TALLINNA
TEHNIKAÜLIKOOL

SP
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Properties of plaster for the fire design of timber structures

Aim

* To determine parameters of plaster for the fire design of timber structures according to EN 1995-1-2.

EUROPEAN SYSTEM FOR PROOFING FIRE SAFETY

"Requirement of safety"
(CPR/national building regulations)

Full-scale testing of building construction

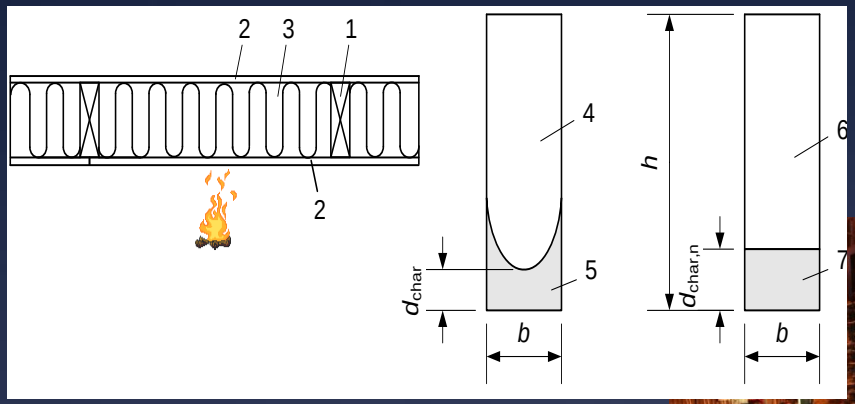
Classification acc. to EN 13501-2

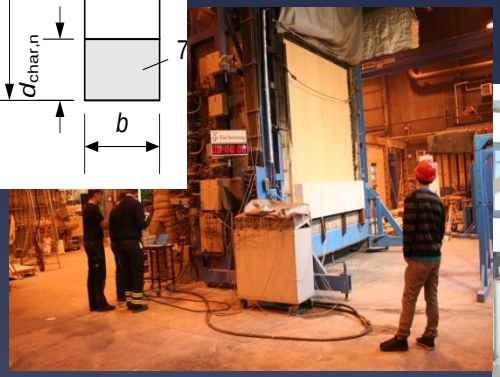
Design of building construction by means of calculations according to design standards

e.g. acc. to EN 1995-1-2

Fire safe use of construction

FULL-SCALE TESTING VS CALCULATIONS

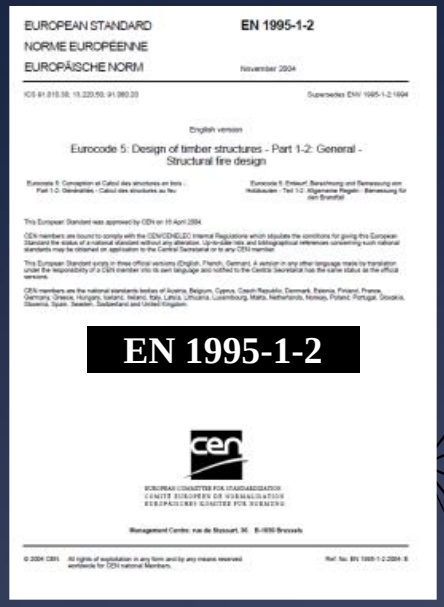




- **Calculations**
  - time and money saving
  - Allow assembling components with nearly endless possibilities
  - On “safe side” in comparison to full-scale fire test results

- **Full-scale testing**
  - time and money consuming
  - Limited to tested build-up (complex EXAPs)
  - Good method for the optimisation of construction build-ups

