Finalisation of the European approach to assess the fire performance of facades

Steering group meeting – June 17th, 2022

Agenda

9:30 Update on the project
   – Secondary opening and gas tests in large scale
   – Updated assessment method

10:30 Discussion

11:00 Break

11:15 Experimental Round Robin

11:35 Discussion

12:20 Next steps

12:25 AOB
Update on the project
Large scale tests
General content of the project

• Theoretical round robin => Completed
• Initial testing activities
• Experimental round robin
• Analysis and fine-tuning of the assessment method
Initial testing activities

- Literature survey
- Define the test program
- Design of a simple test rig
  - Perform the tests
  - Analyse the test results
  - Update the assessment method
**Initial testing activities**

**Objective:** to determine the sensitivity of the test method to variations of its main parameters and, consequently, define the specifications to be imposed on these parameters in order to ensure a robust method
Large fire exposure

Initial large-scale exposure of fires to facade

Research: Emi Holmberg, Fredrik Karlsson
Objectives

- To test repeatability of the Large scale test against a full inert (incombustible) façade
- To test how different parameters affect the temperature readings on the façade
  - Moisture content
  - Density
  - Crib height
  - Crib position
  - Stick size
  - Applied wind
- To test the influence of adding a secondary opening
Main conclusions

1. Indoor repeatability of the Large exposure test is acceptable
2. Density, moisture and stick size variations has only limited impact on the exposure to the façade
3. Wind has a large influence on the results
4. We chose to define the crib *height* rather than the total *weight*  
   • Criterion: 110 ± 2.5 cm
5. A secondary opening has little effect on the temperatures on the higher parts but can expose weaknesses in systems  
   • We propose to include a secondary opening asymmetrical above the combustion chamber. (with some flexibility on position)
6. Similar temperature profile along the façade obtained from using 350 kg of wood cribs can be achieved using propane gas burner if combustion chamber height is reduced (leading to less costs)
Large fire exposure - wind
Large fire exposure - conclusions

• Moisture content – 1%-unit makes little difference
• Section size – makes little effect on the exposure, but effects on stability ... perhaps increase the lower tolerance.
• Fixed height seems more important compared to fixed weight. We suggest $110 \pm 2.5$ cm
• Combustion chamber depth – keep 1.3 m depth – deeper than BS 8414
• Installation of the crib (solid plate with width of chamber opening and depth of chamber)
• Wind and ambient temperature... - sensitive. We need a criterion.
• Falling parts – the method should accept that falling parts ignite from the radiation from the heat source.
Secondary openings...?

- A study of effects of secondary opening is required from the contract
- Several member states include a secondary opening above the combustion chamber
- Experience from these tests is that the opening often represents the weak point
- But DIN 4102-20 and BS 8414 do not include these openings since a void of façade system would decrease the exposure to the rest of the façade.
Testing a real façade system would give results that are applicable to that system only.

We therefore used a homogeneous insulation material (C-s2, d0 - EN 13501-1) and 35 kg/m$^3$. Not complying to installation recommendations

One test without opening
One with asymmetric opening
One symmetric above the combustion chamber
No significant combustion of the facade material

Facade material burns

TC 4500 mm

- No opening 500 mm
- No opening 1250 mm
- No opening 2000 mm
- Asymmetric opening
- Symmetric opening

Temperature (°C)

Time (min)
Very similar result with/without opening.

Placement makes little difference.

The differences that are found are very systematic – Higher temperatures above the location of the secondary opening.

