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Fit-to-NZEB

Innovative training schemes for retrofitting to nZEB-levels

Models produced and installed in the participating training centers

Deliverable 3.2

of the FIT-TO-NZEB project, financed under grant agreement No 754059 of the HORIZON 2020 Programme of the EU

Led by:

Passive House Academy (PHA)

COUNTRY: BULGARIA

1. Location (with photographs)

The new models will be used in the premises of the Bulgarian Building Knowledge Hub, situated in the building of the University of Architecture, Civil Engineering and Geodesy (UACEG) - the most established and renowned educational institution in this area. The university is situated in the centre of Sofia and shares a building with Sofia High School of Architecture, Construction and Geodesy “Hristo Botev”. The offices of several important partners as the Bulgarian Association for Insulation in Construction and the Bulgarian Chamber of Engineers in Investment Design are also situated in the building of the University.

Figure 1: Location and official opening of the Bulgarian BKH with the heads of the University of Architecture, Civil Engineering and Geodesy, Bulgarian Construction Chamber and EnEffect.

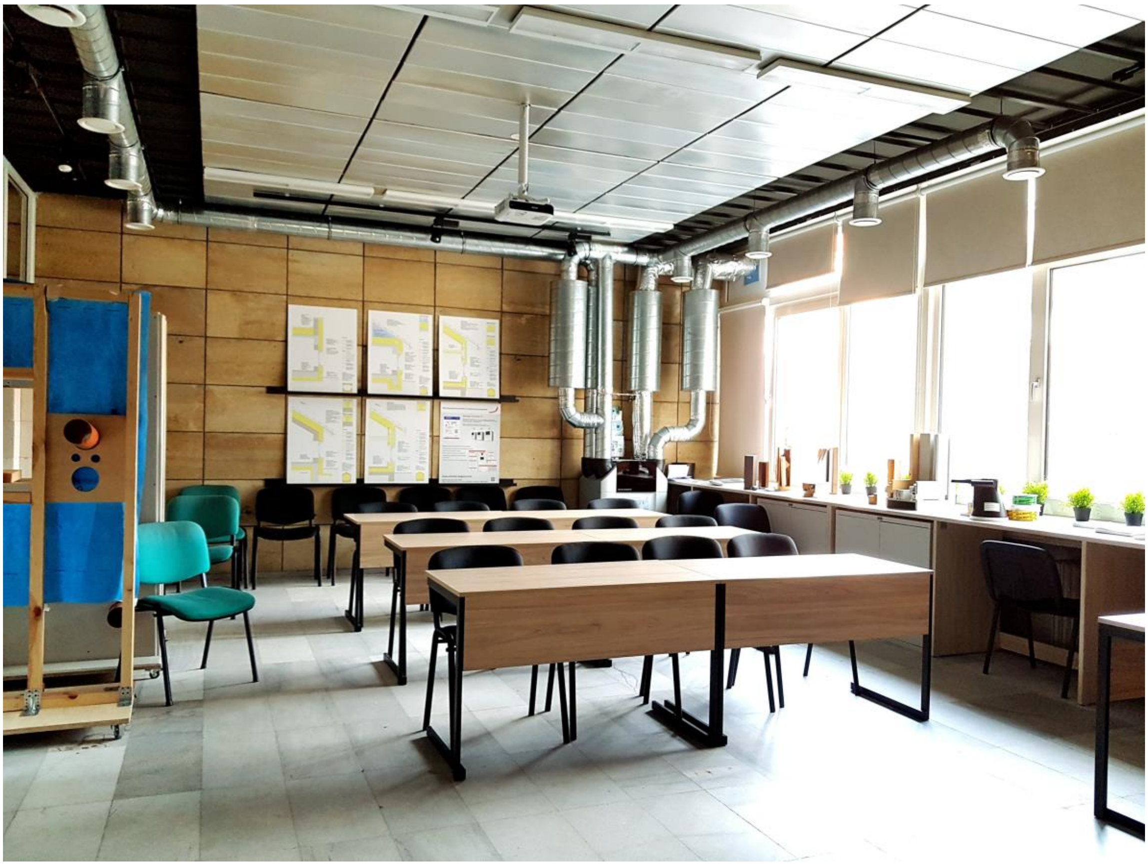
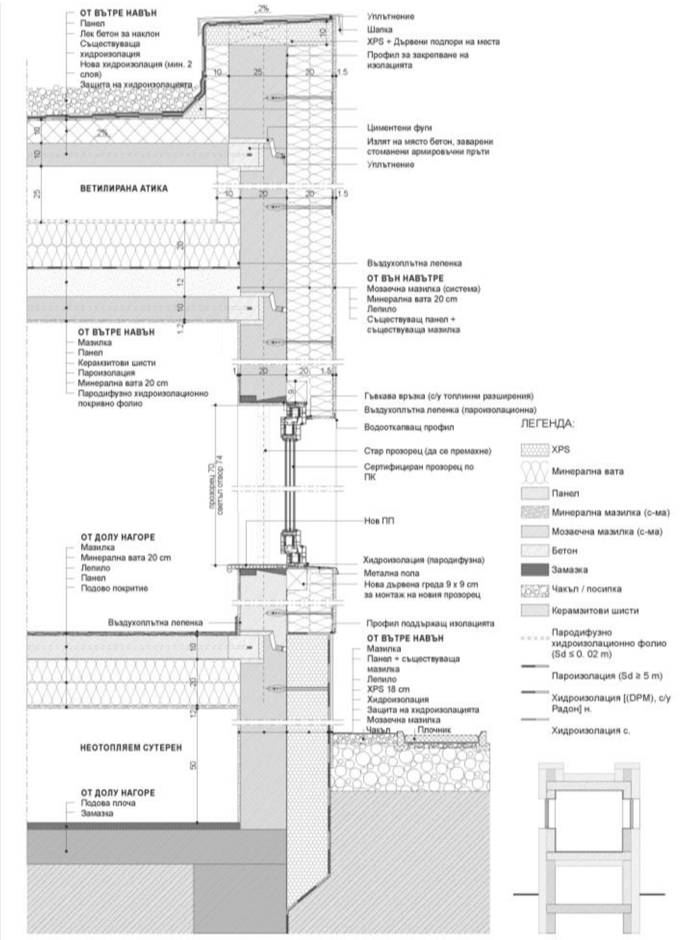


Figure 2: Location of the Bulgarian BKH

2. Design drawings

The drawings represent the basis for the construction of the demonstration models. Both demo models aim to demonstrate a typical for Bulgaria construction in regard to the building traditions. The first model (Fig. 3) is of a prefabricated reinforced concrete panels. These types of construction represent more than 50% of the housing stock in number of major cities throughout the country. The (overall) respectively same age of these buildings (especially compared to other types of constructions) make them have the most imminent and challenging renovation demand in the country. The models shows a typical prefabricated reinforced concrete panel construction, produced in a major construction factory in Bulgaria. The detail shows foundation, walls, floor and roof with all their connections. The aim is to demonstrate straightforward a way for deep energy renovation of this construction in respect to the specifics of prefabrication. Since the panels are only fixed together on site, a strong attention is paid to the joints and their air-tightness.

The second detail shows a typical massive concrete / masonry construction. The key detail is the insulation of the otherwise unheated basement and installation of an insulation 'wedge' in the soil, when it is not possible to insulate under the foundation.



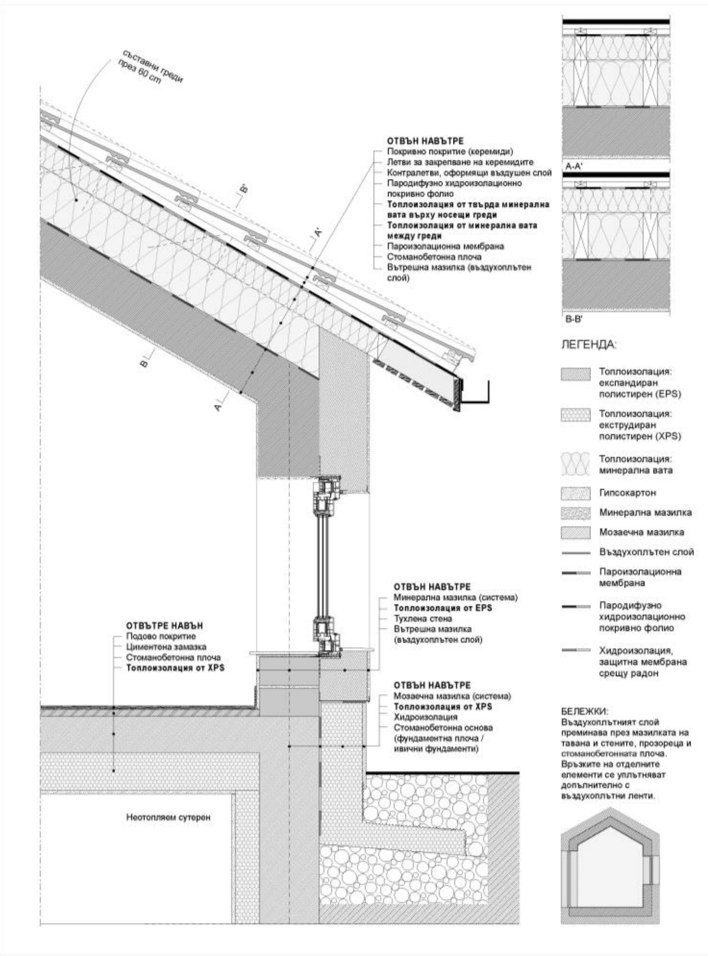


Figure 4: Prefabricated reinforced concrete panel detail

Figure 3: Concrete / masonry detail

3. Construction of the models

During the sixteen month period, significant amount of work was carried out in the design and development of the demonstration models as suggested from the aforementioned ToR document.

4. Concept for use and exercises

Exercise 1:

The trainees should stand in front of once of the practical models and try to redraw it. After that they should explain where the insulation layer and airtightness layer are on the drawing, and respectively on the model. The exercise develops the skills of drawing technical details and comprehending the principles of deep energy retrofits in various construction types in buildings.

The same exercise can be conducted by just the trainees explaining, based on what they have learnt from the presentations, what they can see on the practical models and why it is done in such a way.

Addition to this exercise is locating the different types of insulation laying around in the training centre (not only on the models, but the samples of insulation). Once a trainee has pointed out a sample of insulation, they should explain its peculiarities, where it is used and possible advantages and disadvantages over other types of insulation.

Exercise 2:

The trainees look thoroughly at the practical models. They should explain the sequence of the building renovation process and its peculiarities. In that exercise it is important to stress the specifics of the step-by-step refurbishment and how the different building parts, being renovated at a different time are in connection to each other and which things should be paid particular attention to.

After that the trainees should conduct one of the building works on the demonstration models: putting insulation; installing the windows; airtightness check. In the cases where there are many trainees, some of them should do different tasks after their fellow trainees, e.g. to put insulation after the windows have been installed; or to check the airtightness after the whole process.

The exercise can take from 20 up to 60 minutes depending on the number of students and the amount of time spent on oral explanation from the tutor.

5. Plans for future development of the facilities

The range of models is to be widened in order to be able to serve as an example to all trainees during their practical exercises. The prefabricated reinforced concrete models are supposed to become in two parts, so they can better serve their purpose and be used as explanatory tool. Concept for uninstalling some parts (windows) and installing it back again are about to be implemented. Further implementation of RES systems is also considered and will play a major role in the training materials and foreseen courses.

COUNTRY: CROATIA

1. Location (with photographs)

The new models will be used in the premises of the University of Zagreb, Faculty of Civil Engineering, which is situated in the same building as the University of Zagreb, Faculty of Architecture which are both the most established and renowned educational institutions for Civil Engineers and Architects in the area of energy efficiency and nZEB deep energy renovation. The Faculty of Civil Engineering is situated in the centre of Zagreb. As the recognised training institutions for both university courses on energy efficiency and nZEBs as well as lifelong learning in the field of nZEB it was the best location for the training models. Additionally, the offices of an important stakeholder, Cluster nZEB, are also situated in the same building.

Figure 5: Location of the training centre at the University of Zagreb, Faculty of Civil Engineering

2. Design drawings

The drawings represent the basis for the construction of the demonstration models. All four maquettes aim to demonstrate a typical construction for Croatia in regard to the building traditions. The first model (Fig. 3) is of a prefabricated reinforced concrete panels. These types of construction represent more than 50% of the housing stock in number of major cities throughout the country. The (overall) respectively same age of these buildings (especially compared to other types of constructions) make them have the most imminent and challenging renovation demand in the country. The models shows a typical prefabricated reinforced concrete panel construction, produced in the construction factory Konstrukta in Croatia. The detail shows foundation, walls, floor and roof with all their connections. The aim is to demonstrate straightforward a way for deep energy renovation of this construction in respect to the specifics of prefabrication. Since the panels are only fixed together on site, a strong attention is paid to the joints and their air-tightness.

The second detail shows a typical massive concrete / masonry construction. The key detail is the insulation of the otherwise unheated basement and installation of an insulation 'wedge' in the soil, when it is not possible to insulate under the foundation.

