Case Sabin in Pieve di Soligo, Treviso, Italy – project ID 2194

Multifamily building with 11 residential flats, 3 offices and 2 shops.

Project Designer — Passive House Planner: Marco Filippi engineer (www.edificizeroenergia.it)

Architecture: Stefano Zara architect
Structure: Angelo Favotto engineer
Systems: Michele Dorigo expert
Acoustic: Cristian Bortot expert

This multifamily building was realized in the centre of Pieve di Soligo, a 12.000 people town located in the northern area of Treviso province, Italy. The climate is characterized by mildly cold winters (temperature seldom below -10 °C) and by humid summers (with several weeks over 30 °C and RH over 50%).
The passive house consists of 2 separate buildings (‘grande’ and ‘piccolo’, that is to say respectively ‘big’ and ‘small’ in Italian) of 4 floors above ground plus a 1-floor basement. The structure is made by concrete, for both horizontal (i.e. floors) and vertical (i.e. exterior walls) structures. First families occupied the house in the second part of 2010.

Special features: Photovoltaic field to fully feed electrical needs for heating, cooling and hot water demand, ground source heat pump, use of rainwater.

U-value external wall	0,131 W/m^{2}K
U-value basement ceiling	0,141 W/m^{2}K
U-value roof	0,116 W/m^{2}K
U-value window	0,80 W/m^{2}K
Heat recovery	84,7%

PHPP Annual heating demand	**grande**	**4 kWh/m^{2}a**
	piccolo	**9 kWh/m^{2}a**
PHPP Annual cooling demand	grande	2 kWh/m^{2}a
	piccolo	2 kWh/m^{2}a
PHPP primary energy demand	grande	73 kWh/m^{2}a
	piccolo	103 kWh/m^{2}a
pressure test n_{50}	grande	0,23 h^{-1}
	piccolo	0,27 h^{-1}

2.1 Description of the construction task

The'newer' project for the site area (see 2.12 for details) was firstly intended to be a low-energy building, but not to reach passive house requirements. Klimahaus (Italian voluntary classification standard) class B was the target. The site owner Boscarato Costruzioni S.r.l. decided then to raise the energy efficiency of the envelope to the passive level, balancing the extra costs by minimizing the plants. Thus, heating / cooling with air was chosen.
The certification task was to certify the building with both PHI and Klimahaus. This was successfully achieved.

2.3 Pictures of elevations

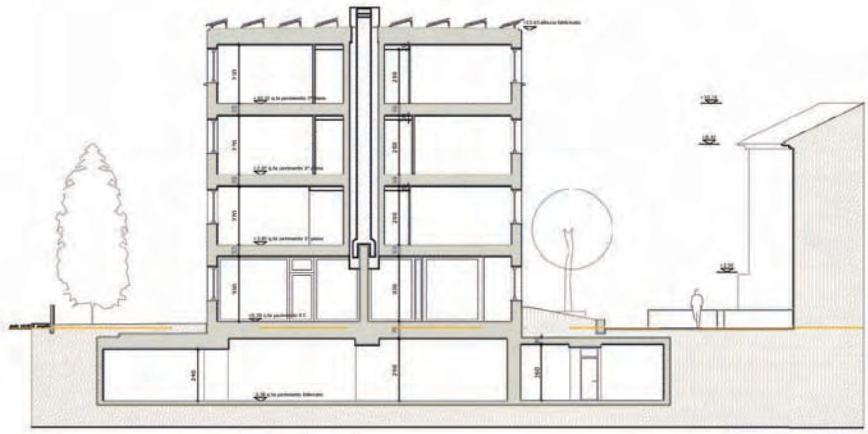
west and north prospect ↑
south and west prospect ↘

Non-heated stairwell,
north prospect ↑
and south prospect ↗
the photovoltaic field →

2.4 Pictures of the interior

2.5 Implementation plan

Transversal cross section and elevations

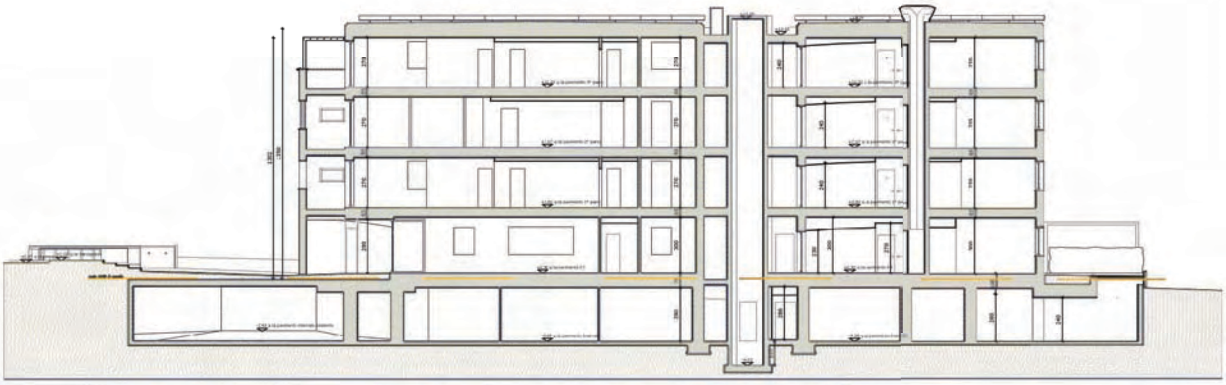


SEZIONE TRASVERSALE

PROSPETTO EST

PROSPETTO OVEST

Longitudinal cross section and elevations

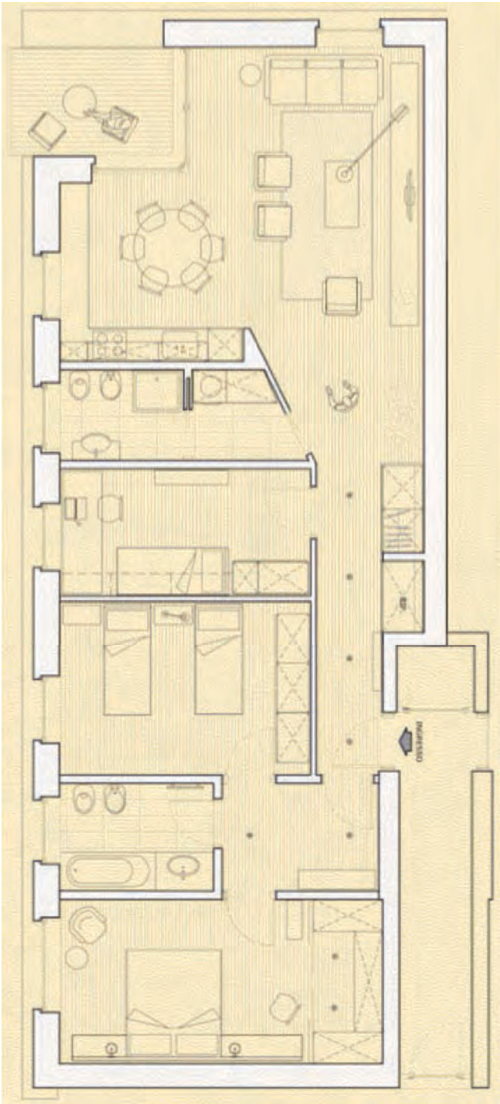


SEZIONE LONGITUDINALE

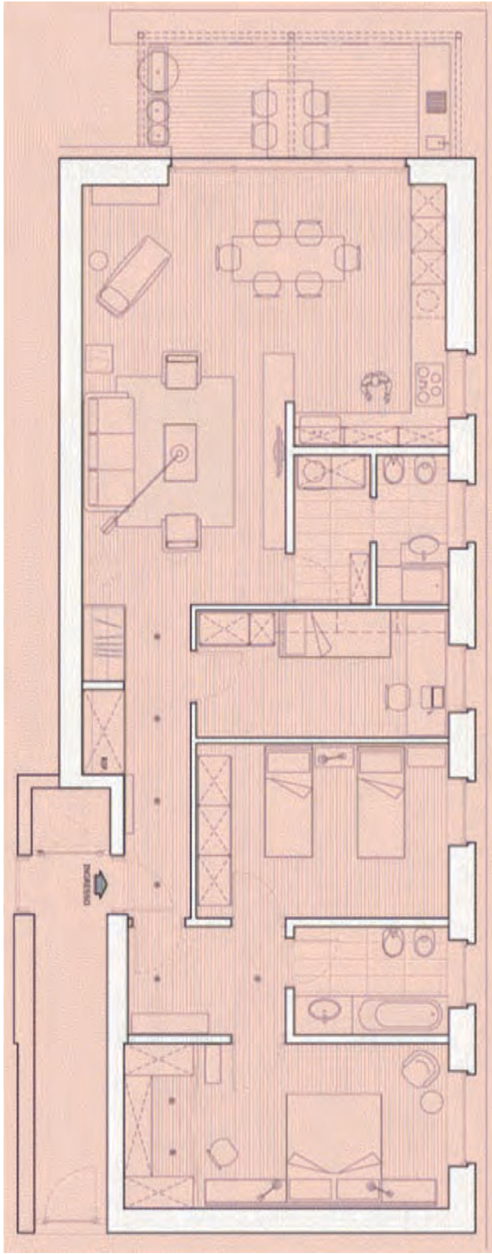
PROSPETTO NORD

PROSPETTO SUD

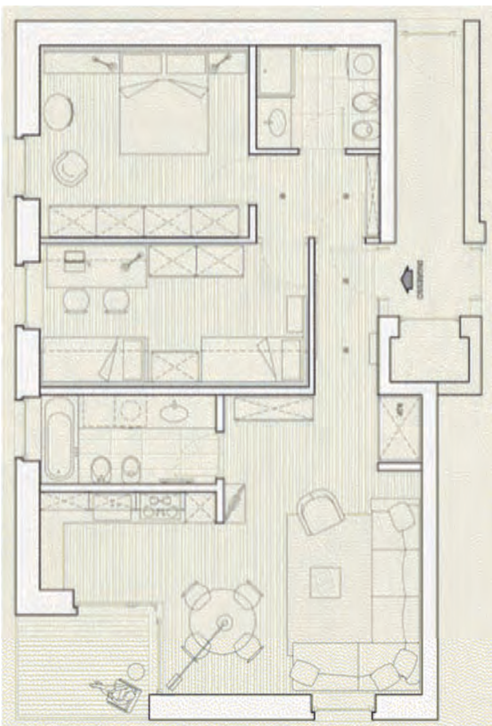
2.6 Floor plans Typical floor layouts:



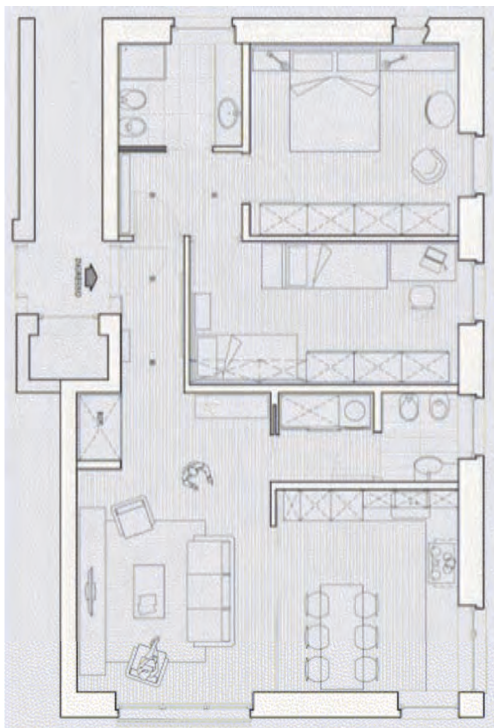
edificio grande, south flat



edificio grande, noth flat



edificio piccolo, south flat



edificio piccolo, noth flat

2.7 Construction details

Initial remark: If not otherwise stated, descriptions are valid for both edificio piccolo and edificio grande.

2.7.1 Construction detail / basement ceiling

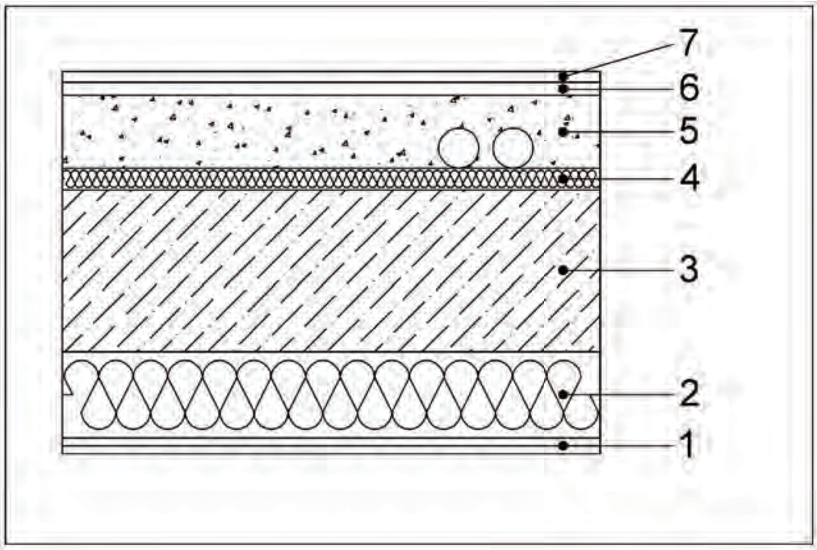
The building having a non-heated basement, in addition to the ceiling insulation the following thermal bridges were corrected as per the sketches below (see points 2. and 3.):

- thermal bridge caused by vertical structures on the basement;
- thermal bridge caused by basement ceiling continuing outside the heated volume on exterior green areas.

Separate (i.e. completely disconnected) structures were designer for ‘edificio piccolo’, ‘edificio grande’ and the non-heated stairwell. This allowed not to insulate the stairwell basement ceiling.

Details:

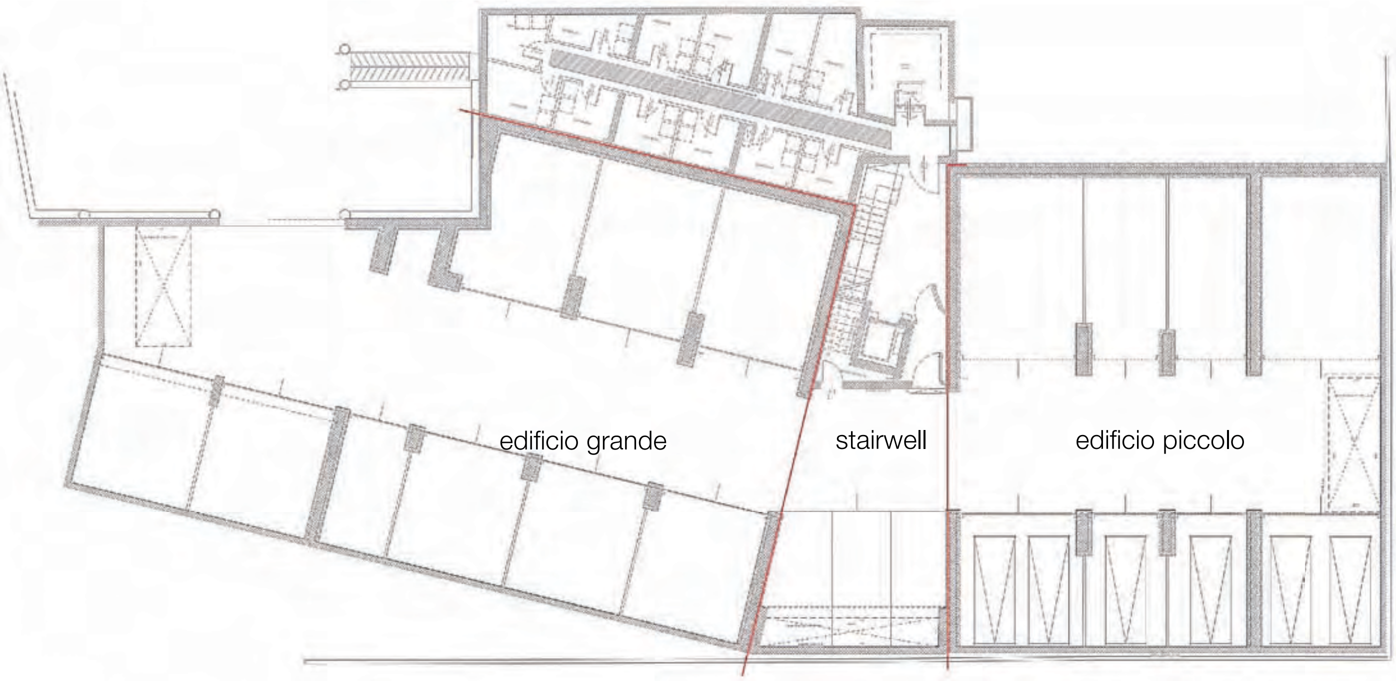
1. Cross section.



1 – REI 60’ double plasterboard – 30 mm
2 – graphite-added EPS – 160 mm
3 – concrete slab – 300 mm
4 – XPS – 40 mm
5 – grit 4/8 mm – 135 mm
6 – plywood panel – 25 mm
7 – wood flooring – 20 mm
Note: for ceramic flooring, 6. is substituted by fiber gypsum panel.

