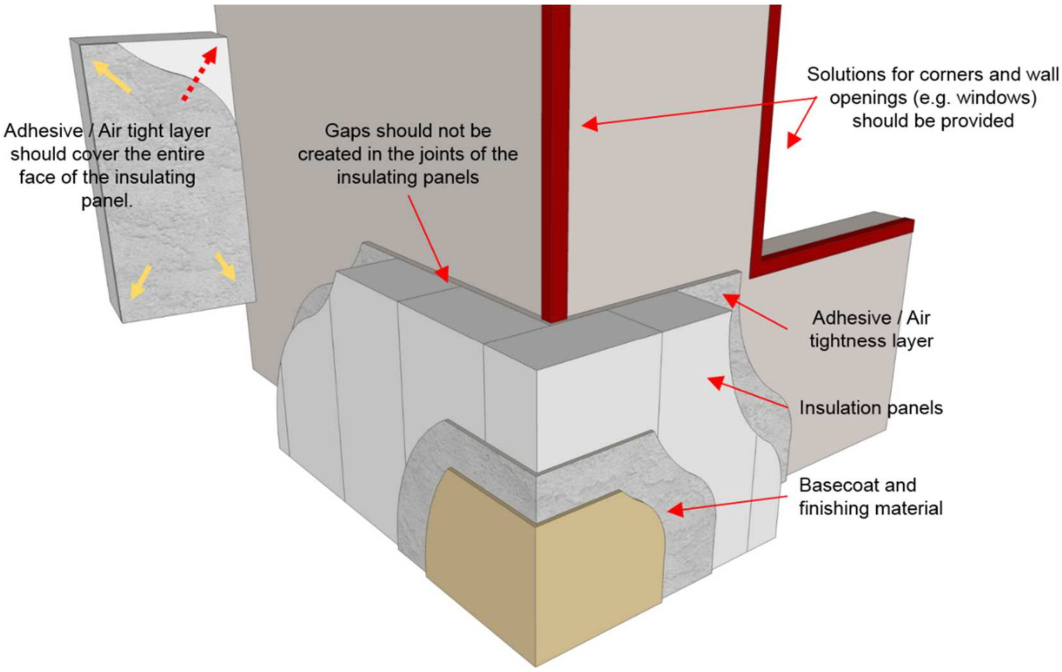
D5.1.15a_Guidelines_External Air-tighting Insulation and Finishing System (EAIFS)



INTELLIGENT ENERGY – EUROPE II

Energy efficiency and renewable energy in buildings

IEE/12/070

EuroPHit

[Improving the energy performance of step-by-step refurbishment and integration of renewable energies]

Contract N°: SI2.645928

Co-funded by the Intelligent Energy Europe Programme of the European Union

Technical References

Project Acronym	EuroPHit
Project Title	Improving the energy performance of step-by-step refurbishment and integration of renewable energies
Project Coordinator	Jan Steiger Passive House Institute, Dr. Wolfgang Feist Rheinstrasse 44/46 D 64283 Darmstadt jan.steiger@passiv.de
Project Duration	1 April 2013 – 31 March 2016 (36 Months)

Deliverable No.	D5.1.15
Dissemination Level	PU
Work Package	WP5_Product Development
Lead beneficiary	05_iEPD
Contributing beneficiary(ies)	01_PHI
Author(s)	Wolfgang Hasper
Co-author(s)	
Date	24.09.2015
File Name	EuroPHit_D5.1.15_EAIFS_PHI

Table of Contents

Co-funded by the Intelligent Energy Europe
Programme of the European Union

Abstract

This document elaborates guidelines and defines a concept for product development for External Air-tighting Insulation and Finishing Systems (EAIFS) for the use in step-by-step energy efficient refurbishments of opaque walls. These present an important enhancement of existing and widely used External Insulation and Finishing Systems (EIFS) in adding the air tightness property to a building element that is installed anyway, and thus avoiding one extra working cycle.

In this concept the air tight layer is added to the exterior face of the existing structural wall. This offers benefits as regards avoiding numerous penetrations and geometric complications encountered in the usual situation of adding air tightness on the inside. No electrical or plumbing installations can interfere with an air tightness layer on the outside, even ceilings or wooden beams present no obstacles. Large areas can thus be treated in short time. Work on cabling or plumbing is also faster as no air tightness measures have to be taken unless a penetration of an exterior wall is required.