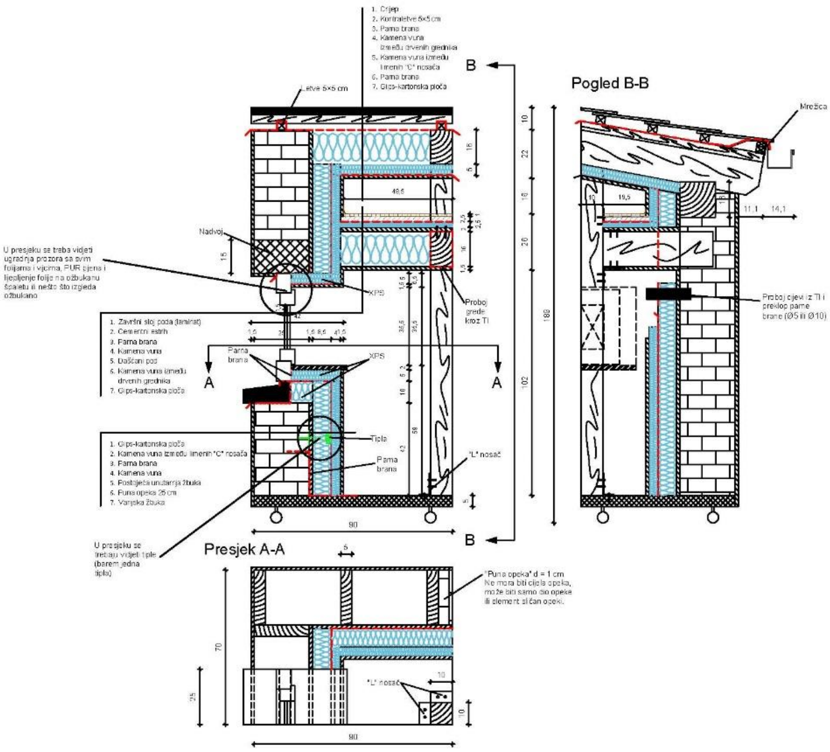


Figure 6: Internal insulation of the existing masonry wall detail

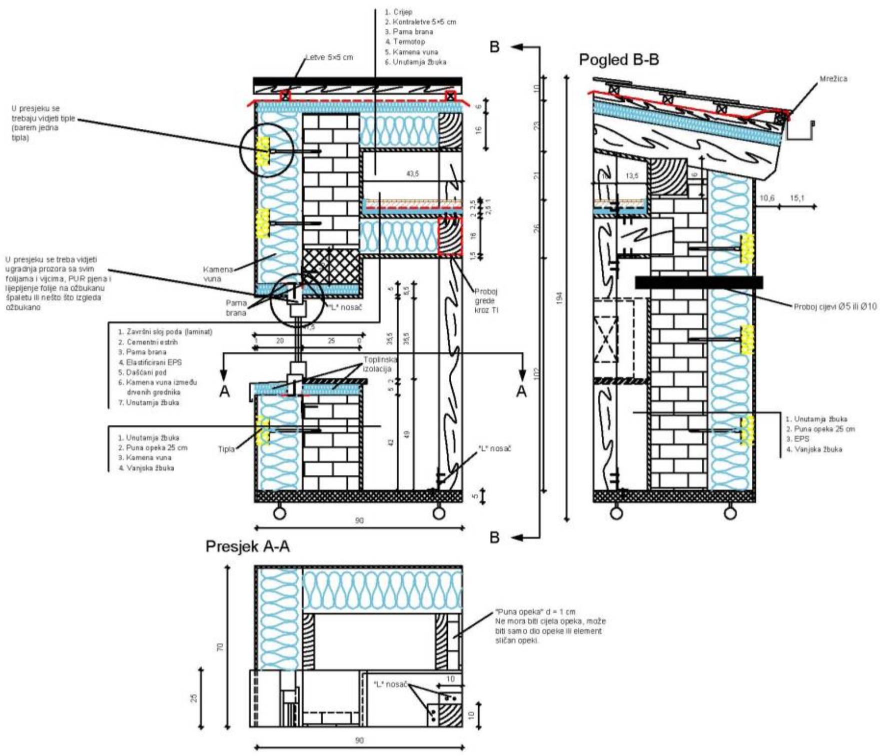


Figure 7: External insulation of the existing masonry wall detail

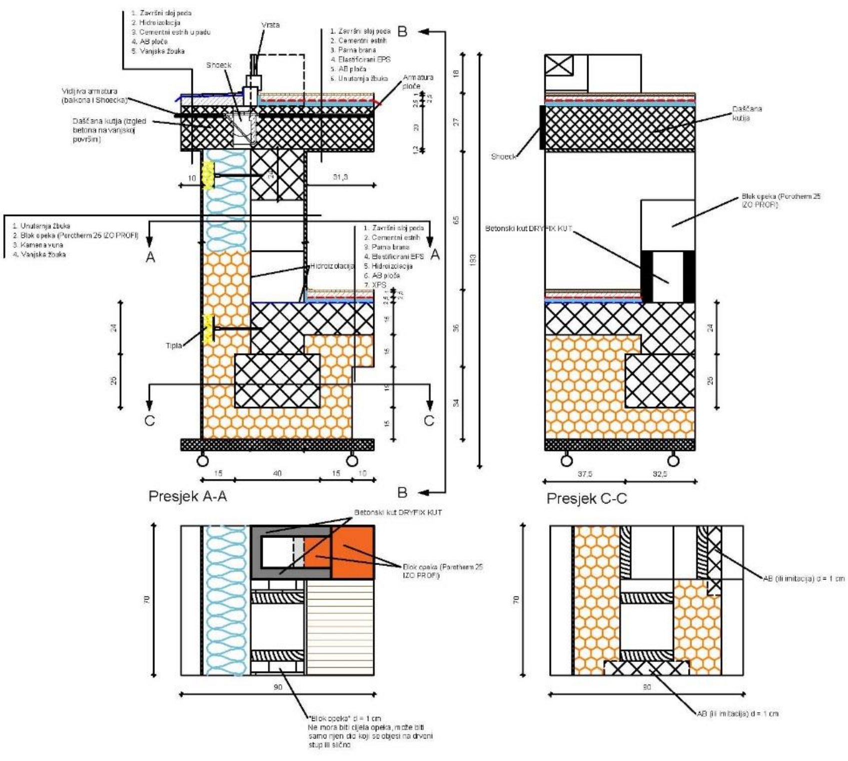


Figure 8: Foundation detail (external insulation) and balcony detail (thermal break)

Figure 9: Model of the internal insulation on the existing masonry wall

Figure 10: Model of the external insulation on the existing masonry wall

Figure 11: Model of the foundation detail (external insulation) and balcony detail (thermal break)

Figure 12: Model of the wooden structure

3. Construction of the models

During the six-month period, great work was carried out in the design and development of the demonstration models as suggested from the aforementioned ToR document.

Figure 13: Construction of the models

4. Concept for use and exercises

Exercise 1:

The trainees should stand in front of one of the practical models and try to redraw it. After that they should explain where the insulation layer and airtightness layer are on the drawing, and respectively on the model. The exercise develops the skills of drawing technical details and comprehending the principles of deep energy retrofits in various construction types in buildings.

The same exercise can be conducted by just the trainees explaining, based on what they have learnt from the presentations, what they can see on the practical models and why it is done in such a way.

Addition to this exercise is locating the different types of insulation laying around in the training centre (not only on the models, but the samples of insulation). Once a trainee has pointed out a sample of insulation, they should explain its peculiarities, where it is used and possible advantages and disadvantages over other types of insulation.

Exercise 2:

The trainees look thoroughly at the practical models. They should explain the sequence of the building renovation process and its peculiarities. In that exercise it is important to stress the specifics of the step-by-step refurbishment and how the different building parts, being renovated at a different time are in connection to each other and which things should be paid particular attention to.

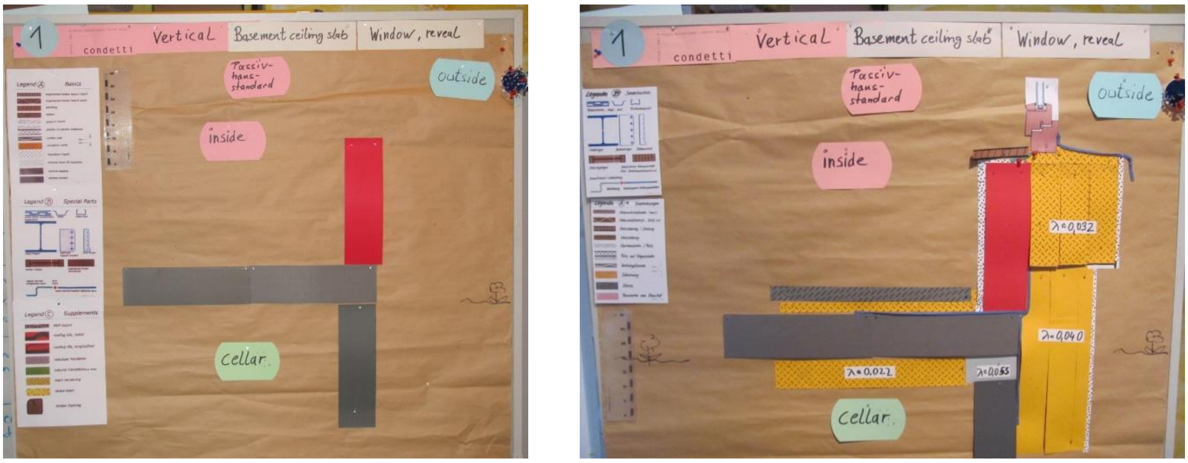


Figure 14: Practical exercise trainees should complete

After that the trainees should conduct one of the practical exercises on the simulation panels: putting insulation; installing the windows; airtightness check. Since UniZG is dealing with EQF level 6 and 7, and due to the health and safety issues, trainees will not be actually installing the insulation and airtightness layer, etc. Instead they will be creating a construction detail with the help of the pre-printed paper strips (Figure 14). This educational tool is very suitable and is used in lifelong education training centers. The educational tool contains tableaus with color strips for solid building materials (concrete, brick, aerated concrete, etc.) and building material cross-hatching (insulation, fibreboards, plasters, gypsum boards), joist cross sections, windows, and other building elements as well as pins, threads (vapour barrier), measuring scale, marker pens, scissors, and other accessories required for the display at the pinboard. The construction detail is pinned to the softboard at the scale 1:2.

The trainees will be divided into teams that work on a detail in small groups of max. 5 persons and present their result to all seminar participants. This result of the small team can be discussed in the whole group and optimized even further.

The exercise can take from 20 up to 60 minutes depending on the number of trainees and the amount of time spent on oral explanation from the trainer.

5. Plans for future development of the facilities

The range of models is to be widened in order to be able to serve as an example to all trainees during their practical exercises. The prefabricated reinforced concrete models are next to be developed. Further implementation of RES systems is also considered and will play a major role in the training materials and foreseen courses. Concept for uninstalling some parts (windows) and installing it back again is being considered.

COUNTRY: CZECH REPUBLIC

1. Location

Models for practical trainings will be installed in the building of the Foundation for the Development of Architecture and Engineering (ABF Foundation), which is right in the centre of Prague on Wenceslas Square. It has excellent public transport (MHD) connections. Wenceslas Square is crossed by a tram line with a stop a short distance from the training centre. Three lines of the Prague metro also intersect on Wenceslas Square. Training participants who will commute to Prague for the training can use the nearby Main Train Station.

The classrooms located in the premises of the training and education centre have sufficient capacity and are very well equipped for a normal theoretical lesson. The area for the practical part of the training is enough to allocate models and participants. Four models of construction details and further equipment are already allocated at this Building Knowledge Hub.

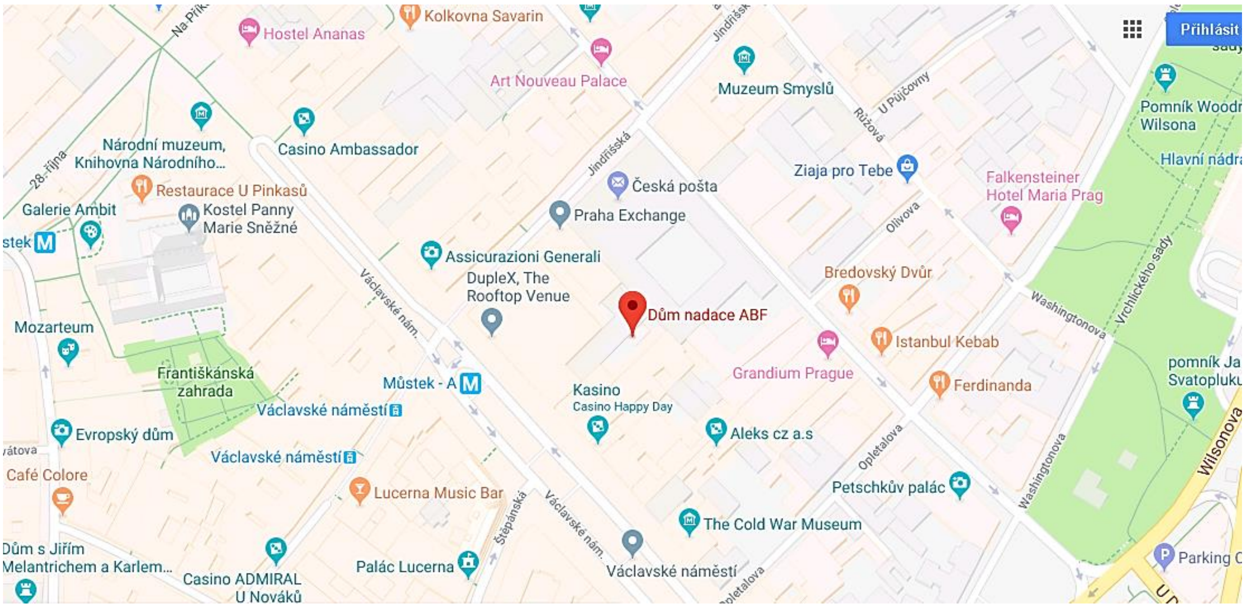


Figure 15: Location of CZ BKH, where training models will be installed.

Figure 16: Conference hall and lecture rooms of the BKH premises.

