TALLINN UNIVERSITY OF TECHNOLOGY

HYGROTHERMAL PERFORMANCE OF CROSS LAMINATED TIMBER AS EXTERNAL WALL LAYER

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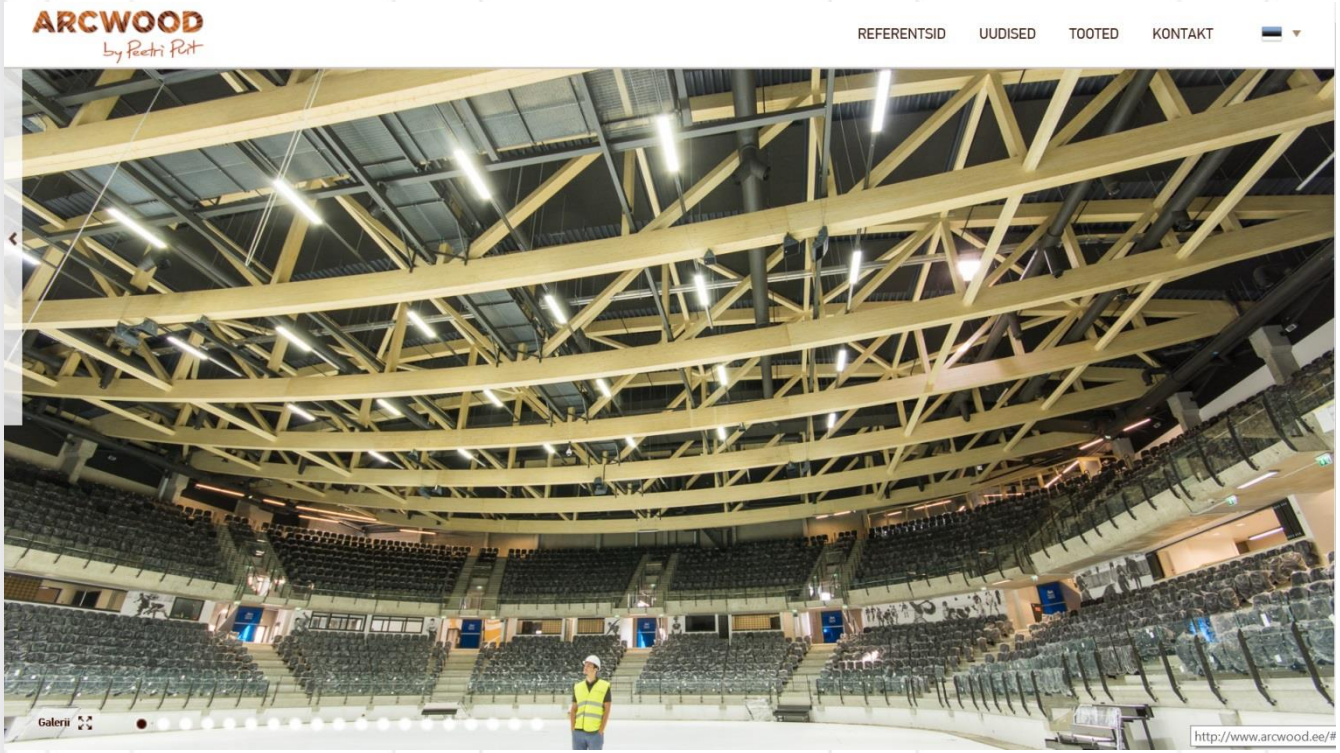
Outline

- Introduction
- Materials & Methods
- Results
- Conclusions

Introduction

Background

Estonian company Peetri Puit OÜ (est. 2002) is producer of GLT beams and elements…



64m long GLT elements in Tondiraba Ice hall in Tallinn

Introduction

Background

…. in 2014 they made first CLT panels 3,5x15m

http://www.woodtec.ch/images/content/Vakuumpresse/Slider1.jpg

11.2015-08.2016 the construction of new 8000m² plant for CLT production to increase production capacity 3 times.

