

# COVERING USED IN THE PROJECT WOOD:UPHIGH

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## Introduction

This report is based on the resistance to fire tests done in the Wood:UpHigh project. To gain further knowledge from the tests, additional thermocouples were added through the different layers of the test specimen. This report summarises some of the different covering used in the project, and their ability to protect the construction. Test with documented covering systems such as a K2 60 system, is not included in this report. The purpose of this report is to show the market, potential solutions that could be developed, tested, and launched as a new fire protection solution.

**This report cannot be used as documentation, but should only be used as inspiration.**

The goal in Wood:UpHigh is to demonstrate how the combination of wooden load-bearing structures and biobased insulation can meet some of the fire safety requirements according to the Danish pre-accepted solutions, while deviating from the reaction to fire properties.

The project has a total budget of 5.3 million DKK and is financed by Realdania, Grundejernes Investeringsfond, the Danish Agency for Higher Education and Science through DBI's performance contract.

## Resistance to fire test

The project has conducted 10 full-scale resistances to fire tests on selected walls and decks after EN 1364-1, EN 1365-1 and EN 1365-2. These constructions are assessed as an element, based on load-bearing capacity (R), integrity (E) and insulation (I).

Internal thermocouples were placed in the 10 full-scale wall and deck test to gain further knowledge of layers fire protection ability.

Criteria for resistance to fire according to EN 1365-1:2012 / EN 1365-2:2014 / EN 1364-1:2015:

### **Load-bearing capacity (R):**

- The test specimen can maintain the load during the test.

### **Integrity (E):**

- Sustained flaming of more than 10 seconds cannot occur during the test.
- The cotton pad cannot ignite during the test.
- No through-going openings in the test specimen during the test.

### **Insulation (I):**

- The average temperature rise on the unexposed surface must not exceed 140°C during the test.
- The maximum temperature rise on the unexposed surface must not exceed 180°C during the test.

## Fire protection ability

Fire protection ability describe a products ability to protect an underlying material. These tests are performed horizontal, measuring temperature, and evaluating the underlying material.

Criteria for fire protection ability according to EN 14135/EN 13501-2 of the covering is described as following:

- The average temperature rise measured on the lower side of the substrate cannot exceed 250 °C during the test.
- The maximum temperature rise measured on the lower side of the substrate cannot exceed 270 °C during the test.

- The covering must not fall down.
- For K1 classification the substrate must not be charred, burnt, melted, shrunk, or visually changed.
- For K2 classification the substrate must not be charred or burnt.

## Disclaimer

The following results from the internal thermocouples in the wall and deck test, **indicates** whether a specific material or combination can pass the fire protection ability test. These results are only assessed based on temperature and not if the insulation is charred, burnt, melted, shrunk, or visually changed. Furthermore, the elements tested in Wood:UpHigh is a mix of walls and decks, meaning it is a deviation according to EN 14135. Furthermore, there might be a deviation regarding the number and placement of thermocouples. Not all insulations materials have a reaction to fire classification. Test reports conducted through the Wood:UpHigh project will be redacted to exclude product names, since the project cannot create competitive advantages. The indications of assessments cannot be used as documentation. Individual assessments of K1 10 and K2 30 performance must be done by DBI in a separate document as an actual assessment.

**This report cannot be used as documentation.**

## Coverings

### 1 Chipboard and fiber gypsum board

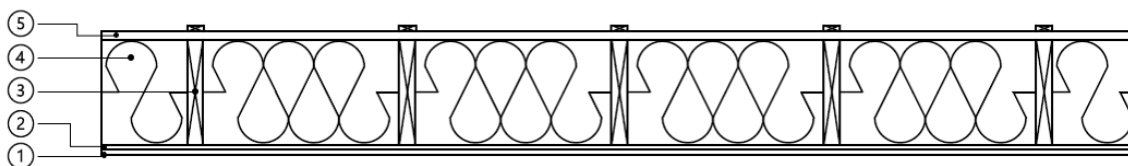
The 2<sup>nd</sup> construction from Wood:UpHigh is an exterior wall using chipboard and fiber gypsum board as covering. The insulation used was blown in wood fiber insulation. The test was stopped after 72 minutes, reaching REI60.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1365-1:2012 Fire resistance tests for loadbearing elements — Part 1: Walls.

This data is extracted from DBI test report PGA12210A.