Eurocode system


EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1995-1-2

November 2004

English version

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

EN 1995-1-2

cen

EN 1990
Basis of design

EN 1991
Actions

EN 1995-1-1
Timber structures

Supporting EN standards

- EN 338
- EN 1194
- EN 520
- …

Other Eurocode Fire Parts

Supporting EN standards

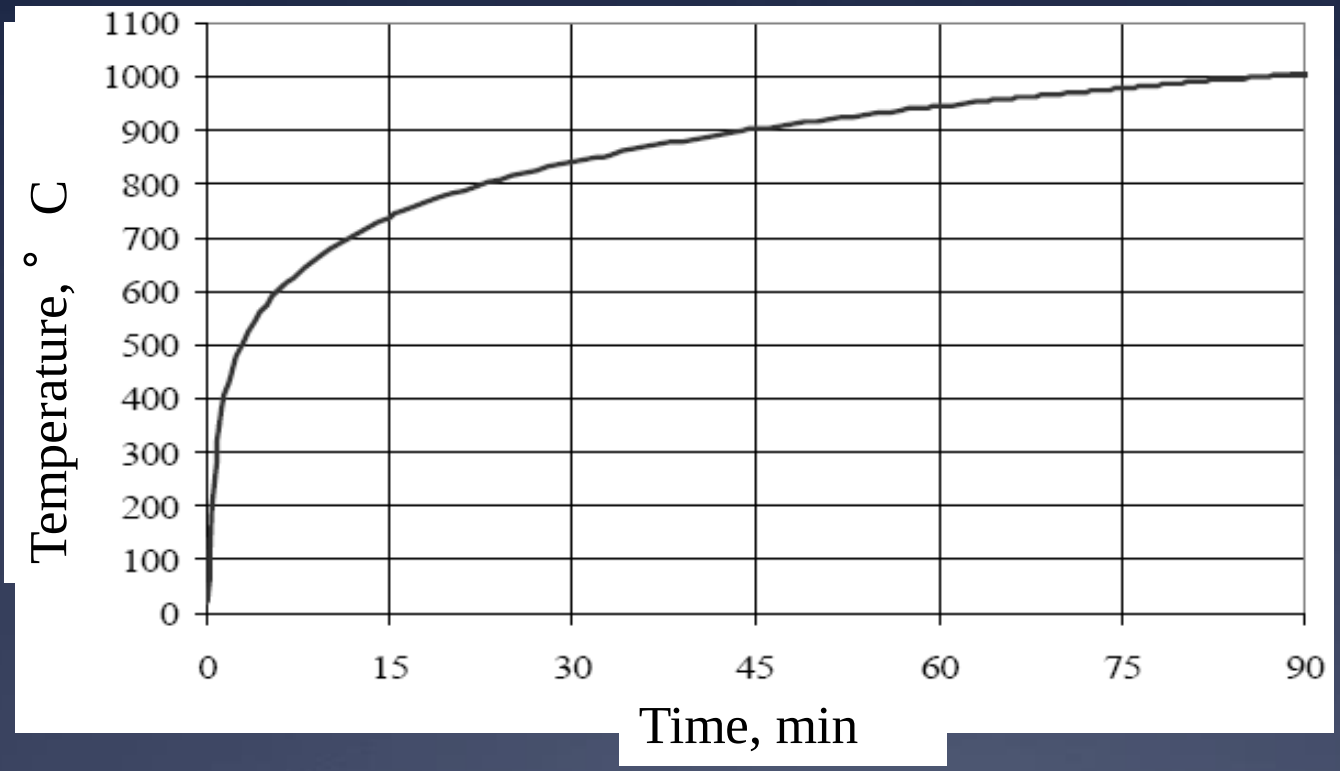
EN 1995-1-2:2020

- Fire safety design of timber structures

Major revision is needed:

- Protective properties of:
  - Fire rated inorganic boards
  - Plaster
  - Mineral wool and other insulations