Introduction

Research groups and topics

- **CLT hygro-thermal properties,** (started 09.2014)

  Group leader: Prof. Jaan Kers,

  4 masterstudents under supervision

- **Building physics, acoustics and fire resistance**

  Co-operation with TUT Chair of Building Physics and Energy Efficiency,

  - Prof. Targo Kalamees
  - Ass. Prof. Alar Just
  - PhD student Eero Tuhkanen

Introduction

FIRST CLT bsed passive house project in Estonia

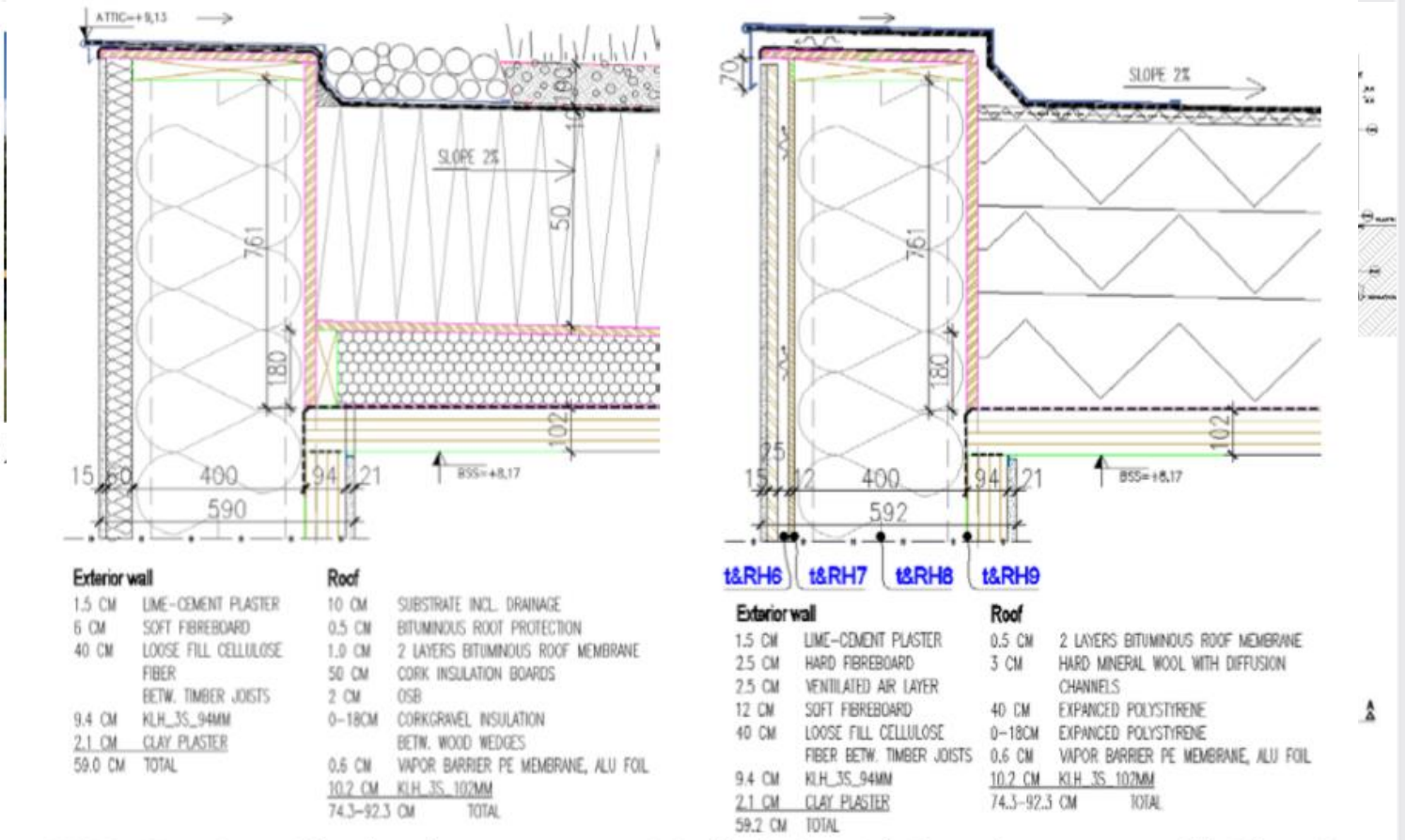
- The first complete and certified PH in Estonia was a detached CLT (by KLH) house in Põlva (2013), designed by Austrian architects and constructed by Estonian designers
- Based on calculations, it achieves the annual basis of nZEB building classification in the Estonian legislation
- By the end of 2018 all new public buildings must meet (nZEB) requirements