#### About the construction (exposed side)

1. 12.5 mm fiber gypsum board
2. 15 mm chip board
3. 45 x 295 mm C24 construction spruce wood with 295 mm wood fiber insulation blown in
4. 22 mm wood fiber board
5. 18 x 46 mm pine wood batten/spacers



Product		Fiber gypsum board	Chipboard	Wood fiber board
Density	kg/m <sup>3</sup>	1205	626	229.6
Moisture content	%	0.9	6.6	6.4
Sampling method		Extra material	Extra material	Extra material
Drying temperature	°C	55	105	105

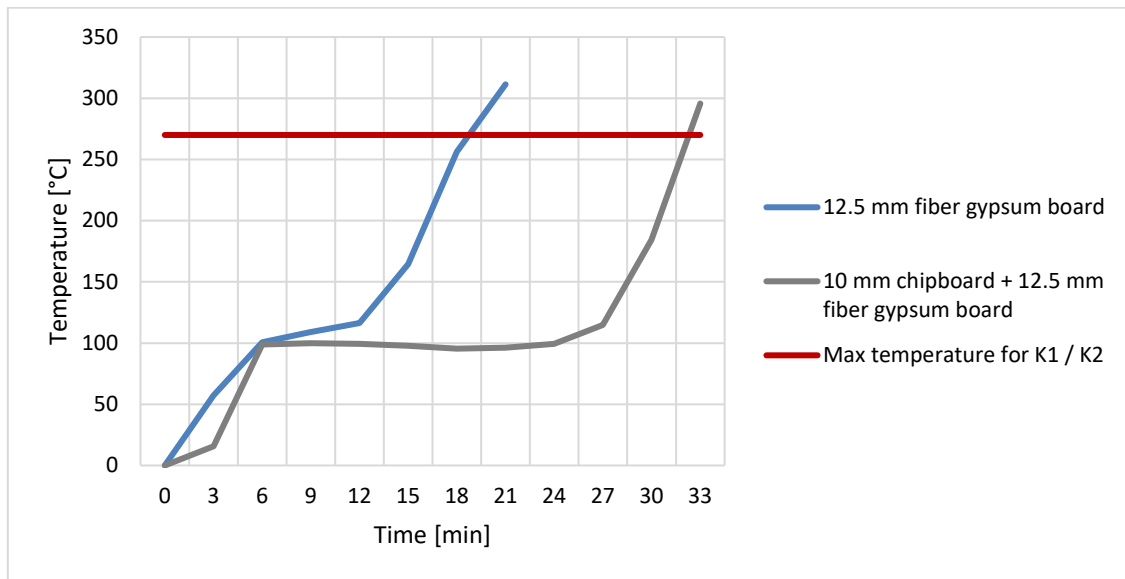
#### Fiber gypsum board

One layer of 12.5 mm thick fiber gypsum board with a nominal density of 1150 kg/m<sup>3</sup> were fixed with 16 Staples 30 mm at a c/c of 200 mm. The staples were fixed 10 mm from the board edges and 50 mm from the board corners. A full-size board measured 900 x 1200 mm.

#### Chip board

A 15 mm thick chipboard with density 650 kg/m<sup>3</sup> was mounted on the exposed side to the load bearing studs with 2.8 x 75 mm strip nail. For each stud behind the board 3 nails were attached, for the maximum board dimension 12 nails were used. A full-size chipboard had the dimensions of 615 x 2500 mm with the tongue and groove. The vertical board joints were backed by the wooden studs.

**Covering performance**



Behind the fiber gypsum board layer, the temperature reached 270°C after 19 minutes. The temperature behind the fiber board and chipboard reached 270°C after 32 minutes. The temperature in the first layer was gathered using 3 thermocouples and the second was gathered using 4 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 25.th minute. This indicates that the insulation is protected until the 25.th minute and therefor K<sub>1</sub> 10 is fulfilled by the gypsum board and chipboard

Based on this test, it is possible for DBI to assess this covering (2 layers) and possibly similar coverings as K<sub>1</sub> 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

## 2 Clay board with clay plaster A

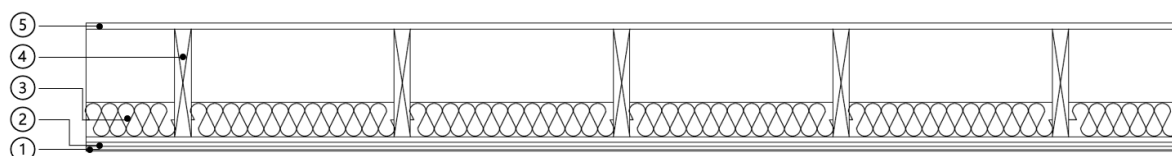
The 3<sup>rd</sup> construction from Wood:UpHigh is a loadbearing deck, using clay board and clay plaster as covering. The test was stopped after 47 minutes, reaching REI45.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1365-2:2014 Fire resistance tests for loadbearing elements - Part 2: Floors.