$U = 0{,}141\ W/m^2K$

2. Separation of structures.

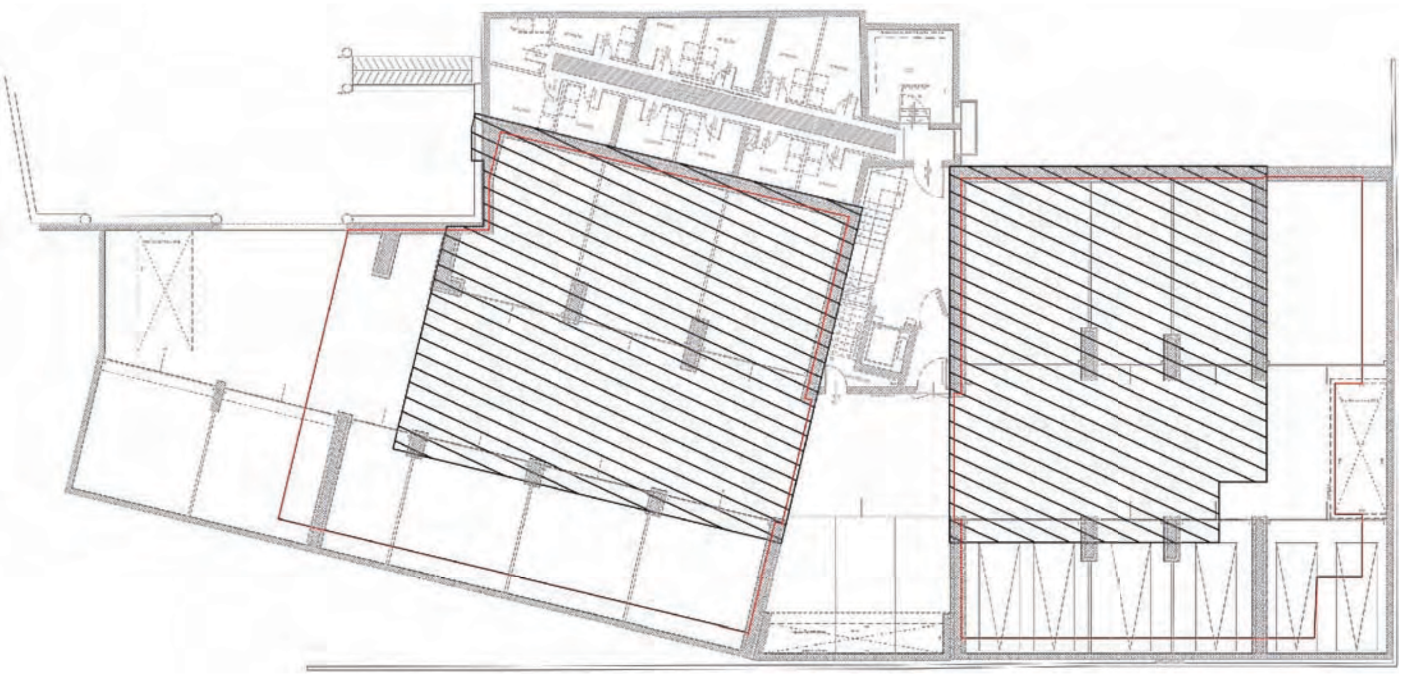


The red lines indicate the interfaces between the 3 different areas (edificio piccolo, stairwell, edificio grande). Only edificio piccolo and edificio grande basement ceilings are insulated thanks to complete disconnection between adjacent areas.

3. Correction of thermal bridges.
Vertical structures of the basement:

In red, septa and walls are insulated by graphite-added EPS (120 mm) fire protected by a double plasterboard layer (30 mm).
In green (number 2 in the sketch above), the wall against the ground is insulated by XPS (160 mm).
In cyan (number 3 in the sketch above), the interface with another existing basement is insulated with EPS (40 mm). This portion of the basement wall was an existing wall deriving from an abandoned previous project.
The dashed area represent the gross area of the two buildings.

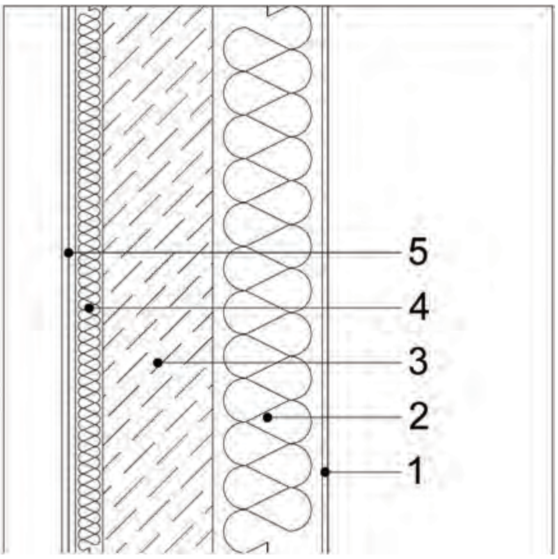
Horizontal structures of the basement:



In red, the insulated portion of the basement ceiling. The dashed area representing the gross area of the two building, one should notice that the insulated portion extends for a length of 4 meters from the external walls of the buildings, in order to correct the thermal bridge. This corrective insulation was laid on both intrados and extrados. Intrados was insulated as the rest of the basement ceiling (i.e. graphite-added EPS, 160 mm plus double plasterboard, 30 mm), while extrados was insulated by XPS (160 mm).

2.7.2 Construction details / exterior walls

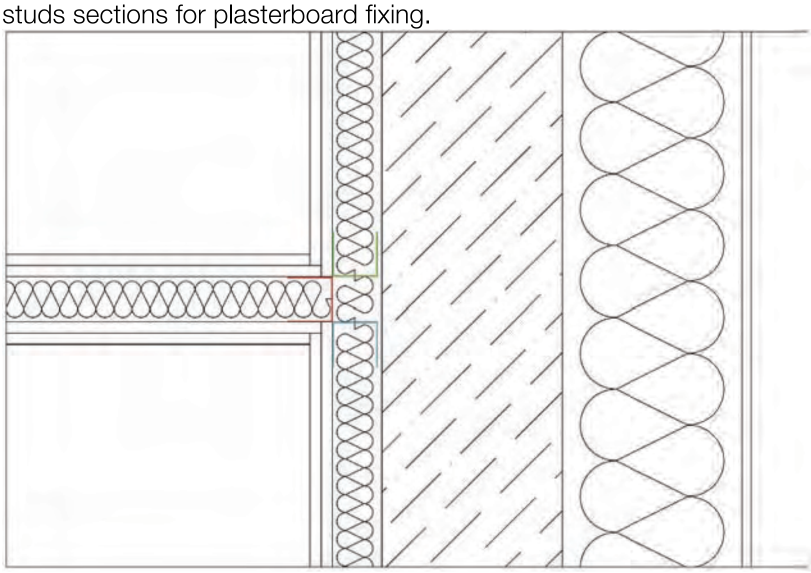
Cross section:



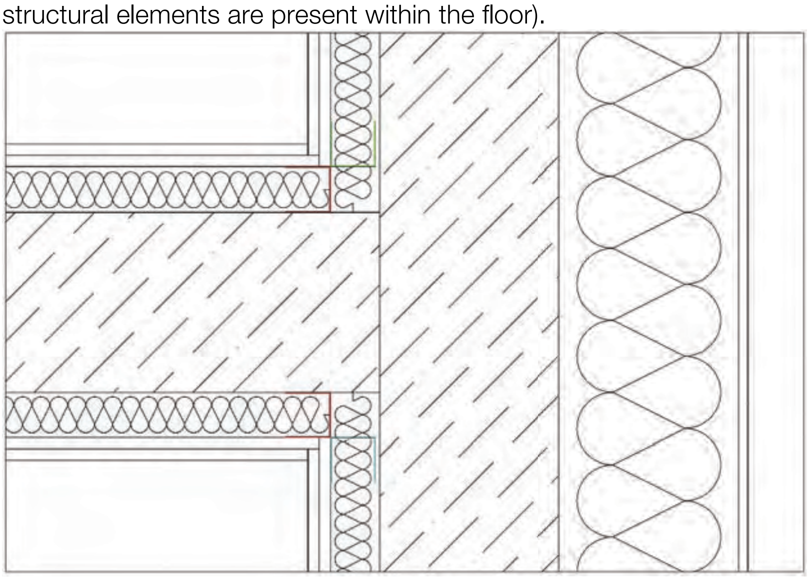
1 – external coat – 10 mm
2 – graphite-added EPS – 200 mm
3 – concrete wall – 200 mm
4 – hemp fiber panels – 50 mm
5 – double plasterboard – 25 mm

$U = 0{,}131\ W/m^2K$

The connection between exterior wall and interior partitions is below detailed. Coloured elements represent the metal 'C' studs sections for plasterboard fixing.

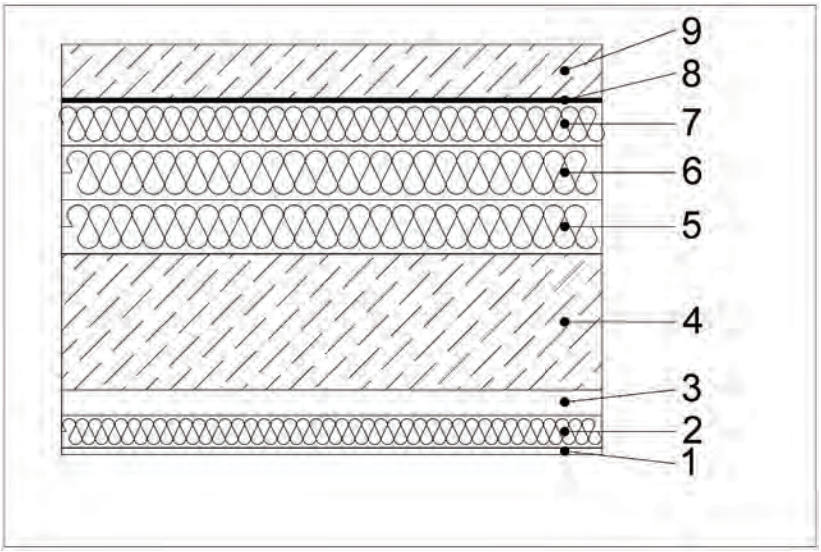


Detail of the connection between exterior wall and interior septum (septum divides north flat from south flat. No other structural elements are present within the floor).



