CAM(B)BRIDGE | Calculation and Measurements in Buildings: Bridging the Gap
Conventions n° 2016 R 59a et 2016 R 59b

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empowering research

L.2.3.4 | Production et adaptation des métadonnées des sites démonstrateurs

Spécifications relatives au site Engeland 1

RUE ENGELAND, UCCLE, 1180, BELGIUM

S. Hinque (UCL) – G. Masy (UCL) - A. Dawans (EJD)

12.04.19

Entreprises Jacques Delens
Avenue du Col-Vert, 1 B-1170 Bruxelles
T : + 32 2 566 96 96 | F : + 32 2 566 97 00
M : ejd@jacquesdelens.be | www.jacquesdelens.be
TVA : BE0400 471 428

UCL, Architecture et Climat
Rue Place du Levant, 1 bte L5.05.02 B-1348 Louvain-La-Neuve
T : + 32 10 47 21 42
M : climat@uclouvain.be | www.climat.arch.ucl.ac.be
TVA : BE0419 052 272

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1. GENERAL INFORMATION

1.1. Introduction

The present document collects all the notes, information and steps concerning the experiment undertaken within the framework of the project *Cam(b)bridge*. This specification is redacted with a dual purpose: sharing data sets enabling modellers to validate their simulation models and also information and process of the experiment to make future measurement campaigns easier and more efficient.

This research project is leaded by *Architecture & Climat* from *UCL University* and *Jacques Delens s.a. Company*. The purpose of the initiative is to develop methods that can be applied on site during the construction phase to assess the actual performance of buildings at a moment when it can still be improved to reach the target without entailing over costs. The measurements are performed in summer, during 9 days without occupancy.

1.2. Apartments Group C

The experiment was undertaken in a building complex in the street Engeland. The site is located in Uccle, at the South of Brussels, in Belgium. The construction, accomplished by "*Jacques Delens s.a.*" [JD], is a part of a complex of 238 dwellings (houses and apartments). The measures have been taken in two apartment of the group C, illustrated in the following figures.

The apartments considered for the study are facing South-West and are located on the first and second floor. At the period of the test, the building facing the units was not yet constructed.

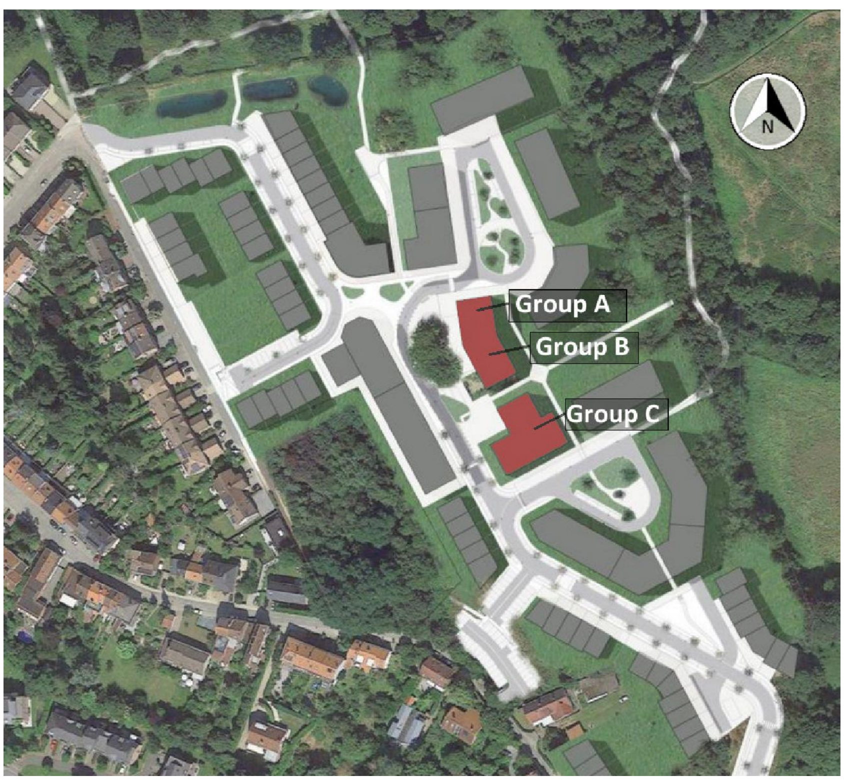


Figure 1 : Site Engeland

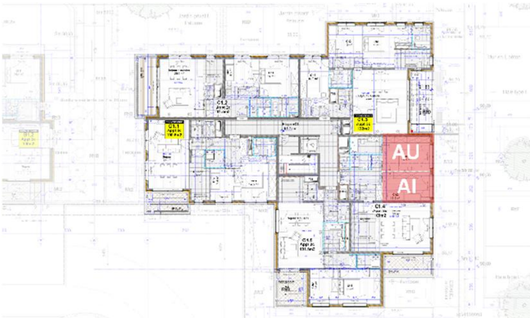


Figure 2 : Apartment location

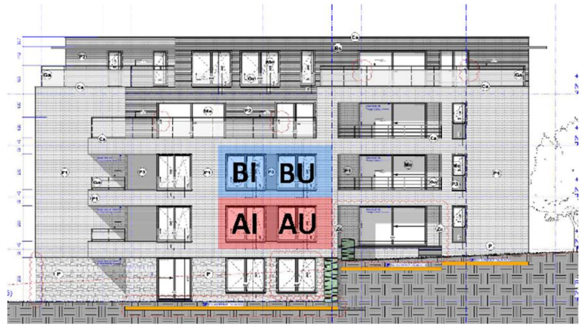


Figure 3 : View of South-West façade

The experiment has been undertaken in two bedrooms of two identical apartments, one located on the first floor and the other on the second floor, just above the first one. The party walls and floors of the slightly smaller bedrooms (AI and BI) as well as their ceilings have been covered by insulation panels on their indoor side. The 4 units are named “AI”, “AU”, “BI”, “BU” according to their location in apartments “A” for C.1.4 (first floor) or “B” for C.2.4 (second floor), and according to the presence “I” or the absence “U” of internal insulation panels. AI and AU units are respectively identical to BI and BU units.

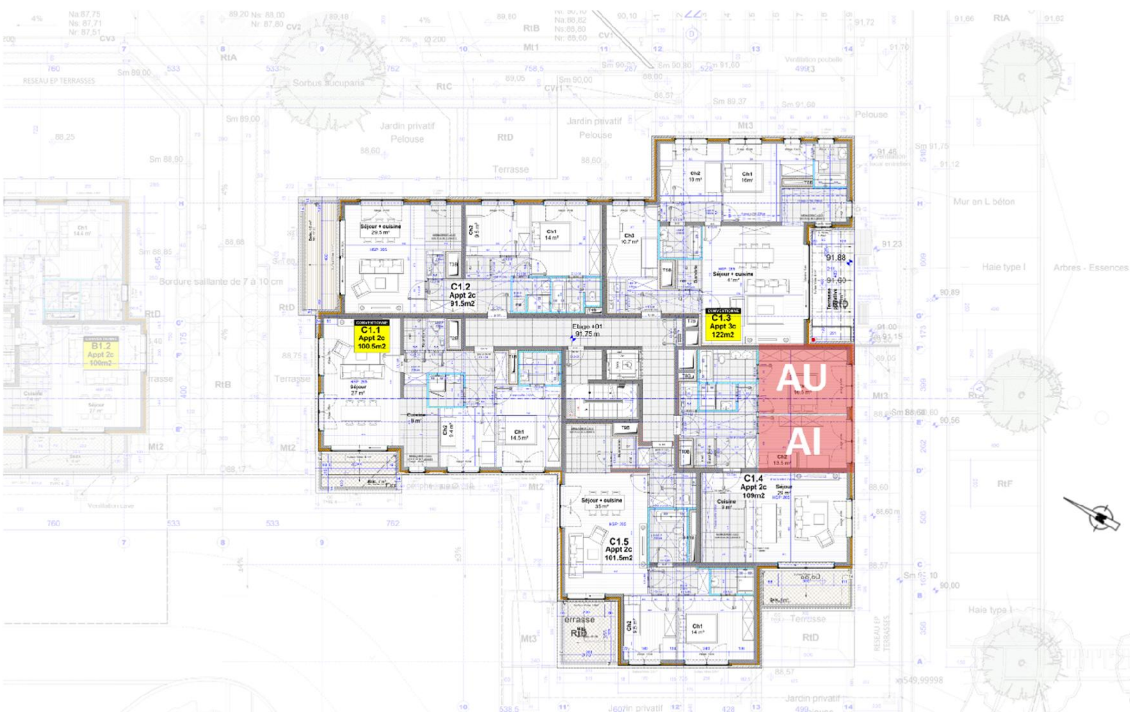


Figure 4 : Units location

2. EXPERIMENT

The conventional measurement procedure for the assessment of the Heat Loss Coefficient (HLC) is based on a coheating test. The coheating test is currently limited to winter month, as a significant internal-external temperature difference is needed. We intend to expand the time window allowable for the assessment of the Heat Loss Coefficient (HLC) by performing measurements in summer. Measurements of Engeland units were performed from 29/06/2018 to 11/07/2018.