Another important benefit of the approach is seen in the fact that work on the EAIFS-System does not interfere with the inhabited space. The impact on tenants is minimised, not least by the general speed of work. Moreover the air tightness layer will be inaccessible to building users, avoiding any user-related damage altogether.

Passive House buildings and deep retrofits with Passive House components (EnerPHit) provide optimal comfort with minimum energy costs and prove cost-effective over their life-cycles. In order to achieve such comfort and low life-cycle costs, the thermal quality of the components used in such buildings must meet stringent requirements. These requirements are directly derived from the energy, hygiene and comfort criteria

Achieving a high level of air tightness in deep retrofits is crucial for the success of any project. Not only does it reduce heat losses related to infiltration, but it also prevents structural damage related to excessive moisture build-up, and enables the efficient operation of MVHR systems. Moreover a high level of air tightness significantly enhances thermal comfort by avoiding droughts.

Experience from a large number of Passive House buildings and EnerPHit refurbishments has shown that, as soon as air tightness is an acknowledged planning task and properly implemented achieving an especially high level of air tightness is also a very cost-effective way to significantly improve building performance.

1 External Air-tighting Insulation and Finishing Systems

1.1 Requirements and testing

The intended advantage of an EAIFS can only be realised when both properties, can be achieved in one single operation. It is therefore required that the insulation blocks are improved to be air tight without compromising the bonding. Typically, the adhesive used to install the insulation blocks is applied as a generous bead along the perimeter and the tight joint of two adjacent blocks is achieved by the adhesive.

Should additional mechanical fixtures be required (dowels), these must be designed to seal the hole in the air tight face created by drilling for the dowel.

For air EAIFS there are different quality levels depending on the climate:

Climate Zone	Permeability q_{50} [m³/(hm²)]	Max. U-Value [W/(m²K)]
Arctic	0,08	0,09
Cold	0,10	0,12
Cool-temperate	0,15	0,15
Warm-temperate	0,15	0,25
Warm*	0,15	0,50
Hot*	0,10	0,50
Very hot*	0,10	0,25

Table 1 – Preliminary requirements for different climate zones

*Variants with air tightness/vapour control layer on the outer face may be beneficial in some climates

The permeability must be established for 3 specimens of the suggested system assembled by a trained person, based on the manufacturer's instructions, but independent from the manufacturer.

Each specimen must consist of at least four insulation blocks of identical size and shape with four linear joints between them and cover an area of at least 1 m². The blocks are installed on a false substrate that presents no relevant air tightness but allows the installation of the blocks with the adhesive material prescribed by the manufacturer and can take any dowelling if such is part of the system. Each block is fastened with the relevant number of dowels, according to the intended application. The whole remains unfinished to establish the effectiveness of the actual air tighting part of the system. The perimeter of the specimen is sealed to ensure one-dimensional flow across the specimen.

The actual permeability is to be measured by a laboratory independent from the manufacturer using the differential pressure method.

Additionally the manufacturer must present and publish an understandable concept for all details normally encountered in the thermal envelope of a building. For each detail the air tighting systematic (e.g. connection to adjacent building elements) and minimal thermal bridging must be proven and detailed instructions for the designer and installer must be provided. If some thermal bridging is unavoidable, each detail must provide the thermal bridge heat loss coefficient (linear Ψ or punctiform χ) based on external dimensions, as required in energy balance calculations.

Typically, the details would include:

1. Regular wall

2. Exterior Corner, interior corner
3. Window installation, side, top, bottom
4. Parapet
5. Eaves
6. Gable
7. Base
8. Duct penetration
9. Cable penetration
10. Fastener penetration (e.g. rails, canopy…)

Furthermore, suitable proof must be given as to the long-term stability of the air tightness layer.

Any further issues should be settled in agreement with PHI certification criteria for construction systems and EnerPHit insulation systems (for retrofits), available at http://passivehouse.com/.

Co-funded by the Intelligent Energy Europe
Programme of the European Union

2 Design principles

The desired advantage of an EAIFS is speed and ease of installation combined with robustness of the air tightness layer thus achieved. For practical and economic reasons, it is therefore limited to insulation blocks that provide the required insulation in one single layer.

2.1 Air tightness layer

For heating dominated climates (arctic to warm-temperate) the air tightness layer must be located on the inner face of the insulation. For other climates, especially those with large seasonal variation in humidity levels, further study may be required to determine the optimal position of the air tight layer. In any case, it should be avoided to expose the air tight layer to large temperature variation or mechanical stress as would be present on the outside.

Vapour diffusion properties of the air tightness layer become more important in locations with continuously high vapour pressure differences between the inside and the outside.