2.7.3 Construction details / roof

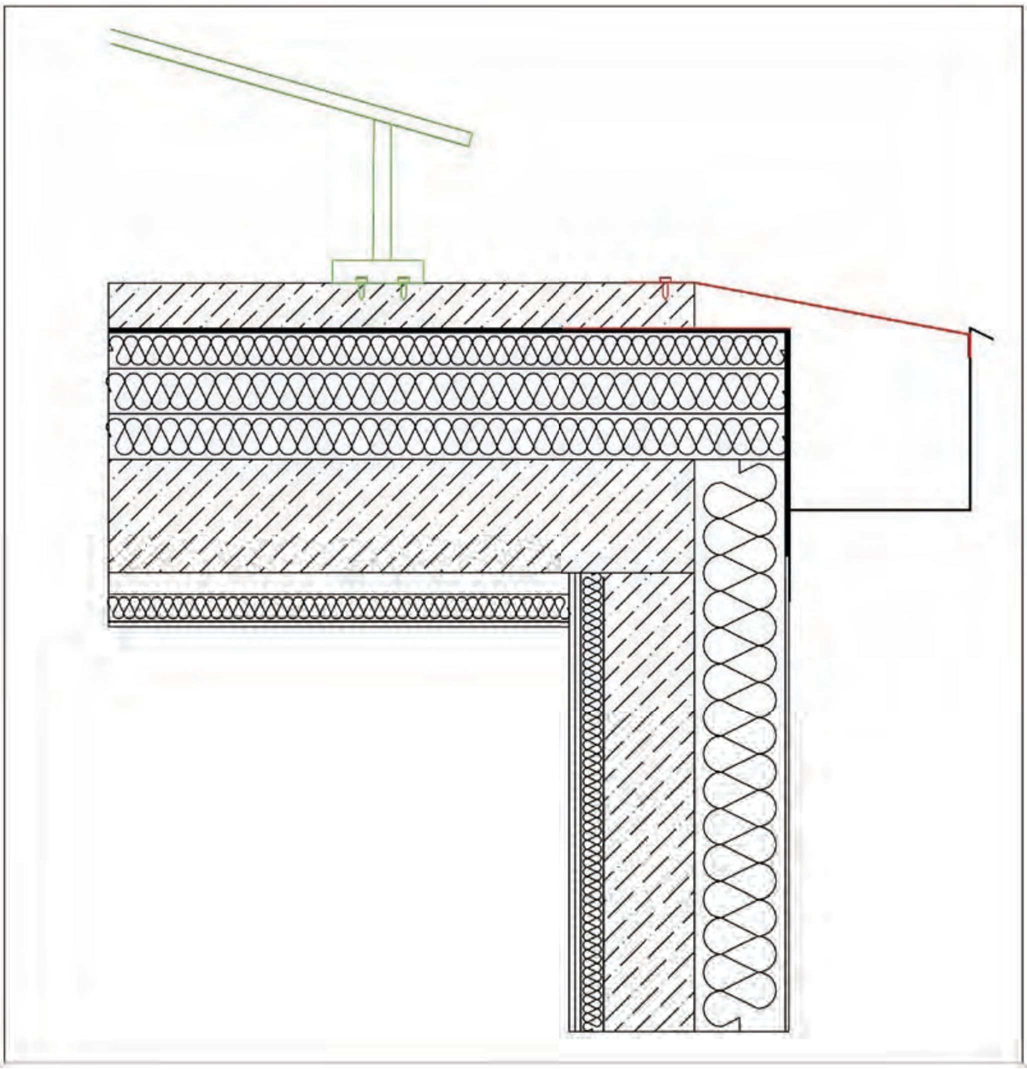
Cross section:



1 – plasterboard – 12,5 mm
2 – hemp fiber – 60 mm
3 – calm air – 40 mm
4 – concrete slab – 250 to 320 mm
5 – XPS – 100 mm
6 – XPS – 100 mm
7 – XPS – 80 mm
8 – waterproof membrane – 4+4 mm
9 – concrete slab – 100 to 150 mm

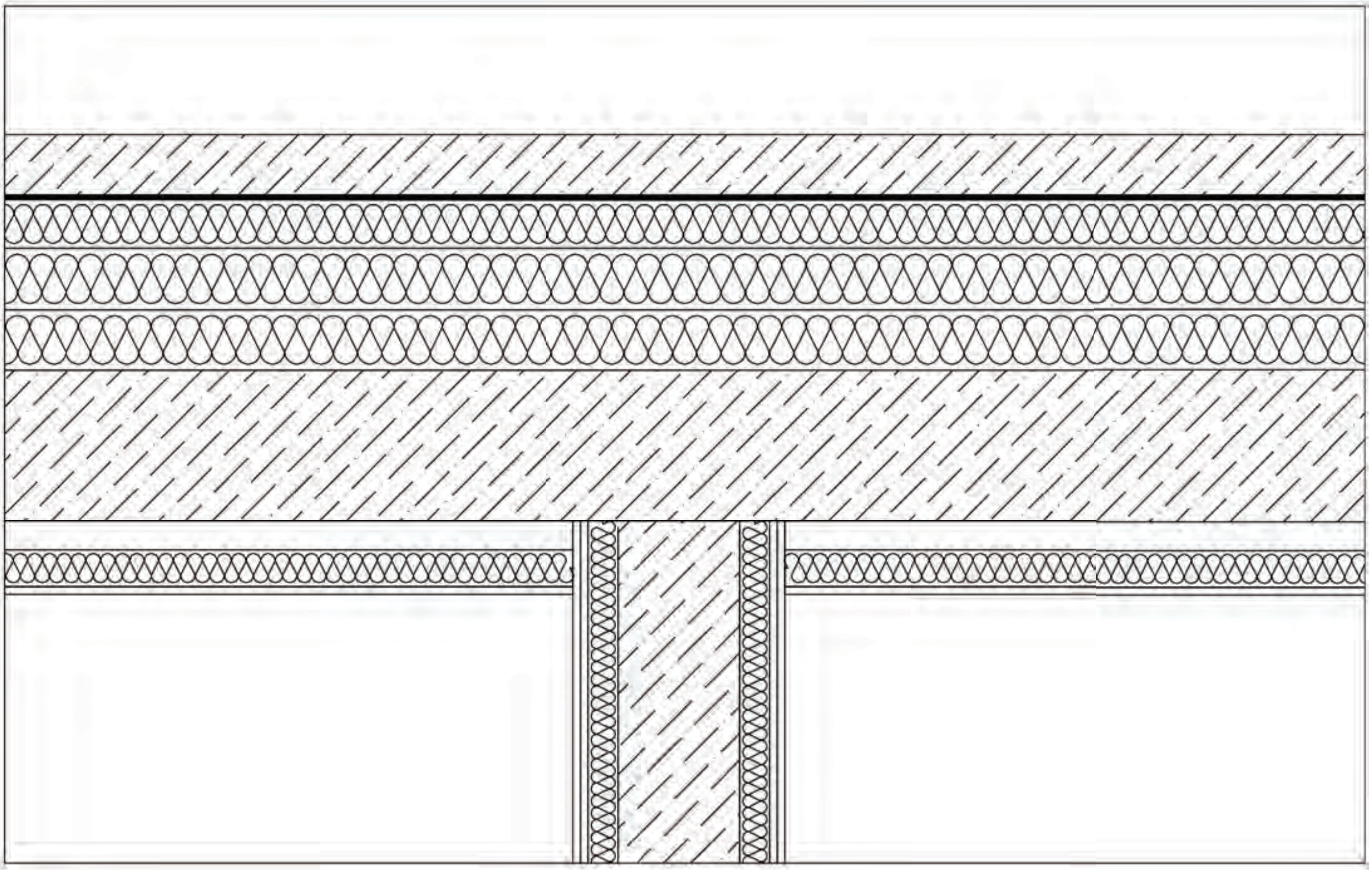
U = 0,116 W/m^{2}K

Detail of the connection with exterior wall:

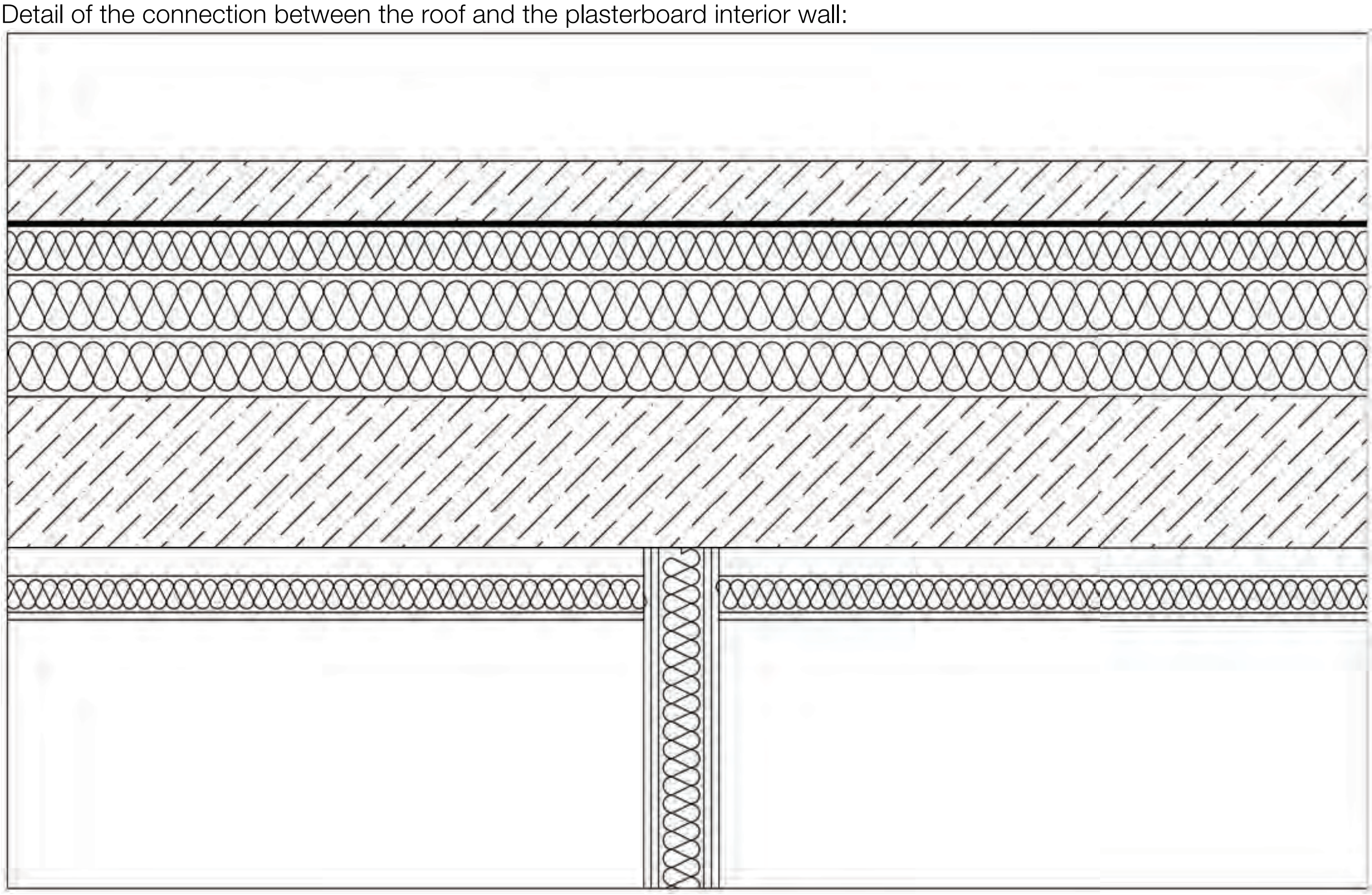


In red, a sketch of the gutter connection. In green, a sketch of the photovoltaic field connection. Both connections do not affect the insulation layers.