The measurement have been realized in identical units in parallel, in order to compare a co-heating test to a method based on the observation of the floating indoor temperature. A reference value of the HLC can be obtained by comparing the input powers and the difference of internal temperatures measured in two parallel identical units, one submitted to coheating and the other being in floating temperature mode, as they are submitted to identical solar heat gains (Figure 5).

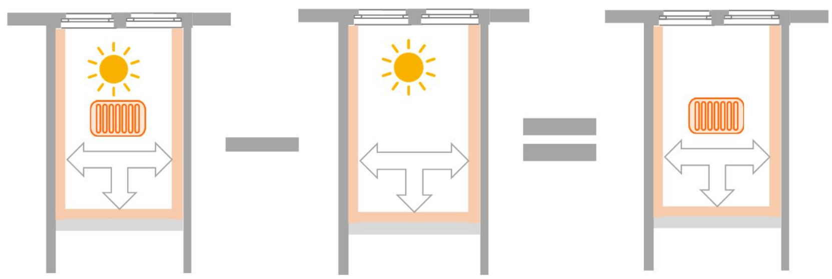
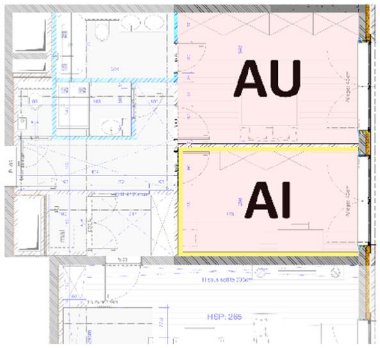


Figure 5 : Analysis process considering the temperature difference between two identical units provided with inside insulation panels: one of the unit is co-heated while both are submitted to identical solar heat gains

The heat loss by common walls and floor, shared with adjacent units, is hardly assessed as the surrounding spaces of the units are not accessible. For that reason, the placement of internal insulation on the party walls allows to focus on the heat loss coefficient of the external façade. It also reduces the heat losses to the neighbouring units and the thermal mass effect of the party walls, floor and ceiling. Moreover, the setup allows to reach higher values of internal temperatures and to obtain a sufficient internal-external temperature difference. Temperatures at the interfaces between inner insulation and original walls were monitored with temperature sensors, to assess the heat flow through the insulation layers.



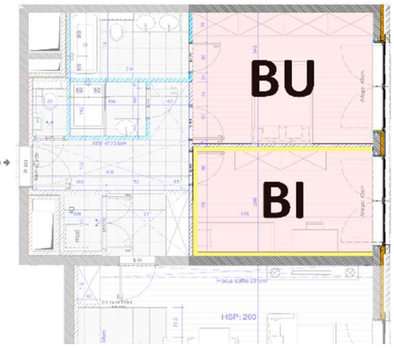


Figure 6: Plan layout of Units A, first floor

Figure 7: Plan layout of Units B, second floor

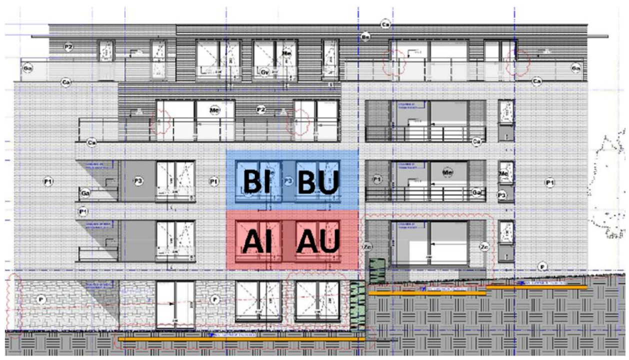


Figure 8: View of South-West façade

Four South oriented units have been tested (Figure 6 and Figure 7): two identical units with insulation panels and two other identical units without insulation panels. In both pairs, one unit is co-heated while the other is in floating temperature mode.

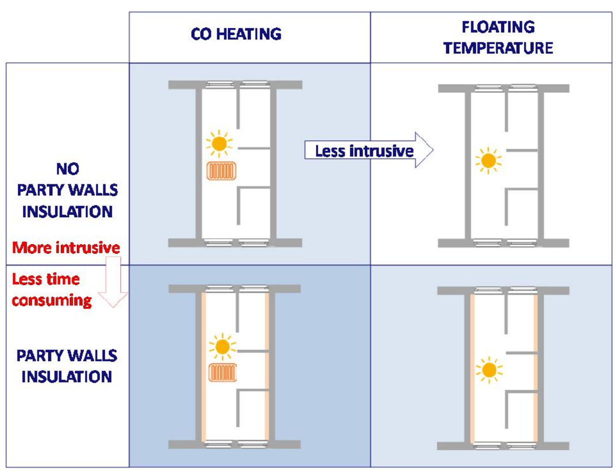


Figure 9 : Different boundary conditions and heat sources for the measurement of the Heat Loss Coefficient

The strong reduction of the thermal mass effect due to the placement of insulation enables to reduce the time period required to assess the façade HLC until 9 days of monitoring without occupancy.

Internal heat gains provided by electric radiators have been monitored. Access was denied during the monitoring. The door and the windows were closed during the whole process.

3. MODEL DETAILS

3.1. Location

The apartments are located in Uccle, at the South of Brussels in Belgium. The land plot is in project to be constructed with more than 200 dwellings. But at the time of the tests, the land plot was still not constructed in front of the units, which limits the effect of mask. However, a scaffold was placed in front of the windows, as shown on Figure 10. The latitude of the buildings is 50.783N and the longitude is 4.345E. The elevation above the sea level is approximatively 77m. The data were measured in local summer time, i.e. in Central European Summer Time (UTC/GMT+2h). They were averaged every 10 minutes and recorded at the end of those ten minutes intervals.

Figure 10 : Panoramic view from C.1.4 apartment, Unit AU

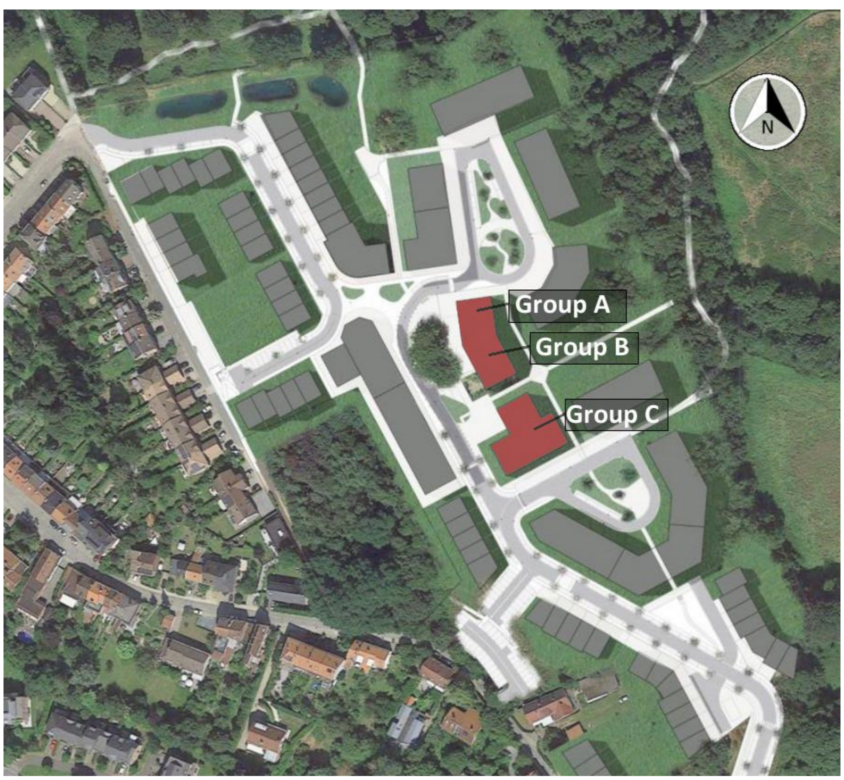


Figure 11 : Site Engeland

3.2. Geometry

Figure 12 shows the internal layout of one apartment (C.1.4). The studied places are both bedrooms. The second apartment (C.2.4) is located just above this apartment. The two apartments are exactly the same. The internal ceiling height is 2.65m for the first floor (AU and AI) and 2.6m for the second floor (BU and BI).