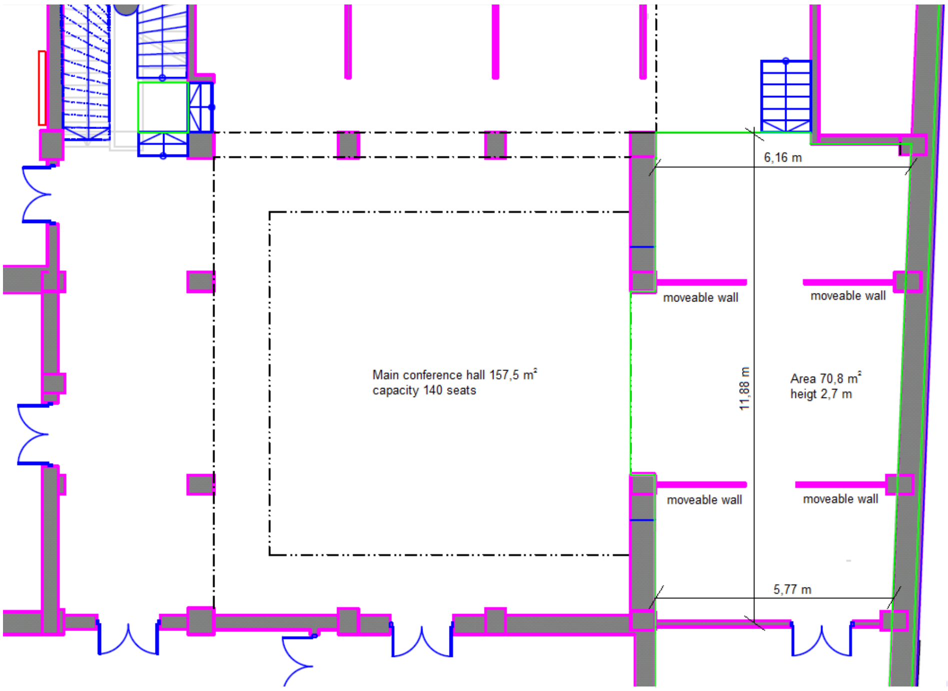


Figure 17: Floor plan of the room behind the conference hall, where BKH equipment is installed.

2. Design drawings

Two types of construction most typical for the housing stock in the Czech Republic were chosen to produce the two models: reinforced concrete prefabricated building and a brickwork building.

The first model shows a solution for insulating existing reinforced concrete prefabricated house. Wooden insulating windows with external jalousies are used in the model. External insulation is polystyrene facade boards EPS 70F, 200mm thick, the roof is insulated with PIR-insulation Topdek 022, 140mm thick and roof attics with XPS boards (100mm).

The second model demonstrates two possible solutions for a brickwork house insulation: external insulation made with PIR Boards Baumit Resolution, and internal insolation with calcium silicate plates of the Ytong Multipor system.

It was necessary to develop 3D drawings to manufacture the models, this was already done by the manufacturer selected through tender procedure.

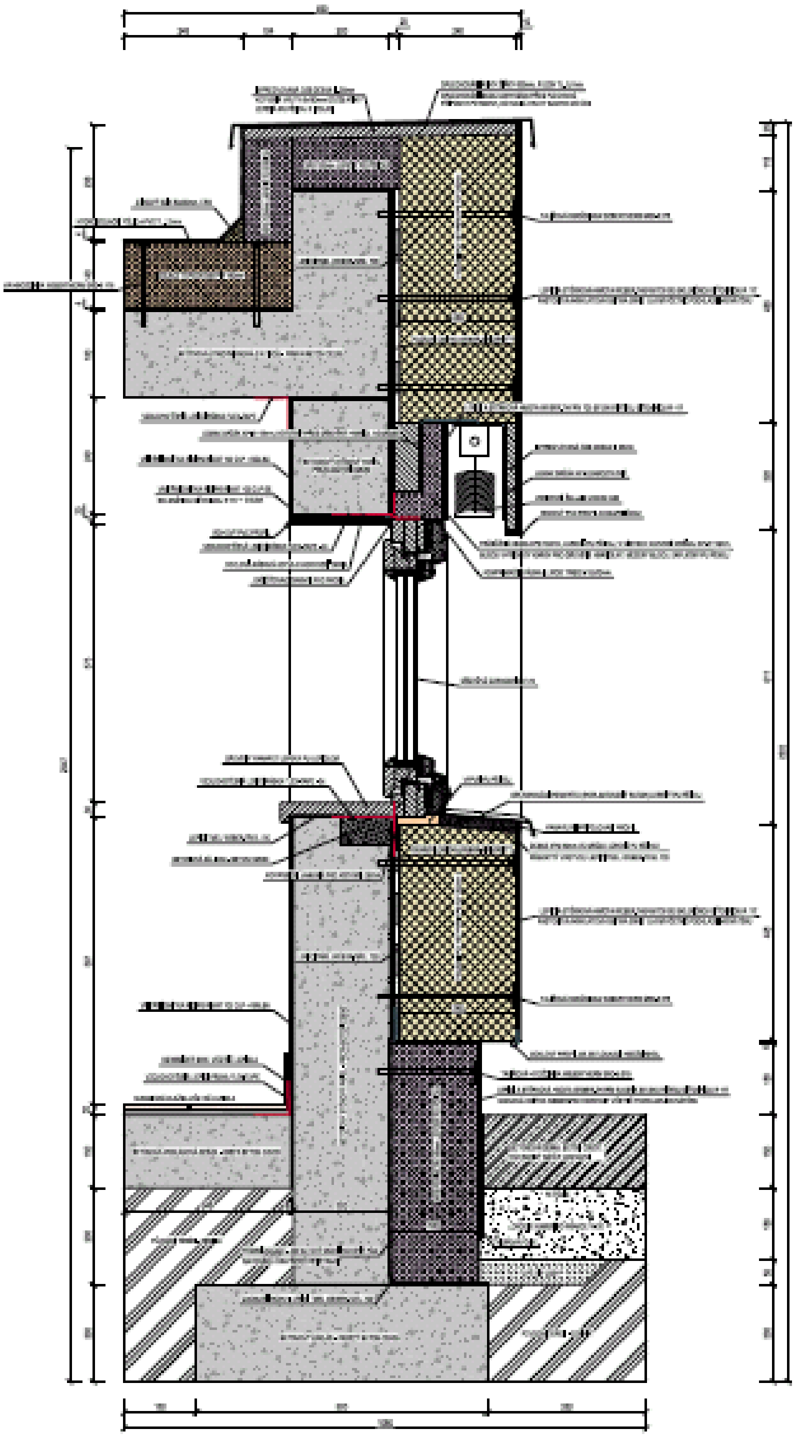


Figure 18: Model No. 1. DER of concrete prefabricated building.

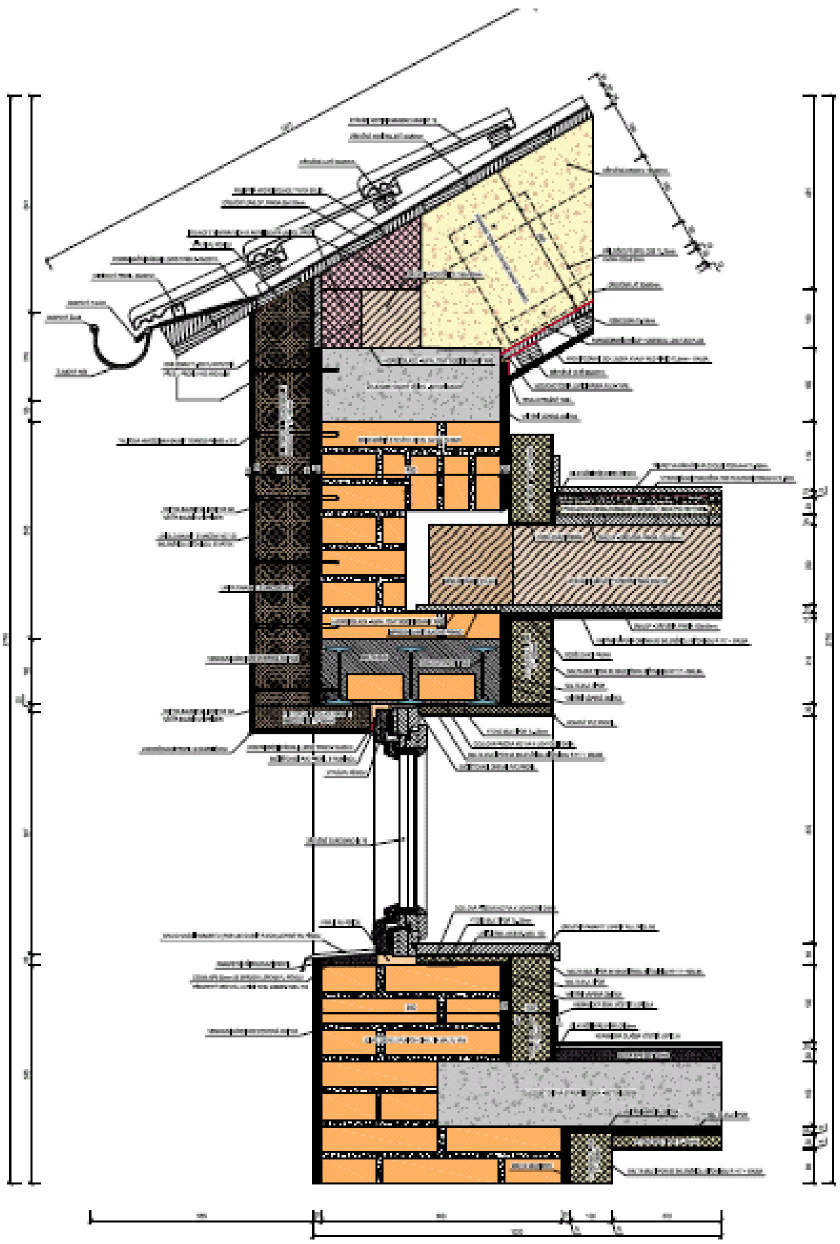


Figure 19: Model No. 2. DER of brickwork house with two solutions for insulating – internal and external.

3. Construction of the models

The contract for production of models was concluded with the selected manufacture, the work on selection and order of materials is going on to start in the nearest days with the manufacture of models. The models will be produced and will be transported to the place of their instalment till middle of September 2018.

4. Concept for use and exercises

The models of building structures will be used for detailed explanation and demonstration of details and structures applied currently as a good practice for deep energy renovation, including description of principles of their proper implementation and analysis of their material composition, as well deep analysis of each model.

Exercise 1:

The trainees should stand in front of once of the practical models and try to redraw it. After that they should explain where the insulation layer and airtightness layer are on the drawing, and respectively on the model. The exercise develops the skills of drawing technical details and comprehending the principles of deep energy retrofits in various construction types in buildings.

The same exercise can be conducted by just the trainees explaining, based on what they have learnt from demonstrations, what they can see on the practical models and why this solution was chosen.

An addition to this exercise can be locating the different types of insulation laying around in the training centre (not only applied in the models, but also samples of insulating materials). Once a trainee has pointed out a sample of insulation, they should explain its peculiarities, where it is used and possible advantages and disadvantages over other types of insulation.

Exercise 2:

The trainees look thoroughly at the practical models. They should explain the sequence of the building renovation process and its peculiarities. In that exercise it is important to stress the specifics of the step-by-step refurbishment and how the different building parts, being renovated at a different time are in connection to each other and which things should be paid particular attention to.

The exercise can take from 20 up to 60 minutes depending on the number of students and the amount of time spent on oral explanation from the tutor.

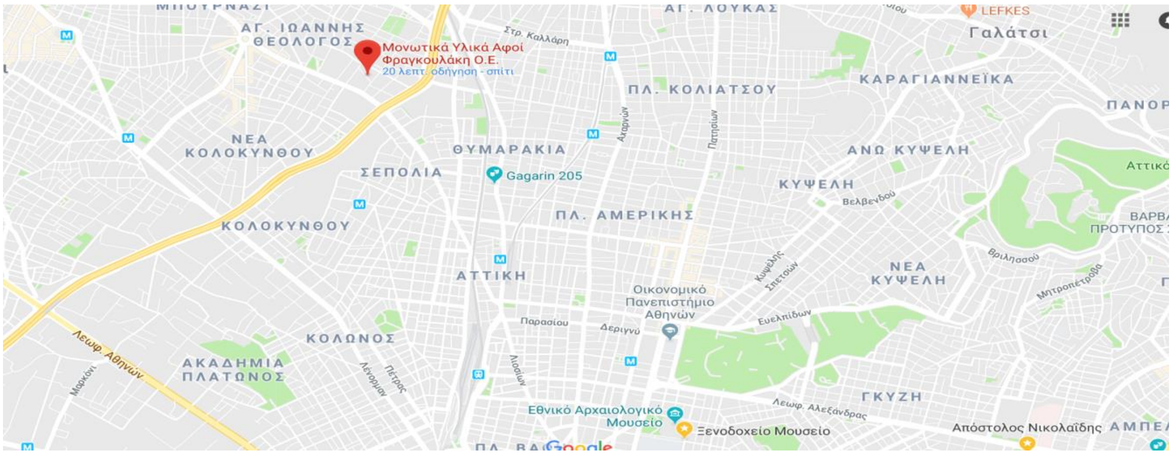
5. Plans for future development of the facilities

It is planned to widen the equipment of the training center, which already includes four structural solutions' models, two models in production, mechanical ventilation units with heat recovery, thermal imagers, blower door testing equipment, and CO_2 concentration measurer. Equipment demonstrating proper use of renewables in renovation practice would be a good addition to that. Besides it is supposed to produce practical walls for participants to apply some of solutions demonstrated during training with their own hands.