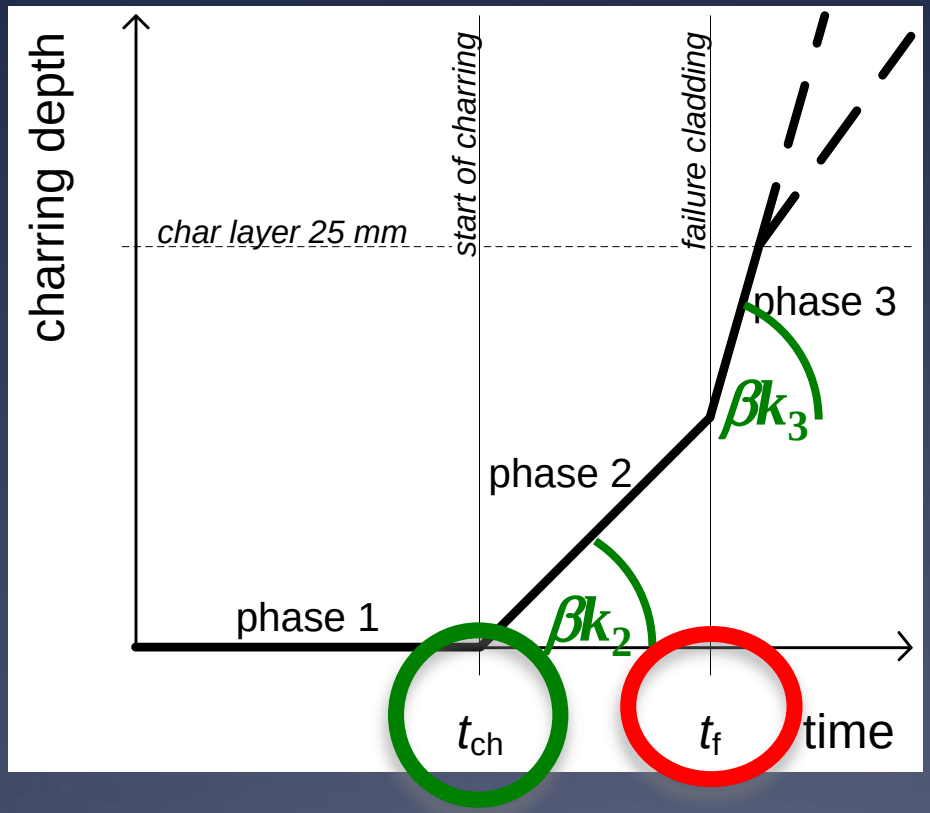
Standard fire curve



Used since 1916

ISO 834

Charring of the protected wood

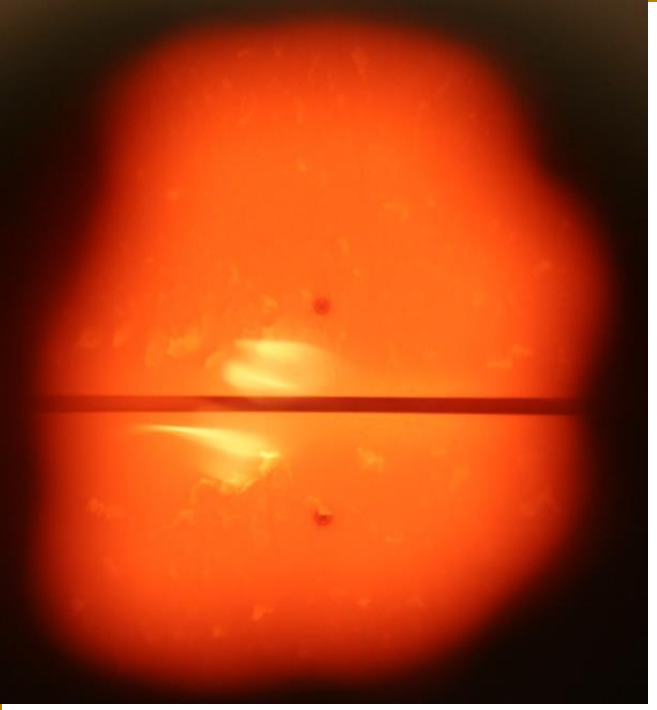


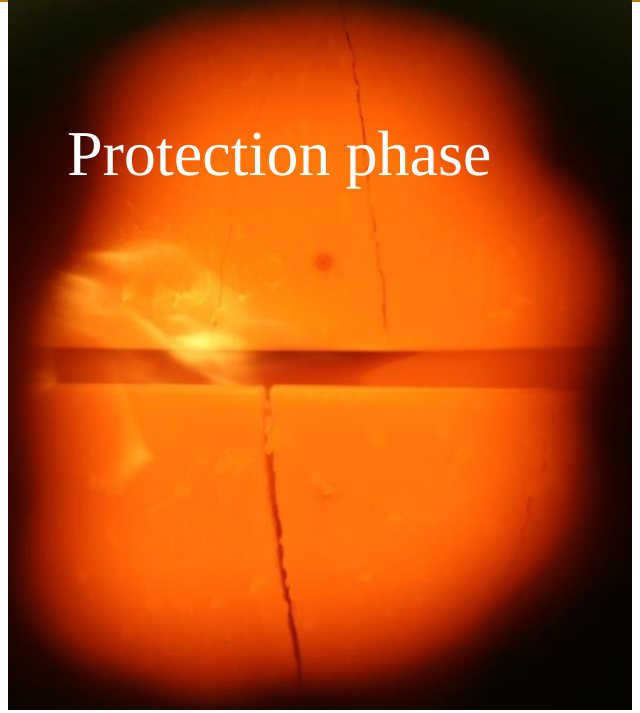
EN 1995-1-2

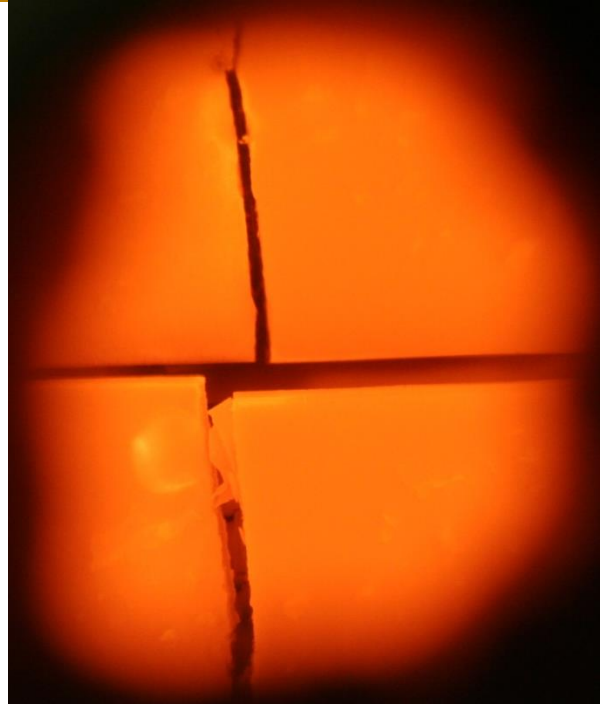
EN 13381-7

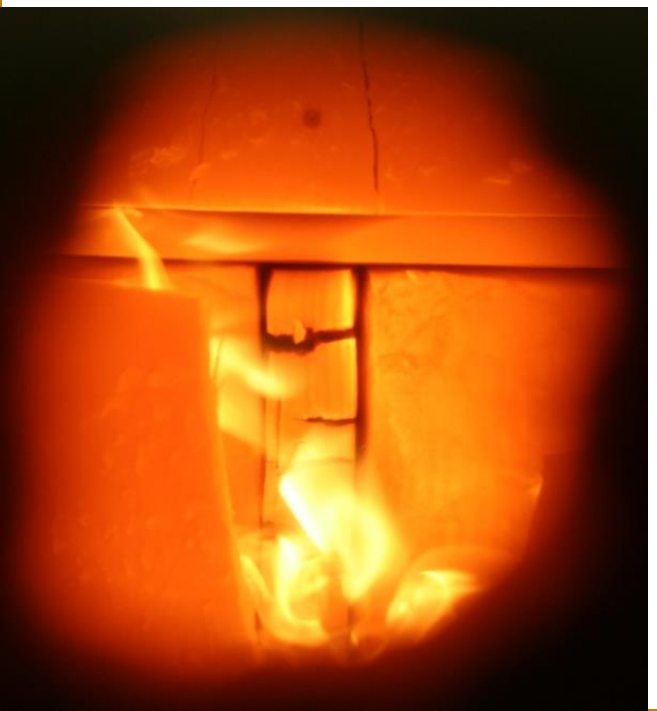
EN 1364-1 -2

EN 1365-1, 2, 3, 4




Protection phase



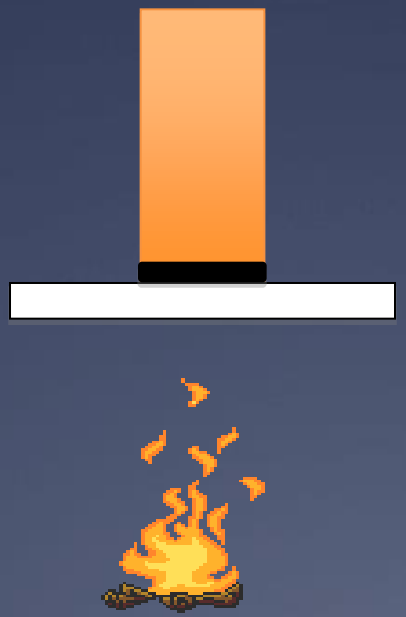


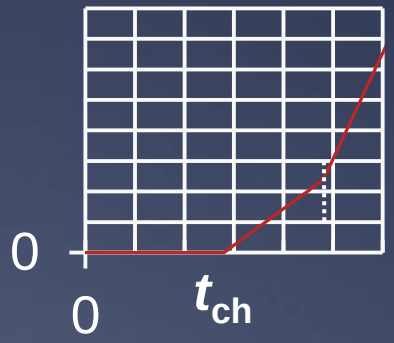

Post-protection phase

START OF CHARRING

- *Start time of charring* is taken as 300° C isotherm

  EN 1995-1-2, clause 3.4.1(4).