All the wall dimensions are specified in the annexes at the end of this document. The reference surface considered for the assessment of the wall dimensions is the layer of interior finishing. The thermal bridges heat loss coefficients (chapter 3.7) are calculated according to this convention.

Insulation layer panels has been attached to the three party walls, the party floor and the ceiling (in yellow on Figure 12). All the South facing façade have the same windows.

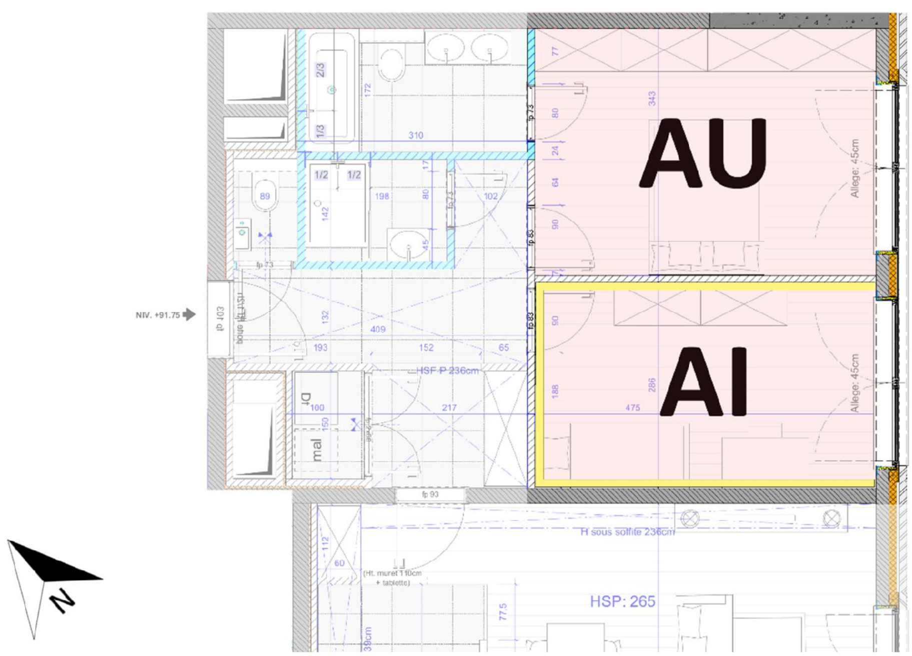


Figure 12 : Layout of apartment C.1.4[Furniture are not present in the apartment during the experiment/ in yellow: insulation layer]

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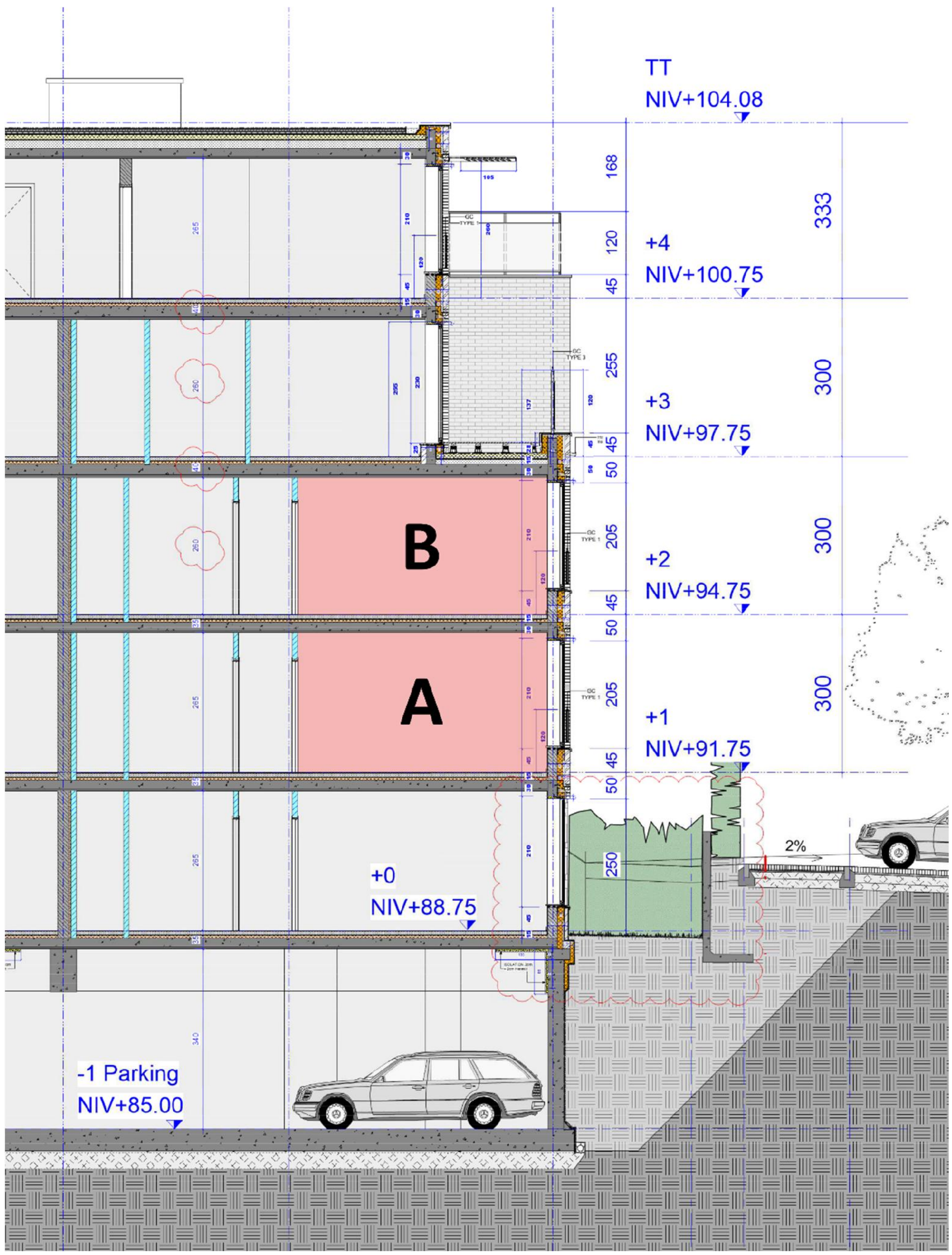


Figure 13 : Longitudinal section in the units

3.3. Glazing and frame areas

The windows are the same for the four units. They are represented in Figure 14. They have two parts: a turning window and a tilting and turning window. During the experiment, there were a scaffold in front of the windows.