Depending on the insulation material in question different paths for achieving an air tightness layer are conceivable, including any combinations:

1. Closed cell insulation material is air tight altogether

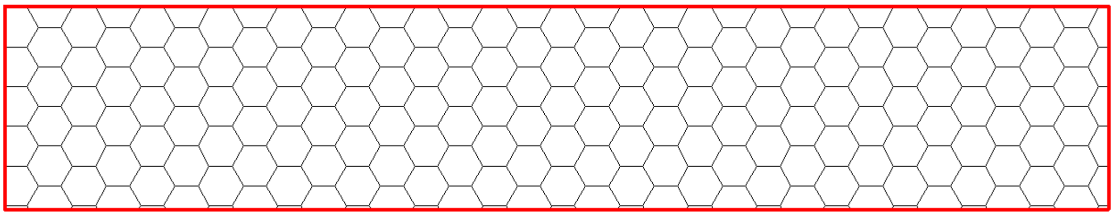


Figure 1: closed-cell airtight insulation material

2. Inner face of insulation material is manufactured of same material but higher density to provide air tightness

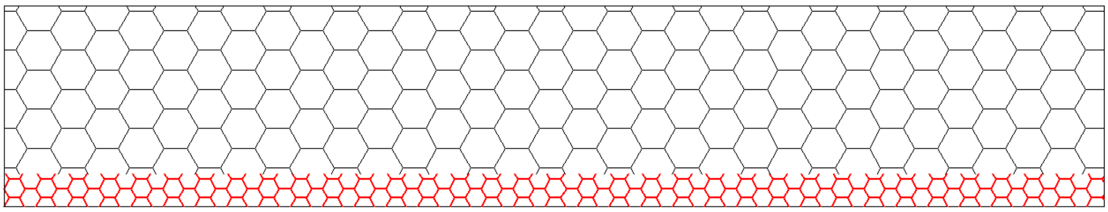


Figure 2: high-density air tight inner layer of insulation material

3. Inner face of insulation material comes pre-coated with sealing compound, probably the regular adhesive material (with reinforcing mesh if required). The coating may also be applied during installation.

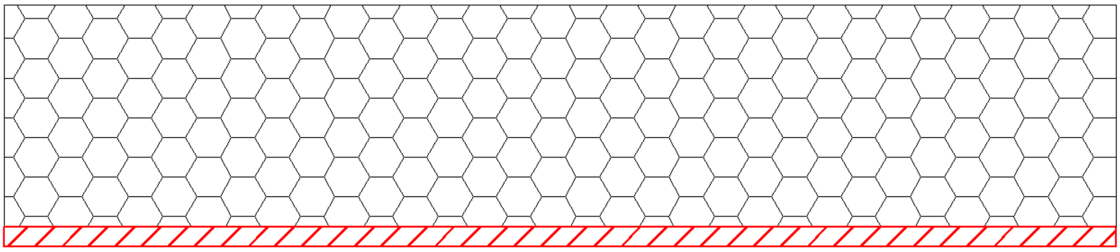


Figure 3: coated inner surface of insulation block for air tightness

4. Air tighting coating and adhesive are united to form a full faced layer between insulation block and wall.
5. Sheet of air tight material is applied to the inner face of insulation material

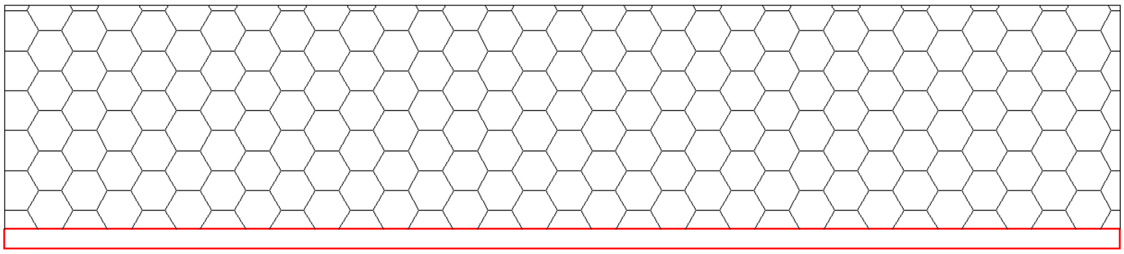


Figure 4: added sheet of air tight material on inner face of insulation block

As a matter of course the inner face of the blocks must allow secure bonding of the adhesive and the air tightness layer must be reliably bonded to the insulation block.