COUNTRY: GREECE

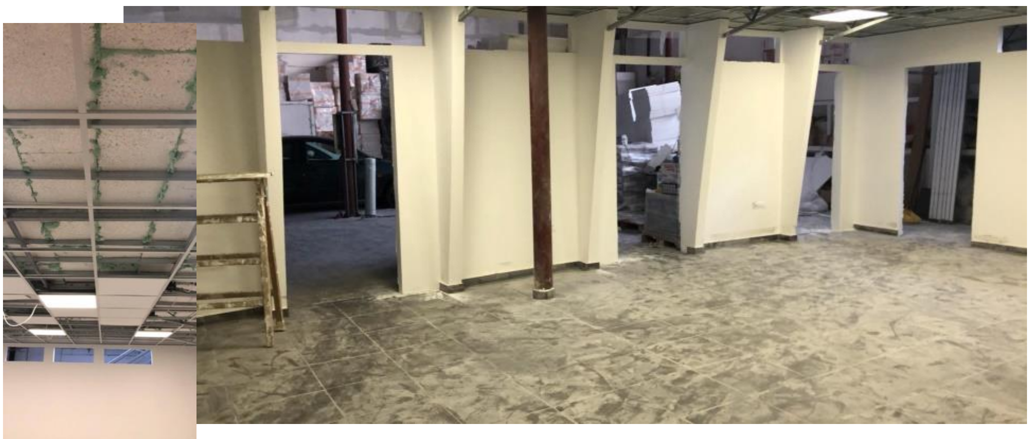
1. Location (with photographs)

The new models will be used in the premises of the first Greek Building Knowledge Hub, situated in the building of the Fragoulakis Bros Company, one of the oldest producers of polysterol and other insulation materials in Greece. HPHI announced last December 2017 a public open invitation for the creation of the Greek building knowledge hub. After 6 months of investigation HPHI came to an agreement with FRAGOULAKIS SA to use a 400m2 part of its facilities for this purpose. HPHI came also to an agreement with the construction company NETZERO OE for the construction of the mockups and the training walls.



The proposed facilities are close to the city center, easily accessible by metro and the main city highway.

They will have a 200m2 airtight classroom for 30 participants, where the lectures and the exercises for airtightness and ventilation systems will take place, and another 200 m2 area where the practice on the training walls will take place. The BKH area is a “box in a box” airtight and well insulated construction, made mainly of galvanized steel and hard EPS. It will have passive house PVC windows and an open Demo-ventilation system with HRV.



2. Design drawings

The drawings represent the basis for the construction of the demonstration models. Both maquettes aim to demonstrate a typical for Greece construction in regard to the building traditions. The first model (Fig. 3) is of a concrete skeleton and uninsulated brick walls with a flat concrete roof. These types of construction represent more than 50% of the housing stock in number of major cities throughout the country. The (overall) respectively same age of these buildings, build before 1980 (especially compared to other types of constructions) make them have the most imminent and challenging renovation demand in the country. The models shows a typical mixed brick+concrete construction, produced on site. The detail shows foundation, walls, floor and roof with all their connections. The aim is to demonstrate straightforward a way for deep energy renovation of this construction in respect to the specifics of mixed construction and new anti-seismic boundary conditions.

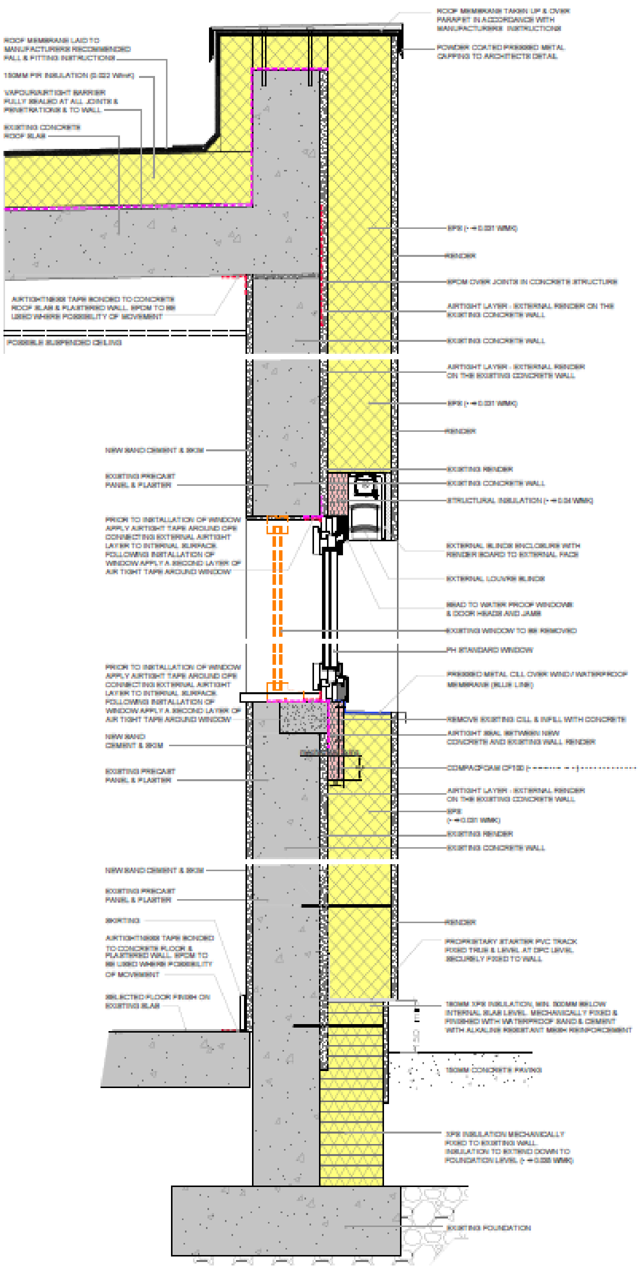


Figure 20: concrete skeleton with flat roof

The second detail shows a typical massive concrete / masonry construction of an old historic building. The key detail is the internal insulation of the building, when it is not possible to insulate on the outside.

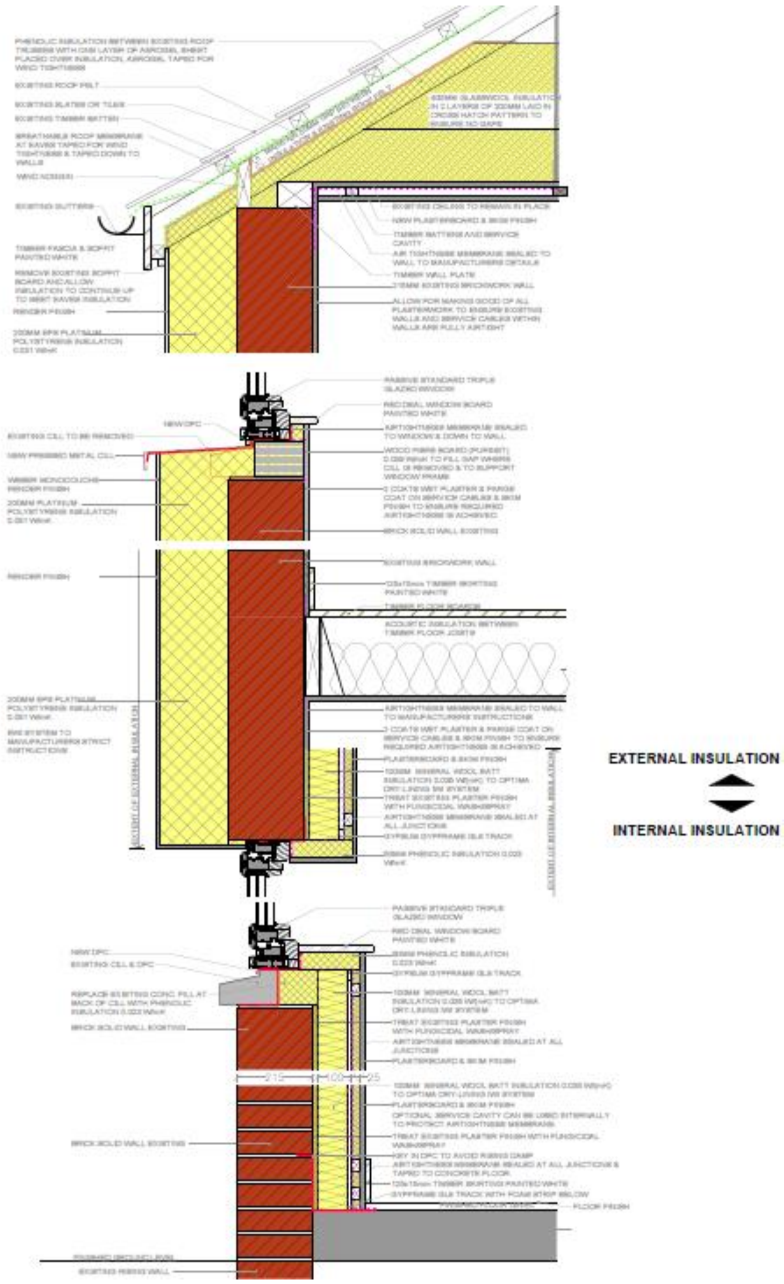


Figure 21: Concrete / masonry detail of historic buildng

3. Construction of the models

During the last 6 months and mainly after the final decision for the creation of the 1st greek BKH, great work was carried out in the design and development of the demonstration models as suggested from the aforementioned ToR document. Beside the two mockups and the three training walls, a complete airtight room with a full equipped ventilation system will be developed, RES systems (solar and PV) will be installed on the mockups.

All models, the three training walls and the complete BKH with all equipment will be ready by the end of the summer for hosting the next DER Courses of HPHI in Athens.

4. Concept for use and exercises

Exercise 1:

The trainees should stand in front of one of the practical models and try to redraw it. After that they should explain where the insulation layer and airtightness layer are on the drawing, and respectively on the model. The exercise develops the skills of drawing technical details and comprehending the principles of deep energy retrofits in various construction types in buildings.

The same exercise can be conducted by just the trainees explaining, based on what they have learnt from the presentations, what they can see on the practical models and why it is done in such a way.

Addition to this exercise is locating the different types of insulation laying around in the training center (not only on the models, but the samples of insulation). Once a trainee has pointed out a sample of insulation, they should explain its peculiarities, where it is used and possible advantages and disadvantages over other types of insulation.

Exercise 2:

The trainees look thoroughly at the practical models. They should explain the sequence of the building renovation process and its peculiarities. In that exercise it is important to stress the specifics of the step-by-step refurbishment and how the different building parts, being renovated at a different time are in connection to each other and which things should be paid particular attention to.

After that the trainees should conduct one of the building works on the demonstration models: putting insulation; installing the windows; airtightness check. In the cases where there are many trainees, some of them should do different tasks after their fellow trainees, e.g. to put insulation after the windows have been installed; or to check the airtightness after the whole process.

Exercise 3:

The trainees look thoroughly at the specific mockup with the internal insulation situation.

They should explain the sequence of the building renovation process of a historic building and analyze the problems that must be solved when we use internal insulation. In that exercise it is important to understand how important it is to avoid any kind of humidity inside the old masonry wall and on the other hand to find technics to have a breathable wall.

Every exercise can take from 20 up to 60 minutes depending on the number of students and the amount of time spent on oral explanation from the tutor.

5. Plans for future development of the facilities

The range of models is to be widened in order to be able to serve as an example to all trainees during their practical exercises. Concept for uninstalling some parts (windows) and installing it back again are about to be implemented. Further implementation of RES systems is also considered and will play a major role in the training materials and foreseen courses.

Our main idea is to develop a “training truck” , so we will transform all mockups and walls to mobile units than can be loaded on a truck and we will try to have a “course on the road” during the next couple of years, with the support of material suppliers.

COUNTRY: IRELAND

1. Location

The training models demonstrating optimal approaches to retrofitting to NZEB will be located in a purpose-built training centre located in Enniscorthy, County Wexford, in the south-east of Ireland (see Figure 1). The training centre will be operated by the Waterford and Wexford Education and Training Board (WWETB) in a new facility being developed by it in the summer of 2018. The exact location of the training centre cannot be released at the time of printing due to the fact that the lease for the property is not yet signed. The facility is due to be fitted out in late August 2018 with the objective of being ready to deliver the first programme in early October 2018. The construction models have been transported to Enniscorthy (see Figure 2) and are currently in storage awaiting refurbishment of the facility. WWETB will be the first of the education and training boards (ETBs) in Ireland to deliver dedicated training to contractors on the topic of NZEB. During the first half of 2018, the WWETB commissioned the development of a National Skills Specification for NZEB training for contractors, with specific programmes being developed for the following trades: (1) brick layers, (2) plasterers, (3) carpenters, (4) plumbers, (5) electricians and (6) foremen. As far as we are aware, the six trade-specific NZEB programmes are the first of their kind to developed anywhere in Europe.
The ETBs in Ireland are acknowledged as being leading innovators in training construction workers in the realm of high performance buildings, with the CDETB in Finglas (Dublin) being the first (and only) to deliver the dedicated Certified Passive House Tradesperson course and CDETB in Ballyfermot (also in Dublin) the first to deliver dedicated airtightness training.

Figure 22: Location of the training centre in Enniscorthy, County Wexford in Ireland's 'Sunny South East'

Figure 23: Image of the construction training models being loaded for transportation to the training centre

2. Design drawings

The drawings depicted below represent the basis for the construction of the demonstration models.

2.1 Cavity Wall Construction

A large proportion of older homes in Ireland (which need retrofitting) are constructed of masonry, consisting of two leaves of solid concrete blockwork with a 100mm cavity in-between, typically 50% filled with polystyrene insulation (50mm thick). A 'ventilated cavity' of 50mm is typically left between the outer face of the insulation and the inner face of the outer block leaf as a means of ensuring that wind-driven rain does not migrate to the inner block leaf thus causing damp and mould in the home. The typical method of upgrading this wall construction to a higher performance (whether NZEB or Passive House) is to (a) pump the cavity with blown-in insulation (usually some kind of polystyrene) and (b) to place an additional insulation layer on either the exterior or interior of the wall (Figure 3). The former (exterior insulation) is much preferred from the perspective of reducing thermal bridging. Regrettably, however, the tradition in Ireland has, to date, been to insulate the interior of the exterior wall which does not avert the risk of mould growing behind the insulation on the cold interior surface of the exterior wall.

