



Fire safety in historic timber buildings

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Fires in historic buildings



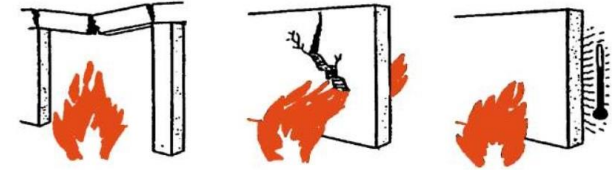
Frankfurt, Germany. <http://www.flickrriver.com/photos/quasebart/sets/72157602268385328/>



<https://www.euractiv.com/section/health-consumers/opinion/eu-should-improve-fire-safety-in-buildings/>

Content

- Fire safety
- Fire design of timber structures
- Traditional building constructions
- Design guidelines for plasters
- Case study
- Conclusion



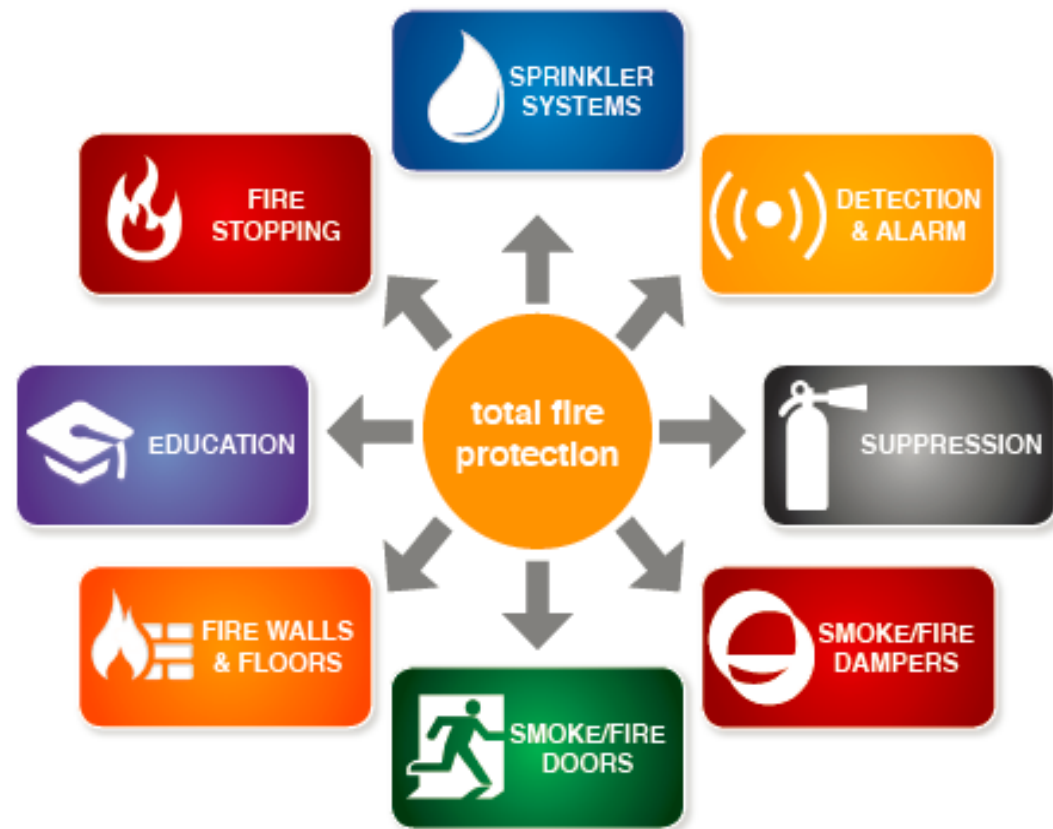
Apartment building on Salme Street. Tallinn, Estonia.
Karl Tarvas, 1932. Photo Peeter Sirge, MEA

Fire safety in buildings

- Fire protection measures:

- Active

- Passive

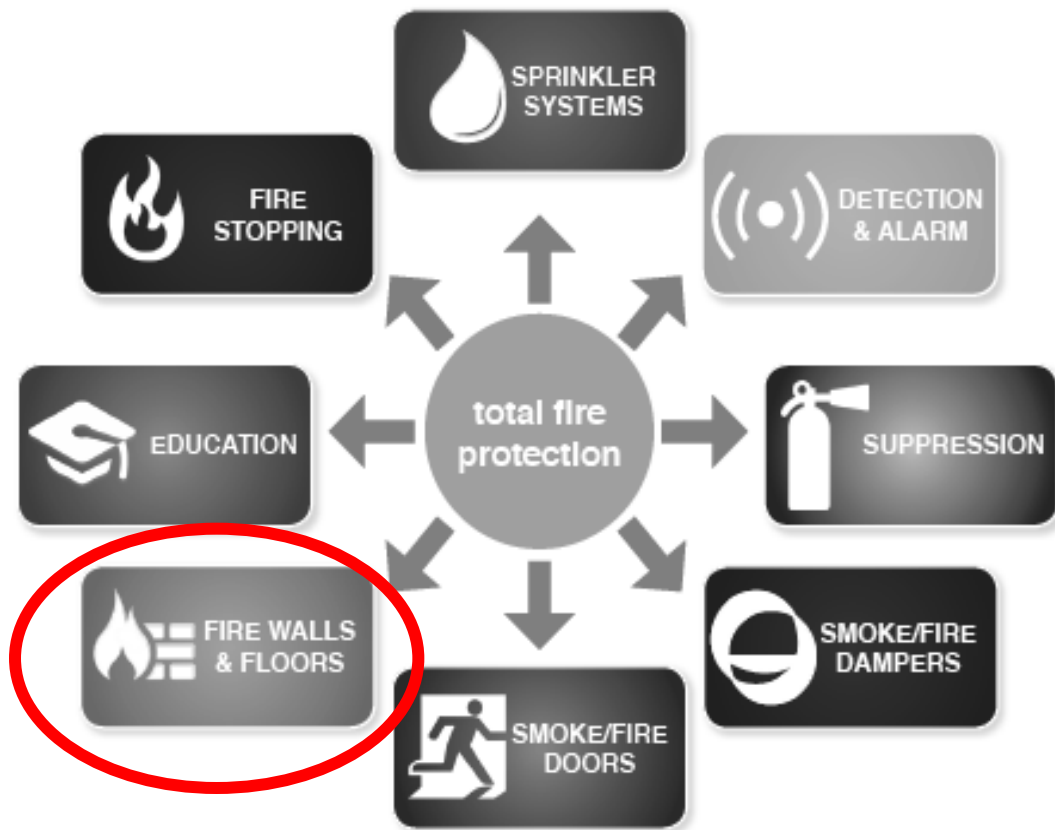


Fire safety in buildings

- Fire protection measures:

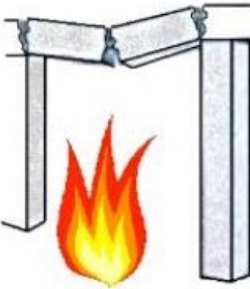

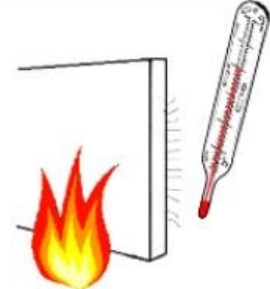
- Active

- Passive



Structural fire safety requirements

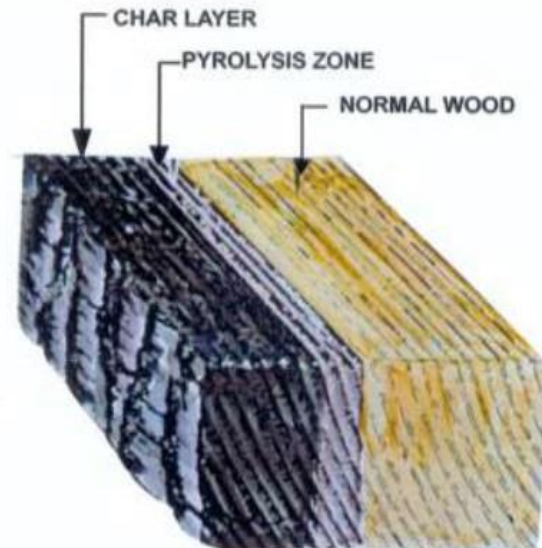
- Fire resistance:

R (load bearing capacity)	E (integrity)	I (insulation)
<p>Carries the required load during the period of fire influence without losing its stability.</p> 	<p>Prevents the flames and hot gases from penetrating the side flanked by fire to the outer side of the fire.</p> 	<p>Prevents the transmission of excess heat from the side flanked by fire to the outer side of the fire.</p> 

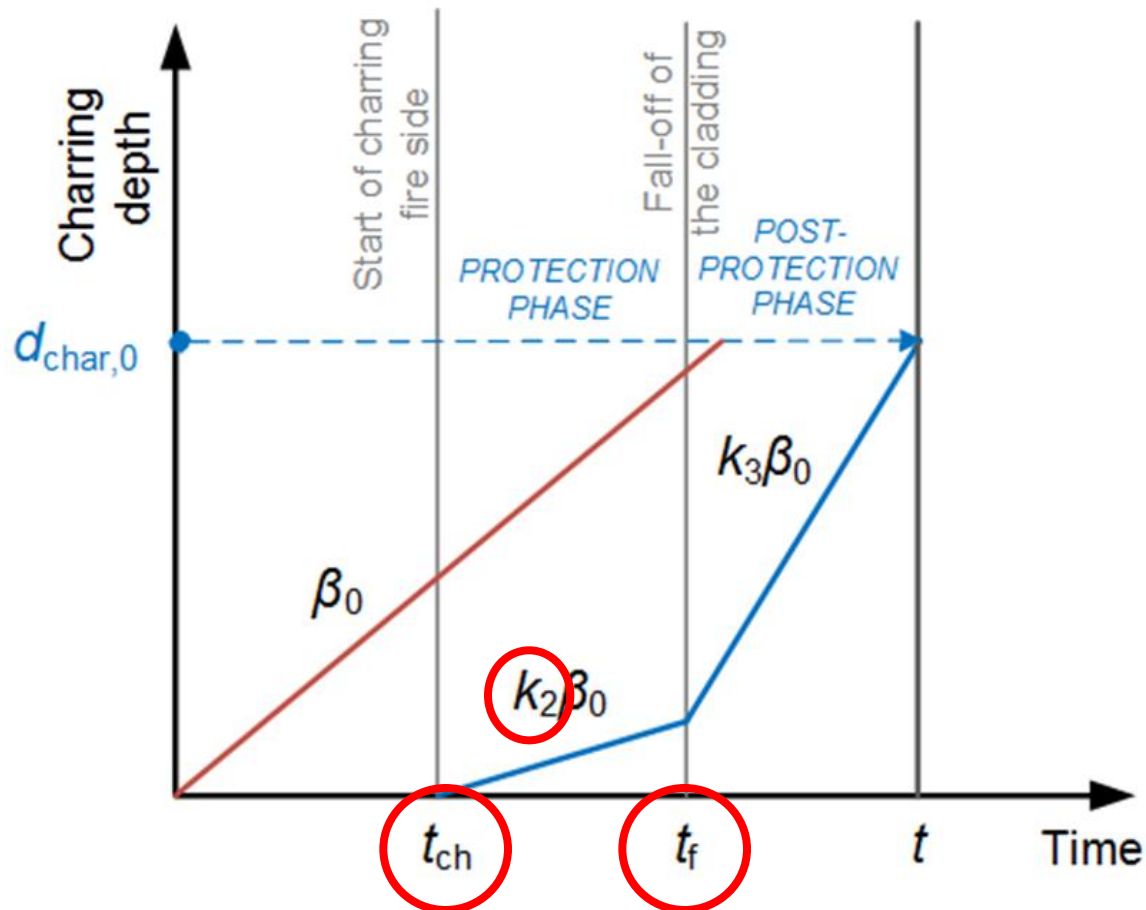
- Verification of resistance to fire for timber structures:
 - EN 1995-1-2
 - Full-scale fire testing