TABLE 1 Energy performance certificate classifications (A-D) and corresponding maximum values of energy performance values (kWh/(m^2·a)) for three different types of buildings.

	Maximum energy performance values (Estonian legislation), kWh/(m^2·a)			
	A *nZEB*	B Low energy buidling	C Minimum requirements for new building	D Minimum requirements for major renovation
Detached house	50	120	160	210
Apartment building	100	120	150	180
Office building	100	130	160	210

Introduction

FIRST CLT based PH project in Estonia



Exterior wall

1.5 CM	LIME-CEMENT PLASTER
6 CM	SOFT FIBREBOARD
40 CM	LOOSE FILL CELLULOSE FIBER BETW. TIMBER JOISTS
9.4 CM	KLH_3S_94MM
2.1 CM	CLAY PLASTER
59.0 CM	TOTAL

Roof

10 CM	SUBSTRATE INCL. DRAINAGE
0.5 CM	BITUMINOUS ROOT PROTECTION
1.0 CM	2 LAYERS BITUMINOUS ROOF MEMBRANE
50 CM	CORK INSULATION BOARDS
2 CM	OSB
0-18CM	CORKGRAVEL INSULATION BETW. WOOD WEDGES
0.6 CM	VAPOR BARRIER PE MEMBRANE, ALU FOIL
10.2 CM	KLH_3S_102MM
74.3-92.3 CM	TOTAL

Exterior wall

1.5 CM	LIME-CEMENT PLASTER
2.5 CM	HARD FIBREBOARD
2.5 CM	VENTILATED AIR LAYER
12 CM	SOFT FIBREBOARD
40 CM	LOOSE FILL CELLULOSE FIBER BETW. TIMBER JOISTS
9.4 CM	KLH_3S_94MM
2.1 CM	CLAY PLASTER
59.2 CM	TOTAL

Roof

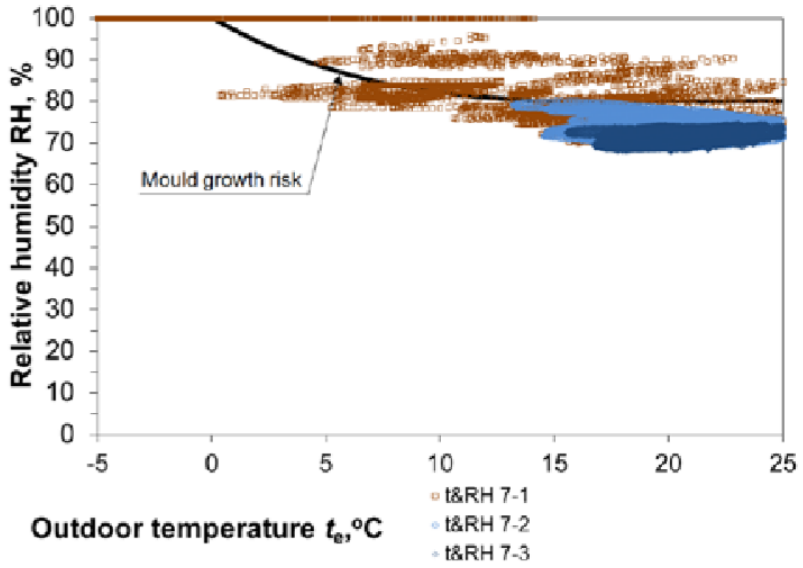
0.5 CM	2 LAYERS BITUMINOUS ROOF MEMBRANE
3 CM	HARD MINERAL WOOL WITH DIFFUSION CHANNELS
40 CM	EXPANCED POLYSTYRENE
0-18CM	EXPANCED POLYSTYRENE
0.6 CM	VAPOR BARRIER PE MEMBRANE, ALU FOIL
10.2 CM	KLH_3S_102MM
74.3-92.3 CM	TOTAL