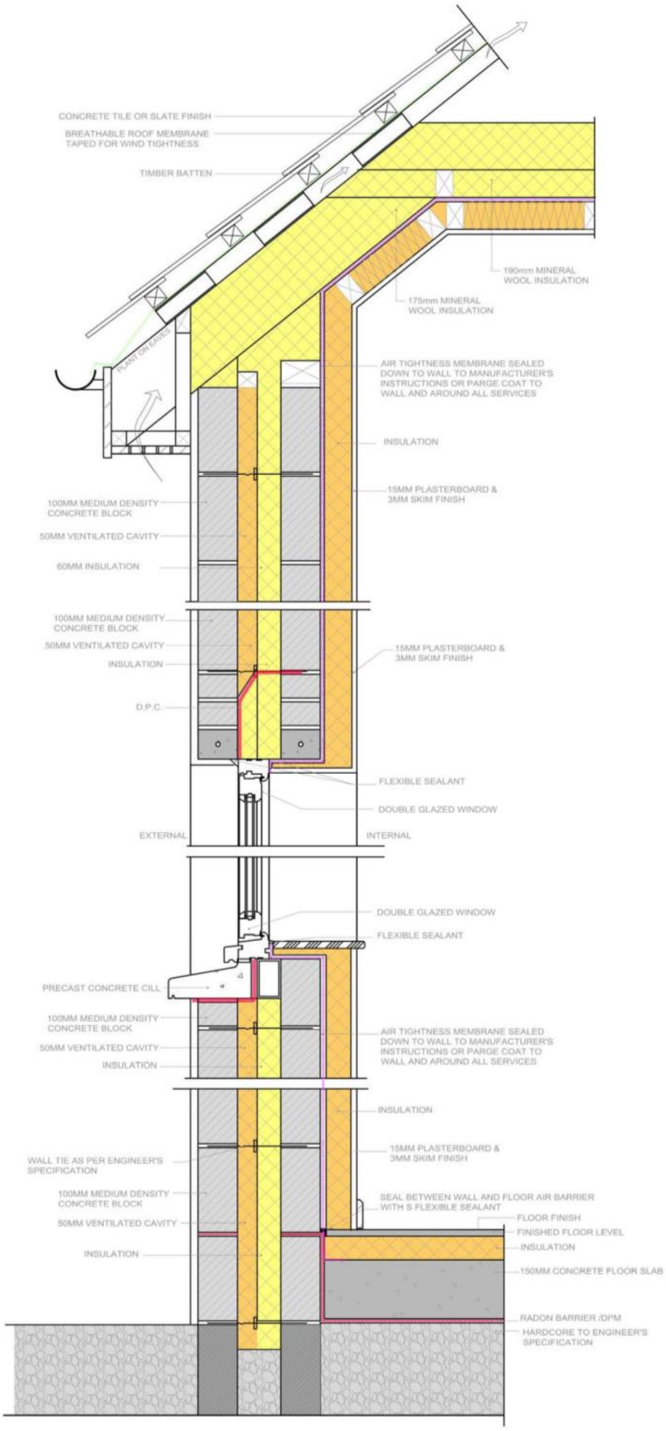


Figure 24: Typical approach used in Ireland to upgrade a cavity wall construction

3.2 Solid Masonry (Block or Brick) Construction

Another popular method of building homes in Ireland was to use a single leaf masonry construction system consisting of concrete blocks 225mm in width with no insulation on either the interior or exterior. The use of hollow concrete blocks was particularly prevalent in the Dublin region where the risk of wind-driven rain crossing the cavity to the home interior was low (unlike the windier regions in the west of Ireland where such as system is rarely used). The optimal method of upgrading such a system to the NZEB standard is to use an external insulation system. However, some homeowners use an internal insulation system (so-called 'dry-lining') as an approach.

The first drawing below (Figure 4) depicts a solid masonry construction with both external insulation (thick) and internal insulation (thin). The second drawing (Figure 5) depicts a brick building with insulation to the exterior on the upper floor and insulation to the interior on the lower section.

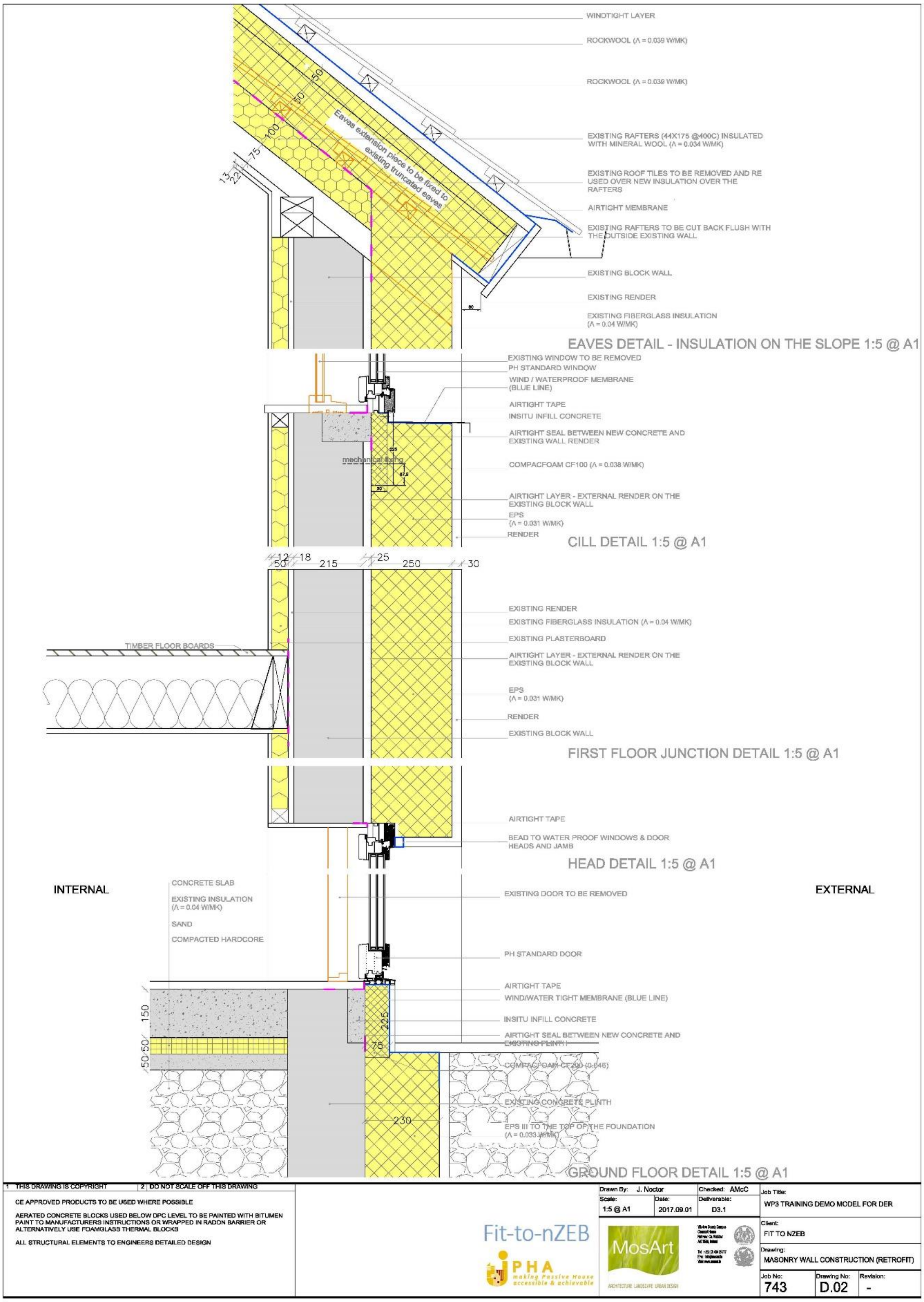


Figure 25: Upgrading a solid block wall (which has previously had a modest insulation layer applied internally (so-called 'dry-lining' in Ireland) with a generous external insulation finishing system.

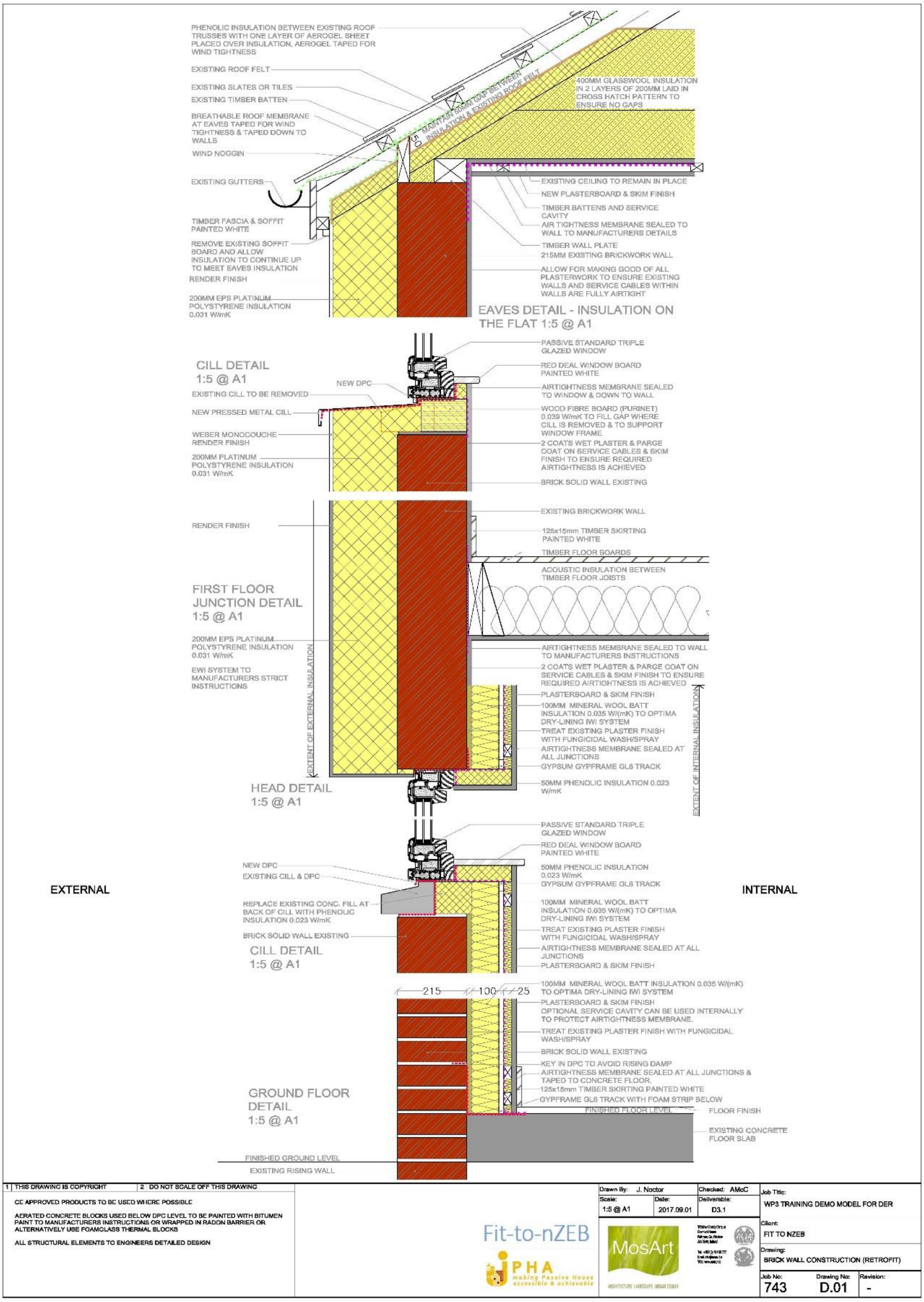


Figure 26: Masonry (brick) building retrofit illustrating both internal and external insulation strategies.

3.3 Timber Frame Construction

Timber frame construction became very popular in Ireland in the 1990's and 2000's, but much of it would not meet the NZEB standards in terms of insulation or airtightness. As a result of this, it is expected there will be a demand from owners of such building types for deep retrofitting services.

Most timber frame homes in Ireland were build with an external block leaf on the exterior and a cavity between this external masonry layer and the internal timber frame wall. This approach was used to reduce the risk of wind-driven rain damaging the timber frame wall.

In retrofitting these types of homes, there are two choices, namely (a) to remove the external block leaf and externally insulate the timber frame (with no cavity) (Figure 6) and (b) to leave the concrete leaf in-place, full-fill the cavity and externally insulate the block leaf (resulting in a wide wall) (Figure 7). Both of these options are depicted below.