Exposure does not seem to be hindered by the secondary opening. We suggest to include it asymmetrically above the opening.
Conclusions secondary openings

• A homogeneous combustible material should be a material which benefits the most from having a secondary opening.
• We see very little difference in the temperatures above the opening regarding the opening position or existence.
• Same result both for when façade material burns and not.
• The small changes that we see is that temperatures are somewhat increased above the opening.
• We suggest to include the secondary opening and placing it asymmetrical with regards to the combustion chamber and ...
• ... also allow for a flexibility (possibly ±150 mm) on its horizontal position.
Alternative heat source

- Many aspects of using large wood crib are cumbersome
- **Variations** in wood crib difficult to control
- Wood crib **collapses** at some point - requires suppression or burning for a long time
Alternative heat source

• Many aspects of using large wood crib are cumbersome
  • Variations in wood crib difficult to control
  • Wood crib collapses at some point - requires suppression or burning for a long time

• Wood cribs are costly – 350 kg of controlled wood
  • Requires cutting, and control of dimensions and density
  • Requires conditioning for an extended period to reach 11±2 % MC
  • Costly to build and nail
  • Requires a very large combustion chamber – making the façade very high

• It is important to keep the threshold low for industry to test products
Gas test ...

• We did ad-hoc tests to investigate if gas burners could be used
Propane gas test …

- Similar instrumentation to previous tests
- Instead of wood crib we use a non-premixed propane gas diffusion burner (140 x 90 cm) with well controlled mass flux regulator calibrated to an oxygen consumption calorimeter.
Propane gas test ...
Propane Gas test ...

- Reducing the opening height
- 1 m high combustion chamber
- 80 cm high opening

- Reducing later to 80 cm and 60 cm opening

140 x 90 cm burner
Gas test ... 2.2 MW
Comparison TCs

- Timber1
- 80/60 cm, 1.6MW
- Timber2
- 80/60 cm, 1.8MW
- Timber3
- 100/80 cm, 2.2MW
Comparison - PTs

Plate thermometers

1 m

Temperature (°C)

Time (min)

2.5 m

Temperature (°C)

Time (min)

5.0 m

Temperature (°C)

Time (min)

Window

Temperature (°C)

Time (min)
Comparison
Average temperatures
Comparison
Average temperatures

Average TC temperature - horizontal lines

- gas - 2.5 m
- timber - 2.5 m
- gas - 5 m
- timber - 5 m

Distance from corner (m)

T (°C)

2.5 m height
5 m height
The 1st version of BS 8414 had an annex on calibration of other fuel sources.

![Diagram showing heat flux profiles and distances in mm.][1]

"Figure A.2 — Mean heat flux time profile for fuels other than cribs."
Conclusions Gas tests ...

- **Similar thermal impact** as that from a timber crib can be achieved by a gas burner.
- The **repeatability** between tests can be very high using mass flux regulators.
- The gas burner can operate using a much **smaller combustion chamber**.
- The lower combustion chamber means that the total height of the façade can be **reduced by 1.5 m** – yielding lower costs of testing.
- There will be **no problem of collapsing** crib falling out in front of the façade.
- Experiment can be **turned off easily**, no need for suppression.
- **Easier for labs to clean** – lower cost.
Updated assessment method
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Medium fire exposure</th>
<th>Large fire exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance of combustion chamber opening from finished corner (mm)*</td>
<td>0</td>
<td>250 ± 10</td>
</tr>
<tr>
<td>Height of combustion chamber opening (mm)</td>
<td>1000 ± 50</td>
<td>1900 ± 50</td>
</tr>
<tr>
<td>Width of combustion chamber opening (mm)</td>
<td>1000 ± 50</td>
<td>2000 ± 50</td>
</tr>
<tr>
<td>Internal height of the combustion chamber (mm)</td>
<td>1000 ± 50</td>
<td>2100 ± 50</td>
</tr>
<tr>
<td>Internal width of the combustion chamber (mm)</td>
<td>1000 ± 50</td>
<td>2400 ± 50</td>
</tr>
<tr>
<td>Depth of combustion chamber (mm) (inside back wall to front surface)</td>
<td>800 ± 50</td>
<td>1300 ± 50</td>
</tr>
<tr>
<td>Opening for Forced Ventilation</td>
<td>Round of 300 mm in diameter</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>
## Fuel source