FIG 3 Exterior wall and roof structures, as originally designed (left), and as constructed (right, with measurement point for hygrothermal performance of exterior wall with temperature and relative humidity (t&RH6, t&RH7, t&RH8, t&RH9) sensors).

Introduction

FIRST Year performance of passive house

- Results showed high temperature readings in most of the rooms, (large windows in south). Small heat loss of the building envelope.
- Due to the high indoor temperatures, the relative



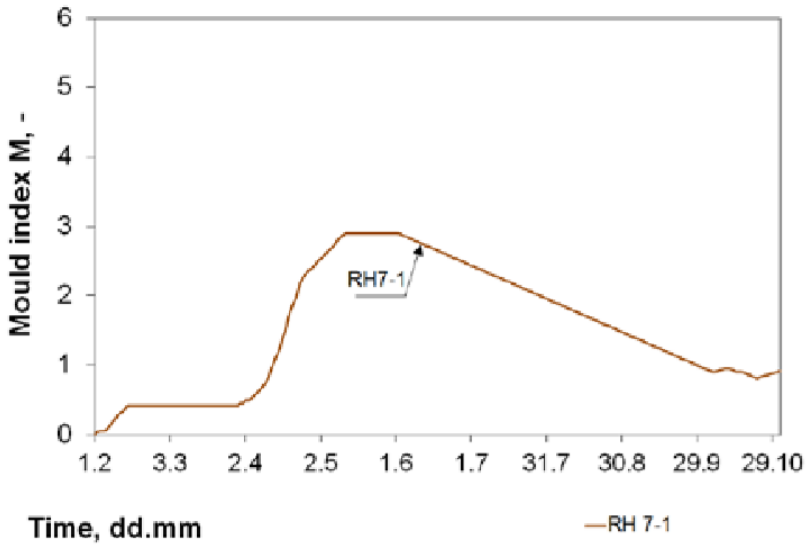


FIG 9 Temperature and RH between the cellulose insulation and the 12 mm thick wood fiber sheathing board (left) were suitable for mould growth, according to the mould growth index (right).

Introduction

Motivaton

- CLT sample panel dry-out (initial MC 12%) in classroom 11.2014-03.2015
- Continuous cracking noise and visible deformations due to low RH (23...25%) and room temperature 23...24°C