This data is extracted from DBI test report PGA12222A.

### About the construction (exposed side)

1. 3 mm clay plaster
2. 2x10 mm clay board
3. 15 mm chip boards
4. 45x195 mm construction spruce wood, with 95 mm blown in wood fiber insulation.
5. 15 mm chipboard



Product		Chipboard	Clay plaster	Clayboard
Density	kg/m <sup>3</sup>	594*	1396	840.6
Moisture content	%	6.63	1.36	1.96
Sampling method		Extra material	Extra material	Extra material
Drying temperature	°C	55	55	105

\* Density differs more than 10 % from the nominal density, the density measured is lower than the nominal density.

### Clay boards

Two layers of 10 mm clay boards, with a nominal density of 750 kg/ m<sup>3</sup> were attached below the chipboard on the exposed side. The clay boards had the maximum dimension of 1000 x 1250 mm.

#### 1<sup>st</sup> layer

The boards are fixed with 3.5 x 25 mm screws with a 300 x 450 mm array resulting in 15 screws in a full board.

#### 2<sup>nd</sup> layer

The boards are fixed with 3.5 x 41 mm screws with a 300 x 450 mm array resulting in 15 screws in a full board. On each screw a steel washer with a diameter of 36 mm and thickness of 0.7 mm was used. The second layer was staggered compared to the first layer with minimum 150 mm.

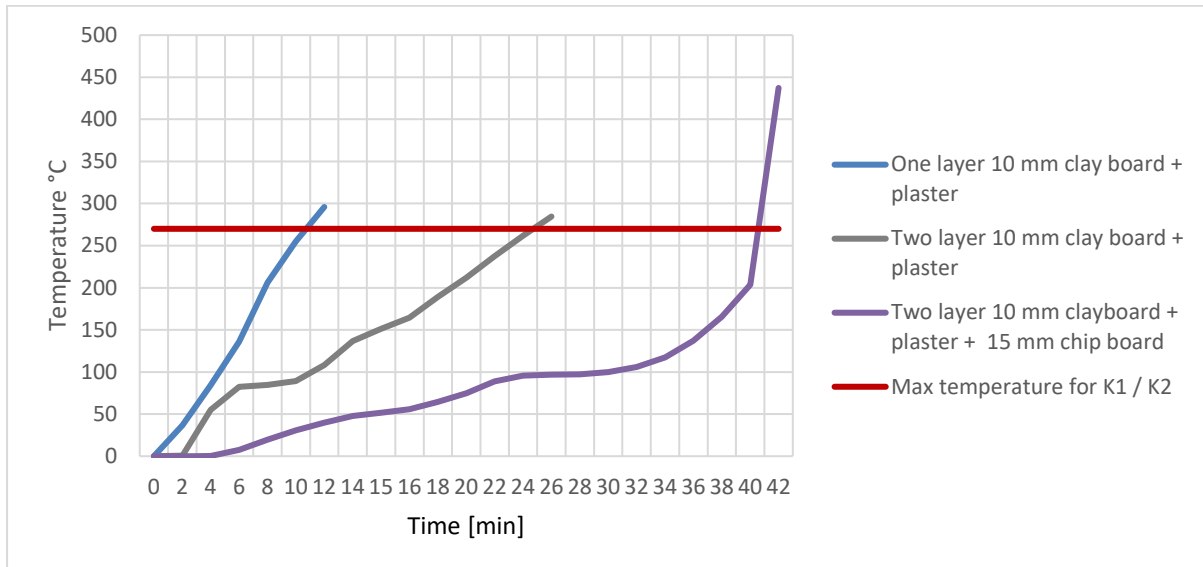
### Clay plaster

The clay plaster was mixed according to the producers instructions. Over all joints a mesh reinforcement with a width of 245 mm and a mesh of 5 x 5 mm and a tread thickness of 0.25 mm was placed.



The mesh was fixed to the clay boards with 10 mm staples. For mesh joint an overlap of minimum 100 mm was used. The applied clay plaster thickness was 2-3 mm.

### Covering performance



Behind the first clay board, the temperature reached 270°C after 11 minutes. The temperature behind the second layer reached 270°C after 24 minutes. The temperature behind the chipboard reached 270°C after 41 minutes. The temperature in the first layer was gathered using 2 thermocouples, the second was gathered using 6 thermocouples and the third layer was gathered using 2 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 10.th minute, between the clay and chip board. Between the chip board and insulation, the temperature is constant at around 100 °C until the 30.th minute. This indicates that the chipboard is protected until the 10.th minute and the insulation is protected until the 30.th minute. Therefor K1 10 is fulfilled by the two clay boards and clay plaster and K2 30 between the chip board and insulation.