Detail of the connection between the roof and the concrete interior wall:



Detail of the connection between the roof and the plasterboard interior wall:

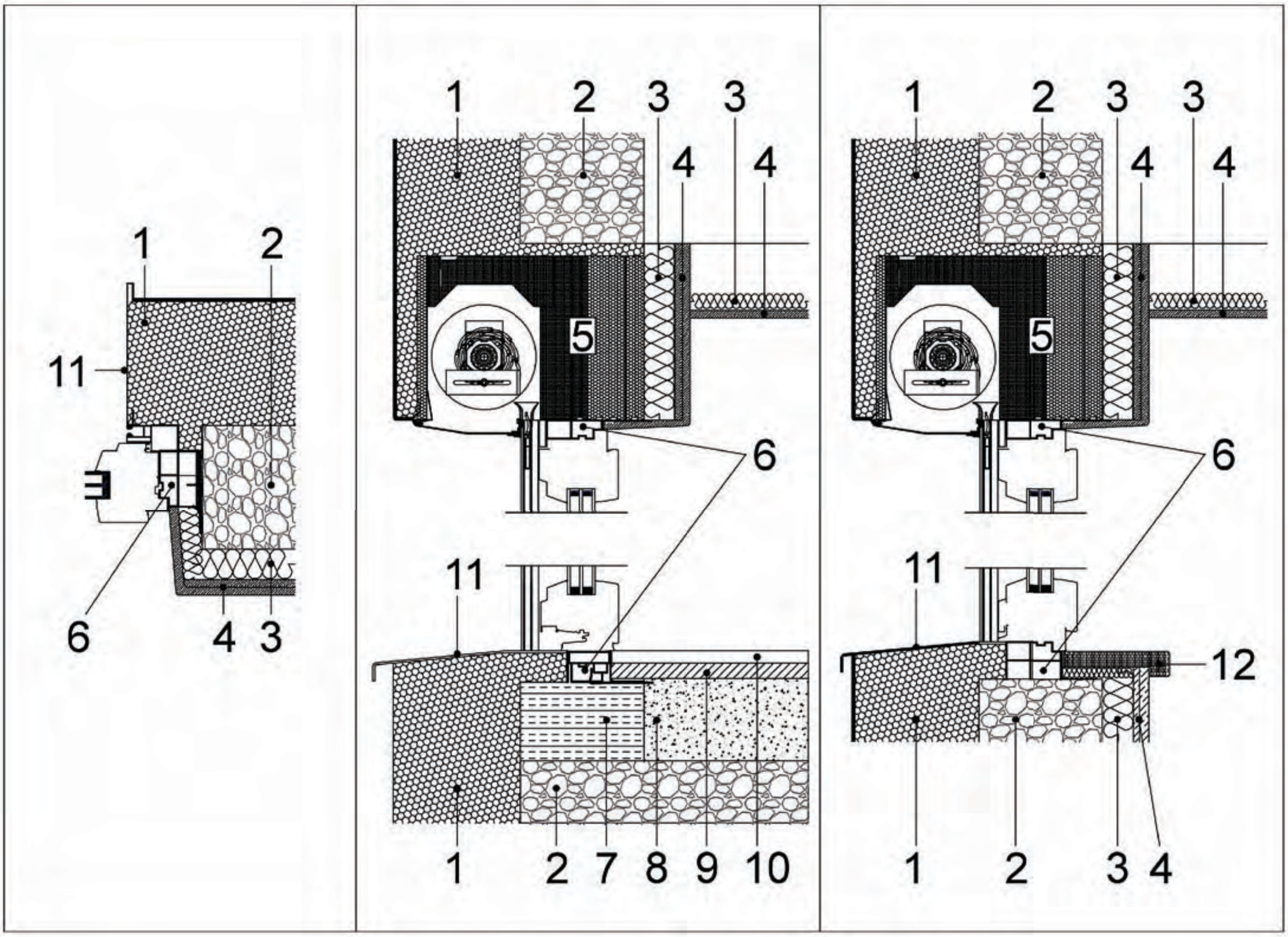


2.7.4 Construction details / windows

Windows installed in Case Sabin are WOLF FENSTER model 115p (wood/aluminium) and model 88c (wood). They have the following characteristics:

type	U▯ (W/m^{2}K)	U▯ (W/m^{2}K)	Ψ▯▯(W/mK)	Ψ▯▯▯(W/mK)
wood/aluminium windows and French windows	0,6	0,72	0,036	lat. 0,07 – inf. 0,026 – sup. (roller shutters) 0,064
wood French windows (connection to the stairwell only)	0,6	1,7	0,042	average value 0,040

Cross sections (wood/aluminium – the same installation sketches apply for wood French windows):



top view French Window - side view Window – side view

Materials:

1. graphite-added EPS
2. concrete structure
3. hemp fiber
4. plasterboard
5. roller shutter box
6. wood counterframe
7. autoclaved aerated concrete block
8. grit 4/8 mm
9. plywood
10. wood flooring
11. inox steel
12. wood sill

Scaled drawings are herewith attached (annex 1).

2.7.5 Construction details / description of the airtight envelope

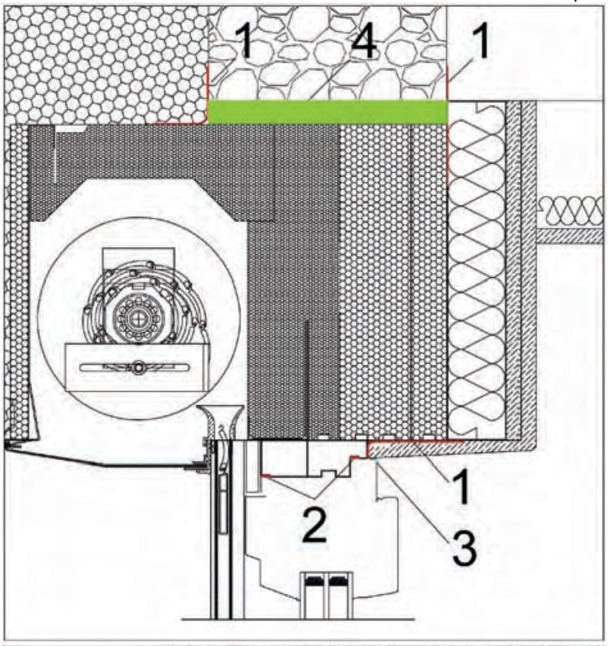
A good help for obtaining an airtight envelope was given by the structure being a concrete (that is to say, sealed) box. The airtight envelope planning is described below.

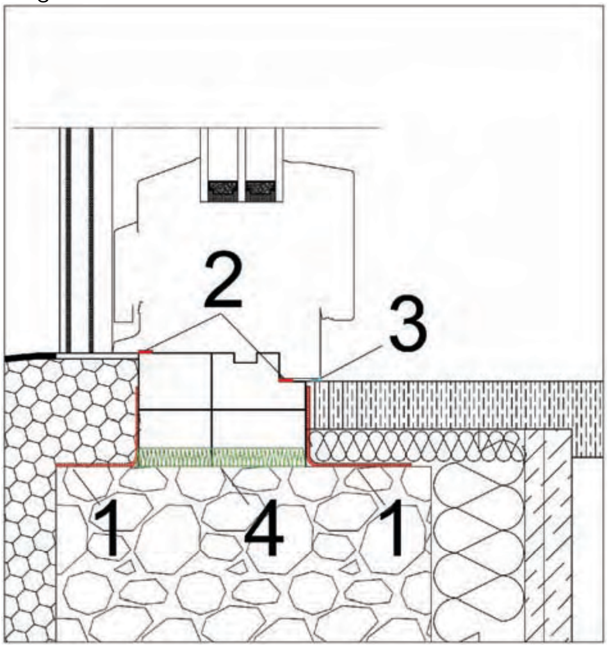
<u>Exterior walls</u>

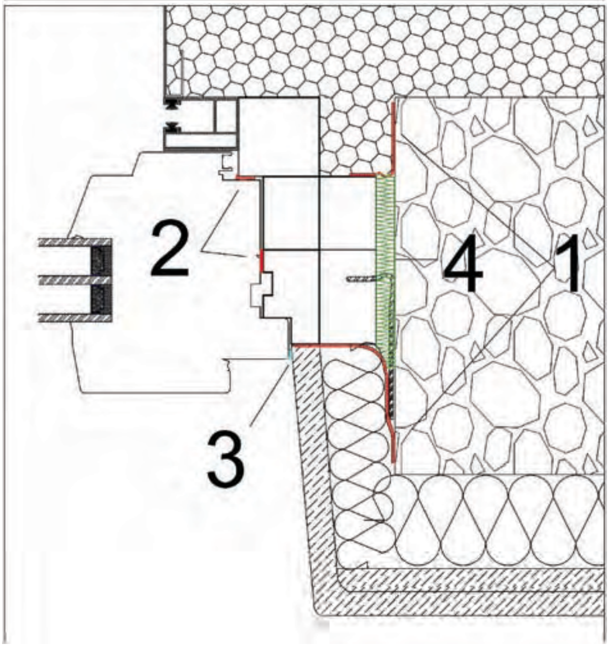
The construction holes caused by the wall-ties were all sealed by means of thyxotropic cement and butyl silicone.