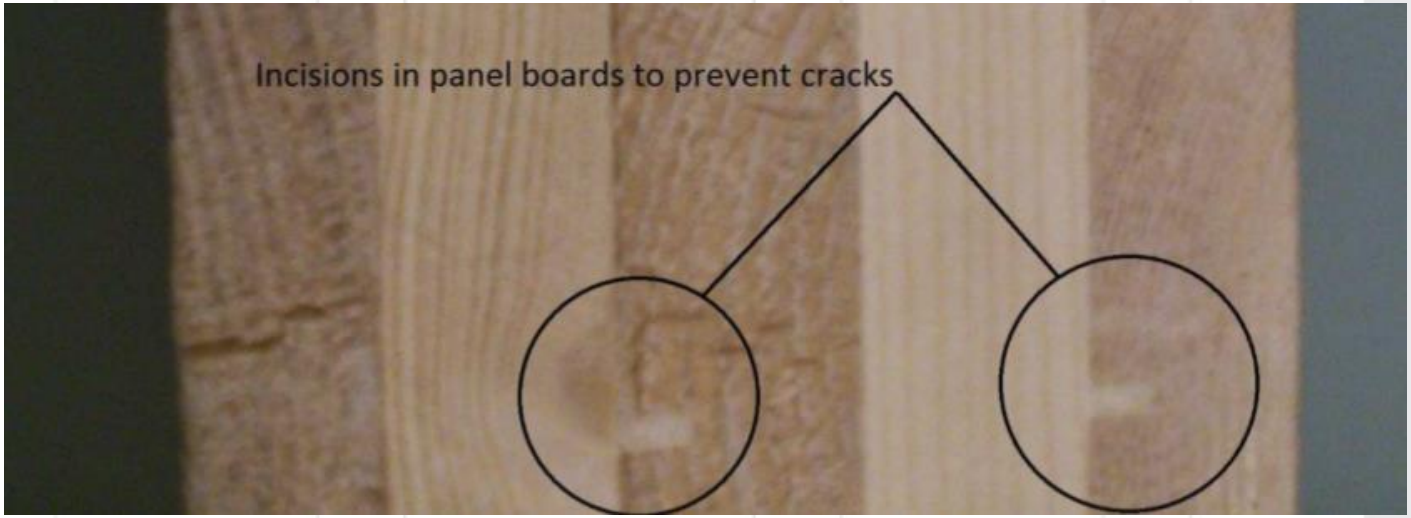
Introduction

THE AIM OF THE STUDY

To observe wood material behavour in every layer of CLT in indoor and outdoor climate test and to find possible causes of crack formation and propagation

Materials & Methods

- 5 layer CLT Panels in two thicknesses made of local spruce (*Picea abies*).
- Climate simulation chamber ILKA PTK-3018
- Digital wood MC meter Testo 635
- Temperature logging by EasyLog GFX
- Thickening wool ISOVER SK and roof membrane tape