Based on this test, it is possible for DBI to assess this covering (2 layers + plaster) and possibly similar coverings as K1 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

Based on this test, it is possible for DBI to assess this covering (3 layers) and possibly similar coverings as K2 30 on all substrates.

### 3 Clayboard with clay plaster B

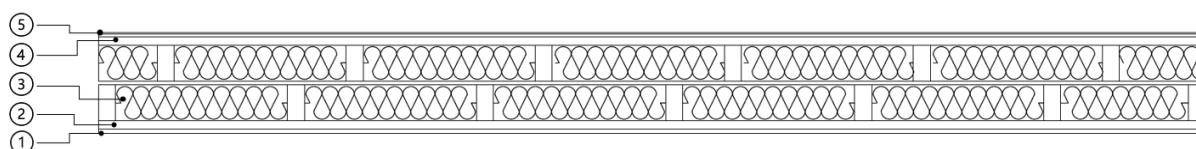
The 6<sup>th</sup> construction from Wood:UpHigh is a loadbearing wall using clay board with clay plaster as covering. The test was stopped after 66 minutes, reaching REI60.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1365-1:2012 Fire resistance tests for loadbearing elements Part 1: Walls.

This data is extracted from DBI test report PGA12247A.

#### About the construction (exposed side)

1. 10 mm clay board + 3 mm clay plaster
2. 22 mm clay board
3. 45x95 mm construction spruce wood with four layers of seaweed wool
4. 22 mm clay board
5. 10 mm clay board + 3 mm clay plaster



Product		Clayboard 1 [10 mm]	Clayboard 2 [22 mm]	Clay plaster
Density	kg/m <sup>3</sup>	597	783	2291
Thickness	mm	23.1	9.6	-
Moisture content	%	3.85	3.02	25.33
Sampling method		Extra material	Extra material	Extra material
Drying temperature	°C	105	105	105

#### Clay boards

##### 1<sup>st</sup> layer

Inner clay board with the nominal dimensions of 22 x 1250 x 1000 mm with a nominal density of 750 kg/ m<sup>3</sup> was mounted on the exposed side to the loadbearing studs with 3,9 x 35 mm gypsum screws. Seven screws were used in three rows against the loadbearing studs, with 15 mm to the board edge.

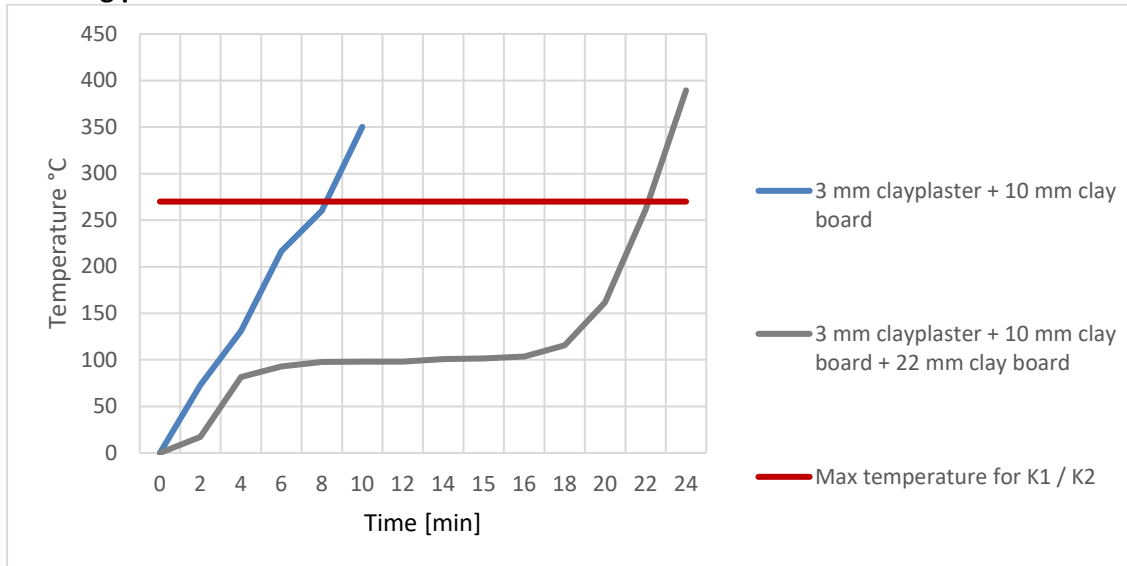
##### 2<sup>nd</sup> layer

Outer layer clay boards with the nominal dimensions of 10 x 1250 x 1000 mm with a nominal density of 750 kg/ m<sup>3</sup>. This layer was fixed with 3.9 x 45 mm screws with a Ø35 mm washer. The washer had a thickness of 0.7 mm. A total of 21 screws were used for a full board with 7 in each row.