START OF CHARRING

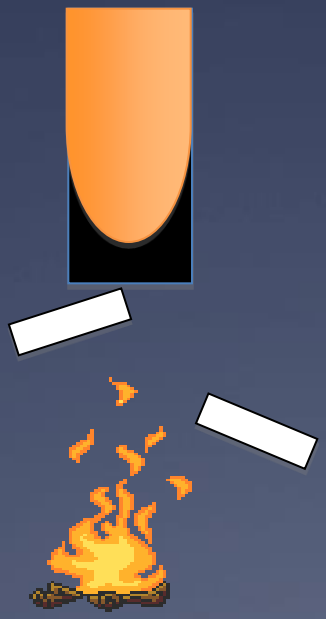
$$t_{ch} = f\left(h_p; \rho\right)$$

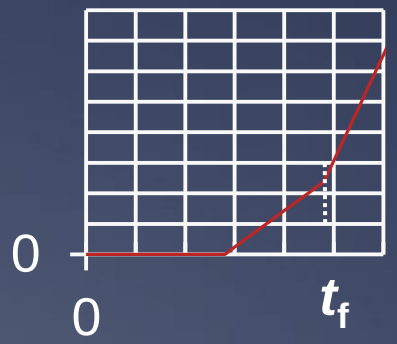
h_p - thickness

ρ - density

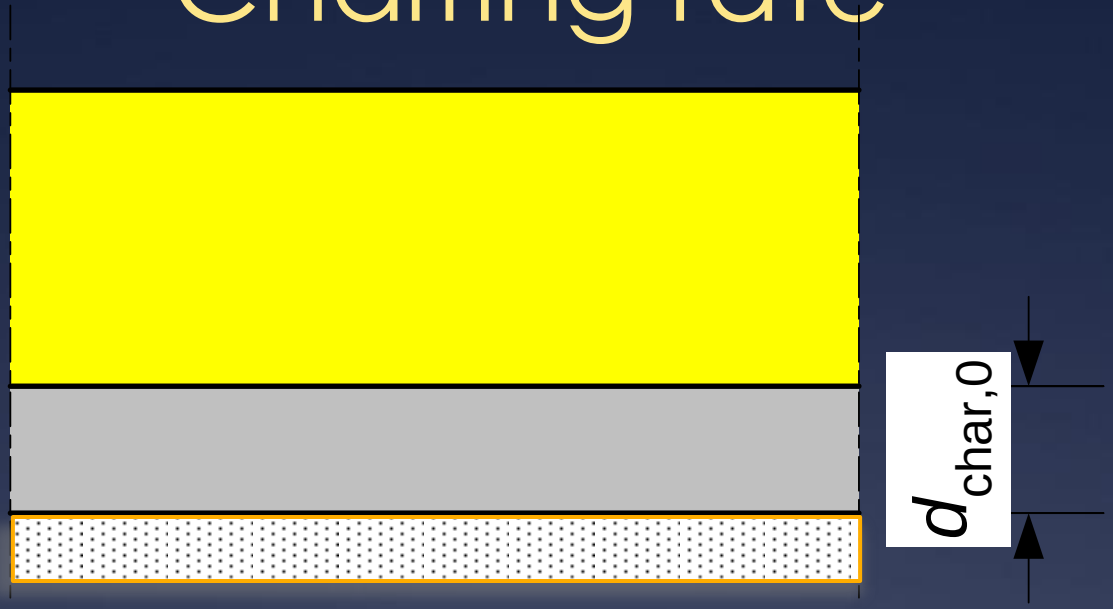
FAILURE TIME

- *EN 13381-7*
- **Failuretime t_f** is the time at which failure of the fire protection system occurs, due to detachment of a significant area or sudden significant temperature rise upon the initially protected timber surface