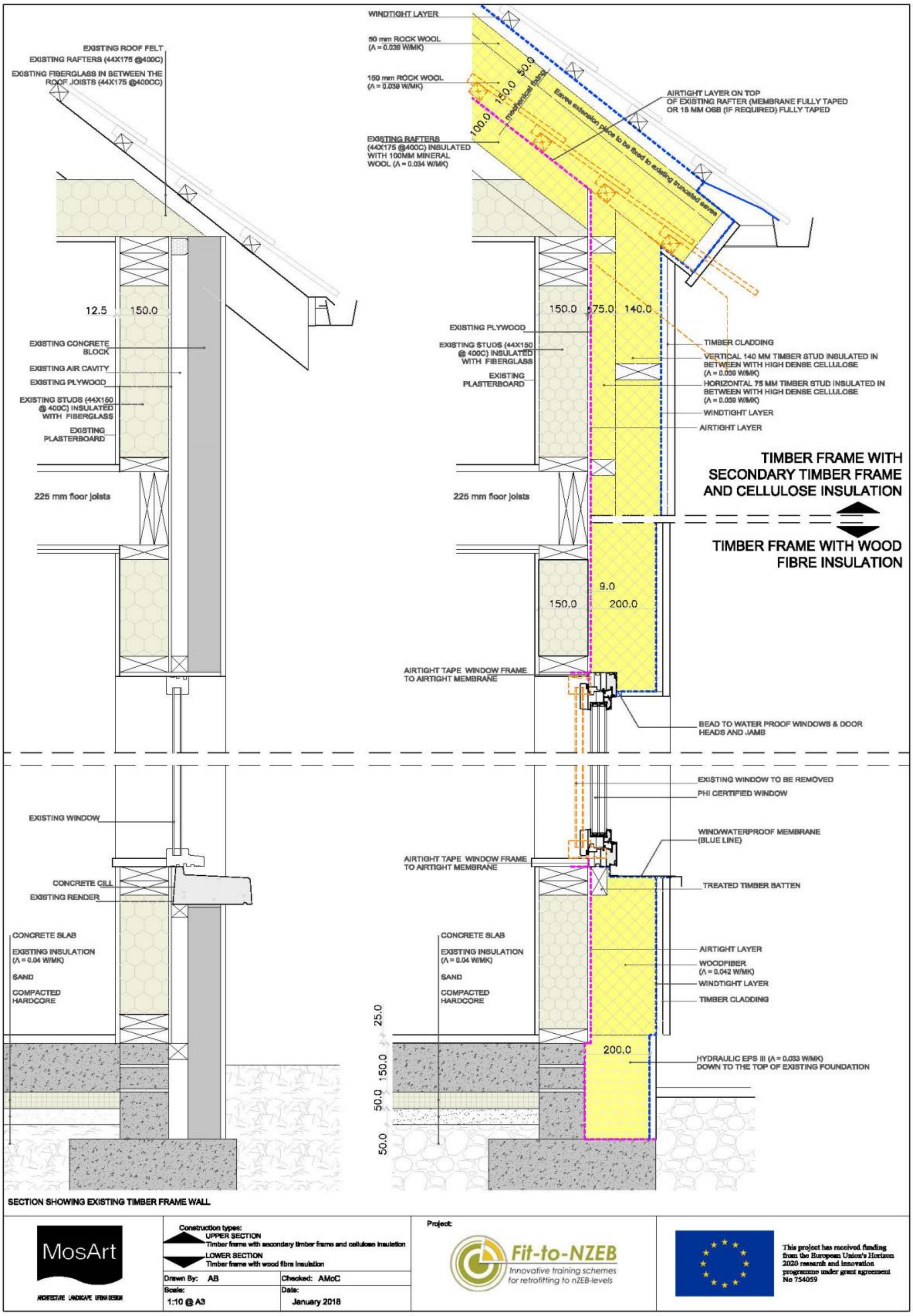


Figure 27: Upgrading a timber frame wall involving removal of external block leaf and directly insulating the timber frame structure with an external insulation finishing system.

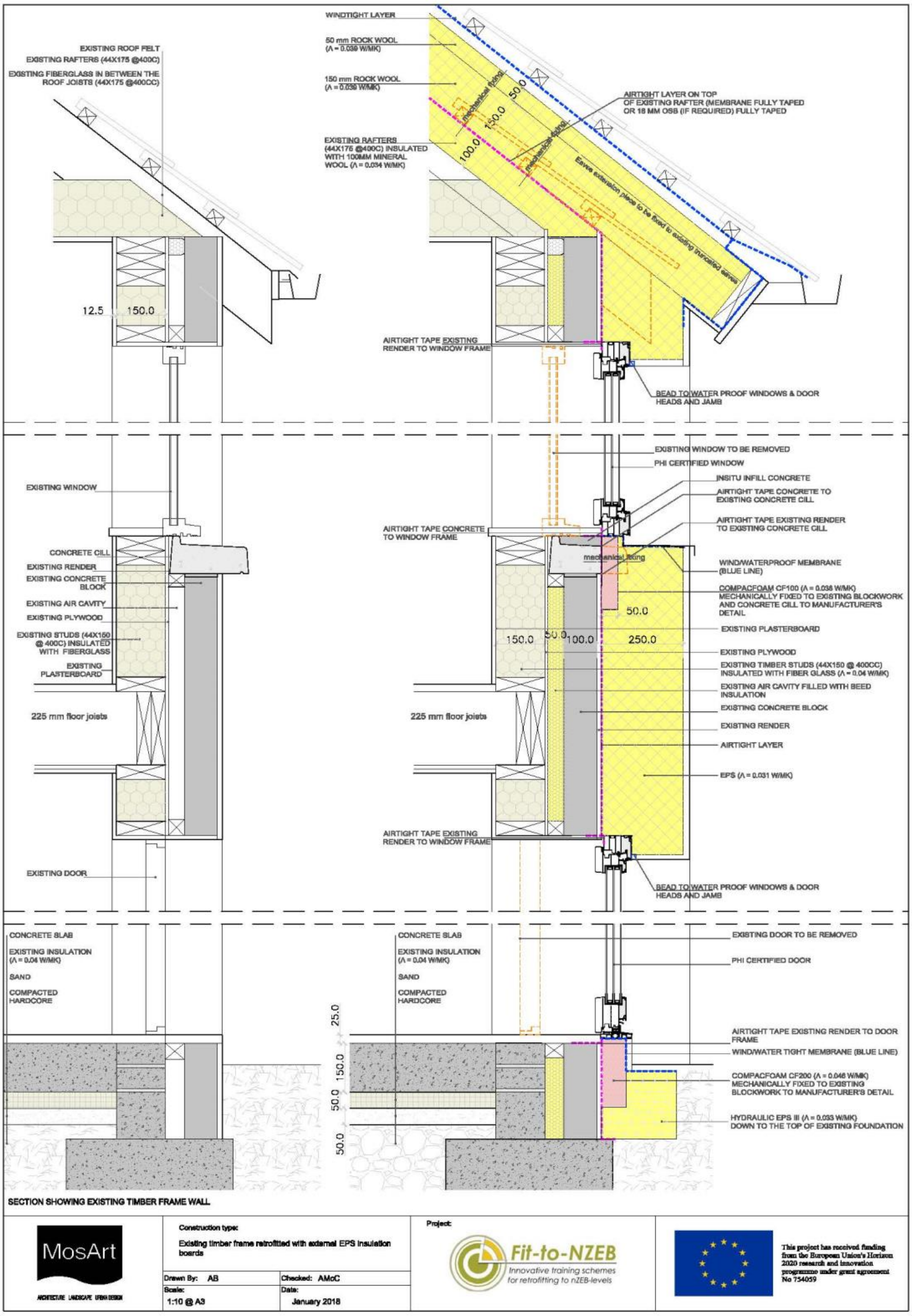


Figure 28: Upgrading a timber frame wall which retains the external block leaf, fills the external ventilated cavity with insulation and applies an external insulation finishing system to the block leaf

3. Construction of the models

3.1 Cavity Wall Construction

An image of one of the training construction models is depicted below (Figure 8), consisting of a cavity wall construction with internal insulation on the ground floor. A vapour control layer on the interior, between the plasterboard and the wall insulation, is used to reduce the risk of warm humid air escaping through the insulation layer and condensing on the inner face of the block wall. This measure is critically important to reduce the risk of mould growing on the internal face of the wall (which will periodically be close to the dew point temperature in the heating season). The upper part of that same model illustrates the placement of insulation on the exterior of the cavity wall. This model, therefore, shows both approaches that are most commonly used (internal and external insulation).

Figure 29: Model constructed depicting cavity block wall with(a) internal insulation and full-fill cavity on the lower level and (b) external insulation with full-fill cavity on the higher level.

3.2 Solid Masonry (Block or Brick) Construction

The images below depict two treatments that are commonly used for solid masonry construction (on the left, internal insulation, on the right, external insulation) (Figure 9). Where insulation is placed on the interior, a vapour control layer is used on the warm side of the insulation to reduce migration of humid internal air passing through the insulation and possibly causing mould. In the case where the wall is externally insulated, no such vapour control layer is required, using plaster in this case to achieve a high level of airtightness.

Figure 30: Images of brick external wall models internally insulated with rockwool (on the left) and externally insulated with polystyrene (on the right).

3.3 Timber Frame Construction

The model used to depict the classic retrofitting approach to timber frame construction is depicted below (Figure 10). In this case, the external block leaf has been removed and insulation placed directly on the exterior of the structural wall.

Figure 31: Timber frame model depicting retrofit of external insulation on wall and roof using wood fibre

3.4 Equipment other than Construction Models

In addition to the above construction models, the Fit-to-NZEB training facility will also include a miniature air-tightness testing 'house' (depicted under-construction below) as well as an MVHR (the Nilan Compact P model, which includes not only an MVHR but also a domestic hot water tank and an exhaust-air heat pump). Lastly, photo-voltaic panels (PV) will also be displayed at the facility as part of the most popular renewable energy systems currently used in Ireland.

Figure 32: Airtight room for airtightness testing

4. Concept for use and exercises

Exercise 1 (theoretical): Draw and Explain What You See

The core use of the models is to demonstrate the optimal retrofitting approach to the most common construction methods in Ireland. In PHA's experience with such training, having trainees simply 'passively' looking at the models is not enough to ensure that they truly appreciate the insulation, airtightness and thermal bridge details being presented. Instead, therefore, they are required to sketch what they see using pencil and paper as depicted in the images below (Figure 11).

Figure 33: Trainees Sketching the Construction Models

The trainees are guided to draw the key aspects of insulation, airtightness / vapour control and thermal bridging. They should be very conscious of the need to create continuity of both the insulation layer and airtightness / vapour control layer and the need to minimise and highly conductive materials interrupting the insulation layer and causing a thermal bridge.

The next step in this process is to get the trainees to explain verbally, using their sketches, what they 'see' in the construction model. Their presentation should cover the key aspects of insulation, airtightness / vapour control and thermal bridging, pointing out the different materials, connections and details used to create the highest-performing external envelope.

If trainees have suggestions on alternative methods of creating the same result, using different materials and / or methods, this is to be encouraged. Where such suggestions are ill-founded and might cause energy, moisture or comfort-related problems, the trainer should explain why this is so and engage with the trainee to work through a 'safer' approach.

It is important to teach the trainees to be able to adapt to different circumstances that they might encounter on site (such as use of different insulation or membrane types) and to know when it is important for them to see the advice of other more experienced colleagues when unsure of the path forward.

The final step in this theoretical part of the training is to get the trainee to explain the construction sequence involved in achieving the desired result. They should list the steps in a logical sequence from start to finish.

Exercise 2 (practical): Apply What You See

The next phase for the trainees is to apply in practice what they have learned in theory. This consists of an exercise running over a period of 90 minutes or so in application of insulation and airtightness membranes and tapes to bare 'skeletal' structures (Figure 12). Continuity of insulation and airtightness / vapour control is essential for this exercise, and also neat workmanship. The trainee needs to be able to explain the sequence of works involved and the challenges they encountered. The trainer, on the other hand, needs to give a full critique of the trainee's work and suggest where improvements might be required.

Figure 34: Trainee Application of Theory into Practice

COUNTRY: ITALY

1. Location (with photographs)

The new model will be used in the accordance with the ITS Varese and will be situated in the building of the Scuola Edile Varese – Formedil – a renowned VET educational institution in Italy.

Figure 35: Location of the Scuola Edile Varese - Formedil

2. Design drawings

The drawings represent the basis for the construction of the demonstration model. It is a mock-up of an entire house with dimensions 2 m x 2m. It consists of a lightweight construction with a wooden roof. In the last decade wooden building construction has become very common in Italy. The model, together with the construction process has been designed to have a mock-up that can be used several times for training: all components can be installed, uninstalled and installed back in the next training session.