Behaviour of timber in fire

- Charring of timber
- Reduction of cross-section



Fire design of timber structures



t_{ch} - start time of charring

β_0 - one-dimensional charring rate

k_2 - protection factor

k_3 - post-protection factor

t_f - fall-off time of cladding

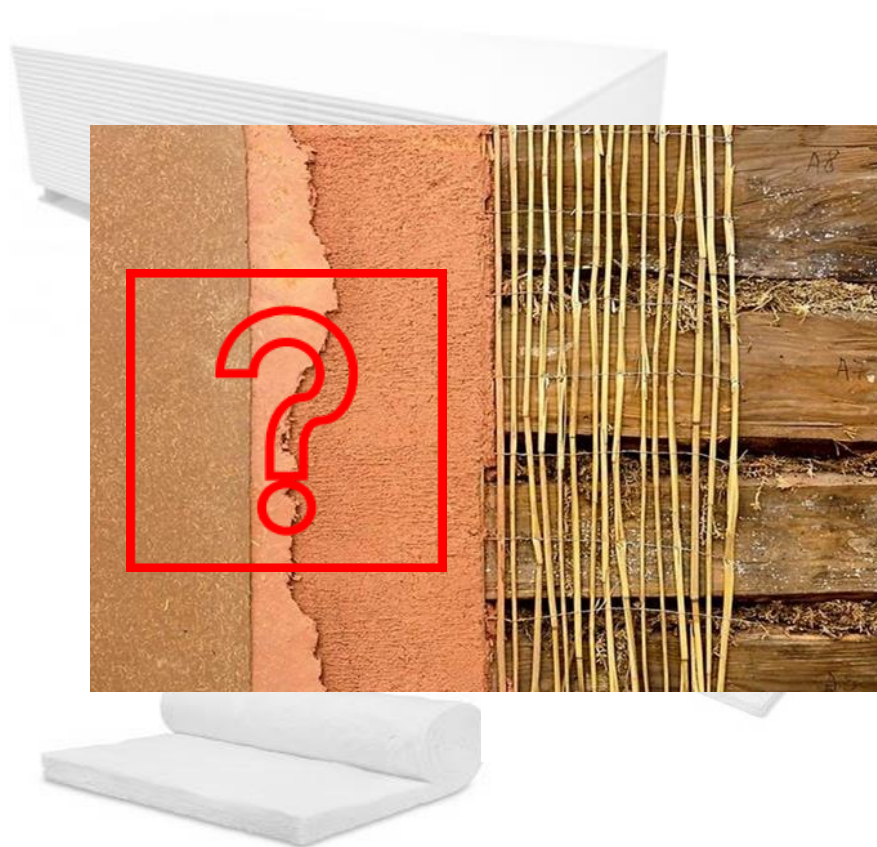
Fire design of initially protected timber structures

- EN 1995-1-2: 2004. Design of Timber Structures. Part 1-2: General - Structural Fire Design



Fire design of initially protected timber structures

- EN 1995-1-2: 2004. Design of Timber Structures. Part 1-2: General - Structural Fire Design



Fire performance of historic structures

▪ Current situation:

- Loss of original fabric and character of the buildings due to the restriction in fire safety requirements
- Limited data on traditional building materials
- Conflict between building regulations and preservation philosophy of historic buildings



Fire Safety Performance of Japanese Traditional Wall/Soil Walls and Implications for the Restoration of Historic Buildings in Urban Districts. Fire Technology, 38, 391-402. (2002) Hasemi, Y., Yasui, N., Akizuki, M.



Timber building in Tallinn, Estonia.