Charring rate



Protection phase

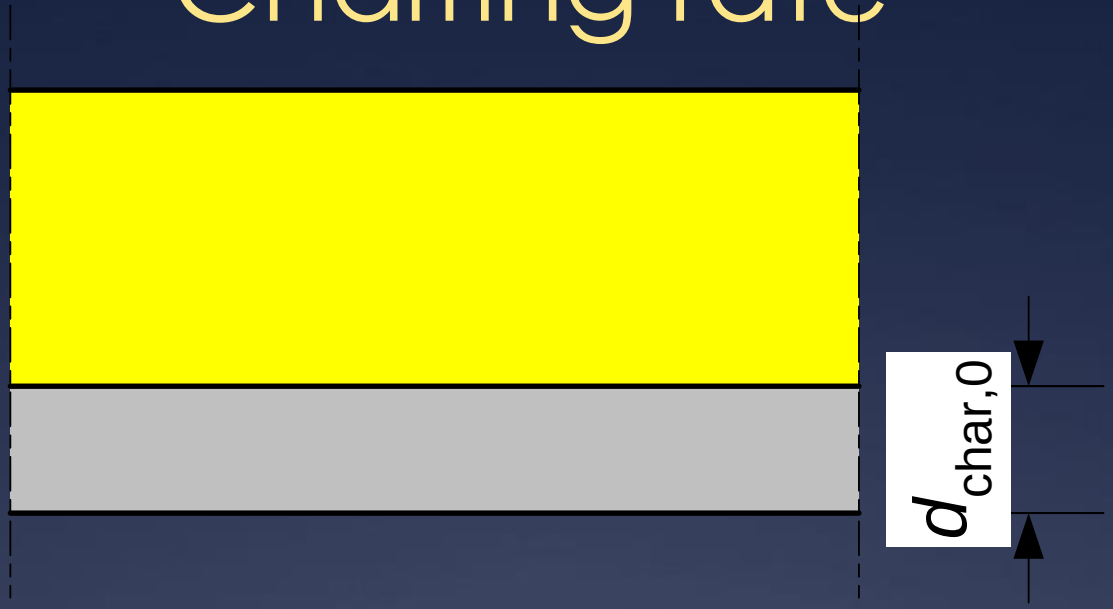
$d_{char,n} = \beta_n \, t$

$\beta_n = k_2 \, \beta_0$

k_2 – protection factor

Need to determine for the plaster

Charring rate



Post-protection phase

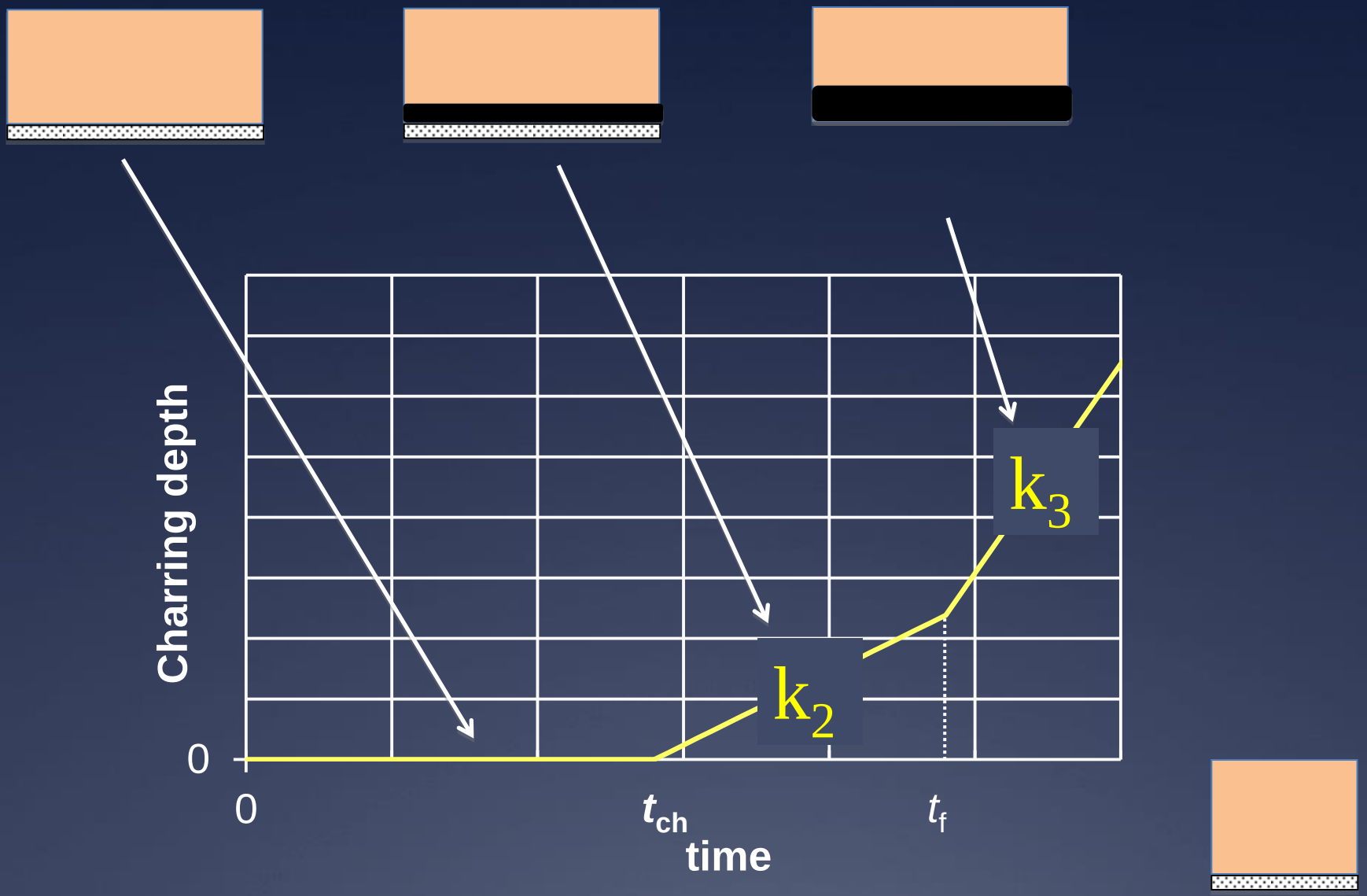
$d_{char,n} = \beta_n \, t$

$\beta_n = k_3 \, \beta_0$

$k_3 = 2$ (EN 1995-1-2)

k_3 – post protection factor

Need to determine for the plaster?



t_{ch} – start time of charring

t_f – failure time

EN 1995-1-2:2020

- Revised design rules for timber structures
- Will be published at 2020

Improvement is needed for:

- Protective properties of different materials:
  - Fire rated gypsum plasterboards
  - Plasters
  - Mineral wool and other insulations

Research study

- Protective properties of plaster for the fire design of timber structures

- Theoretical part
- Experimental part
- Analysis
- Proposal for the standardization