#### Clay plaster

The clay plaster was used on both the exposed and unexposed side of the test specimen. The plaster was mixed according to the producers mixing instructions. The plaster was applied with approximately 3 mm layer.

### Covering performance



Behind the first clay board, the temperature reached 270°C after 8 minutes. The temperature behind the second clay board reached 270°C after 22 minutes. The temperature in the first layer was gathered using 2 thermocouples and the second was gathered using 5 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 16.th minute. This indicates that the insulation is protected until the 16.th minute and therefore K<sub>1</sub> 10 is fulfilled by the two clay boards and clay plaster.

Based on this test, it is possible for DBI to assess this covering (2 layers + plaster) and possibly similar coverings as K<sub>1</sub> 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

## 4 Gypsum and wood fiber board

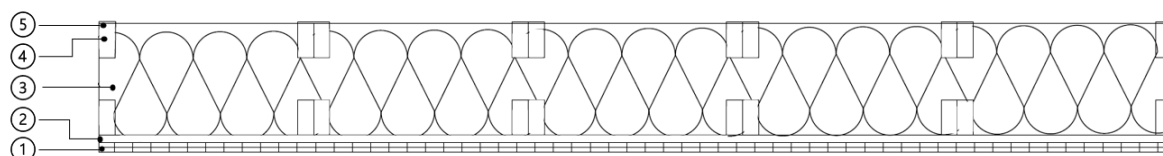
The 4<sup>th</sup> construction from Wood:UpHigh loadbearing wall using gypsum and wood fiber plaster as covering. The test was stopped after 113 minutes, reaching REI90.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1365-1:2012 Fire resistance tests for loadbearing elements Part 1: Walls.

This data is extracted from DBI test report PGA12233A.

### About the construction (exposed side)

1. 2x12.5 fiber gypsum boards
2. 22 mm wood fiber board
3. 44x93 mm wooden studs with 5 standard straw element insulation
4. Wood spacers
5. Felt membrane



Product		Fiber gypsum board	Wood fiber board	Wood spacers	Construction wood
Density	kg/m <sup>3</sup>	1150	220	450	450
Moisture content	%	0.9	7.0	6.5	11.1
Sampling method		Extra material	Extra material	Extra material	Extra material
Drying temperature	°C	55	55	105	105

### Fiber gypsum board

Two layers of 12.5 mm thick gypsum fiber with a nominal density of 1150 kg/m<sup>3</sup> were fixed with staples 30 mm at a c/c of 200 mm. The staples were fixed 10 mm from the board edges and 50 mm from the board corners. A full-size board measured 900 x 1200 mm.

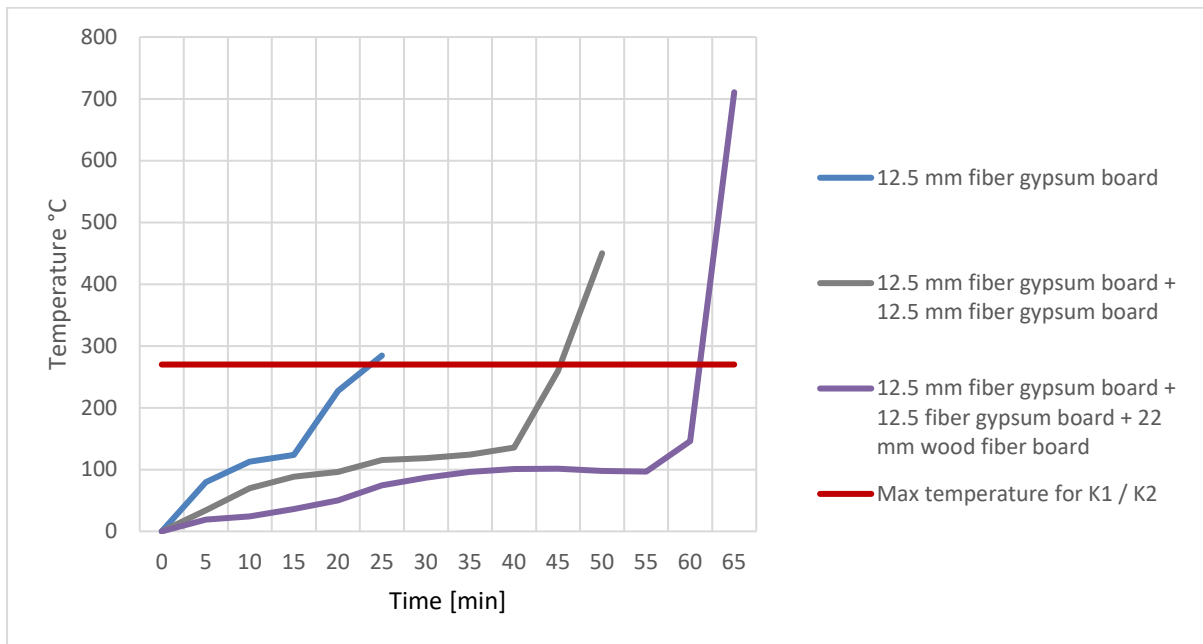
Approximately 2 mm thick layer of spackle was applied to the joints on the gypsum boards.