Traditional timber building constructions

- Different building types:



Timber frame construction with a panel infill



Log and double-plank timber structures covered by claddings

Traditional timber building constructions

- **Surface finish materials:** clay and lime plaster



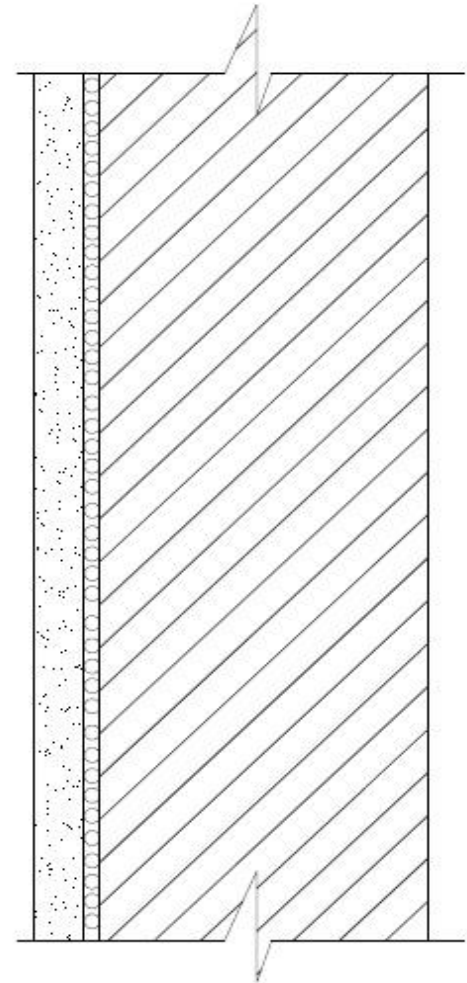
Clay plaster applied with a reed mat on a log wall



Lime plaster applied with a wooden lath on a log wall₁₃

Fire design guideline for plasters

- **Clay plaster**
DIN 19847
- **Lime plaster**
EN 998-1
- **Plaster substrates on timber:**
Reed mat
Reed board



Plaster substrate on timber (1)

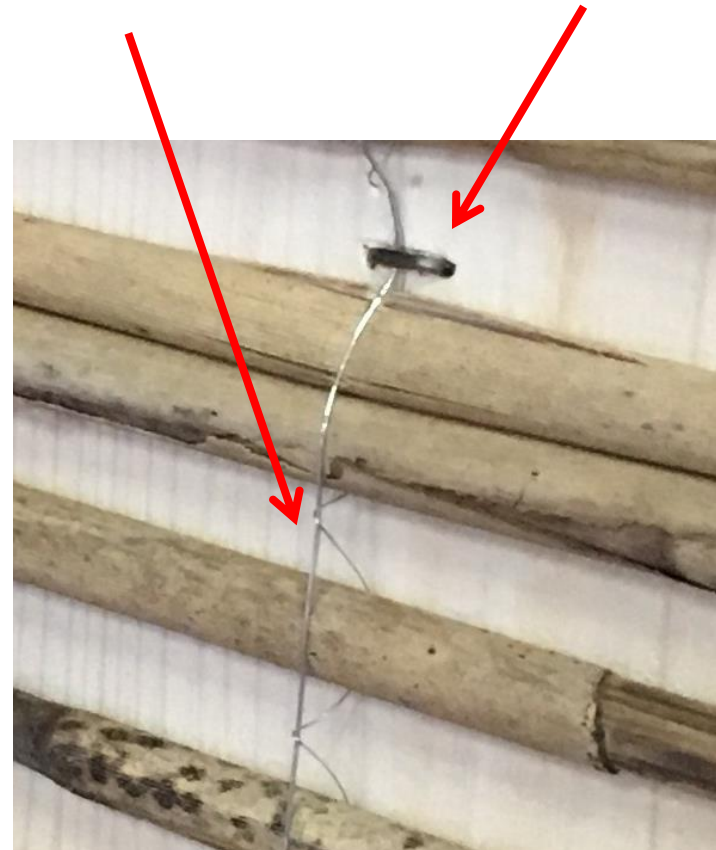
▪ REED MAT



➤ Fixation on timber:

WIRES

STAPLES



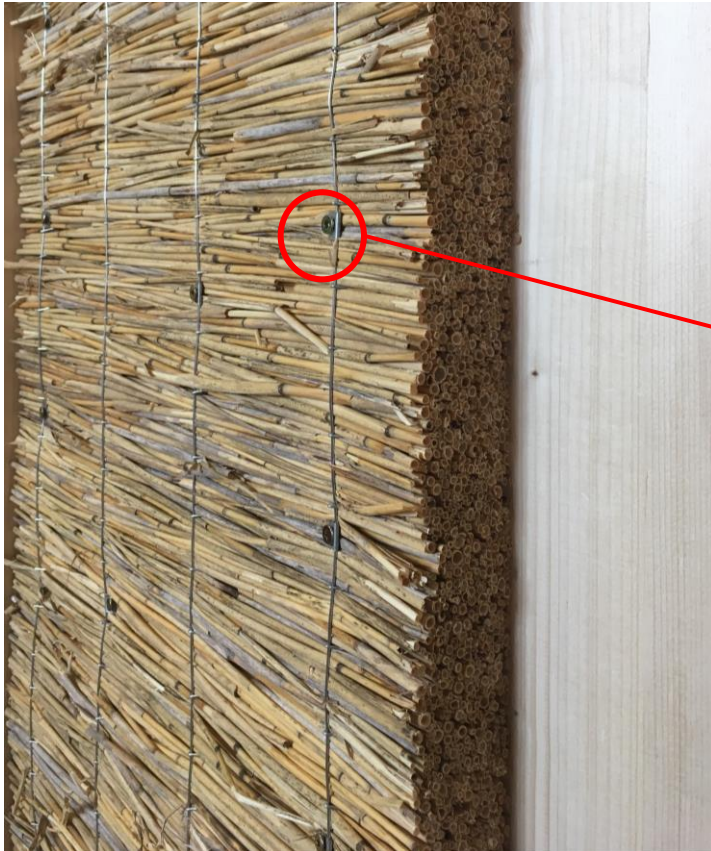
Plaster substrate on timber (2)