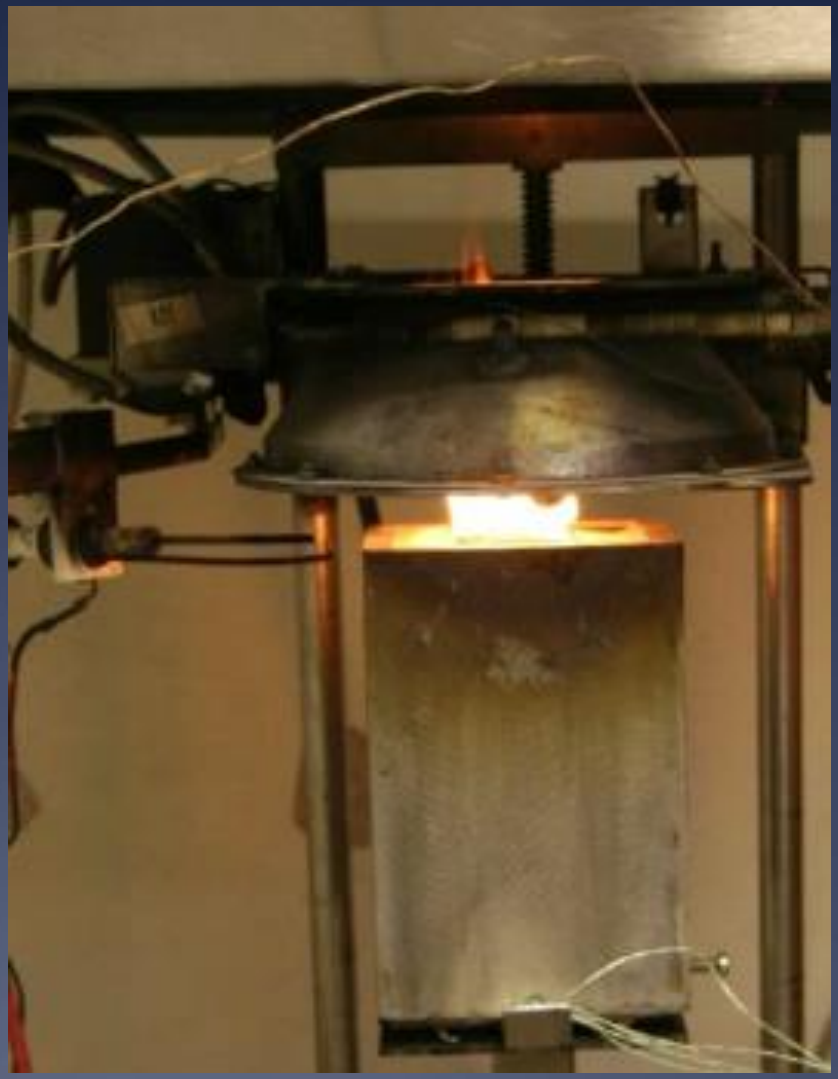
Theoretical part

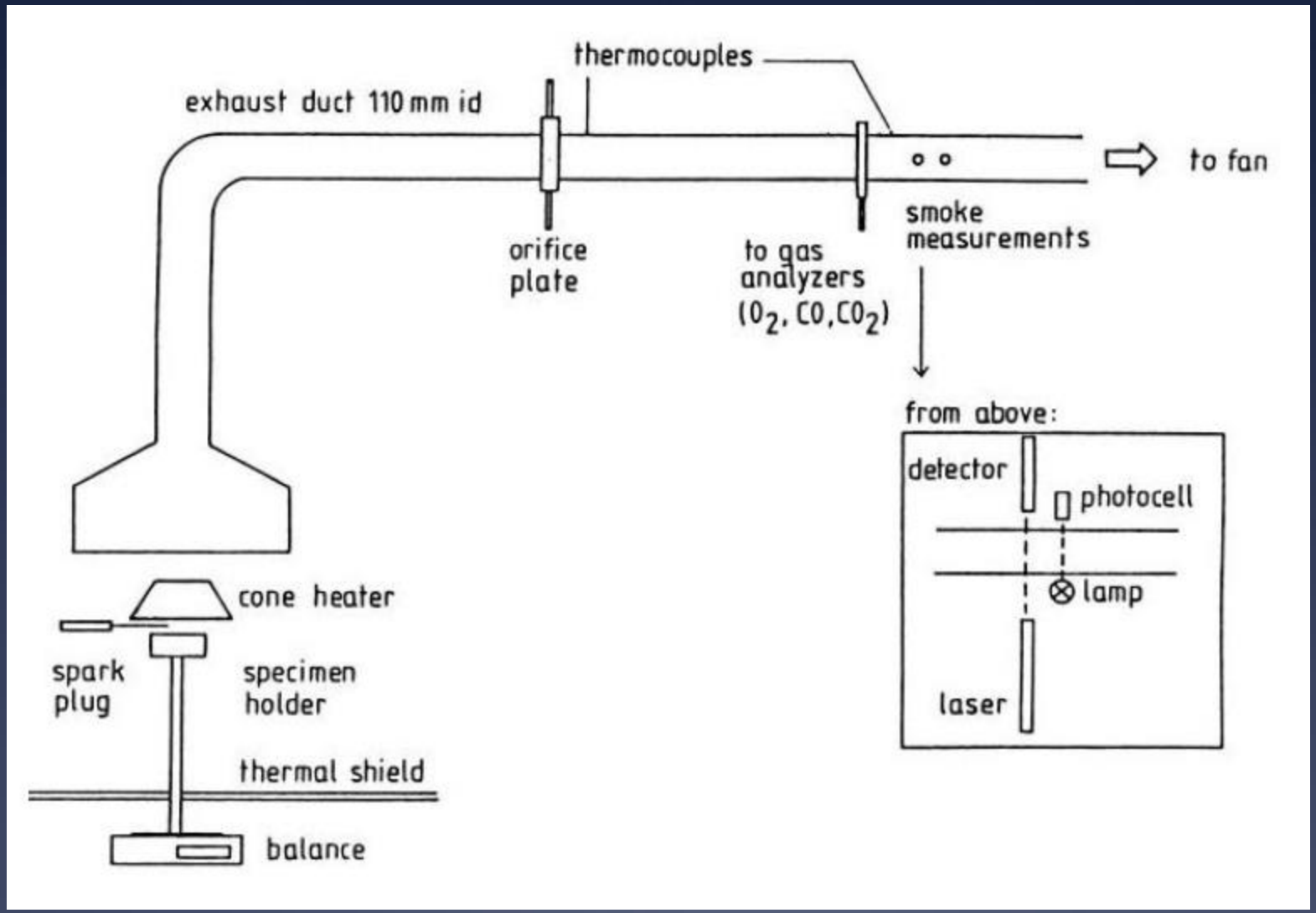
- Literature study
- Determination of the relevant parameters of plasters
- Limits for the further work

