire (CLT) 86 min SFC



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Conclusions

CLT exposed to fire

- Exposed CLT can be fire resistant (EN 13501-2, SFC), but:
  - Failure probability of fire compartmentation increases
  - Probability of burn down scenario increases:
    CLT building is less fire resilient than a traditonal building
  - Stay-in-place concept / partial evacuation: not possible
  - Probabilty of fire spread to neighbouring plots increases
  - More water needed for fire suppression

Conclusions

CLT exposed to fire

- Exposed CLT can be fire resilient:
  - Prevent flashover by sprinkler protection
- Residential sprinkler:
  - T_{act} = 68 °C – RTI = 35 $(m.s)^{0.5}$
  - Increased spray density
    LH: 2.25 mm/min → 3.94 mm/min

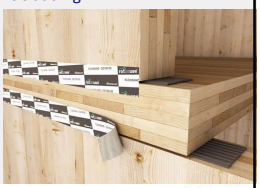
Robust solutions

Active reduction of thermal action: sprinkler protection

Passive protection of CLT construction: fire resistant cladding

Need for research:

- What is the critical radiation flux for
  self extinguishing effect of CLT due to the char layer?



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