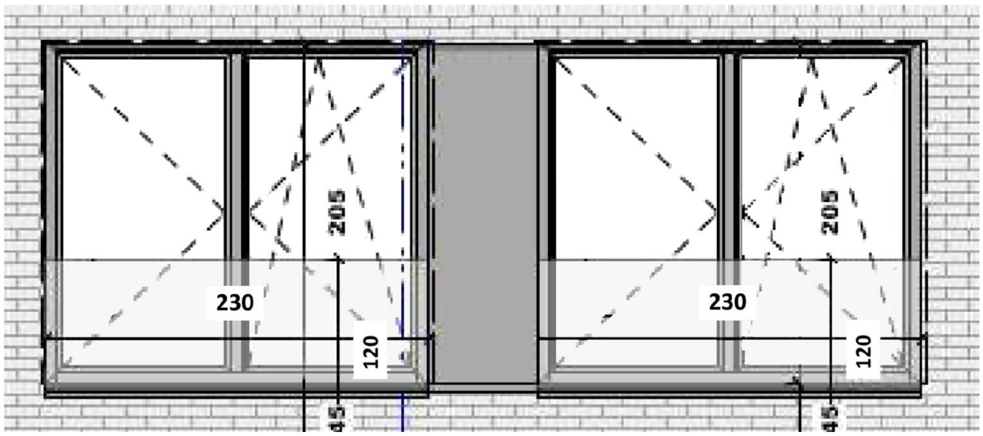


Figure 14 : Façade windows

Table 1 : Dimensions of the windows

Glazing ID	Overall dimensions				Visible Glass area	Glass edge length	Frame area
	l [m]		h [m]	A [m²]	A [m²]	[m]	A [m²]
G1	1.15	x	2.05	2.36	1.80	5.63	0.56
G2	1.15	x	2.05	2.36	1.80	5.63	0.56
Total living				4.72	3.60	11.26	1.12

3.4. Construction

The constructional properties are presented in the Table 2 ***for the walls and the***

Table ***3*** : Floors construction thermo-physical properties (green color: Manufacturer's data or as built documents, blue color: assumptions)

Table ***3*** for the floors and ceilings. The Figure 15, Figure 16 and Figure 17 present the wall and floors numeration used in the tables.

Walls

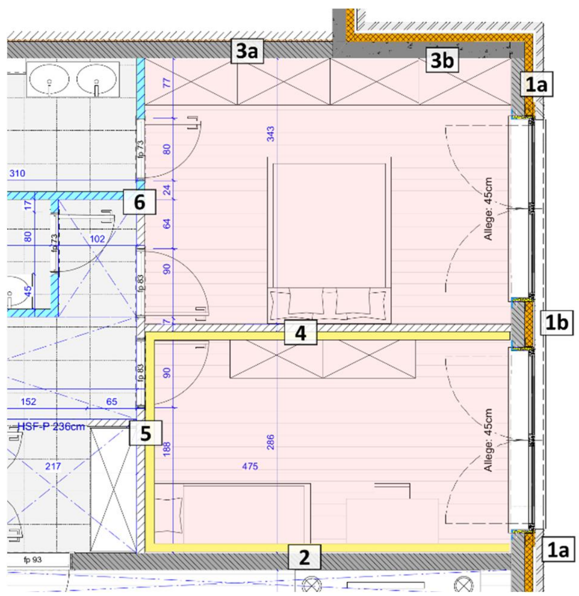


Figure 15 : Plan layout with wall numbering

Table 2 : Walls construction thermo-physical properties (green color: Manufacturer's data or as built documents, blue color: assumptions)

	Thickness	Thermal conduct.	Density	Spec Ht	SW Absorbtion	LW Emission
Layer	m	W/mK	kg/m3	J/kgK	-	-
[1a] External façade wall - *from outdoor to indoor // Rse = 0.04 m²K/W , Rsi = 0.13 m²K/W*						
Facade bricks (Floren Polaris)	0.1	0.6	1700	1000	0.54	0.9
Air	0.03	2	-	-		
Insulation XPS	0.12	0.029	1200	1000		
Silica blocks	0.175	0.91	1800	1000		
Plaster	0.003	0.52	1200	1000	0.25	0.9
Total	0.428			U =	0.213	W/m²K
[1b] External façade wall btwn windows - *from outdoor to indoor // Rse = 0.04 m²K/W , Rsi = 0.13 m²K/W*						
Insulation XPS	0.12	0.029	1200	1000	0.55	0.9

Silica blocks	0.175	0.91	1800	1000		
Plaster	0.003	0.52	1200	1000	0.25	0.9
Total	0.298			U =	0.22	W/m²K
[2] Party wall between bedroom 1 and living room *// Rsi = 0.13 m²K/W*						
Plaster	0.003	0.52	1200	1000	0.25	0.9
Silica blocks	0.214	0.91	1800	1000		
Plaster	0.003	0.52	1200	1000		
XPS	0.1	0.0357	35	1450	0.55	0.9
Total	0.32			U =	0.30	W/m²K
[3a] Party wall between bedroom 2 and adjacent apartment *// Rsi = 0.13 m²K/W*						
Plaster	0.003	0.52	1200	1000	0.25	0.9
Silica blocks	0.214	0.91	1800	1000		
Rockwool	0.03	0.035	45	130		
Plaster blocks	0.1	0.3	900	1000	0.25	0.9
Total	0.347			U =	0.59	W/m²K
[3b] External wall : first floor : AU *// Rsi = 0.13 m²K/W*						
Facade bricks (Floren Polaris)	0.1	0.6	1700	1000	0.54	0.9
Air	0.03	2	-	-		
Insulation XPS	0.12	0.029	1200	1000		
Reinforced Concrete	0.214	1.7	2500	880	0.25	0.9
Total	0.464			U =	0.22	W/m²K
[3b] External wall : second floor : BU *// Rsi = 0.13 m²K/W*						
Facade bricks (Floren Polaris)	0.1	0.6	1700	1000	0.54	0.9
Air	0.03	2	-	-		
Insulation XPS	0.12	0.029	1200	1000		
Silica blocks	0.214	0.91	1800	1000	0.25	0.9
Total	0.464			U =	0.21	W/m²K
[4]-[5] Party walls with insulation *// Rsi = 0.13 m²K/W*						
Plaster blocks	0.1	0.3	900	1000	0.25	0.9
XPS	0.1	0.0357	1200	1000	0.55	0.9
Total	0.2			U =	0.29	W/m²K
[6a]-[6b] Party walls without insulation *// Rsi = 0.13 m²K/W*						
Plaster blocks	0.1	0.3	900	1000	0.25	0.9
Total	0.10			U =	1.69	W/m²K
[5]-[6a]-[6b] Int. doors						
Wood	0.05	0.14	1200	1000	0.25	0.9
Total	0.05			U =	2.80	W/m²K

Floors and ceilings

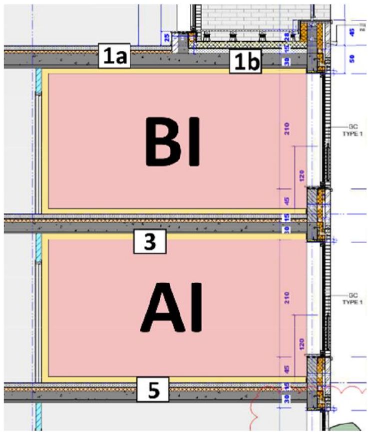


Figure 16: Section in units AI and BI with wall numbering

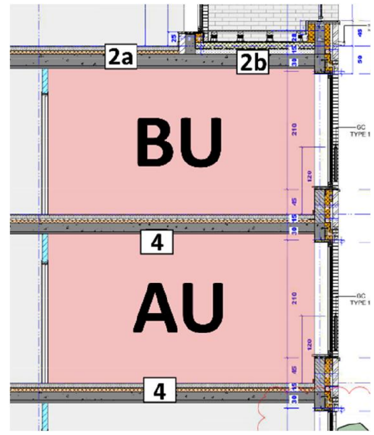


Figure 17: Sections in units AU and BU with wall numbering

Table 3 : Floors construction thermo-physical properties (green color: Manufacturer's data or as built documents, blue color: assumptions)

	Thickness	Thermal conduct.	Density	Spec Ht	SW Absorbtion	LW Emission
Layer	m	W/mK	kg/m3	J/kgK	-	-
[1a] Roof (BI - top int) - top down						
Wooden floor	0.01	0.102	1700	1600	0.44	0.9
Screed	0.07	1.300	1200	880		
Concrete (béton mousse)	0.07	0.090	400	1000		
Reinforced Concrete	0.2	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000		
XPS	0.1	0.036	1200	1000	0.55	0.9
Total	0.5			U =	0.24	W/m^2K
[1b] Roof (BI - terrasse) - top down						
Insulation PIR	0.1	0.026	40	1400	0.25	0.9
Concrete (béton de pente)	0.1	1.300	1200	1000		
Reinforced Concrete	0.2	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000		
XPS	0.1	0.036	1200	1000	0.55	0.9
Total	0.55			U =	0.14	W/m^2K
[2a] Roof (BU - top int) - top down						
Wooden floor	0.01	0.102	1700	1600	0.44	0.9
Screed	0.07	1.300	1200	880		
Concrete (béton mousse)	0.07	0.090	400	1000		
Reinforced Concrete	0.2	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000	0.25	0.9
Total	0.4			U =	0.74	W/m^2K