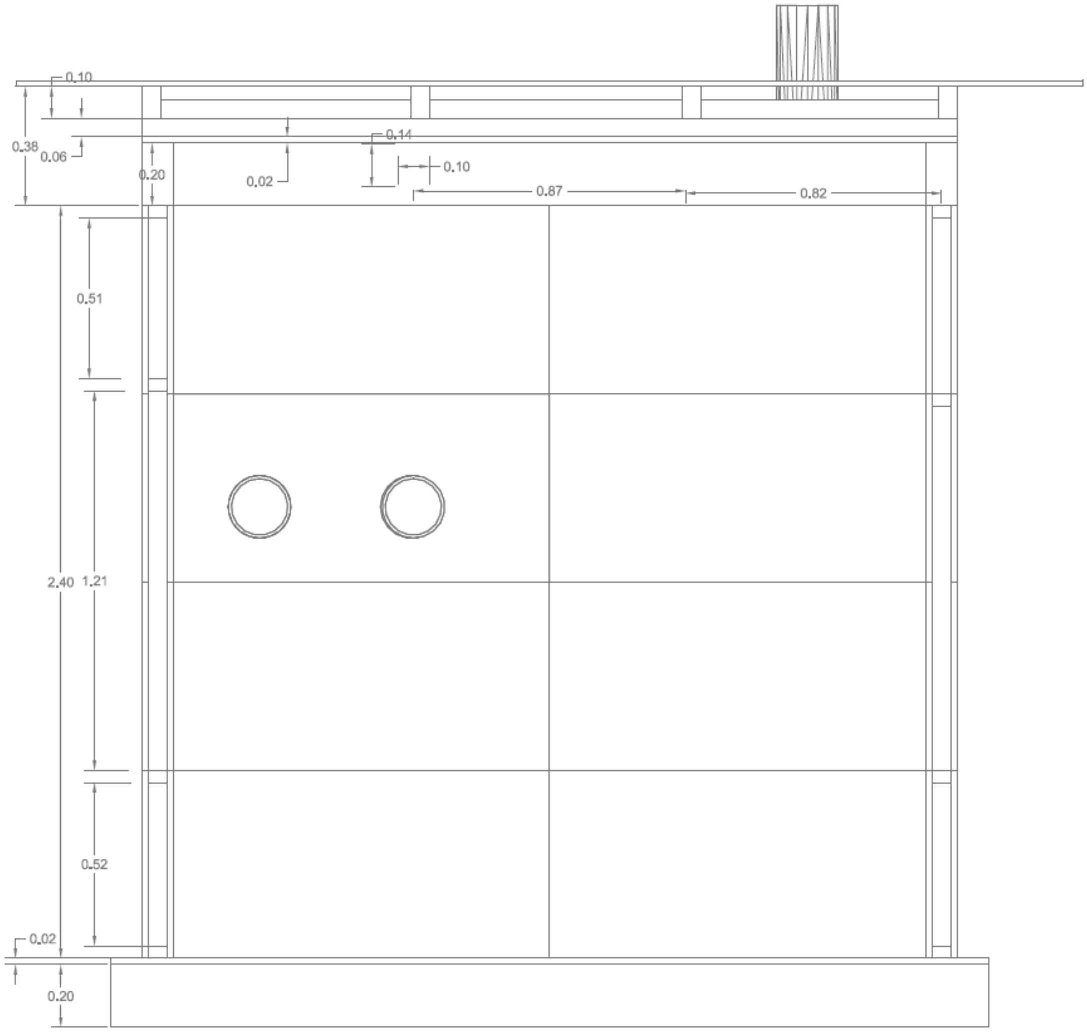


Figure 36: Cross Section of the mock-up

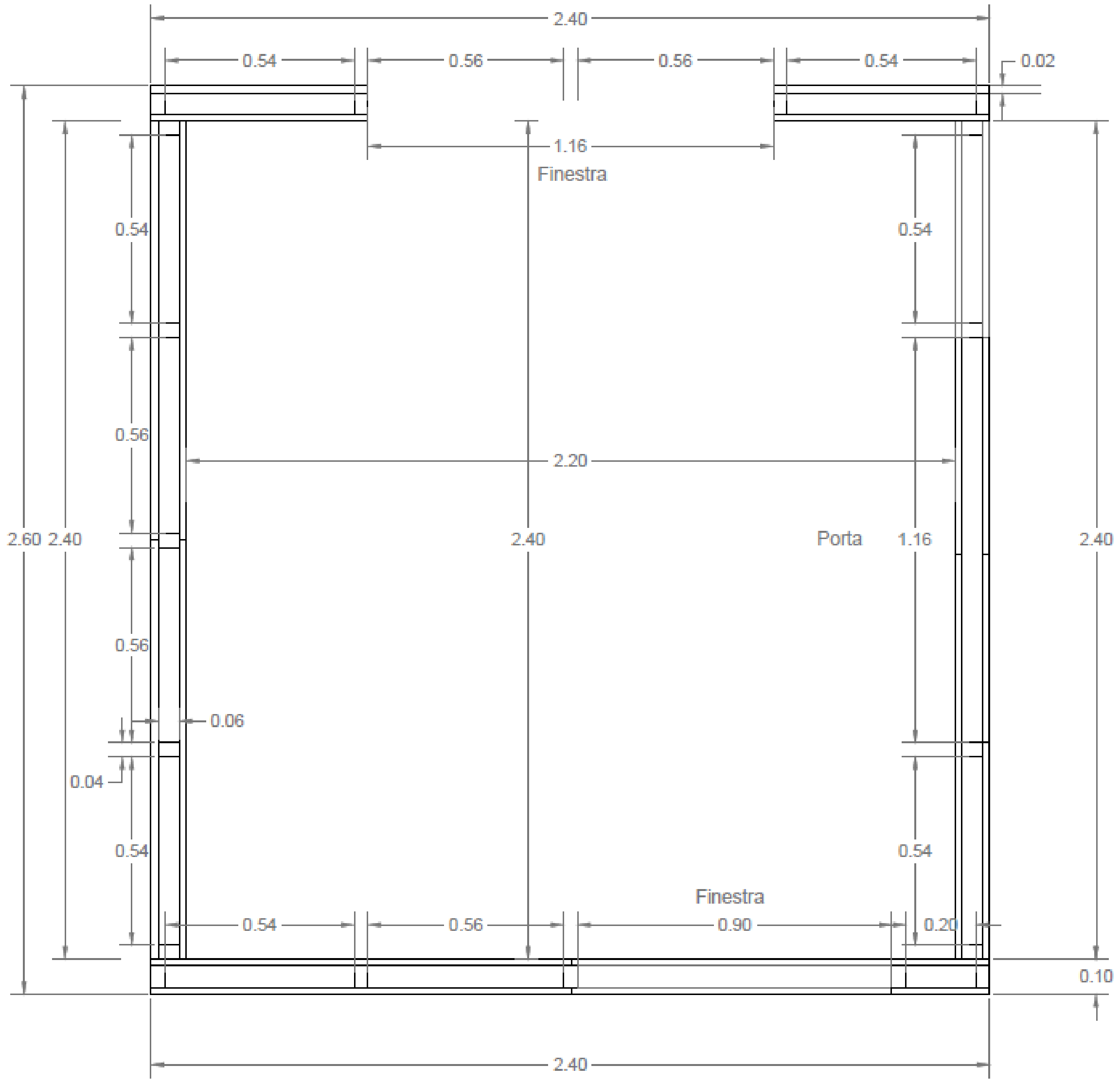


Figure 37: Plan of the mock-up

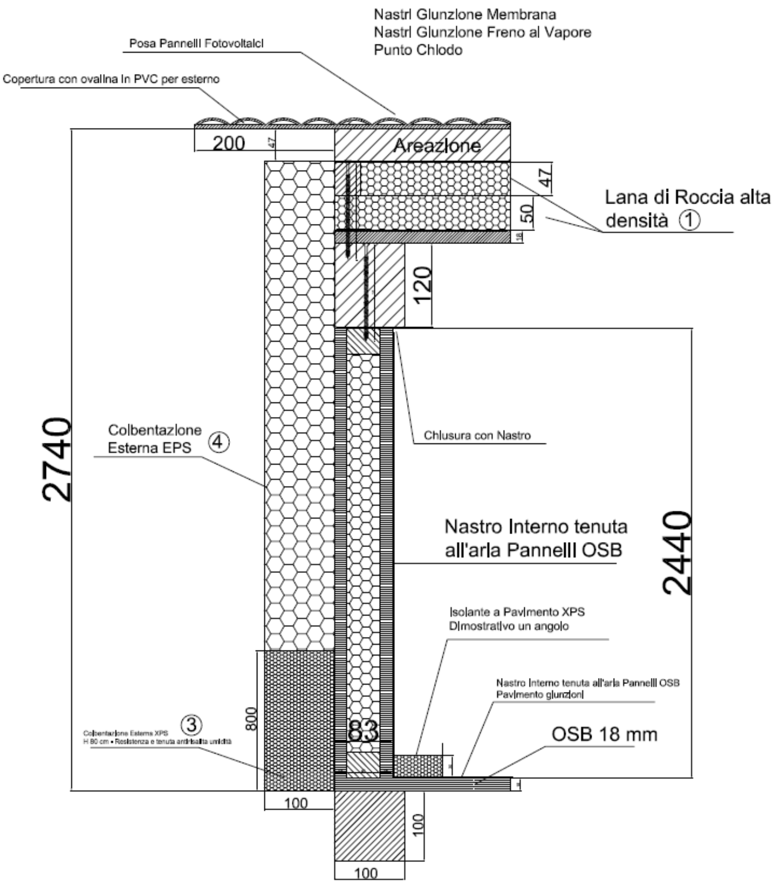


Figure 38: Connection detail: Exterior wall / Roof

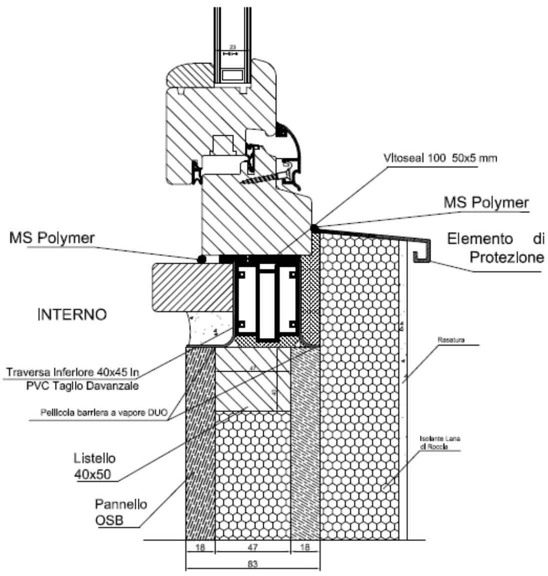


Figure 39: Window installation detail

. Construction of the models

During the training day all trainees and teachers have worked together to build the model.

4. Concept for use and exercises

Exercise 1:

The trainees should install all the components on the mock-up, namely wall insulation, roof insulation, floor insulation, airtightness layer, window, ventilation ducts. They will be helped by the teacher. Airtightness layer is the most difficult component to be installed in a proper way and each error on the airtightness layer can compromise the durability of the building structure, therefore at the end of the lesson a blowerdoor test will be done to detect all airtight errors done by trainees. In this way they can learn by doing.

5. Plans for future development of the facilities

The range of models is to be widened in order to be able to serve as an example to all trainees during their practical exercises. Concept for another building system model will be planned in the future.

COUNTRY: ROMANIA

1. Location (with photographs)

The new models will be used in the premises of the Bucharest Centre of Building Knowledge Hub Romania (BKH RO), situated within the platform of NIRD URBAN-INCERC as well as in the premises of the Technical College of Architecture and Public Works “I.N. Socolescu”.

The National Institute for Research and Development (NIRD) URBAN-INCERC is situated in the East part of Bucharest and hosts the main headquarters and two of the 5 branches in the Bucharest platform, which includes strategic research infrastructure in buildings (covering seismic and structural strength, energy performance, building services, indoor environment, acoustics and fire protection). The functionalities of the Romanian Building Knowledge Hub in Bucharest are ensured through a dedicated Conference & Training Building and the Practical Training Hall within the main building of the Building Services building. “Ioan N. Socolescu” College of Architecture and Public Works is a century-old school with a long and important tradition in offering tuition to students interested in the area of architecture and construction. The college is located in the centre of Bucharest, at walking distance from Victoria Palace (the Government of Romania) and from North (main) Train Station.