<u>Windows and roller shutter boxes</u>

Windows and roller shutter boxes were sealed as per the following sketches:







1. sealant tape, installed with previous application of an adhesive primer
2. joint sealant (elastic, silicones based)
3. silicone joint, mainly to avoid cracking on the surface between wood and plasterboard
4. PU elastic foam

<u>Electrical systems</u>

The non-heated basement was used for main cabinets and measuring devices, and for the cables connecting the building to the public electric network. Electrical cables starting from the cabinets on the basement and pertaining to the flats entered the heated volume holing the airtight envelope in only one point. Thus, it was sufficient to seal that point to guarantee the envelope air tightness. Other points to be sealed were the cables for the mechanized roller shutters and the cables for external lights (i.e. light on terraces).

<u>Heated/cooled and hot water distribution</u>

Heated/cooled water and hot water is produced on the basement by means of a heat pump. Similar to the electrical systems, the distribution system also holes the airtight envelope in one single point. Again, it was sufficient to seal the passage point. The following pictures illustrate the passage point, for both electrical and distribution systems:

Ventilation – External air ducts

As further explained in the following section, comfort ventilation units are connected to the external air via a couple of ducts installed in a dedicated cavity within the heated volume. These ducts hole the airtight envelope on the roof, thus that point has been sealed by air tightening tapes and butyl silicone.

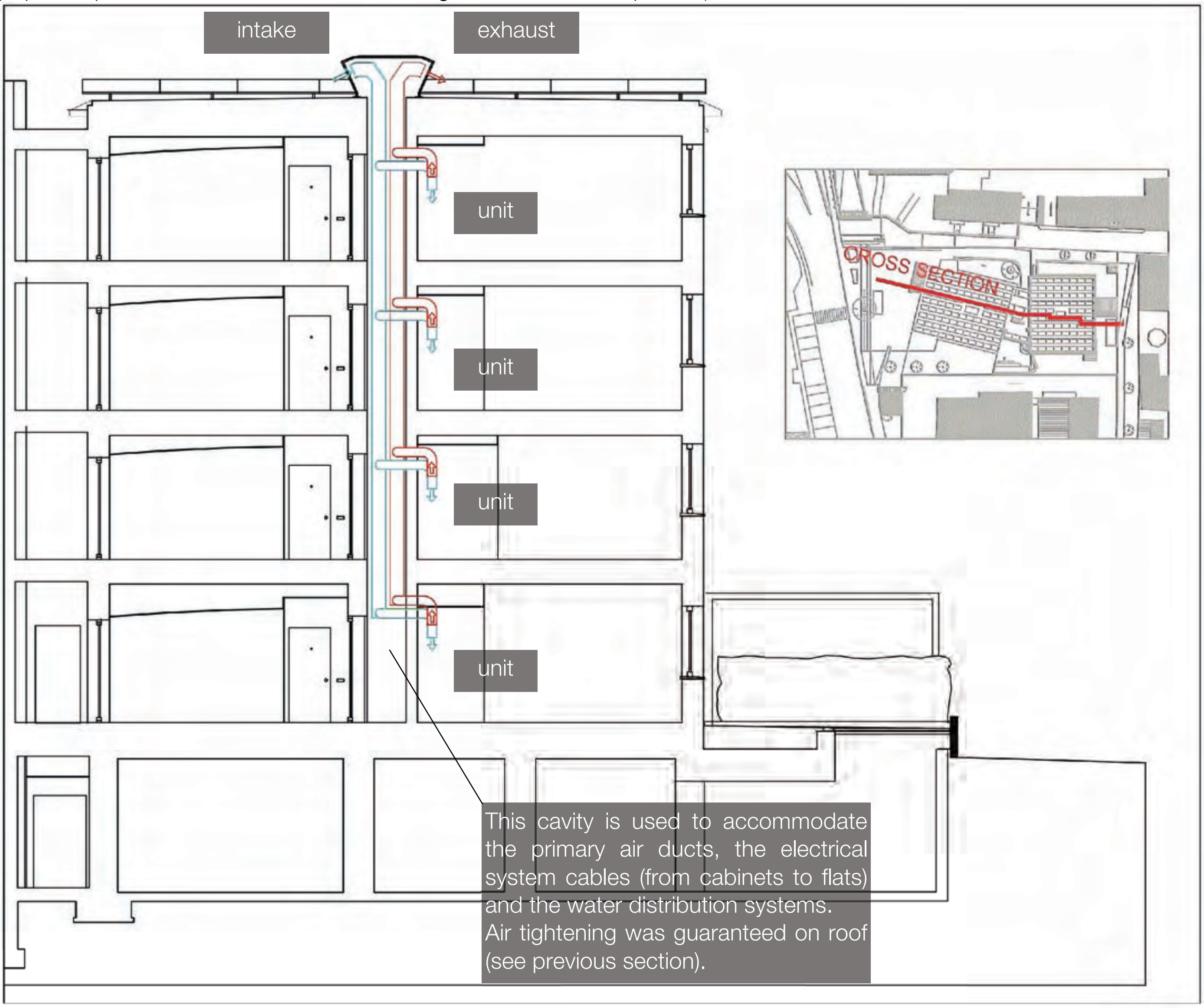
Sewer drain and kitchen hoods

In order to guarantee a good acoustic protection, both sewer drain system and kitchen hoods evacuation ducts were installed outside the concrete structure (within the external insulation). Accordingly, the passage between interior and exterior was sealed by means of a thixotropic cement and a butyl silicone.

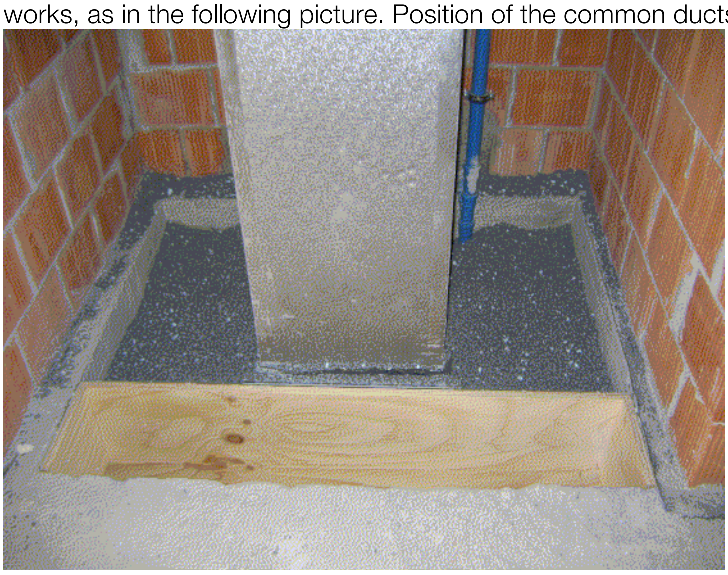
Documentation of the pressure test is hereby attached (annex 2).

2.7.6 Construction details / ventilation plan for the ductwork

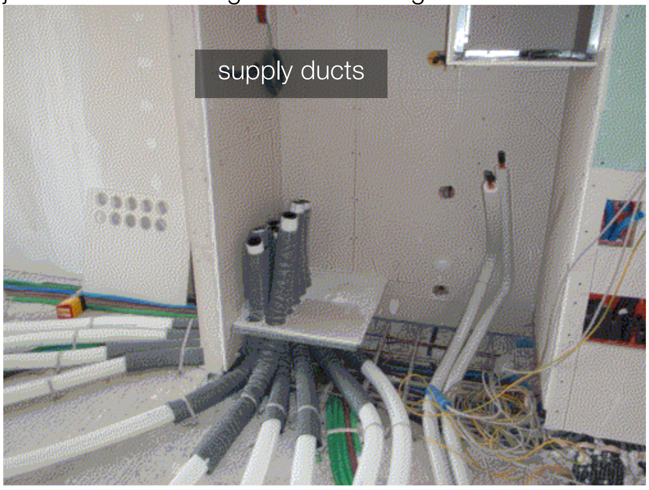
Each flat is provided with a ventilation unit. External air ducts (intake and exhaust) are in common, as per the sketch below (separate pairs of ducts are used for edificio grande and edificio piccolo):