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Medium test</th>
<th>Large test</th>
<th>Argument</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood species</td>
<td>Spruce (Picea abies)</td>
<td>Spruce (Picea abies)</td>
<td>Chapter 3.2.3</td>
</tr>
<tr>
<td>Cross section of sticks</td>
<td>40 x 40 mm(^2) ± 2 mm</td>
<td>47 x 47 mm(^2) ± 3 mm</td>
<td>Chapter 3.2.9</td>
</tr>
<tr>
<td>Length of sticks</td>
<td>500 ± 5 mm</td>
<td>Long: 1500 ± 5 mm</td>
<td>Chapter 3.2.9</td>
</tr>
<tr>
<td>Nominal density of sticks</td>
<td>475 ± 25 kg/m(^3)</td>
<td>500 ± 100 kg/m(^3)</td>
<td>Chapter 3.2.5</td>
</tr>
<tr>
<td>Weight of crib</td>
<td>30 ± 1.5 kg</td>
<td>350 ± 20 kg</td>
<td>Chapter 3.2.5</td>
</tr>
<tr>
<td>Number of sticks per layer and number of layers</td>
<td>6 sticks per layer</td>
<td>Long: 10 sticks/layer</td>
<td>Chapter 3.2.9 and RISE Report 2021:85.</td>
</tr>
<tr>
<td></td>
<td>The number of layers and number of sticks in the top layer are adjusted so the weight of the crib is within the tolerances.</td>
<td>Short: 15 sticks/layer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>The number of layers is adjusted to keep the crib within 110 ± 2.5 cm.</td>
<td></td>
</tr>
<tr>
<td>Joining of sticks</td>
<td>Nailing</td>
<td>Nailing</td>
<td>Chapter 3.2.8</td>
</tr>
<tr>
<td>Moisture content</td>
<td>11 ± 2 %</td>
<td>11 ± 2 %</td>
<td>Chapter 3.2.4</td>
</tr>
<tr>
<td>Surface finish</td>
<td>Planed</td>
<td>Sawn or planed</td>
<td>Chapter 3.2.6</td>
</tr>
<tr>
<td>Floor for crib</td>
<td>Grating</td>
<td>Solid</td>
<td>Chapter 3.2.7</td>
</tr>
</tbody>
</table>
Secondary opening

• The objective of the secondary opening is to simulate the presence of any kind of feature – such as windows - at levels above the fire source opening.

• The secondary opening is asymmetrically placed in relation to the fuel source.

• The objective is, both in medium and large scale, thus to be able to test the interaction between the secondary opening fittings, wall cladding and the fuel source.
Falling parts

- A weighing load cell platform with an accuracy of ± 50 g shall be used to measure the mass of falling parts during the test.

- A plate that covers the rectangular area which is defined by the main face and the wing shall be used on top of the weighing cell platform to collect falling parts during the test.
Falling parts

After evaluation of the questionnaire on falling parts the following improvements on the criteria in the Assessment method are recommended:

• Limits for individual falling part (not burning), mass of 1 and 5 kg.

• Total amount is either less than 10 kg or other sufficient criterion to prevent total mechanical failure of the façade.

• Time (sustained flaming) to recognise a falling part as burning: 30 s.

Note: This is to be evaluated in the RR.

E.g. As a tiny falling burning part would lead to failure of the test a minimum required weight/area is thought to be introduced after the Round Robin.
Uplift

• It was determined from the full inert tests that several combustible materials such as paper, XPS or polyethylene, ignited at 1-2 m distance from the façade using a 0.5 m uplift.

• Collapse of the crib at the later stages will destroy assessment of the falling parts even if they have not ignited previously.

• The falling parts should be assessed at the moment they touch the floor and that there therefore is no need for an uplift.
Discussion
10:30 – 11:00
Break
11:00-11:15
Experimental Round Robin
Experimental Round Robin

3.3 Task 3: Experimental round robin

**Objective:** To quantify the within-lab and between-labs variability of the test results, i.e. the repeatability and the reproducibility of the proposed method.