▪ REED BOARD

➤ Fixation on timber:

WIRES

SCREWS



Experimental studies

▪ Fire tests

- Clay plaster
- Lime plaster
- Base and top coat plasters
- Thicknesses: 10 – 40 mm

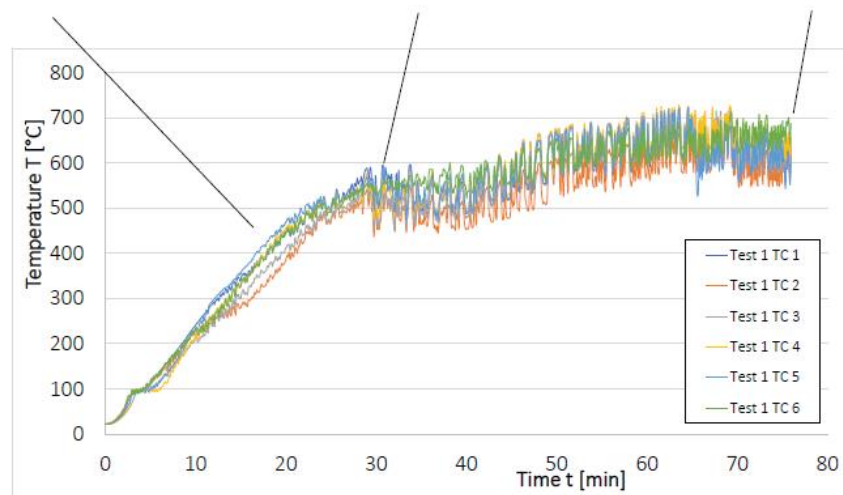
Plaster substrates on timber:

- Reed mat
- Reed board



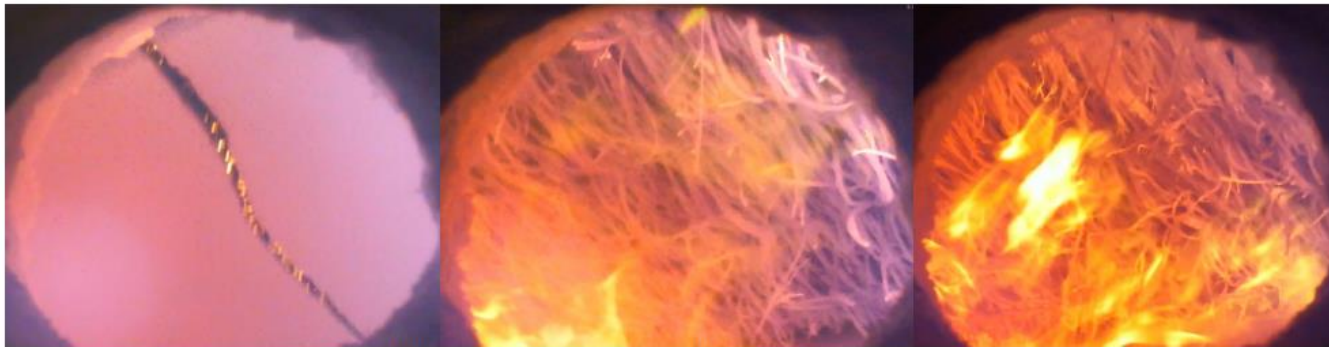
Furnace fire tests

- Clay plaster and reed mat on timber



Furnace fire tests

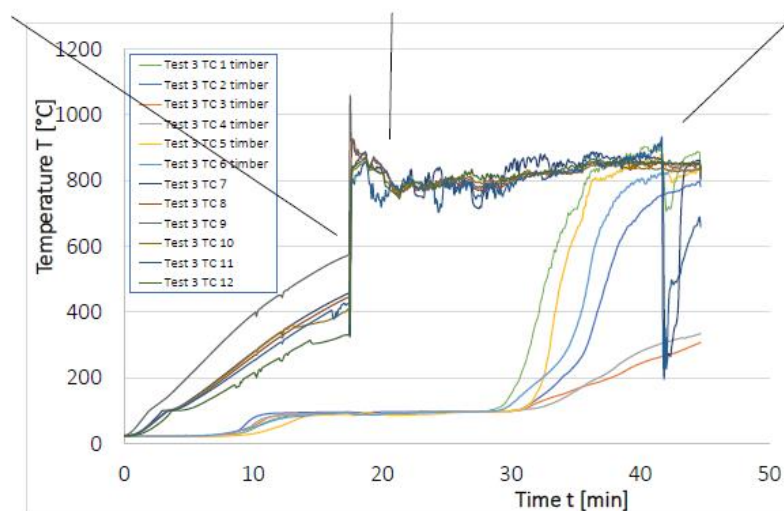
- Clay plaster and reed board on timber



Failure of plaster 17 mm. (no cracks before the fall off)