Experimental part

- Cone calorimeter tests with different plaster compositions
- Model scale tests with selected plasters

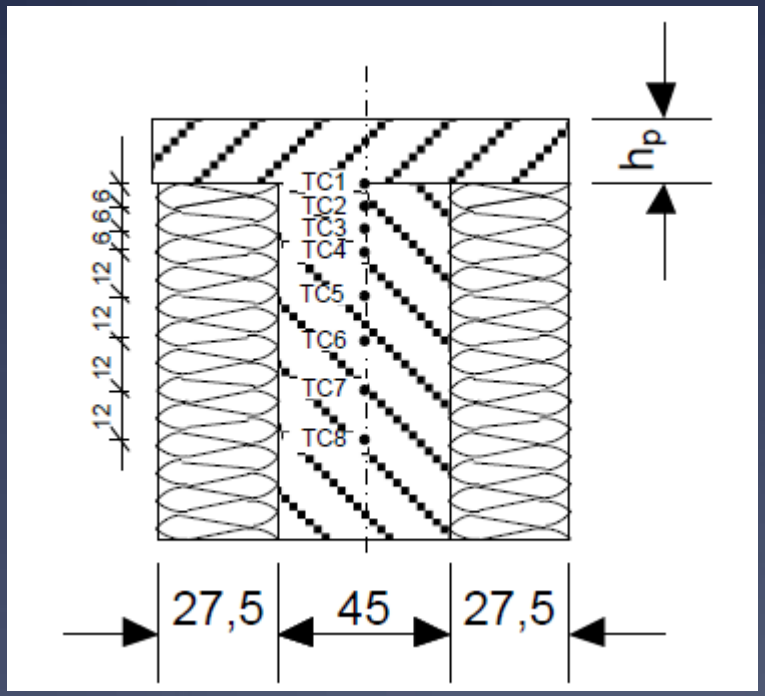
Cone calorimeter




thermocouples
exhaust duct 110 mm id
to fan
orifice plate
to gas analyzers (O_2, CO, CO_2)
smoke measurements
from above:
detector
photocell
lamp
laser
cone heater
spark plug
specimen holder
thermal shield
balance