EMI is work package leader.
Applicable parts of ISO 5725 series is to be used.

Test specimen shall be designed so all performance criteria can be assessed.
- vertical fire spread
- horizontal fire spread
- burning parts
- falling parts (level 1)
- falling parts (level 2)

*ISO 5725 Accuracy (trueness and precision) of measurement methods and results*
Experimental Round Robin – proposed criterias

- flame spread both vertically and horizontally (thermocouples and visual) (proposed 500 K temperature rise)
- fire spread within the test specimen (thermocouples in cavities and layers) (proposed 500 K temperature rise)
- falling parts (platform scale and visual) (Level1 – 1 kg, Level2 - 5kg)
- burning debris/droplets (visual) (sustained flaming 30s)

+ mass loss of the timber crib (scale under the crib)
# Test program

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Number</th>
<th>Exposure</th>
<th>Location</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tests in lab 1</td>
<td>4</td>
<td>Large</td>
<td>BRE</td>
<td>Indoor</td>
</tr>
<tr>
<td>Tests in lab 2</td>
<td>4</td>
<td>Medium</td>
<td>RISE</td>
<td>Indoor</td>
</tr>
<tr>
<td>Tests in lab 3</td>
<td>4</td>
<td>Large</td>
<td>RISE FRN</td>
<td>Indoor</td>
</tr>
<tr>
<td>Tests in lab 3</td>
<td>3</td>
<td>Medium</td>
<td>RISE FRN</td>
<td>Indoor</td>
</tr>
<tr>
<td>Tests in lab 4</td>
<td>4</td>
<td>Large</td>
<td>EMI</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Tests in lab 5</td>
<td>4</td>
<td>Medium</td>
<td>Efectis France</td>
<td>Outdoor</td>
</tr>
<tr>
<td>Tests in lab 6</td>
<td>1</td>
<td>Medium</td>
<td>MFPA Leipzig</td>
<td>Indoor</td>
</tr>
</tbody>
</table>
Proposals for Medium scale tests (3 systems + inert)

- Test rig greater than 5100(H)×3200(WM)×1500(WW)mm
- Combustion chamber 1000(H)×1000(W)×800(D)mm
- Chamber lined with ceramic fibre blanket 25mm
- Air inlet 300mm (diameter) 400 ± 40 m³/h
System 1 – ETICS with render

- **Tested according to DIN 4102-20**
- **EPS white**
- **Apparent density: 20 - 30 kg/m³**
- **Insulation thickness: 300 mm**
- **Fixing method:** bonded with adhesive mortar; mineral binder; outer ribbon and additional dabs; 3,5 kg/m²
- **Without supplementary anchors**

- **Reinforced base coat**  Organic binder, reinforcement: glass fibre mesh, 160 g/m², Layer thickness (applied stage): 3 mm - 4 mm
- **Finishing coat**  Organic binder, 3 mm layer thickness
- **Fire protective measures** 1 fire break, MW lamella strips, Apparent density: 90 kg/m³, Height of strips: 200 mm, Thickness: 300 mm, Fully bonded without anchors

the sample and construction work is provided by a stakeholder
System 2 – Ventilated alu facade

- tested according to BS8414 with falling parts SP Fire 105
- External cladding – cassettes, solid aluminium (2mm)
- Supporting system – Aluminium profiles
- Fixing brackets – Aluminium profiles
- Wall fixations – Screws + plastic anchors
- Joints – open joints
- Insulation – Rockwool (180mm thickness)
- Horizontal fire barriers w/o intumescent at each level
- Edges of specimen closed
System 3 – Wooden facade

- **Tested according to** ad hoc SP Fire 105
- High performance wooden facade
- The wooden façade system is a rainscreen design composed of pure wood cladding boards and ventilating battens.
- Both pine or spruce can be used.