### Wood fiber board

A 22 mm thick wood fiber board was mounted on the exposed side to the straw elements with 2.8 x 75 mm screws. For each stud behind the board two screws were fixed, for the maximum dimension 10 nails were used.

A full-size wood fiber board had the dimensions of 750 x 2500 mm with the tongue and groove. The vertical board joints were backed by the wooden studs.

### Covering performance



Behind the first fiber gypsum board, the temperature reached 270°C after 24 minutes. Behind the second layer of fiber gypsum, the temperature reached 270°C after 45 minutes. The temperature behind the third layer of wood fiber board, reached 270°C after 63 minutes.

The temperature in the first layer was gathered using 2 thermocouples, the second was gathered using 6 thermocouples and the third was gathered using 6 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 55.th minute. This indicates that the insulation is protected until the 55.th minute and therefor K1 10 and K2 30 is fulfilled by the two gypsum boards and wood fiber board.

Based on this test, it is possible for DBI to assess this covering (3 layers) and possibly similar coverings as K1 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

Based on this test, it is possible for DBI to assess this covering (3 layers) and possibly similar coverings as K2 30 on all substrates.

## 5 Hemp and clay board

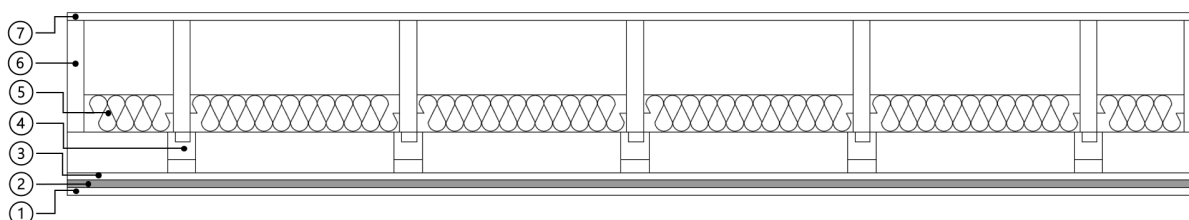
The 8<sup>th</sup> construction from Wood:UpHigh is a loadbearing deck using hemp and clay board as covering. The test was stopped after 60 minutes, reaching REI60.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1365-2:2014 Fire resistance tests for loadbearing elements - Part 2: Floors and roofs.

This data is extracted from DBI test report PGA12249A

### About the construction (exposed side)

1. 19 mm hemp board
2. 22 mm clay board
3. 95x20 mm wooden battens
4. Sound dampening service
5. 100 mm grass insulation
6. 45x295 mm construction spruce wood
7. 21 mm plywood



Product		Clay board	Hemp board	Plywood	Wood beams
Density	kg/m <sup>3</sup>	656	628	766	434
Thickness	mm	22.2	19.6	20.7	45
Moisture content	%	3.85	2.76	9.5	11.07
Sampling method		Extra material	Extra material	Extra material	Extra Material
Drying temperature	°C	105	105	105	105