Reed board after failure of plaster

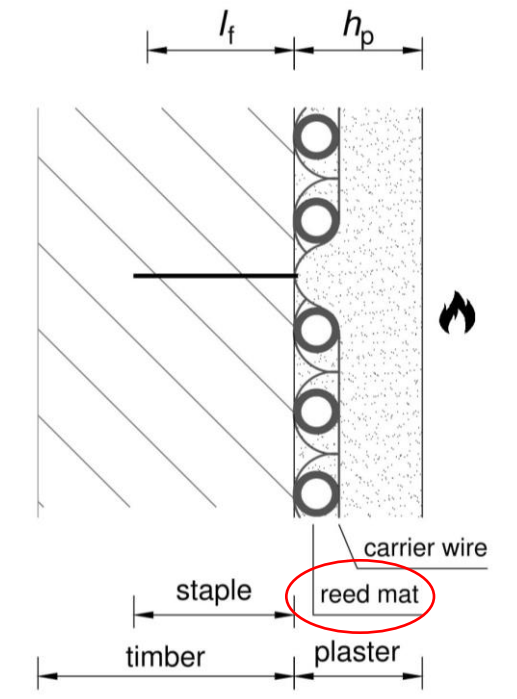
Before the end of test 44 min



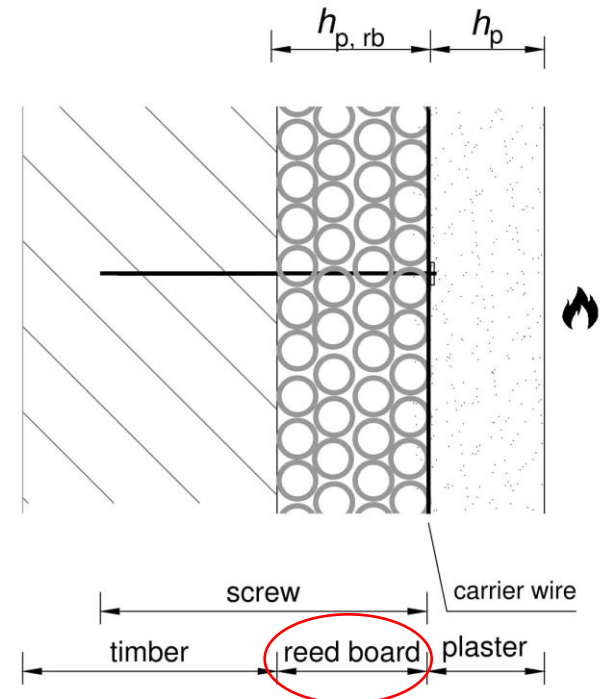
Design model for plaster

- In relation to the plaster substrate:

REED MAT

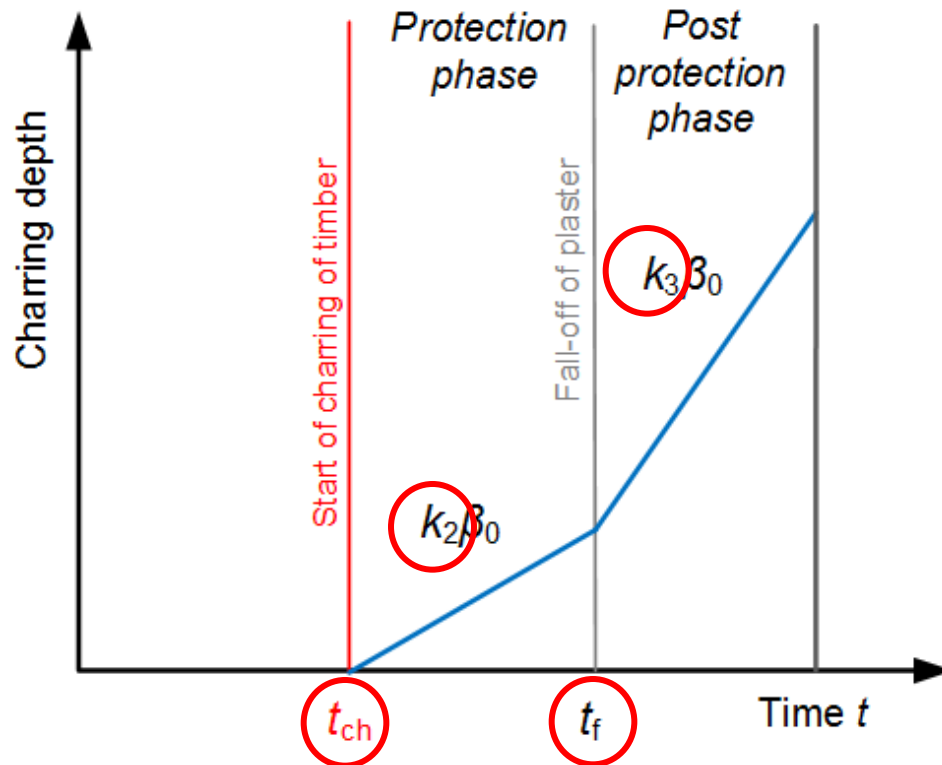


REED BOARD



Design parameters for plaster

REED MAT

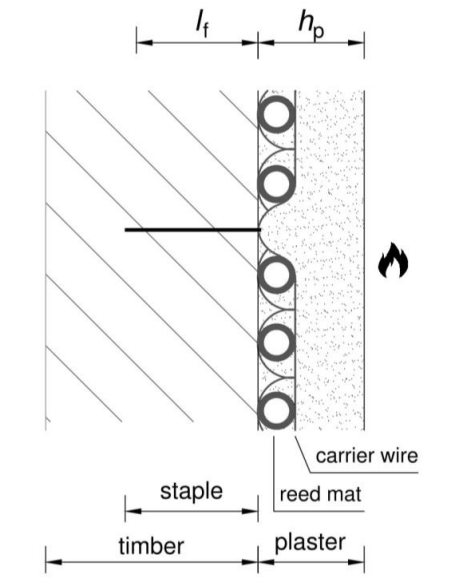


$$t_{ch} = h_p - 7$$

$$k_2 = 1 - 0,01 h_p$$

$$t_f = t_{ch} + \frac{l_f - 10}{k_2\beta_0}$$

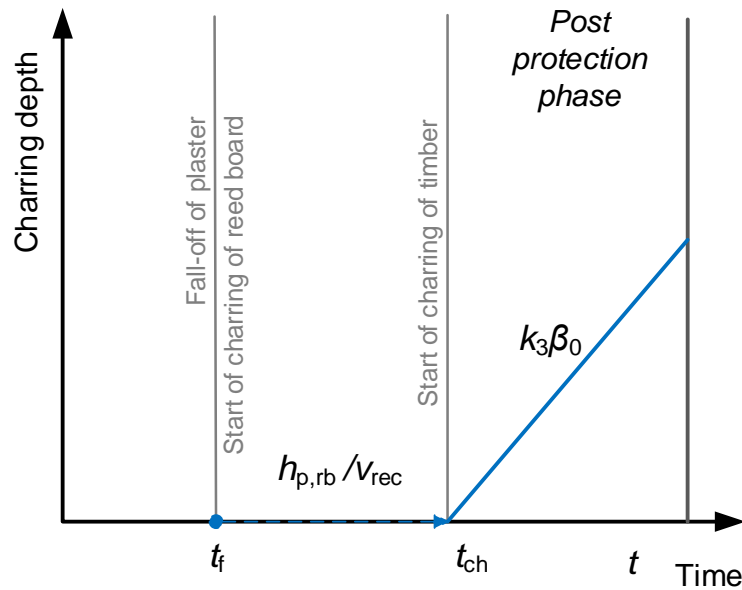
$$k_3 = 2$$



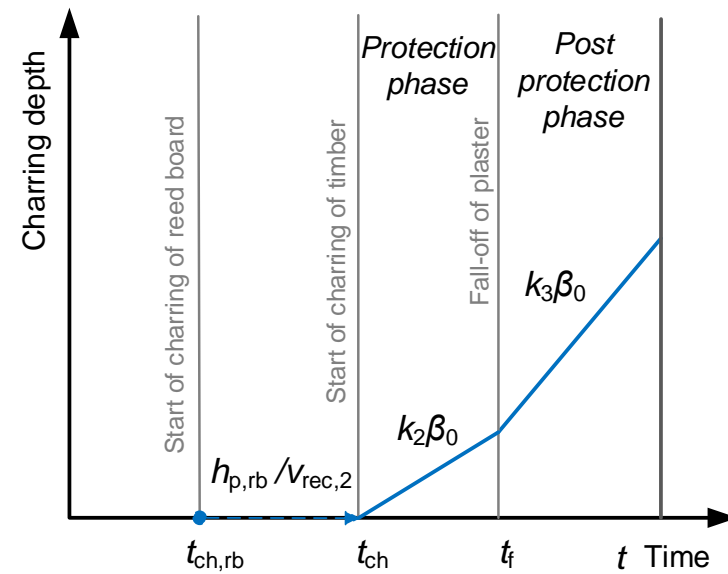
Design parameters for plaster

REED BOARD

1



2



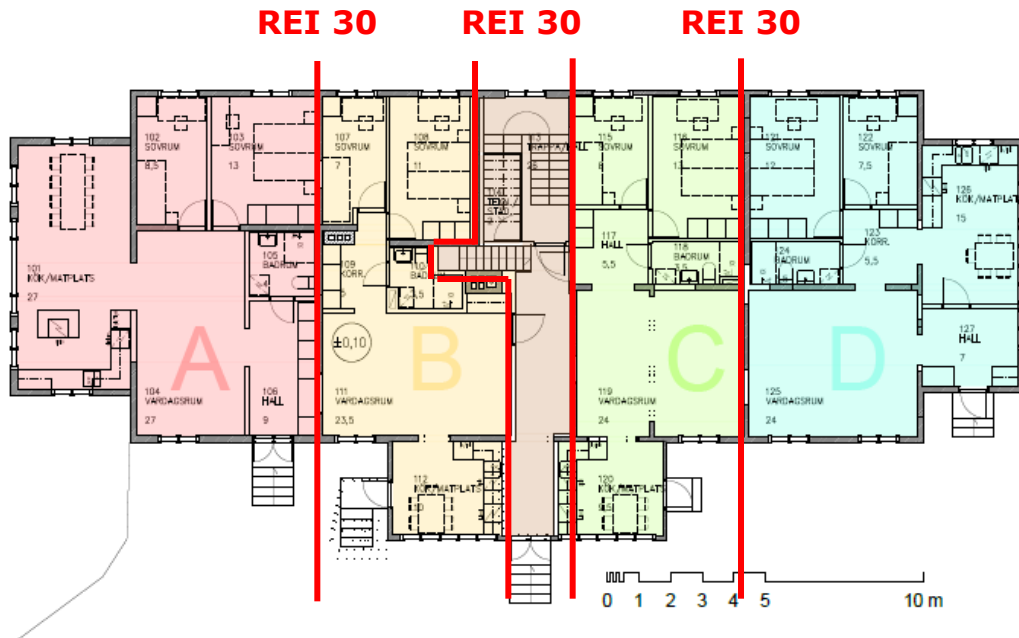
Case study

- Fiskars village, Raseborg, Finland
- Historic log building from 1800s
- **Design philosophy:** Preserve the authenticity of the building while using traditional and natural materials