- A series of nine ad hoc full-scale façade tests to the CW Test (Norwegian Standard NS 3912).
- SP Fire 105 was passed. Fire spread on façade surface reached lower sill of second fictitious window, not above, in early part of test.
- SP Fire 105 test at RISE was ordered by sponsor to extend the duration of flaming exposure to 30 min, which the test specimen passed.

the sample and construction work is still not provided by any stakeholder
Proposals for Large scale tests (3 out of 4 systems + inert facade)

- Test rig greater than 8500(H)×3200(WM)×1500(WW)mm
- Chamber lined with ceramic fibre blanket 25mm
System 1 – ETICS with render tested according to BS 8414

• **Insulation**  EPS grey, Apparent density: 15 – 17 kg/m³, Insulation thickness: 250 mm, Fixing method: bonded with adhesive mortar; mineral, binder; outer ribbon and additional dabs, Without supplementary anchors

• **Reinforced base coat**  Mineral binder, Layer thickness (applied stage): 2,5 mm - 3,0 mm, Reinforcement: glass fibre mesh, 145 g/m²

• **Key coat**  Yes

• **Finishing coat**  Organic, colored, 2 mm layer thickness

• **Decorative coat**  no

• **Fire protective measures**  3 fire breaks (each floor level), MW-HD strips, Apparent density: 140 kg/m³, Heighth of strips: 100 mm, Thickness: 250 mm, Fully bonded without anchors

the sample and construction work is provided by a stakeholder
System 2 – Ventilated Aluminum facade

- tested according to BS 8414 with falling parts to SP Fire 105
- External cladding – cassettes, solid aluminium (2mm), with open joints
- Supporting system/fixing brackets – Aluminium profiles
- Wall fixations – Screws + plastic anchors
- Insulation – Rockwool (180mm thickness)
- Horizontal fire barriers w/o intumescent at each level
- Edges of specimen closed

the sample and construction work is provided by a stakeholder
System 3 – Wooden facade

- tested according to ad hoc SP Fire 105
- High performance wooden facade
- rainscreen design composed of pure wood cladding boards and ventilating battens.
- pine or spruce.

- A series of nine ad hoc full-scale façade tests to the CW Test (Norwegian Standard NS 3912).
- SP Fire 105 was passed. Fire spread on façade surface reached lower sill of second fictitious window, not above, in early part of test.
- SP Fire 105 test at RISE was ordered by sponsor to extend the duration of flaming exposure to 30 min, which the test specimen passed.
System 4 – ACM ventilated cladding

- tested according to BS 8414-1
- 4mm-thick ACM FR plate
- Supporting system – Aluminium profiles
- Fixing brackets – Aluminium profiles
- Wall fixations – Screws + plastic anchors
- Insulation – PIR (100mm-thick)
- Edges of specimen closed

- Cavity depth 50mm between insulation and facade
- Vertical cavity barriers RSV 90/30 vertical cavity barriers (75mm-thick x 155mm-deep)
- Horizontal cavity barriers RH25G 90/30 horizontal open state cavity barriers (75mm-thick x 125mm-deep)

The sample and construction work is provided by a stakeholder.
Other system proposals

1. ETA certified rainscreen cladding, based on the EAD Kits for external wall cladding tested with NFPA 285

2. **External cladding – high pressure laminate HPL, flame retardant, class B – s2, d0** tested according to ON 3800-5 and LEPIR II

3. Rainscreen - Ventilated façade system with Kingspan Kooltherm (3 different versions) tested according to BS8414

4. External wall cladding - fiberglass-reinforced polyester tested according to NFPA 285, SP Fire 105

5. Wooden facade tested according to SP Fire 105.

6. Several curtain walling systems

- The inert facade may be taken as just the lightweight concrete, this is to minimize any variations in the system.
- The purpose would be to see the interlab variability.

the sample is provided by a stakeholder but not the construction works
Gathering information - letter to the stakeholders

"Dear All,

We are now in the process of planning the Round Robin.