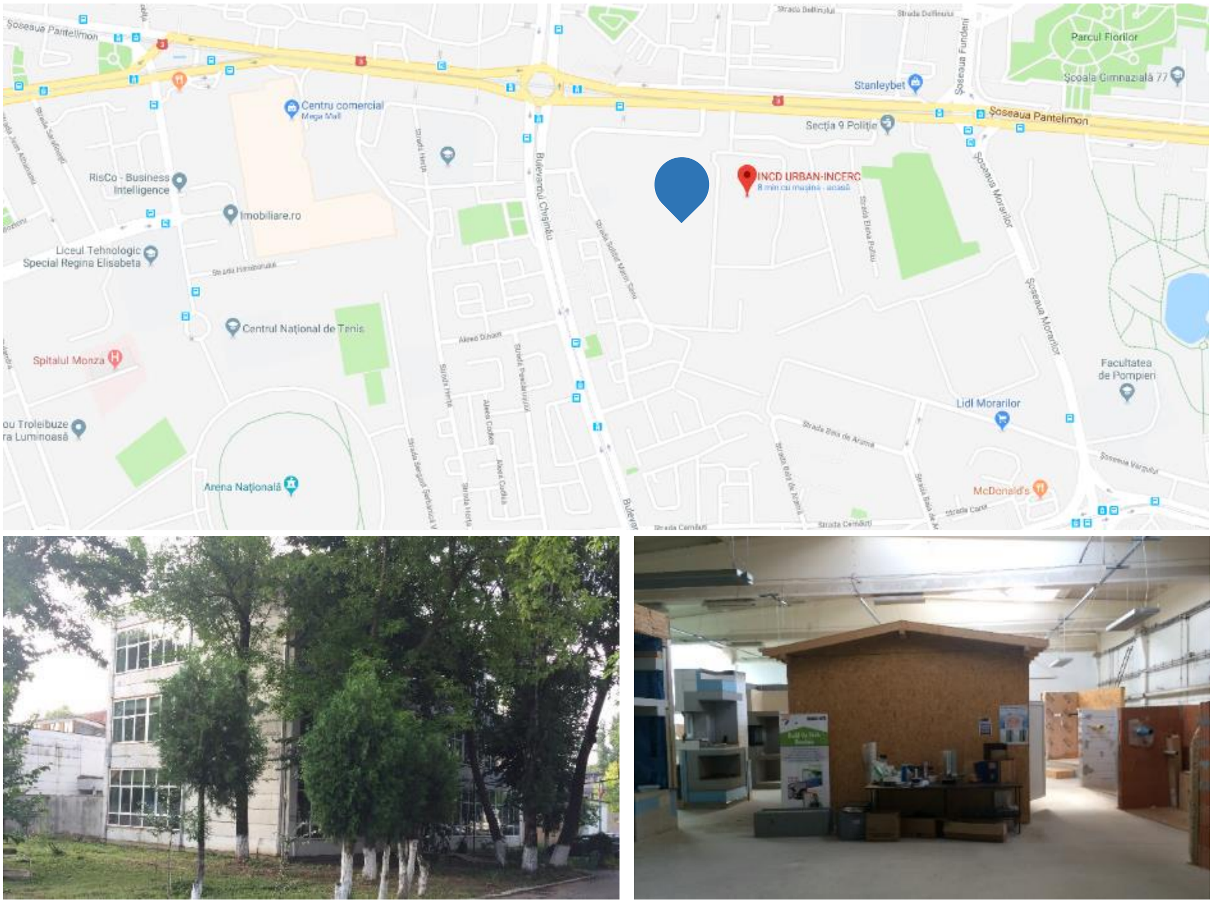


Figure 40: Location of the Romanian BKH in Bucharest

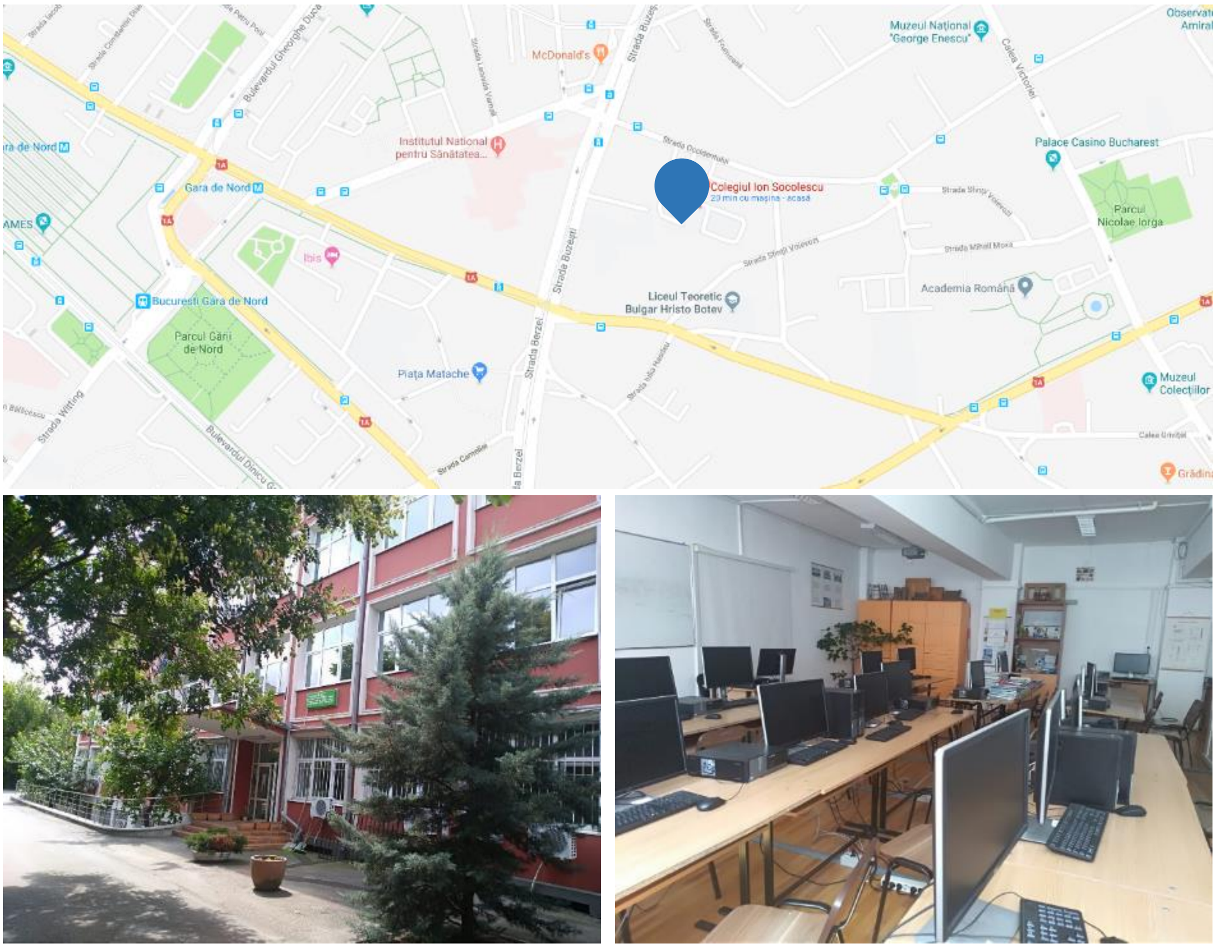


Figure 41: Location of the "I.N. Socolescu" Technical College

2. Design drawings

The drawings produced for the Fit-to-nZEB project represent an adaptation for renovation situation of the models developed for the development of BKH RO and are representative for the construction tradition of Romanian building stock. The detail shows foundation, walls, floor and roof with all their connections. One additional full demonstration model for the building envelope (Figure 7) is produced within the BKH RO premises, with in the Socolescu premises only small details will be delivered (thermal bridges, ETICS and airtightness of joints and penetrations).

Special attention is paid to renewable energy systems, in particular solar thermal and PV systems (Figure 8). In both locations (URBAN-INCERC and Socolescu) one system for each solar technology will be fully available before the beginning of the courses (estimated September 2018). In the BKH RO the systems will be accommodated indoors on a special demonstration roof structure (2 different coverings and fixings), while the PV system has two additional panels outside in order to demonstrate the impact of solar irradiation, temporary shading and dynamics of energy demand with the possibility to switch between network and battery storage. At Socolescu premises, the solar thermal and PV systems will be placed outside, while part of the electrical system of the PV demo will be placed in the classroom for practical exercises.

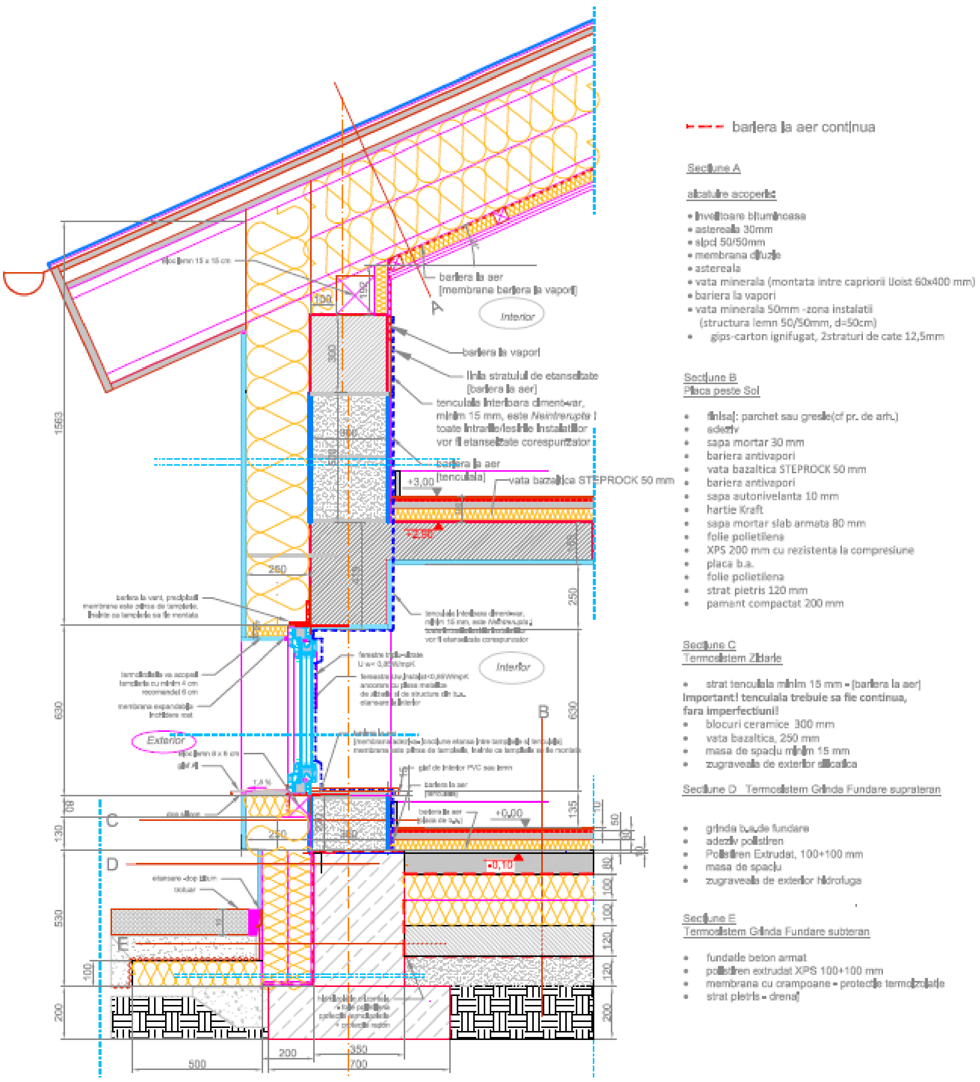


Figure 42: Detail for renovation of mixed reinforced concrete framework and light-wave concrete walls

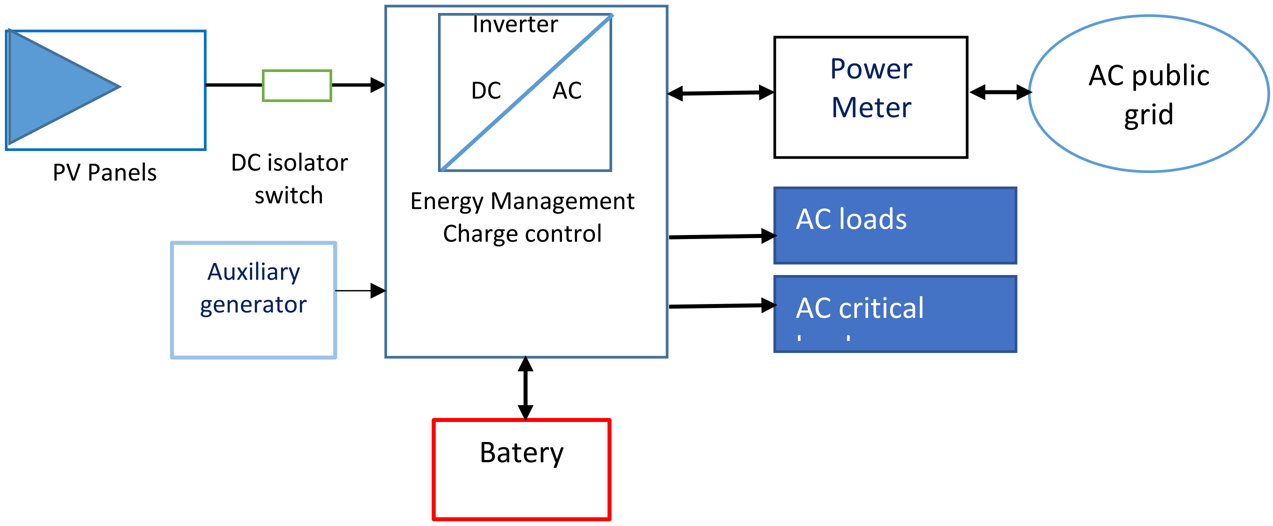


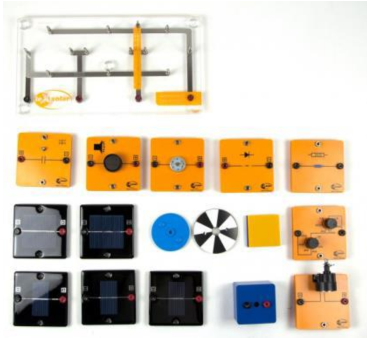
Figure 43: Detail for renovation of mixed reinforced concrete framework and light-wave concrete walls

3. Construction of the models

During the sixteen-month period, developments are noted in the design and realization of the demonstration models as suggested from the ToR document (D3.1).

In addition to the full-scale demo models for solar energy use in buildings, two didactical kits for the electrical use of solar energy are under procurement (for the two locations) and will serve to apply experiments related to solar energy conducted in normal room lighting and focused on correlating school physics with practical usage of the photovoltaic cells.





4. Concept for use and exercises

Exercise 1:

The trainees should stand in front of once of the full scale practical models (building envelope) and try to redraw it. After that they should explain where the insulation layer and airtightness layer are on the drawing, and respectively on the model. The exercise develops the skills of drawing technical details and comprehending the principles of deep energy retrofits in various construction types in buildings.

The same exercise can be conducted by just the trainees explaining, based on what they have learnt from the presentations, what they can see on the practical models and why it is done in such a way. This can be done at the white board, using additional drawings for various details (which have been also simulated for heat transfer and thermal bridging calculation).

Addition to this exercise is locating the different types of insulation laying around in the training centre (not only on the models, but the samples of insulation). Once a trainee has pointed out a sample of insulation, they should explain its peculiarities, where it is used and possible advantages and disadvantages over other types of insulation.

Exercise 2:

The trainees look thoroughly at the practical models. They should explain the sequence of the building renovation process and its peculiarities. In that exercise it is important to stress the specifics of the step-by-step refurbishment and how the different building parts, being renovated at a different time are in connection to each other and which things should be paid particular attention to.

After that the trainees should conduct one of the building works on the demonstration models: putting insulation; installing the windows; airtightness check. In the cases where there are many trainees, some of them should do different tasks after their fellow trainees, e.g. to put insulation after the windows have been installed; or to check the airtightness after the whole process.

The exercise can take from 20 up to 60 minutes depending on the number of students and the amount of time spent on oral explanation from the tutor.

Exercise 3:

Different experiments can be performed based on the solar PV kit, facilitating the understanding of the basic phenomena related to the use and conversion of solar energy and interaction with the grid:

- power dependence on the area of the solar cell, on the angle of incidence or on the level of illumination;
- determination of efficiency ratio of energy conversion,
- dark characteristic curve of solar cell,
- inhibiting and conducting direction in illumination and darkness,
- characteristic of the solar cell in dependence on the level of illumination, dependence of the solar cell power on temperature,
- shading of solar cells in series connection and in parallel connection,
- power dependence on the frequency of the incident light

Exercise 4:

This exercise is based on the solar energy module of the Renewables topic and demo models for solar thermal and PV systems finalized. The trainees look thoroughly at the practical models. They should explain the sequence of the installation of a solar thermal and/or a solar PV system in the building renovation process and its peculiarities (e.g. different roof systems and fixings, stand-alone or grid connected PV systems etc.).

Discussion is conducted towards what is important in completing a high-quality design and installation, safely, within a reasonable time. Practical discussion on how to ensure a proper performance of a PV system, structured in five main topics: (1) on site visit, (2) sizing / design, (3) Installation, (4) Maintenance/Inspection, (5) Operation & maintenance manual /customer needs.