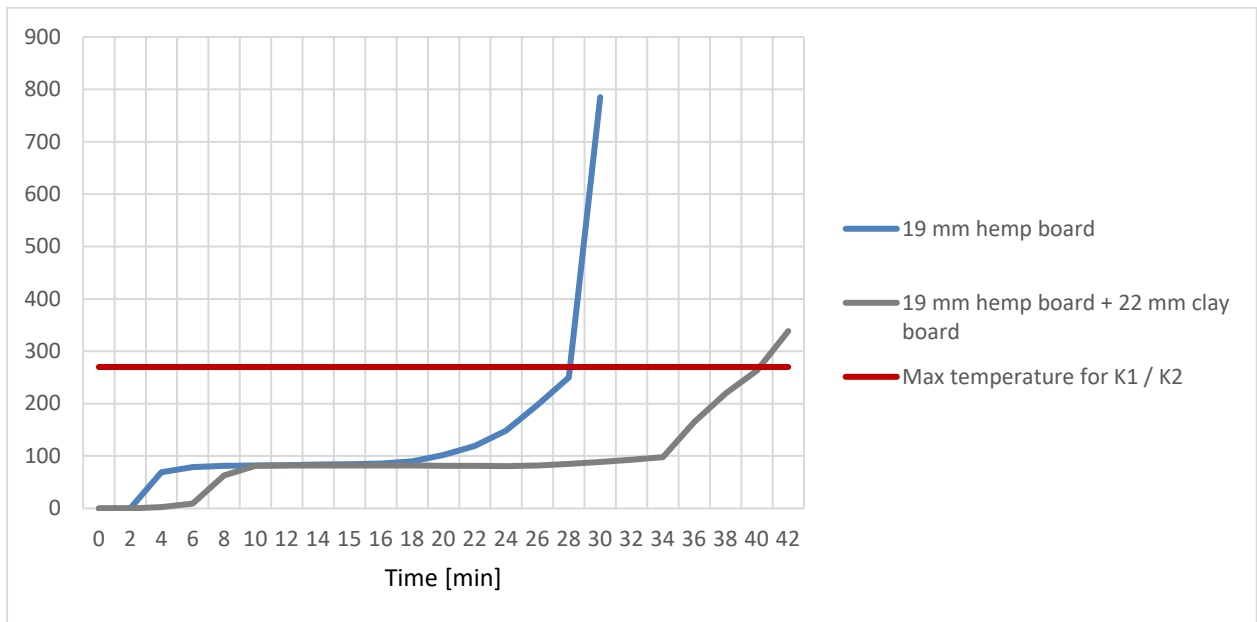
### Clay boards

Clay boards with the nominal dimensions of 22 x 1200 x 1000 mm and a nominal density of 750 kg/ m<sup>3</sup> were mounted on the exposed side to the 20 x 95 mm battens with 3.9 x 35 mm gypsum screws. Seven screws were fixed in four rows into the battens, with 15 mm to the board edge.

### Hemp boards

Hemp boards the nominal dimensions of 19 x 800 x 1200 mm and a nominal density of 650 kg/ m<sup>3</sup> were mounted on the exposed side to the clay boards with 3.9 x 57 mm gypsum screws. Each full board have 12 screws with 15 mm to the board edge.

### Covering performance



Behind the hemp board, the temperature reached 270°C after 28 minutes. The temperature behind the hemp board and clay board reached 270°C after 39 minutes. The temperature in the first layer was gathered using 2 thermocouples and the second was gathered using 3 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 34.th minute. This indicates that the insulation is protected until the 34.th minute and therefor K1 10 and K2 30 is fulfilled by the hemp board and clay board.

Based on this test, it is possible for DBI to assess this covering (2 layers) and possibly similar coverings as K1 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

Based on this test, it is possible for DBI to assess this covering (2 layers) and possibly similar coverings as K2 30 on all substrates.

## 6 Wood fiber board and particle board

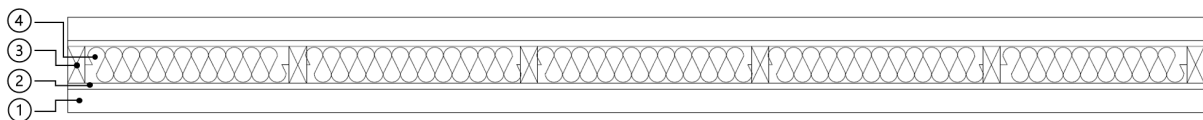
The 9<sup>th</sup> construction from Wood:UpHigh was a non-loadbearing wall using a wood fiber board and a particle board as covering. The test was stopped after 81 minutes, reaching REI60.

The test specimen has been subjected to a standard fire test in accordance with the standard: DS/EN 1363-1:2020 Fire resistance tests – General requirements, in conjunction with EN 1364-1:2015 - Fire resistance tests – Non-Loadbearing Wall

This data is extracted from DBI test report PGA12336A.