We urgently need to know a few parameters:
1. How long is the installation time?
2. Curing time?
3. When will the installation teams be available?"

(only 1 answer)
## Availability of samples

<table>
<thead>
<tr>
<th>Samples for Medium scale tests</th>
<th>Available from</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 1</td>
<td>September/October</td>
</tr>
<tr>
<td>System 2</td>
<td>September/October</td>
</tr>
<tr>
<td>System 3</td>
<td>Not available at the moment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Samples for Large scale tests</th>
<th>Available from</th>
</tr>
</thead>
<tbody>
<tr>
<td>System 1</td>
<td>September/October</td>
</tr>
<tr>
<td>System 2</td>
<td>September/October</td>
</tr>
<tr>
<td>System 3</td>
<td>September/October/End of 2022?</td>
</tr>
<tr>
<td>+ System 4</td>
<td>September/October/End of 2022</td>
</tr>
</tbody>
</table>
## Availability of Laboratories

<table>
<thead>
<tr>
<th>Location</th>
<th>Available from</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Research Sweden</td>
<td>September 2022</td>
<td>x</td>
</tr>
<tr>
<td>Efectis France</td>
<td>September 2022</td>
<td>x</td>
</tr>
<tr>
<td>Fire Research Norway</td>
<td>September 2022</td>
<td>x, x</td>
</tr>
<tr>
<td>BRE - UK</td>
<td>October 2022</td>
<td>-, x</td>
</tr>
<tr>
<td>ÉMI Hungary</td>
<td>Mid-September 2022</td>
<td>-, x</td>
</tr>
<tr>
<td>MFPA Leipzig</td>
<td>End of 2022</td>
<td>x, -</td>
</tr>
</tbody>
</table>

*(from November till February the weather is unsuitable, some difficulties with the data logger)*
## How to follow the RR tests

<table>
<thead>
<tr>
<th></th>
<th>Physical</th>
<th>Live video transmittance</th>
<th>Detailed reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consortium members</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Stakeholders</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Provider of the sample</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>EC representatives</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Proposed simplification of the secondary opening

If

\[ 50 \leq v \leq 150 \text{ mm} \] then \( X = 1250 \text{ mm} + 100 \text{ mm} \)

\[ 150 < v \leq 250 \text{ mm} \] then \( X = 1250 \text{ mm} + 200 \text{ mm} \)

\[ 250 < v \leq 400 \text{ mm} \] then \( X = 1250 \text{ mm} + 300 \text{ mm} \)

Result:

If the facade thickness is between 150-250 mm, there is no need to rebuild the secondary opening.
Comparative measurements in large scale with BS 8414

- Only surface temperatures added at the same locations as in BS 8414.
- Important to know how a test compares to the previous BS 8414 test in terms of temperatures and starting time.
Discussion on Round Robin
11:35-12:20
Next steps
• Updating the Comments Handling Document including reviewing the older documents.

• Discussions with stakeholders

• Reviewing drawings

• Update assessment method into two documents one medium scale and one large scale for better readability.
AOB
Questions and comments

• You are also welcome to send your questions or comments after the meeting (email to Johan and Heikki)
Johan Anderson

E-mail: johan.anderson@ri.se
Phone: +46 10 516 59 26
Large fire exposure
Large fire exposure

All numbers refer to distances in mm

- 1 mm shielded Thermocouple
- 100 x 100 mm standard plate thermometer
- Gardon gauge