[2b] Roof (BU - terrasse) - top down						
Insulation PIR	0.1	0.026	40	1400	0.25	0.9
Concrete (béton de pente)	0.1	1.300	1200	1000		
Reinforced Concrete	0.2	1.700	1200	1000		
Predalle	0.05	1.700	1800	1000	0.25	0.9
Total	0.45			U =	0.23	W/m²K
[3] Floor (AI-BI) - top down						
XPS	0.1	0.036	1200	1000	0.55	0.9
Wooden floor	0.01	0.102	1700	1600		
Screed	0.07	1.300	1200	880		
Concrete (béton mousse)	0.07	0.090	1200	1000		
Reinforced Concrete	0.15	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000		
XPS	0.1	0.036	1200	1000	0.55	0.9
Total	0.55			U =	0.14	W/m²K
[4] Floor (AU-BU and AU-down) - top down						
Wooden floor	0.01	0.102	1700	1600	0.44	0.9
Screed	0.07	1.300	1200	880		
Concrete (béton mousse)	0.07	0.090	1200	1000		
Reinforced Concrete	0.15	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000	0.25	0.9
Total	0.35			U =	0.76	W/m²K
[5] Floor (AI-down) - top down						
XPS	0.1	0.036	1200	1000	0.55	0.9
Wooden floor	0.01	0.102	1700	1600		
Screed	0.07	1.300	1200	880		
Concrete (béton mousse)	0.07	0.090	1200	1000		
Reinforced Concrete	0.15	1.700	1800	1000		
Predalle	0.05	1.700	1800	1000	0.25	0.9
Total	0.45			U =	0.24	W/m²K

3.5. Glazing thermal and optical properties

The double glazing is composed by two glass layers of 4mm, separated by 16mm of gas (Argon), with low emissivity layer.

The main thermal properties are specified in the Table 4.

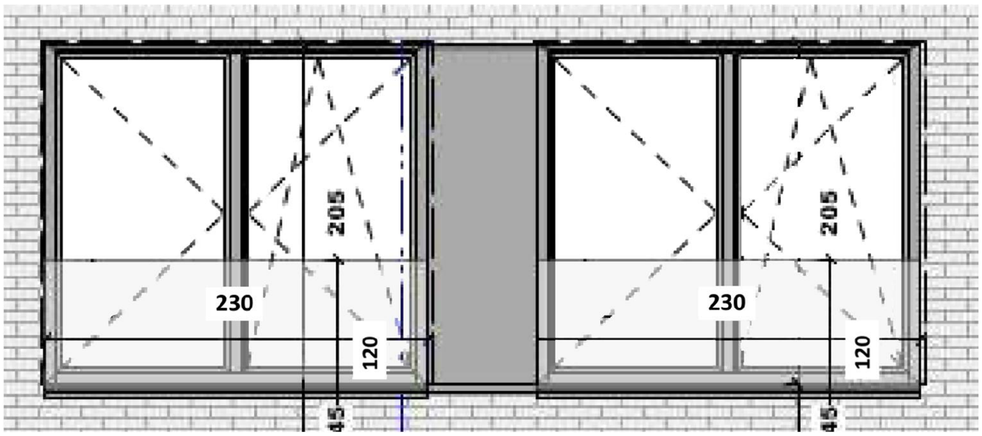


Figure 18 : Façade windows description

Table 4 : Windows main thermal properties

Glazing ID	UG	UF	Ψ glass edge	Uw	SF	LT
	W/(m²K)	W/(m²K)	W/mK	W/(m²K)	%	%
G1	1.00	3.00	0.029	1.54	45	70
G2	1.00	3.00	0.029	1.54	45	70
Total living	1.00	3.00	0.029	1.54	45	70

Table 5 gathers other properties of the glasses:

Table 5 : Other window properties

Propertie	Value	
Light reflexion (exterior)	20	%
Light reflexion (interior)	21	%
Light absorption	10	%
Solar energy direct transmission	39	%
Solar energy direct reflexion	30	%
Solar energy direct absorption	31	%
Réémission thermique vers l'intérieur:	6	%
UV transmission	0	%
UV reflexion	5	%
UV absorption	95	%
Indice général de rendu des couleurs (trans.):	94	
Sélectivité (transmission lumineuse / g):	1.6	
Coefficient d'ombrage (g / 0.87):	52	%
Coefficient d'ombrage (g / 0.8):	56	%

3.6. Shade screen

During the experiment, a scaffold was present in front of the windows. It has an influence on the solar heat gains. The placement of pyranometers in front of the window, inside the units BU and BI allows to assess the heat gains despite of these shade screen. Beyond this scaffold, there were no other masks affecting the solar gains as the site was clear in front of the building of the experiment.

Figure 19 : Internal view in the bedroom unit B, effect of the shade screen

Figure 20 : View of the scaffold, Unit BI

Figure 21: Pyranometer in front of the window in unit BU

3.7. Thermal bridges

The thermal bridges Ψ values were assessed via the THERM software. The thermal loss calculation is performed on the basis of internal wall dimensions. The main thermal bridges are illustrated in Figure 22.

Figure 23 and Figure 24 show the location of the thermal bridges specified in Table 6.