### About the construction (exposed side)

1. 60 mm wood fiber board
2. 15 mm particle board
3. 45x95 m
4. 95 mm blown in wood fiber insulation



Product		Wood fiber board	Particle board	Wood stud
Density	kg/m <sup>3</sup>	197	690	485
Thickness	mm	53	15	45
Moisture content	%	5.2	6.6	7.4
Sampling method		Extra material	Extra material	Extra material
Drying temperature	°C	105	105	105

### Particle board

#### 1<sup>st</sup> layer (inner layer)

A 15 mm thick particleboard was mounted on both sides of the wooden frame with 5.0 x 60 mm screws. For each stud behind the board 6 screws were fixed with a c/c of 100 mm, for the maximum board dimension 30 screws were used. A full-size particleboard had the dimensions 625 x 2500 mm with tongue and groove.

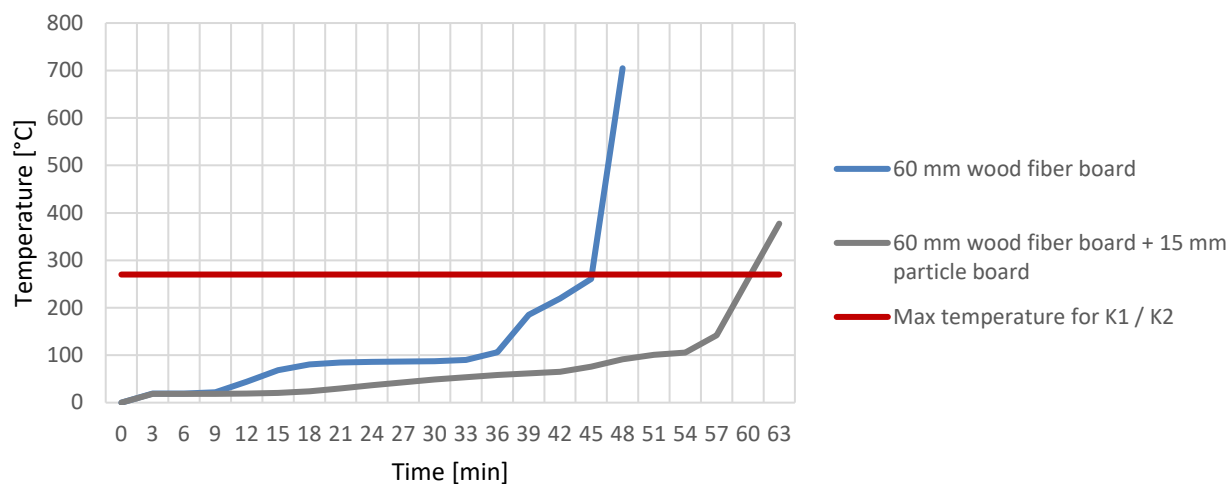
### Wood fiber board

#### 2<sup>nd</sup> layer (outer layer)

The outer layer consisted of wood fiber boards with the nominal dimensions of 60 x 580 x 2000 mm and a nominal density of 180 kg/ m<sup>3</sup>. The layer was fixed with 100 x 26 x 1.9 mm staples per c/c 200 mm along the edges of the board.



## Covering performance



The wood fiber board reached 270°C after 45 minutes. The wood fiber board and particle board reached 270°C after 60 minutes. The temperature in the first layer was gathered using 2 thermocouples and the second was gathered using 6 thermocouples, a covering test uses 8 thermocouples. The temperature rise is constant at around 100 °C until the 55.th minute. This indicates that the insulation is protected until the 55.th minute and therefor K1 10 and K2 30 is fulfilled by the wood fiber and particle board.

Based on this test, it is possible for DBI to assess this covering (2 layers) and possibly similar coverings as K1 10 on some substrates (insulation) with a density lower than 300kg/m<sup>3</sup>.

Based on this test, it is possible for DBI to assess this covering (2 layers) and possibly similar coverings as K2 30 on all substrates.

## Assessments

Accordance with the guidelines for Chapter 5, Section 8.7.b of the Danish Building Regulation, an assessment can be used as documentation in all fire classes, even if it does not lead to an actual classification.

The assessments can be done by fire laboratories accredited according to the EN17025, such as DBI - The Danish Institute of Fire and Security.

The assessments can be either positive or negative, while only positive assessments can be used as documentation according to Chapter 5, Section 8.7.b of the Danish Building Regulation.

### The process of assessments



Relevant test reports and technical data from product / system / structure are collected by the requisitioner, as well of a description and specification of deviation.

DBI perform an initial review containing an indication if a positive assessment is possible and an estimation of cost and time.

Initial review takes 2-5 hours.

Assessments are invoiced based on the time spent, including the time for the initial review.

Contact DBI for assessments: [www.brandogsikring.dk/en/contact/](http://www.brandogsikring.dk/en/contact/)