Test specimens

* Cone calorimeter

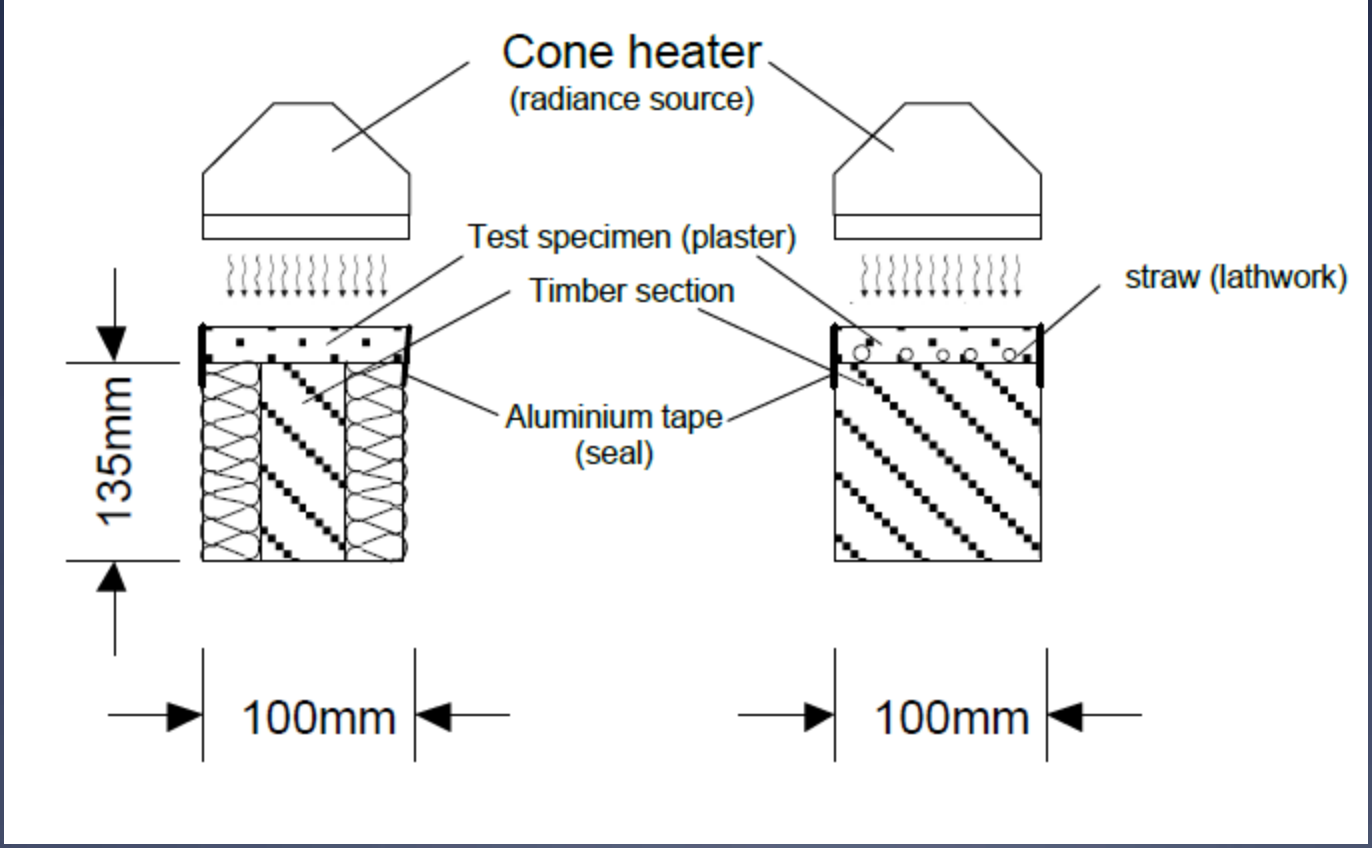


Plaster

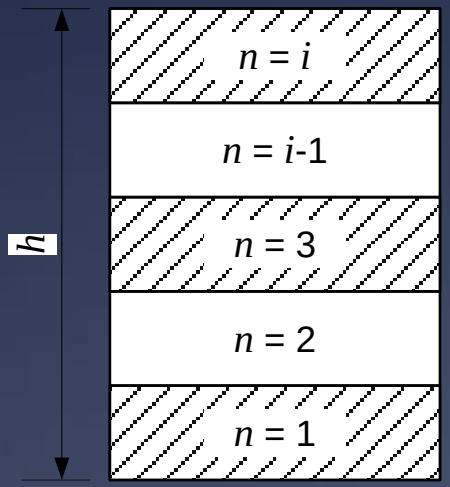
Timber insulated with stone wool

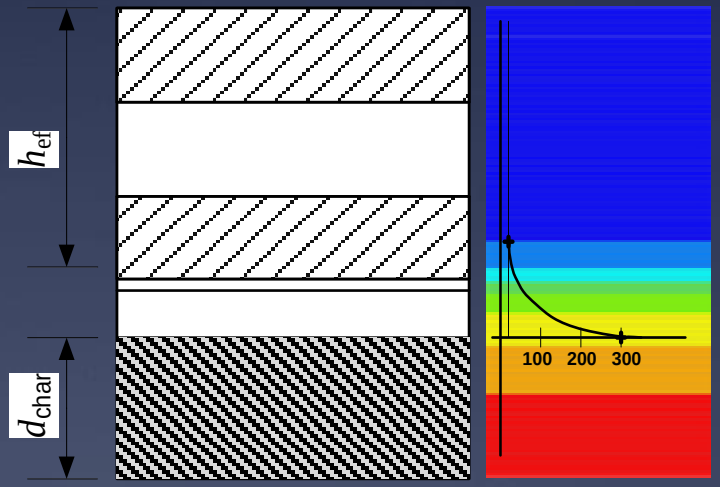
Test set-up

* Cone calorimeter



Simulations





SAFIR

Model scale test

- Fire test(s) of 1x1 m horizontal timber slab with plaster protection
- Start time of charring, failure time and charring rate.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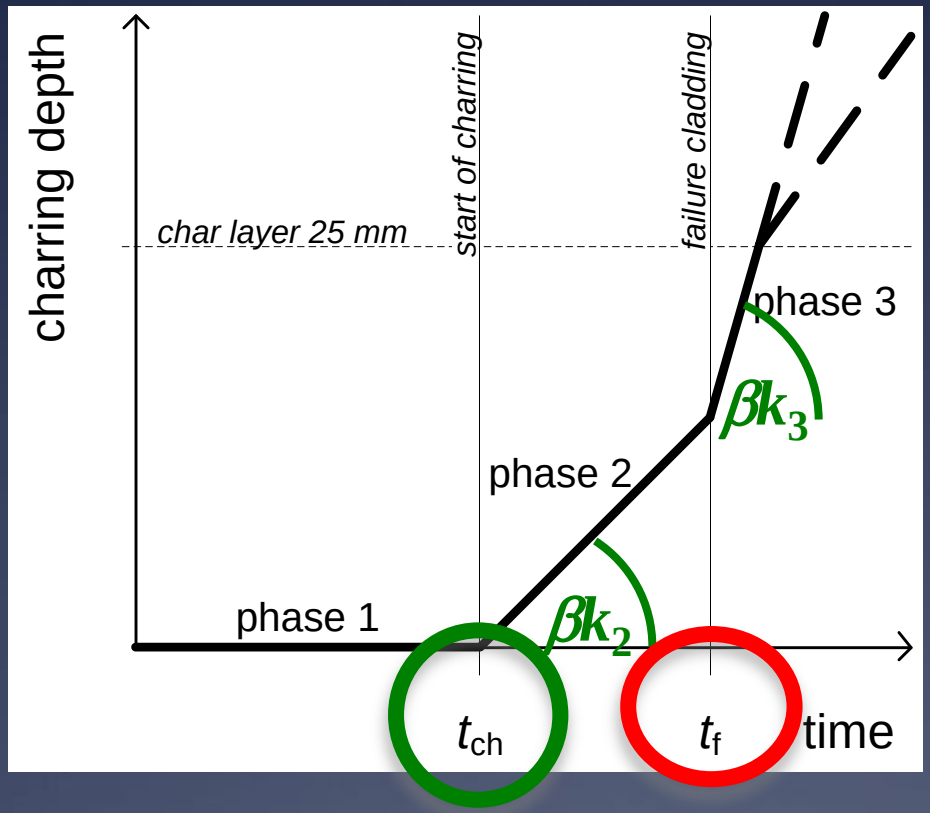
Analysis

- Determination of parameters for plaster:
- t_{ch}
- t_f
- k_2
- All of them will be given as function of thickness and/or density

Charring of the protected timber



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Program

- Literature study — July-August 2014

Defining limits

- Fire tests at SP — september-october 2014
- Analysis — october-december 2014
- MSc presentation — january 2015
- Journal article, — spring 2015
- Conference presentation — Summer 2015
- Presentation of design method at INTER — August 2015
-

Project team

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- Johanna Liblik – master student, TUT
- Joachim Schmid – consultant, SP
- Lazaros Tsantaridis – consultant, SP

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