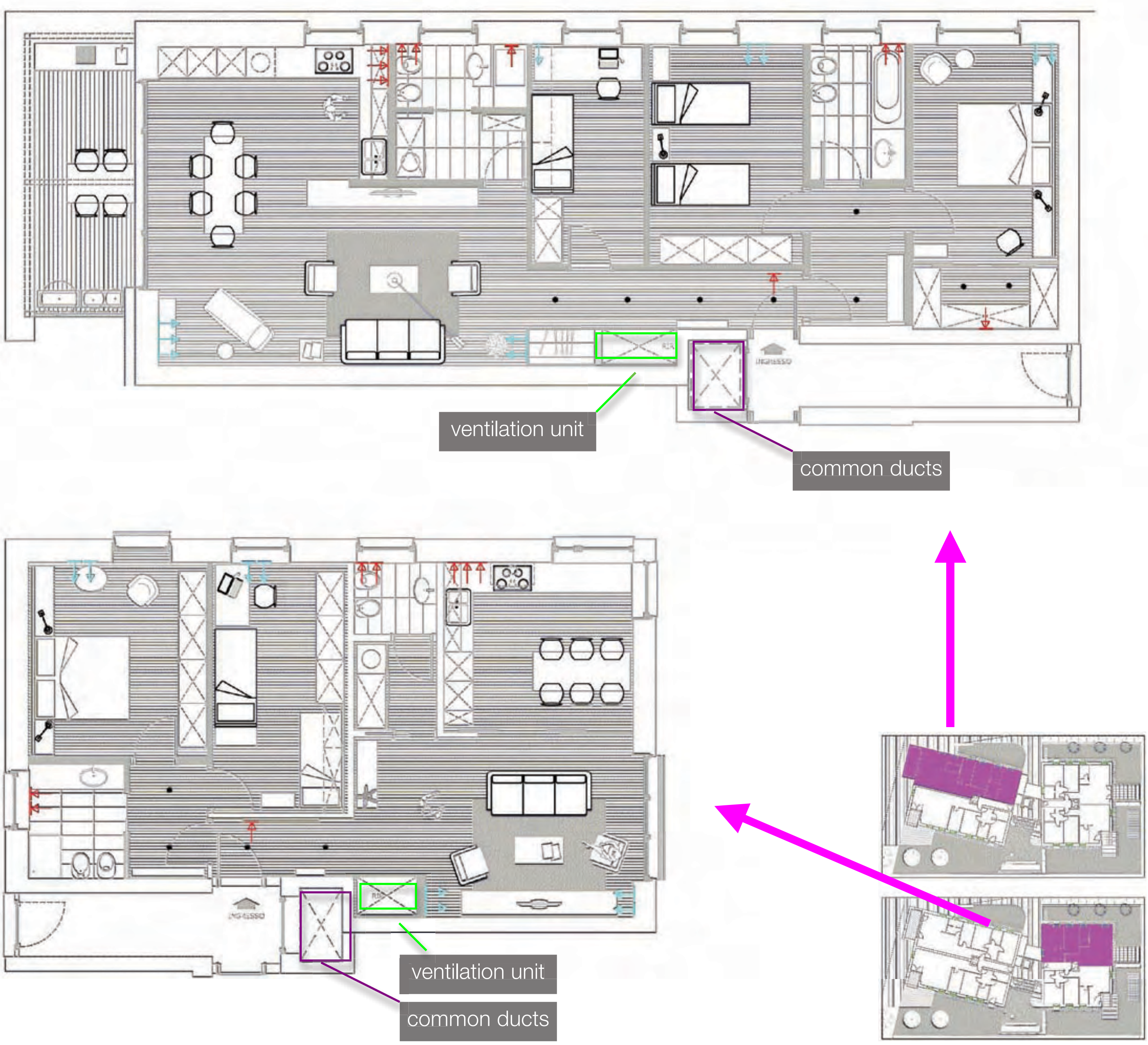
The common ducts are insulated with a minimum of 100 mm thick raw EPS, milled from the scraps of external insulation works, as in the following picture. Position of the common ducts is described on next page.



Within each flat, all supply ducts are placed on the floor, just above the concrete slab, so that fresh air is supplied at approx. 40 cm from finished floor. Extract ducts are placed within the plasterboard ceiling, so that exhaust air is extracted just below the ceiling. This allows a good circulation of air within the flats.



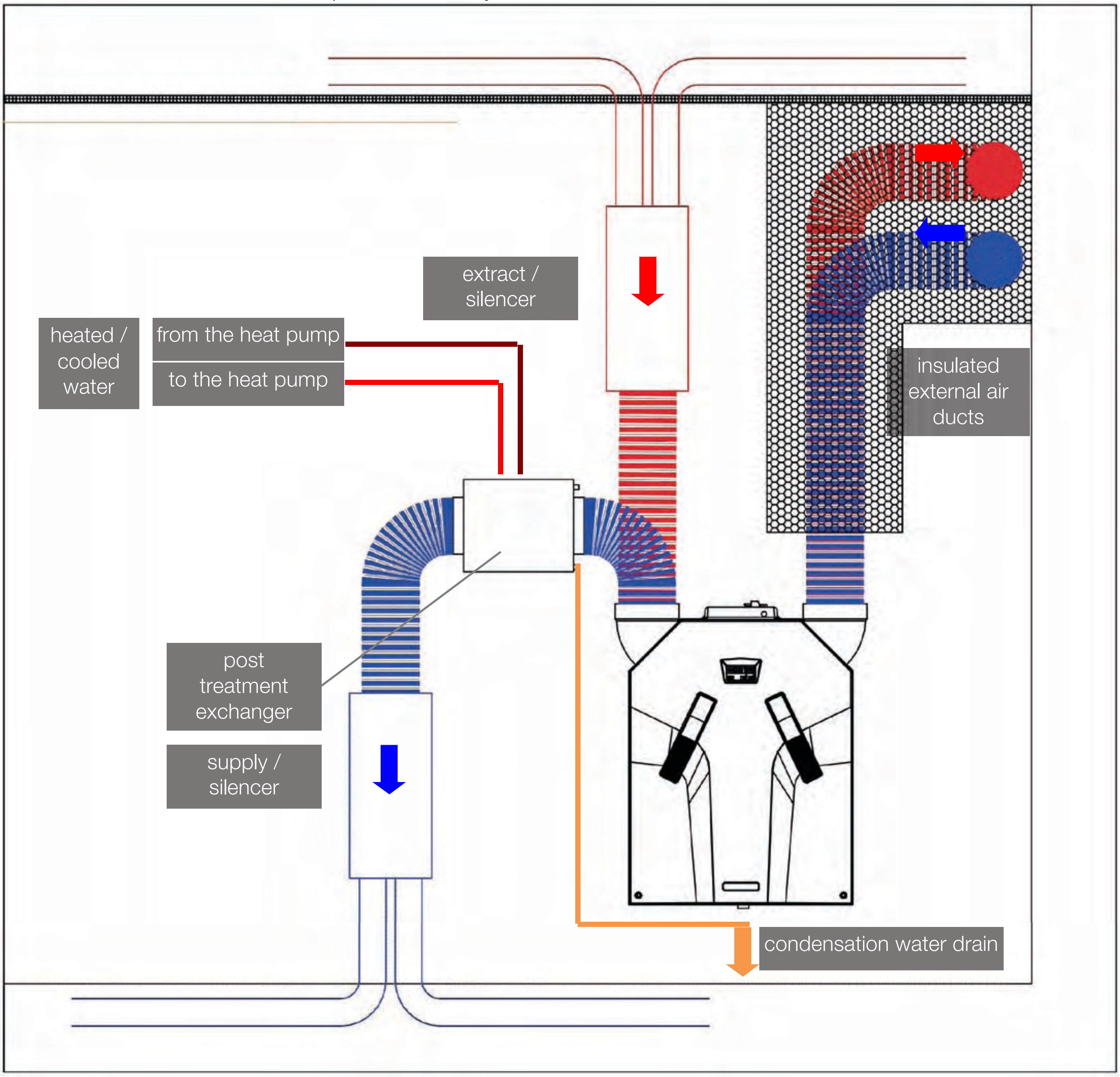
The typical distribution plan, with indication of the common ducts position, is sketched below:



?

2.7.7 Construction details / ventilation plan for the units (typical)

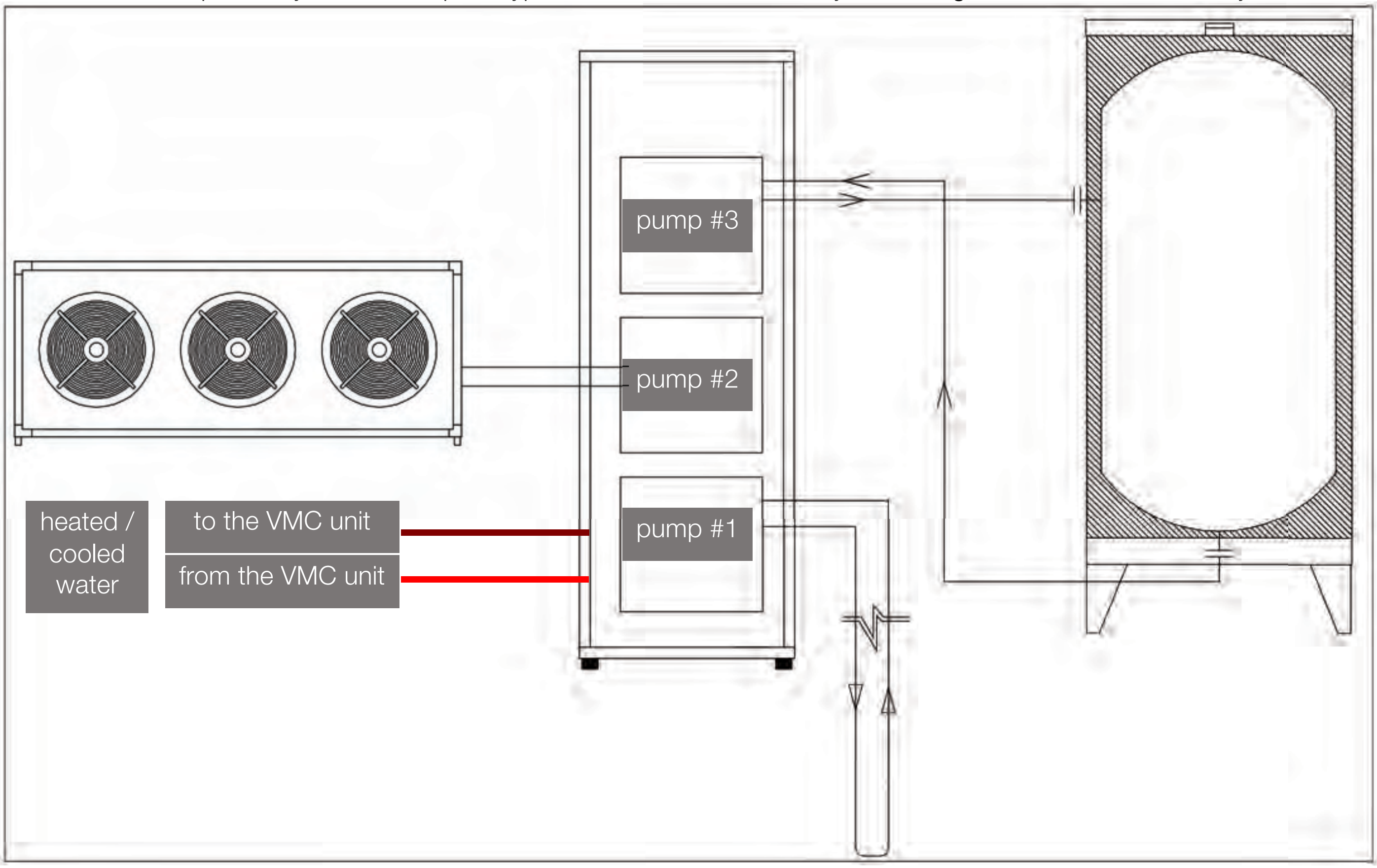
The sketch of the ventilation units is presented hereby:



Ventilation units are ZEHNDER mod. Comfoair 350, with a 84% PHI-certified heat recovery efficiency.

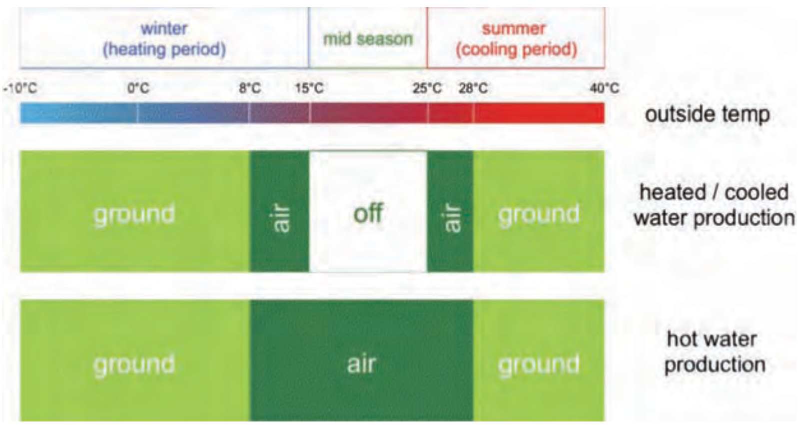
2.7.8 Construction details / heat supply

Units are heated / cooled through the ventilation system. A post treatment air/water exchanger is installed after the ventilation unit in order to raise the supply air temperature in cold season, and to cool it down in hot season. In winter, circulating water is distributed at a temperature of 40 °C. During the summer it is important to de-humidify the supply air, thus water circulating within the post-treatment exchanger shall guarantee the air condensation. Therefore, 7 °C circulating water is distributed.
Distribution exploits common tubes, which are iper-insulated in their non-heated path. Analytic calculation of the distribution energy losses revealed an average efficiency of 95% (87% for hot sanitary water).
Production of heated / cooled water and hot sanitary water is made by a system of 3 heat pumps from manufacturer AERNOVA. This specific system was a prototype, manufacturer is currently evaluating industrialization of the system.



- pump #1: vertical, closed loop, ground source heat pump with 250 m of (double) dia 32 mm circulation pipes. Nominal power of 20 kW.
- pump #2: air source heat pump. Nominal power of 20 kW.
- pump #3: vertical, closed loop, ground source heat pump. Only used to heat water up to 70 °C for anti-legionella cycle. Nominal power of 10 kW.

Pump #1 (ground) or pump #2 (air) will work together only for pick periods. Normally, only one of the two pumps are operational. A software decides which pump has the better efficiency in every instant. The basic principle is hereby sketched:



2.8 Important PHPP results

Specific Demands with Reference to the Treated Floor Area	grande: 6 units		piccolo: 8 units	
Treated Floor Area:	689,4	m²	683,0	m²
	Applied:	annual calcolation	Applied:	annual calcolation
Specific Space Heat Demand:	4	kWh/(m²a)	9	kWh/(m²a)
Pressurization Test Result:	0,2	h⁻¹	0,3	h⁻¹
Specific Primary Energy Demand (DHW, Heating, Cooling, Auxiliary and Household Electricity):	73	kWh/(m²a)	103	kWh/(m²a)
Specific Primary Energy Demand (DHW, Heating and Auxiliary Electricity):	40	kWh/(m²a)	53	kWh/(m²a)
Specific Primary Energy Demand Energy Conservation by Solar Electricity	58	kWh/(m²a)	67	kWh/(m²a)
Heating Load:	5	W/m²	7	W/m²
Frequency of Overheating:		%		%
Specific Useful Cooling Energy Demand:	2	kWh/(m²a)	2	kWh/(m²a)
Cooling Load:	6	W/m²	6	W/m²

The calculation was made without commercial units on the ground floor of edificio grande, because of PHPP limit in multi-zone buildings. Nevertheless, the construction quality of the commercial units is the same as the rest of Case Sabin.

2.9 – 2.10 Costs

Construction cost is 1.500 € per square meter of usable area. Ancillary spaces (i.e. garage and lumber-room) not included.
The building overall cost is 3.500.00 €.

2.11 Year of construction

The project started October 2008 and finished September 2010.

2.12 Architectural design

From an architectural point of view, Case Sabin has quite a long story. The site area was covered by the second part of a project dated 2004, the first being the renovation of a 19th century building. This original project was not characterized by any energy efficiency goal; moreover, ground floor spaces were devoted to private green areas and car parking areas, thus badly linking the building to the surrounding urban tissue.
The site owner, Boscarato Costruzioni, decided then to abort this project and entrusted architect Stefano Zara to redesign the building with new features in terms of energy efficiency and 'social' linking function. Moreover, municipality of Pieve di Soligo was deeply interested in the project, because of the project of a new pedestrian path passing alongside.
For shaping Case Sabin, Zara then considered all these inputs and added other guidelines, such as the need for a communicating forehead, the need for a pedestrian square and for a wide pedestrian path, the existing differences in level.
The façades shapes, colours and materials also refer to the main historical buildings of Pieve di Soligo and of the surrounding main towns.

2.13 Services planning

The system used for heating, cooling and hot sanitary water has been described in some of the previous paragraph. To summarize:

- production is made by three heat pumps, two of which exploiting geothermal probes;
- the fluids are then delivered to the units via a hyper isolated copper tube distribution system;
- emission is integrated in the mechanical ventilation system (one single system for each flat) though a post-treatment exchanger;

- indoor temperature can be controlled by both modifying the set temperature in the thermostat and varying the ventilation fan speed.

Other important features are the re-usage of rainwater, which is stocked in two 15.000 litres tanks and then used for WC and gardens watering and the 40,89 kWp photovoltaic field, able to cover all the electrical needs of the above described systems.

2.14 Structural physics

Great attention has been put over the following aspects:

- acoustic behaviour;
- calculation of thermal bridges;
- evaluation of the surface and interstitial moisture.

Acoustic

Structures were firstly calculated by a software released by 'Brüel & Kjær' in order to comply with Italian law limits and then verified by on-site measurements.

Results were extremely positive and are summarized in the following table:

Analyzed structure	Law requirement	Calculated result	measured result
Wall dividing two adjacent units	R'w ≥ 50 dB	58 (-1, -4) dB	65 dB
floor between two aligned units	L'n,w ≤ 63 dB	47,0 dB	44 dB
external wall	D2mn,nT,w ≥ 40 dB	45,0 (-3, -7) dB	46 dB

Thermal bridges

Thermal bridges were calculated to verify both energy loss and surface temperature. PSI values were inserted in the PHPP calculation; surface temperature met comfort criterion (Tsi,min > 17 °C).

Moisture

All structure were verified according to EN 13788:2003 with positive result.

2.15 Structural analysis

Italy is a country with an elevated seismic risk. Pieve di Soligo in particular is classified zone 2 (in a scale form 1 to 4, being 1 the most dangerous zone) according to national regulatory, with a maximum ground acceleration between 0,225 g and 0,250 g.

As for each building project, statics calculation was analyzed and approved by the board of Civil Engineering of the Venetian region.

The calculator, engineer Angelo Favotto, is a anti-seismic building specialist, who worked as a consultant in the reconstruction after the devastating earthquake of Friuli Venezia Giulia in 1976.

For the project Case Sabin, a fully concrete structure was chosen. Foundation slab and walls have a strength class C 30/37 (according to EN 206:2006), while above ground structure have a strength class C40/50.

2.16 Experiences

At present three families and two design offices occupy the building. Overall user feedback is positive. The author of the present documentation and his family also live in Case Sabin and found no inconsistencies between planned and real behaviour. Monitoring will start in 2012.

2.17 Bibliography

This project was presented at:

- 3. convegno nazionale Case Passive, Rovigo, October 02, 2009 (Italian PH meeting, third edition),
- 'Costruire il futuro' (Building the future) conference within Klimahouse fair, Bolzano, January 23, 2010,
- 15th Passive House Conference, Innsbruck, May 27, 2011,

and published in the relevant proceedings.

Annexes

Annex 1: windows cross sections

Annex 2: pressure test results