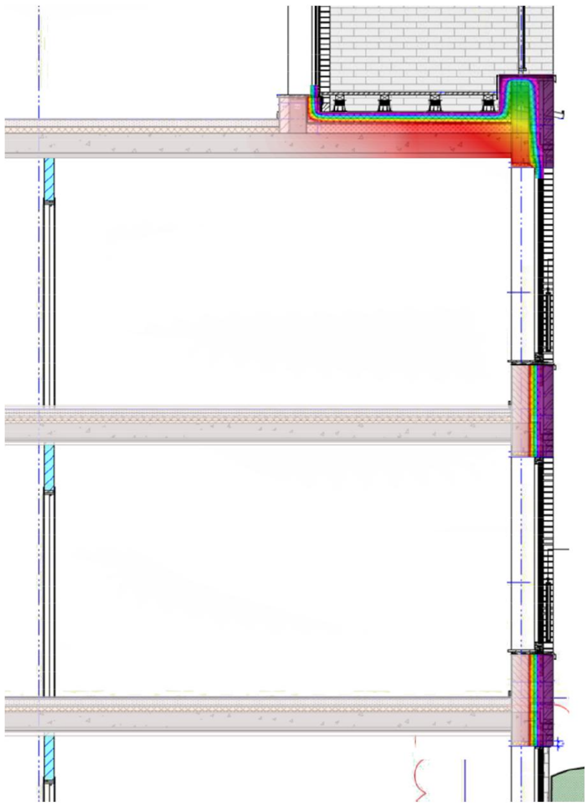


Figure 22 : Section drawing of the main thermal bridges

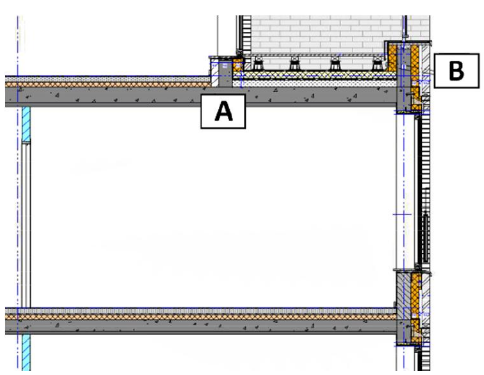


Figure 23 : Location of thermal bridge, section in units B

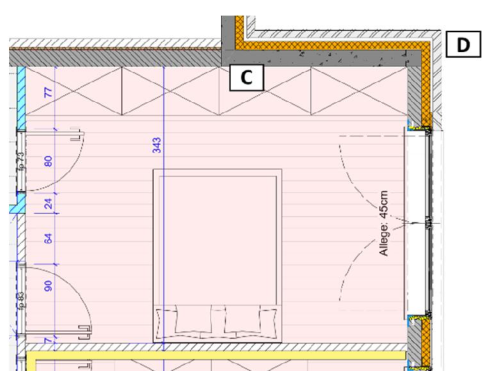
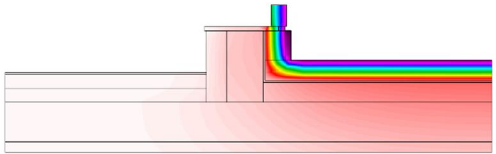
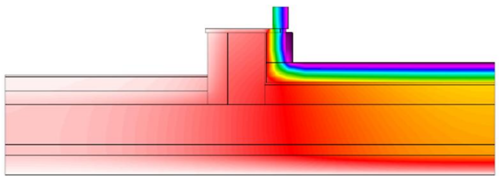
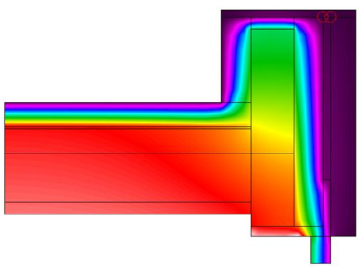
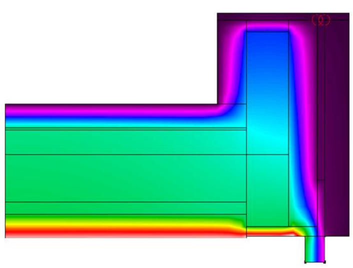
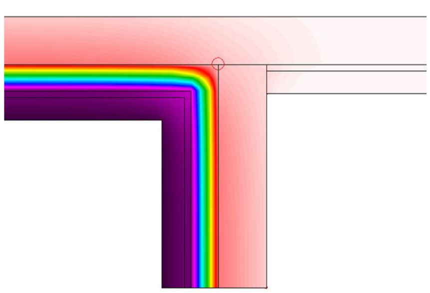


Figure 24 : Location of thermal bridge, plan

Table 6 : Thermal bridges dimensions and heat losses

	Dimension	Ψ	TB heat loss
[A] Losses by the door of the terrace of the apartment above unit B			
BU 	3.43 m	0.014 W/Km	0.05 W/K
BI 	2.86 m	-0.04 W/Km	-0.11 W/K
[B] Roof parapet			
BU 	3.43 m	0.23 W/Km	0.81 W/K
BI 	2.86 m	0.11 W/Km	0.32 W/K
[C] Junction between walls [3b] and [3a]			
AU 	2.65 m	-0.05 W/Km	-0.13 W/K

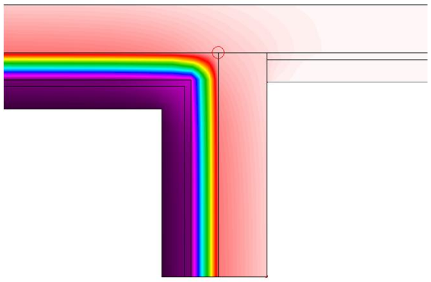
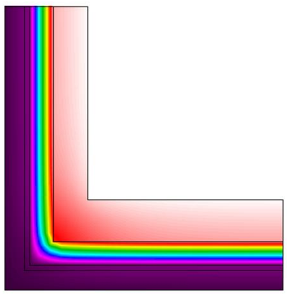
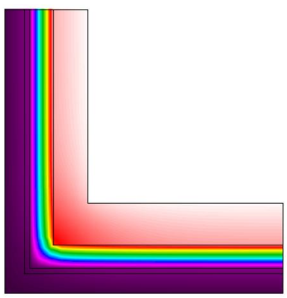
BU 	2.60 m	-0.05 W/Km	-0.13 W/K
[D] Outgoing angle			
AU 	2.65 m	0.09 W/Km	0.23 W/K
BU 	2.60 m	0.09 W/Km	0.23 W/K

Table 7 : Total of thermal bridge losses for each unit

AI	AU	BI	BU
0 W/K	0.10 W/K	0.22 W/K	0.95 W/K

3.8. Internal Thermal Bridges

There are additional thermal bridges leading to heat loss between internal rooms. Descriptions and values of those different internal thermal bridges are outlined in Table 8.

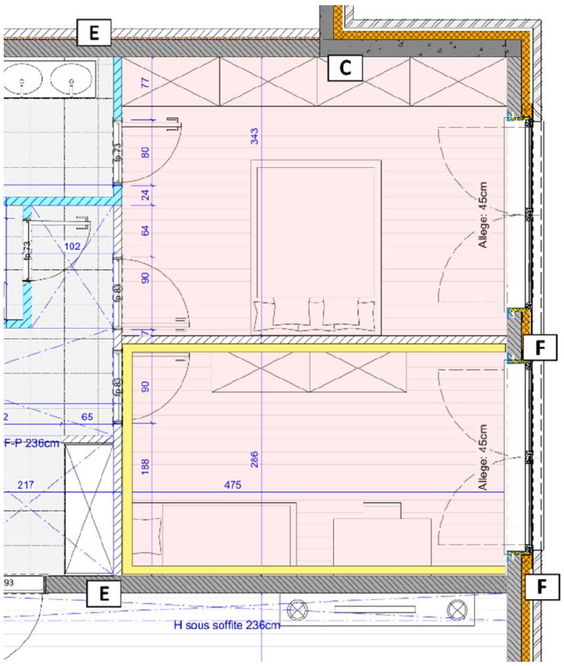


Figure 25 : Position of internal thermal bridge, plan layout

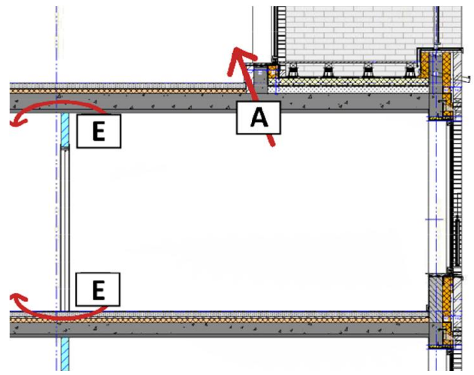
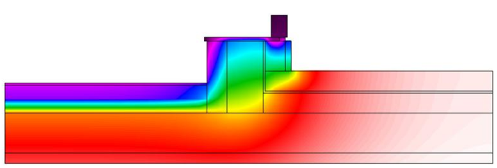
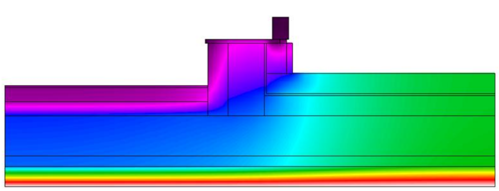
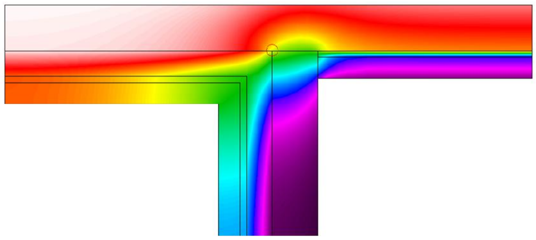
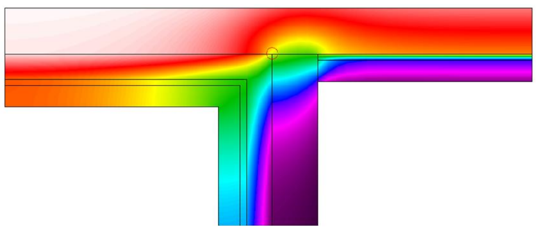
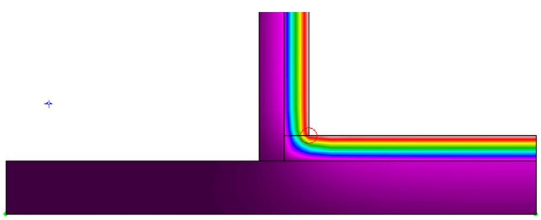
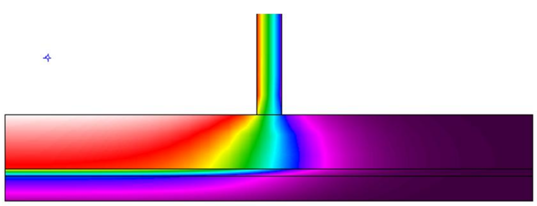
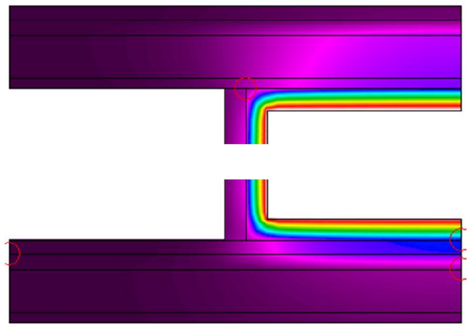
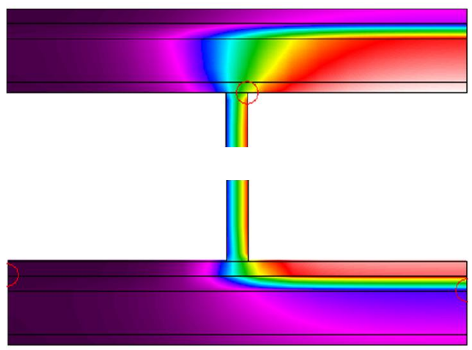
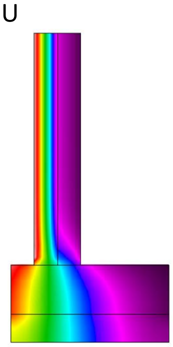
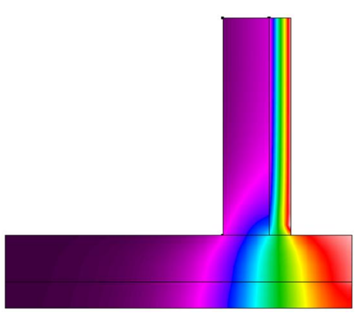