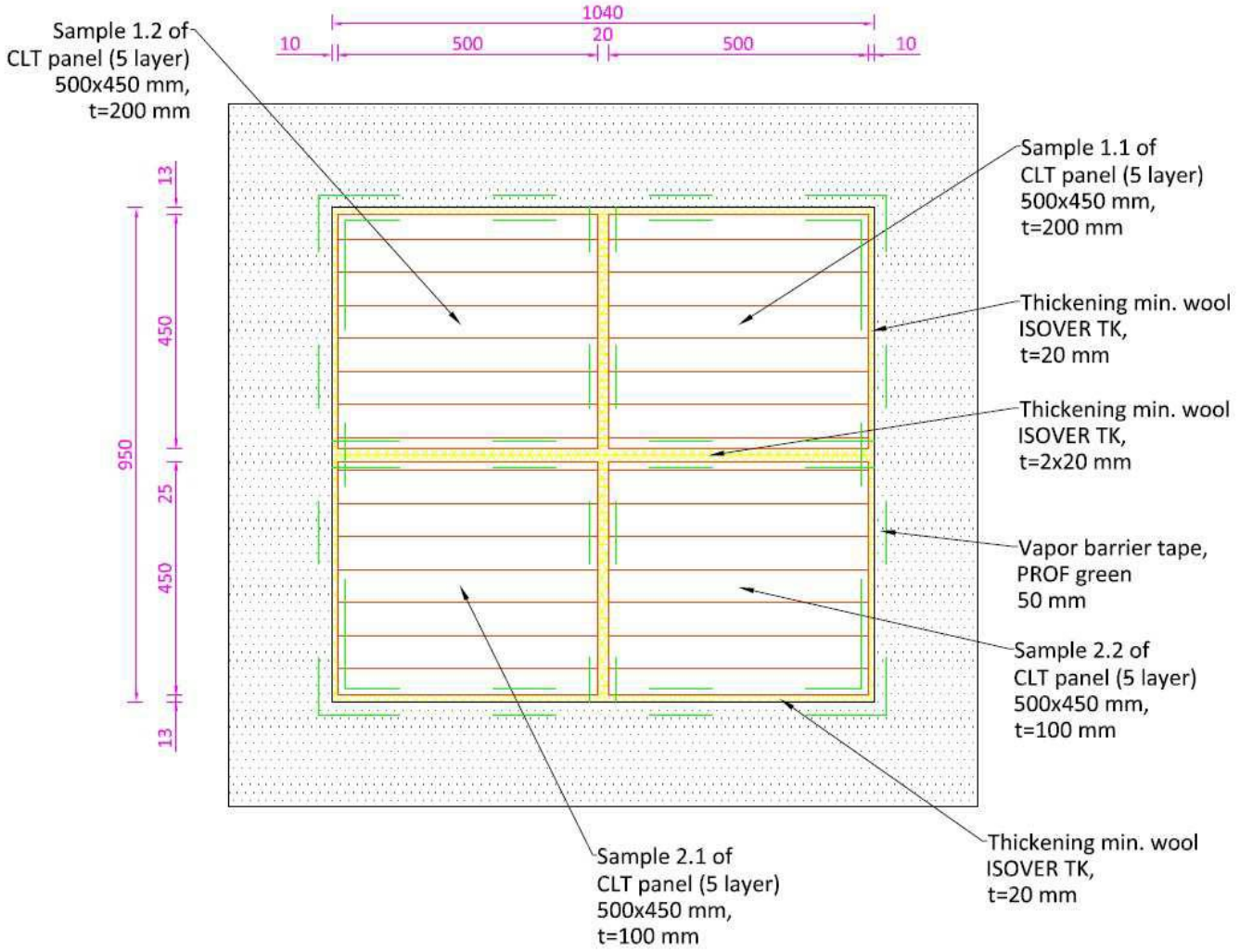
Materials & Methods

Four samples of:
W=500 mm,
H=450 mm

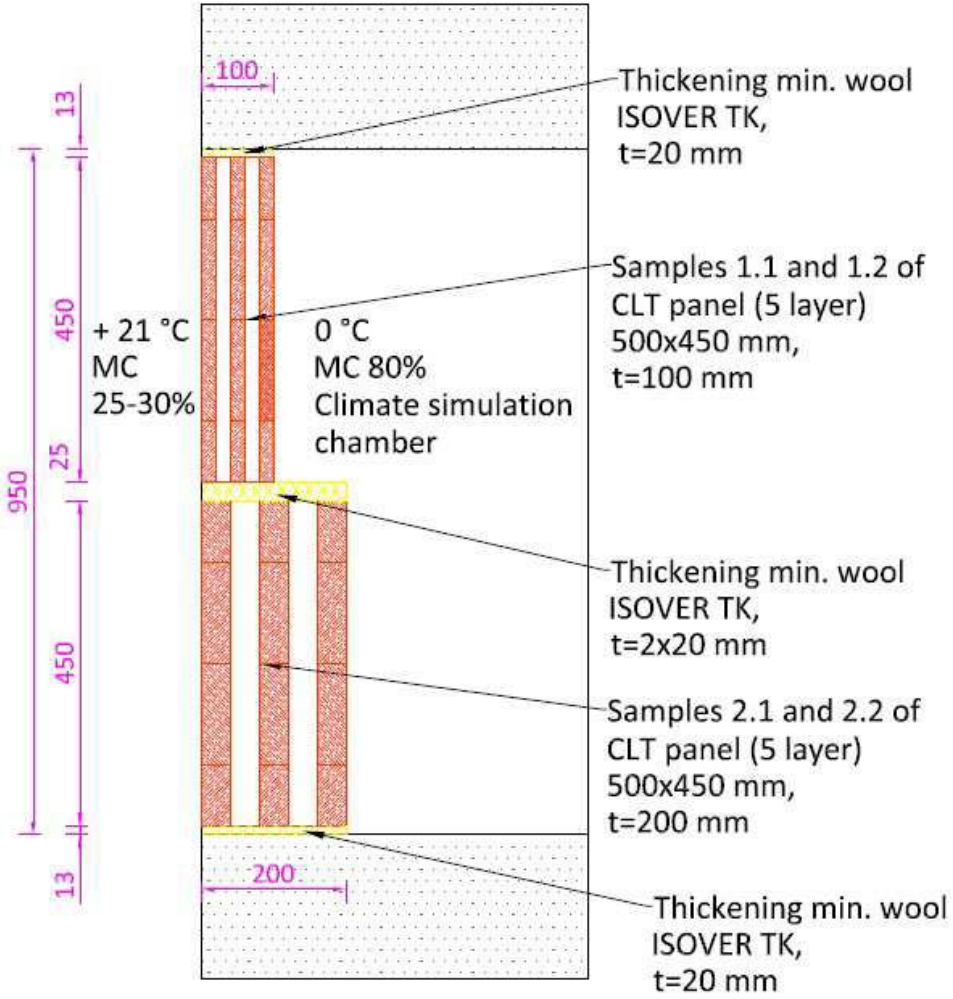
2pc 5x20=100 mm
2pc 5x40= 200 mm

- CLT panel edges were sealed with acrylic paint

Materials & Methods



Materials & Methods



Materials & Methods

- Simulated external condition 4-7°C with RH about 80%.
- Simulated internal condition +26°C with RH about 25...30%.
- Testing period 30 days
- Main measured parameters in each layer:
  - Temperature
  - Moisture content (MC)
  - Measuring width and length of the cracks in outer surface layer

Results

Temperture measurements

- Temperature growth rate of samples 1 and 2 (thicker panels) in first internal (indoor) layers are low 1-3%
- In two middle layers the temperature growth rate was 3-5%
- In external layers, L4 and L5, the temperature growth rate was the highest, 7-10%
- Opposite environments do have more impact to thinner (100 mm) samples.
- External layers cooled down very quickly and then temperature growth slow down because of the impact of internal condition

Results

RH measurements

- Internal layers did not show mostly any change.
- Middle layers showed MC growth rate in all samples 0-3 %.
- External layers (RH 80%) showed highest MC growth rate of 5-7%
- During one month of exposing panels to external condition (RH 80%) only outer layers (L5) of CLT panels absorbed moisture.
- Moisture did not go through to the following layers.

Results

Crack measurements

- x1- check with ending and places in the middle of the layer board;
- x1´- check crosses over the board and places in the middle of the layer board;
- x1´´- check between two boards (connection line which is not fulfilled with glue) and marks as beginning of the check;
- x1(´´)-check between two boards (connection line which is not fulfilled with glue) and marks as the end of the check.

Results

Crack measurements

- The width of checks in each sample wide sides were measured before and after the hygrothermal tests
- The checks widths in internal (26^{o}C, RH 25-30%) wide sides increased (drying) and in external wide sides decreased (swelling).
- These test results did not showed any spectacular differences in check appearing and growing between thick and thin panels.
- The thick panels had much more checks than in the thin panel’s surfaces.

Conclusions

- From MC measurements it can be concluded that during one month of exposing panels to external condition only outer layers (L5) of CLT panels absorbed moisture.
- Moisture did not go through to the following layers. In internal layers the moisture absorption or desorption was not significant.
- From the results of check measurements it was clearly seen that checks widths in internal wide sides increased and in external wide sides decreased.
- The thick panels had much more checks than in the thin panel’s surfaces.


Thank you!