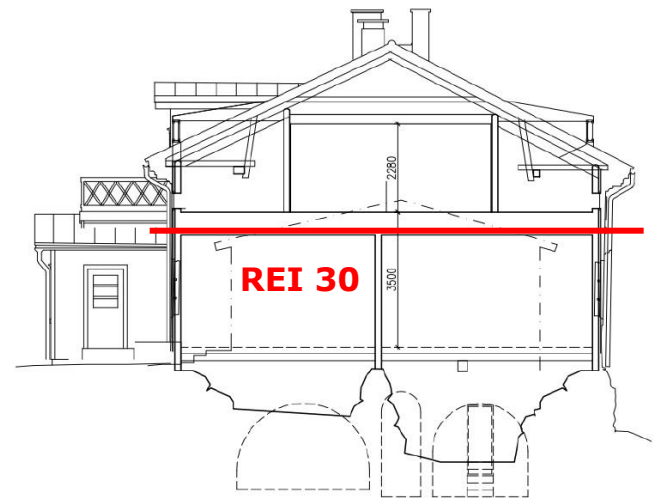


Case study

- Design concept



Floor plan



Section

Case study

- Existing structures:
 - Log walls
 - Timber joist floors



Case study

- Existing structures:



Wooden blank ceiling;
floor joist cavities filled
with sand and sawdust

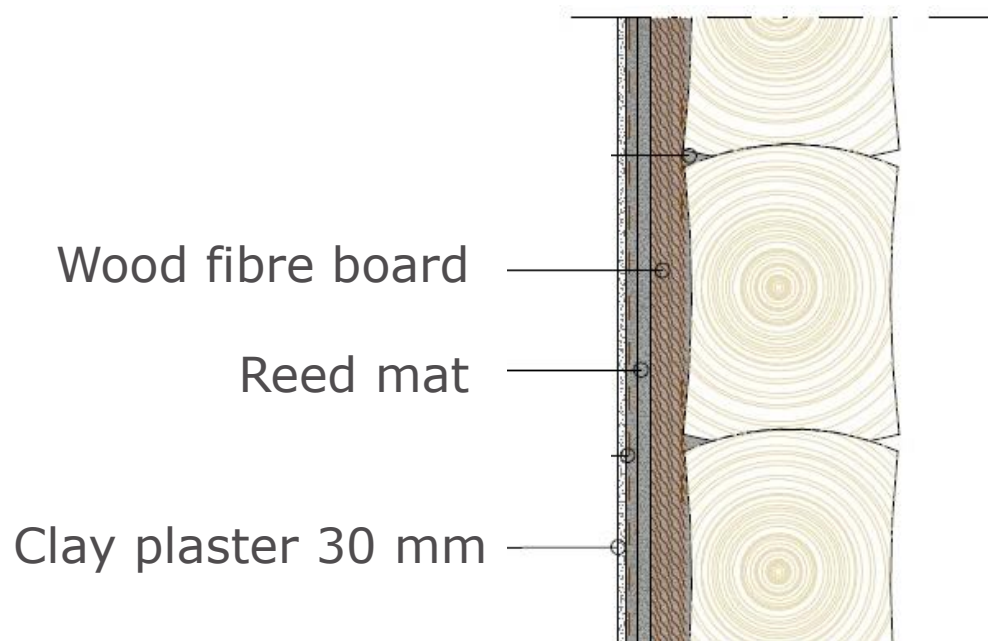


Roughened log walls
for a better adhesion
with plaster

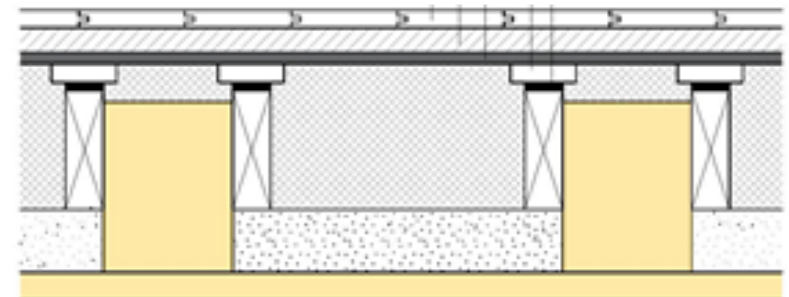
Case study

- Design solutions:

Walls



Floors



Case study

- Renovation planned to be finished in 2019
- Project encourages a wider use of traditional surface finish materials in timber buildings



Conclusion

- Clay and lime plasters are suitable fire protection materials for timber structures
- Design model for traditional plasters is being developed for the implementation to the European fire design standard
- Developed design parameters:
 - support the preservation of historic fabric
 - provide the assessment of existing plasters
 - encourage the use of old building technologies
 - retain the authentic character of timber buildings



Thank you for your attention!