Gardon gauge

1500

7500

5000

2500

8500

3200

1250

2100

1000

2500

5000

7500

Gardon gauge
## Large fire exposure

<table>
<thead>
<tr>
<th>Test number</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section size (mm)</td>
<td>47.6 ±0.5</td>
<td>47.7 ±0.5</td>
<td>47.6 ±0.7</td>
<td>47.5 ±0.7</td>
<td>47.7 ±0.7</td>
<td>47.5 ±0.8</td>
<td>44.9 ±0.8</td>
</tr>
<tr>
<td>Layers</td>
<td>24</td>
<td>23</td>
<td>25</td>
<td>24</td>
<td>23</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Crib height (cm)</td>
<td>114</td>
<td>110</td>
<td>119</td>
<td>114</td>
<td>110</td>
<td>114</td>
<td>117</td>
</tr>
<tr>
<td>Density (#sticks probed)</td>
<td>469 (24)</td>
<td>454 (32)</td>
<td>421 (74)</td>
<td>423 (105)</td>
<td>442 (65)</td>
<td>436 (70)</td>
<td>448 (80)</td>
</tr>
<tr>
<td>Total mass (kg) probed</td>
<td>382</td>
<td>355</td>
<td>358</td>
<td>343</td>
<td>347</td>
<td>351</td>
<td>353</td>
</tr>
<tr>
<td>Total mass (kg) Load cells</td>
<td></td>
<td>352</td>
<td>340</td>
<td>N.A.</td>
<td></td>
<td></td>
<td>349</td>
</tr>
<tr>
<td>MC (%) #sticks probed</td>
<td>14.0 (24)</td>
<td>13.84 (32)</td>
<td>13.12 (303)</td>
<td>12.19 (105)</td>
<td>13.44 (65)</td>
<td>11.35 (70)</td>
<td>12.94 (80)</td>
</tr>
<tr>
<td>Nailing</td>
<td>2nd layer, 3rd joint</td>
<td>2nd layer, 3rd joint</td>
<td>all layers, 2nd joint</td>
<td>all layers, 2nd joint</td>
<td>all layers, 2nd joint</td>
<td>all layers, 2nd joint</td>
<td>all layers, 2nd joint</td>
</tr>
</tbody>
</table>

- **Burn the structure**
- **Repeatability**
- **Moving crib to the front**
- **Wind applied**
- **Smaller stick sections**
**Large fire exposure - repeatability**

<table>
<thead>
<tr>
<th>Test number</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stick layers</td>
<td>23</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Crib height (cm)</td>
<td>110</td>
<td>119</td>
<td>114</td>
</tr>
<tr>
<td>Density (kg/m³)</td>
<td>454</td>
<td>421</td>
<td>423</td>
</tr>
<tr>
<td>Total mass (kg)</td>
<td>355</td>
<td>358</td>
<td>343</td>
</tr>
<tr>
<td>MC (%)</td>
<td>13.8</td>
<td>13.1</td>
<td>12.2</td>
</tr>
<tr>
<td>Nailing</td>
<td>2nd layer, 3rd joint</td>
<td>2nd layer, 3rd joint</td>
<td>all layers, 2nd joint</td>
</tr>
<tr>
<td>Average MLR (kg/s) 5 – 20 min</td>
<td>-0.204</td>
<td>-0.206</td>
<td>-0.202</td>
</tr>
<tr>
<td>Max TC temp @5000 mm (30 s average)</td>
<td>479</td>
<td>509</td>
<td>503</td>
</tr>
<tr>
<td>Max $q''$ to Schmidt-Boelter gauge in façade (kW/m², 30 s average)</td>
<td>144</td>
<td>143</td>
<td>133</td>
</tr>
</tbody>
</table>

**Flame height, Tests 1-3**

**Height above combustion chamber (mm)**

**Average temperatures, 15 - 20 min (°C)**
Large fire exposure – wind – Compare to outdoor tests

Lower temperatures on the outdoor test

Identified possible reasons:

- Size of solid plate changes the oxygenation of the crib
- Extension of floor in front of the chamber can modify the path of air supply
- Ambient temperature and moisture of façade concrete during long time before (test performed in December)
- => To be clarified during RR phase