2.2 Joints

Apart from the air tightness of the EAIFS blocks as such, the performance of the system is determined by the reliability of the sealing of the block-to-block joints. Defining a failsafe block-to-block joint is therefore crucial.

It is obvious to employ the adhesive for this purpose as it is an integral part of the system anyway and available at no extra cost or labour. Precondition is the proper application of adhesive along the whole perimeter of any block. To define the uniform application of sufficient amounts of adhesive along the entire perimeter of each block special spreaders or applicators may be helpful. Very clear guidelines must be given to installers including suitable quality-assurance procedures.

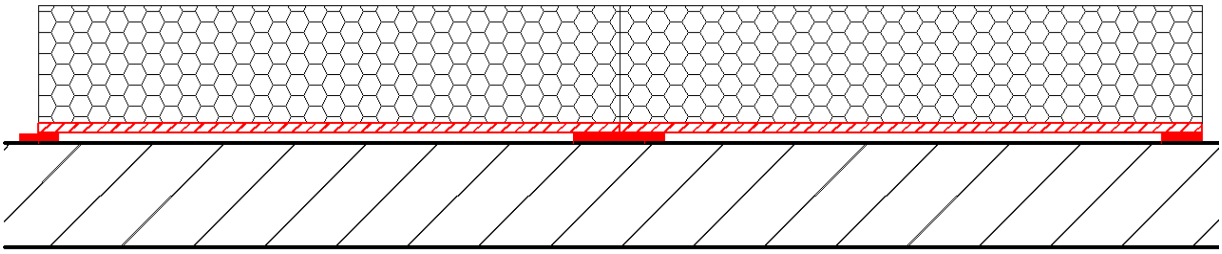


Figure 5: adhesive (solid red) along respective block perimeter connects air tight layers

A major problem to solve in this context is how to reliably join the adhesive from two neighbouring blocks and at the same time avoid any adhesive squeezing into the joint between the blocks, causing unwanted gaps in the insulation. It is also possible, however, to assist the process with sealing and reinforcing tapes provided at one long and one short side of each block (quick and easy to apply in undisturbed areas, but needs special attention elsewhere).

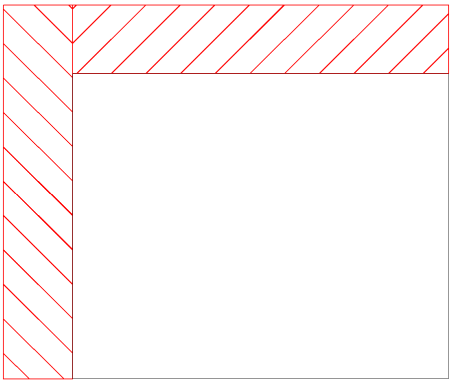


Figure 6: added sealing/reinforcing tapes (hatched) along two sides of insulation block

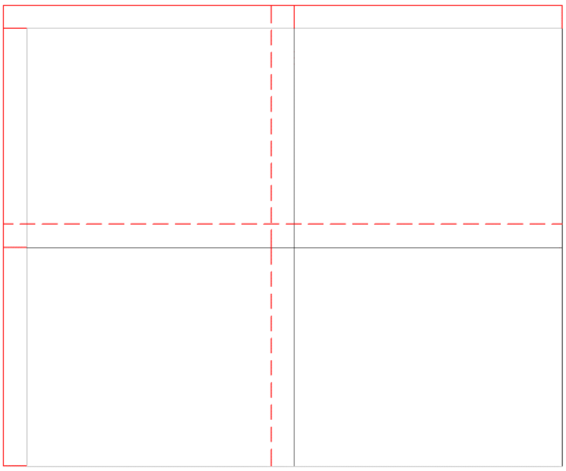


Figure 7: principle of adding multiple blocks with tape-supplemented joints

In cases where the adhesive forms the main constituent of the block-to-block bridge special remark is also required for any circumstances that disable wet-to-wet connection. Any interruption of work can cause this situation. Comprehensive studies should be carried out to make sure adequate procedures are found and clear guidelines for installers must be derived.

However, it is also conceivable to define alternative approaches to sealing the joints, e.g. by special adhesive tapes or sealing tongue-and-groove systems at the expense of more complicated handling, especially where cutting blocks to irregular shapes is concerned.