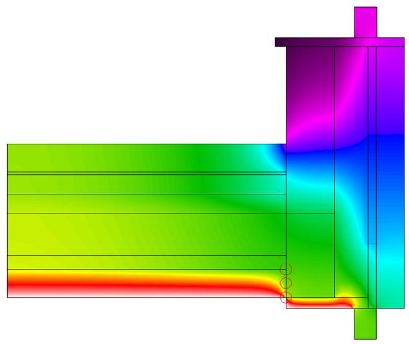
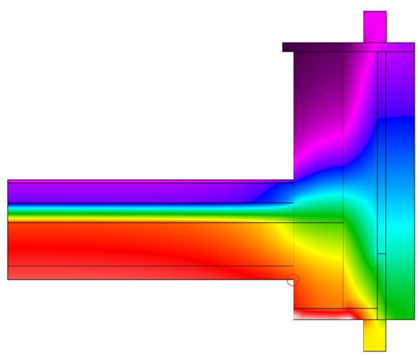
Figure 26 : Position of internal thermal bridges, section

Table 8 : Internal thermal bridges dimensions and heat losses

	Dimension	Ψ	TB heat loss
[A] Losses toward the apartment above unit B			
BU 	3.43 m	0.49 W/Km	1.69 W/K
BI 	2.86 m	0.25 W/Km	0.71 W/K

[C] Losses toward apartment adjacent to units AU and BU			
AU 	2.65 m	0.48 W/Km	1.26 W/K
BU 	2.60 m	0.48 W/Km	1.26 W/K
[E] Losses toward the north part of the apartment, by the walls and floor			
Vertical junction wall – wall : AI/BI 	2.6 m	0.02 W/Km	0.06 W/K
Vertical junction wall – wall : AU/BU 	2.6 m	0.36 W/Km	0.93 W/K

Horizontal junctions wall – ceiling and floor : AI/BI 	2.86 m	0.13 W/Km	0.38 W/K
Horizontal junctions wall – ceiling and floor : AU/BU 	3.43 m	0.80 W/Km	2.73 W/K
[F] Losses of insulated units, by the silica blocks of the façade, towards adjacent units			
AI/BI toward AU/BU 	2.6 m	0.4 W/Km	1.04 W/K
AI/BI toward wet adjacent apartment 	2.6 m	0.37 W/Km	0.96 W/K

[G] Losses upward (from A to B units), by the silica blocks of the façade			
AI toward BI 	2.86 m	0.25 W/Km	0.73 W/K
AU toward BU 	3.43 m	0.38 W/Km	1.30 W/K

3.9. Ventilation

Mechanical ventilation was shut off during the whole measurement period. The ventilation inlets/outlets were sealed with tape to limit heat exchanges due to infiltration.

3.10. Heating

Co-heating was performed with an electric radiator, with the configuration shown in Figure 27. The power of the radiator is directly controlled by the indoor temperature measured by the temperature sensor located at the center of the room.

Figure 27 : Electric radiator in the insulated unit (AI)

The goal of the experiment is to perform side by side experiments with a time duration of 9 days. The units AI and AU were heated while units BI and BU were in floating temperature mode. The heating set point was 33°C.

3.11. Air leakages

Pressurisation tests (blowerdoor) were carried out on construction site on the 29/06/2018 with the conditions of the experiment (i.e. with insulation in units BI and AI). Different air leakages values for each unit have been obtained, gathered in the following table:

Table 9 : Air leakage results

Blowerdoor test 50 Pa	AI	AU	BI	BU
V50 [m³/h]	144	139	69	96

The windows were not well fixed at the time of the test and those frome zone A were less fixed. This can explain the difference of air leakage measured in this zone in comparison with zone B. However those results are kept as they represents the conditions of the test and the infiltration occurring during all the experiment.

3.12. Weather

The weather data during the experiment were collected on site with a weather station located on roof. This station collected the data of wind speed and direction (at approximatively 10 m above the ground), atmospheric pressure, air temperature, relative humidity, rain fall and intensity and global solar radiation on a horizontal plane. The data were recorded as average values every 10 minutes. One supplementary station was placed on the roof, just next to the first weather station, collecting global solar radiation on a vertical plane at the same frequency. Two other pyranometers were placed in the BU and BI units, just behind the windows, to collect global solar radiation entering the units.

Figure 28 : Weather station on the roof

Figure 29 : Pyranometer in front of the window in unit BU

3.13. Ground reflectivity

The ground reflectivity wasn't measured. The scaffold interfere surely with those data. In front of the building, the main ground surfaces are sand, roads and the construction lodges.

Figure 30: Panoramic view toward the window of unit AU

Figure 31 : View from unit BI

Figure 32: View from unit BU

Figure 33: View of the parcel with the building in the background

3.14. Predicted HLC

The calculation of a theoretical heat loss coefficient is summarized in the following table. It takes into account:

- External wall heat loss coefficient: depending on the U-value of the external wall and windows
- Thermal bridges heat loss coefficient: the values were described in chapter 3.7
- Infiltration heat loss coefficient: the blower door test shows air leakages resulting from a wind pressure of 50 Pa. In real conditions, a mean value of 2 Pa is assumed.

Table 10 : Predicted HLC

	AI			AU			BI			BU		
Wall loss												
	Dimension	U	TB loss [W/K]	Dimension	U	TB loss [W/K]	Dimension	U	TB loss [W/K]	Dimension	U	TB loss [W/K]
External wall [1a]	2.45 m^2	0.21 W/Km^2	0.52	3.76 m^2	0.21 W/Km^2	0.80	2.31 m^2	0.21 W/Km^2	0.49	3.59 m^2	0.21 W/Km^2	0.77
Ext. wall btw windows	0.41 m^2	0.22 W/Km^2	0.09	0.62 m^2	0.22 W/Km^2	0.14	0.41 m^2	0.22 W/Km^2	0.09	0.62 m^2	0.22 W/Km^2	0.14
External wall [3b]				6.09	0.22	1.34				5.97 m^2	0.21 W/Km^2	1.25
Roof							6.12 m^2	0.14 W/Km^2	0.86	7.89 m^2	0.23 W/Km^2	1.82
Window	4.72 m^2	1.54 W/Km^2		4.72 m^2	1.54 W/Km^2		4.72 m^2	1.54 W/Km^2		4.72 m^2	1.54 W/Km^2	
Window - glass	3.60 m^2	1.00 W/Km^2	3.60	3.60 m^2	1.00 W/Km^2	3.60	3.60 m^2	1.00 W/Km^2	3.60	3.60 m^2	1.00 W/Km^2	3.60
Window - frame 1	1.12 m^2	3.00 W/Km^2	3.35	1.12 m^2	3.00 W/Km^2	3.35	1.12 m^2	3.00 W/Km^2	3.35	1.12 m^2	3.00 W/Km^2	3.35
Window - glass edge	11.26 m	0.03 W/Km	0.33	11.26 m	0.03 W/Km	0.33	11.26 m	0.03 W/Km	0.33	11.26 m	0.03 W/Km	0.33
Total wall loss		[W/K]	7.89		[W/K]	9.55		[W/K]	8.71		[W/K]	11.24

	AI			AU			BI			BU		
Thermal Bridge loss												
	Dimension	Ψ	TB loss [W/K]	Dimension	Ψ	TB loss [W/K]	Dimension	Ψ	TB loss [W/K]	Dimension	Ψ	TB loss [W/K]
[A] Terrace parapet	-	-	-	-	-	-	2.86 m	-0.04 W/Km	-0.11	3.43 m	0.01 W/Km	0.05
[B] Parapet	-	-	-	-	-	-	2.86 m	0.11 W/Km	0.32	3.43 m	0.23 W/Km	0.80
[C] Ingoing angle	-	-	-	2.65 m	-0.05 W/Km	-0.13	-	-	-	2.60 m	-0.05 W/Km	-0.13
[D] Outgoing angle	-	-	-	2.65 m	0.09 W/Km	0.23	-	-	-	2.60 m	0.09 W/Km	0.23
Total thermal bridges		[W/K]	0		[W/K]	0.10		[W/K]	0.22		[W/K]	0.95

	AI			AU			BI			BU		
Infiltration loss												
	V50 value [m^3/h]	ACH conversion [m^3/h]	TB loss [W/K]	V50 value [m^3/h]	ACH conversion [m^3/h]	TB loss [W/K]	V50 value [m^3/h]	ACH conversion [m^3/h]	TB loss [W/K]	V50 value [m^3/h]	ACH conversion [m^3/h]	TB loss [W/K]
	144.00	7.20	2.40	139.00	6.95	2.32	69.00	3.45	1.15	96.00	4.80	1.60
Total infiltration loss		[W/K]	2.40		[W/K]	2.32		[W/K]	1.15		[W/K]	1.60

	AI			AU			BI			BU		
Total heat loss		**[W/K]**	**10.29**		**[W/K]**	**11.97**		**[W/K]**	**10.08**		**[W/K]**	**13.79**

4. EXPERIMENTAL SCHEDULE

The experiment was undertaken in parallel in 4 similar units so that all units were submitted to the same weather conditions. The experiment lasted from the 2018/06/29 to 2018/07/11. There are holes in the data recording from 2018/06/29 14:51 to 2018/07/01 12:13 and from 2018/07/02 13:00 to 2018/07/03 11:05. For this reason the heating period has been extended from 9 days to 11 days and the units were heated during all this time.

The units AI and AU were heated (set point 33°C) while units BI and BU were in floating temperature.

5. INSTRUMENTATION

5.1. Internal sensors

Sensors are named with 5 letters, to identify in which apartment they are located and where precisely. The following table summarizes the meaning of letters composing the name of the sensors.

Logger zone	Unit	Sensor type	Sensor location - 1	Sensor location - 2
A *Apart. C.1.4*	I *Insulated*	T *Temperature*	B *Back*	E *East*
B *Apart. C.2.4*	U *Uninsulated*	R *Radiation*	F *Front*	W *West*
			M *Middle*	N *North*
			I *Interface*	C *Ceiling*
			S *Sanitary*	G *Ground*
				M *Medium*
				H *High*

Notes:

Sensor location 1:

- (B, F, M): according to the depth from the façade (B: back of the room, F: next to the façade, M: middle of the room)
- (I) : interface between wall and insulation
- (S) : neighbor Northern zone

Sensor location 2:

- (M,H): If air temperature sensor: at medium height (M) or near the ceiling (H)
- (E,W,N,C,G): If interface temperature sensor: at the East (E), West (W) or North (N) wall surface or at the ceiling (C) or floor (G) surface

Description of different sensors:

- 9 Temperature sensors per unit: 5 sensors located on the ceiling, floor and party walls either on the wall surfaces in uninsulated units, or at the interface between walls and insulation panels in insulated units, 2 air temperature sensors in the tested unit (in the center of the room, one high and the other at 1m20), 1 temperature sensor in the adjacent Northern zone in the same apartment.
- 1 pyranometer in each unit B, named BIRFM and BURFM. It was located in front of the windows as shown in Figure **34**. It allows to collect the total amount of solar irradiance entering the units.
- Co-heating consumptions were monitored in kWh. NOTE: The recorded powers are computed from the differences of the recorded consumptions. As data were recorded with a 10 minutes interval, recorded power must be multiplied by 6 to be expressed in Watt.

Figure 34 : Pyranometer in unit BU

5.2. Weather sensors

A weather station located on the roof collected:

- Solar radiation data: direct and global on a horizontal plane + calculation of the difference for diffuse radiation in W/m2 ;
- Wind: speed in m/s / orientation and maximal speed in degree from North ;
- Temperature in °C ;
- Relative humidity in % ;
- Atmospheric pressure in Pa;

A vertical pyranometer was let on the roof, near the weather station and south-east oriented, measuring the total solar radiation on a vertical plane in W/m²

6. PROVIDED MEASURED DATA

All the data are provided in three Excel files, with a10 minutes time step:

- L_3.3.3.8_Table_A_180629_180711.xlsx : for data in unit A (apartment C.1.4)
- L_3.3.3.8_Table_B_180629_180711.xlsx : for data in unit B (apartment C.2.4)
- L_3.3.3.8_Table_W_180629_180711.xlsx : for weather data

ANNEXES

INTERNAL DIMENSIONS

C.1.4 and C.2.4		AI	BI	AU	BU
		Room			
Floor area	m²	12.37	12.37	16.29	16.29
Interior ceiling height	m	2.65	2.60	2.65	2.60
Volume	m³	32.78	32.16	43.18	42.36

Walls

		AI	BI	AU	BU
[1a] External wall_S	m²	2.45	2.31	3.76	3.59
[1b] External wall_S between windows	m²	0.41	0.41	0.62	0.62
[1] Windows	m²	4.72	4.72	4.72	4.72
Glass	m²	3.60	3.60	3.60	3.60
Frame	m²	1.12	1.12	1.12	1.12
Glass percentage	%	76	76	76	76
Glass edge	m	11.26	11.26	11.26	11.26
[2] Party wall between bedroom 1 and living room	m²	12.59	12.35		
[3a] Party wall btwn bedroom 2 and adjacent apartment	m²			6.50	6.38
[3b] External Wall	m²			6.09	5.97
[4] Party wall between bedrooms	m²	12.59	12.35	12.59	12.35
[5] Party wall between bedroom 1 and corridor	m²	5.60	5.46		
[5] Int. door between bedroom 1 & corridor	m²	1.98	1.98		
[6a] Party wall between bedroom 2 and corridor	m²			2.29	2.21
[6a] Int. door between bedroom2 & corridor	m²			1.98	1.98
[6b] Party wall between bedroom 2 and bathroom	m²			3.04	2.95
[6b] Int. door between bedroom2 & bathroom	m²			1.76	1.76

Floors and ceilings

[1a] Roof (BI - top int) - top down	m²		6.25		
[1b] Roof (BI - terrasse) - top down	m²		6.12		
[2a] Roof (BU - top int) - top down	m²				8.40
[2b] Roof (BU - terrasse) - top down	m²				7.89
[3] Floor (AI-BI) - top down	m²	12.37	12.37		
[4] Floor (AU-BU and AU-down) - top down	m²			16.29	16.29
[5] Floor (AI-down) - top down	m²	12.37			

LIST OF FIGURES

LIST OF TABLES