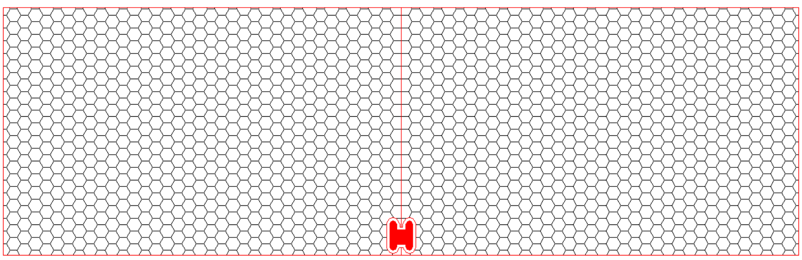


Figure 8: exemplary block-to-block connection with sealing strip (red) in undercut groves

Summing up, much of the system performance depends on the adhesive used to install the blocks. Investigations should be carried out to explore the air tighting properties of currently used materials and identify any need for optimisation. Application properties, short-term and long-term behaviour should be well known. Avoiding cracks and provide a reasonable level of elasticity are meaningful for the long-term success.

2.3 Dowels

In some cases additional elements are required to mechanically secure the blocks to the wall. This is normally achieved by dowelling. To avoid compromising the thermal insulation, full-plastic dowels without metal are a proven way to avoid thermal bridges.

In this particular application, however, each dowel will penetrate the air tightness layer and present a hazard to the air tightness of the system.

The required number of dowels should therefore be minimised. This will also reduce labour in the installation process.

Furthermore a reliable sealing principle must be found. It is conceivable to

1. Drill the hole, inject a generous quantity of normal adhesive material and finish with punching in the dowel. Equipped with reusable injection presses that can be set to a fixed injection volume per stroke work should be reasonably easy and fast.

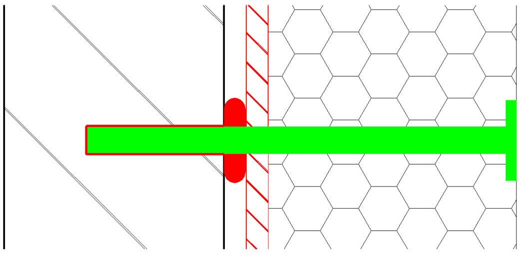


Figure 9: adhesive (red) injected in hole and gap between wall and insulation

2. Drill the hole and insert a specialised dowel that expands or releases sealing collars or liquid sealants to seal the hole in the air tightness layer. In-depth product development would be required to define such dowels suitable for the individual EAIFS. Handling adhesive would be avoided but the dowels would become much more expensive. Moreover the dowels must exactly match the system.

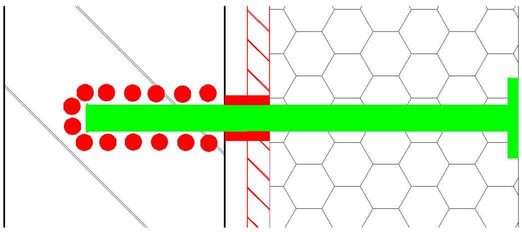


Figure 10: specialised self-sealing dowel

3. Drill the hole an insert dowels of slightly greater diameter at the point of penetration to seal with the air tight layer and that are generally in themselves air tight (test tube shape) to seal the

borehole walls and bottom. In effect these dowels would represent protuberances of the air tightness layer into the holes. The sealing action between dowel and air tightness layer would be assisted by elasticity of the air tightness layer material providing an undersized hole from the drill bit and a firm joint with the dowel.

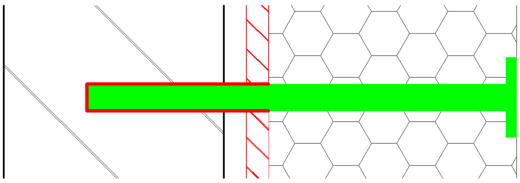


Figure 11: air tight dowel dives into wall and seals with air tight layer of insulation

2.4 Exterior corners, Openings and penetrations

Each window represents an opening in the wall and will thus interfere with the regular area of the EAIFS. On the circumference of the opening exterior corners will result. Depending on the general system approach different strategies will result:

1. As the air tight layers meet at the corner at right angles, no further measures need to be taken as long as the sealing block-to-block joint is maintained. This is, however, not a matter of course as the linear joint is in two separate planes. Special measures might be required to increase the reliability of the system.
2. The general approach would be to increase the air tight bonding surface and thus make it easier to achieve reliable results
    a. Adhesive is applied to the corner in advance to make sure the air tight faces of the blocks are connected. Uses no extra components but some extra labour. Very flexible as regards irregular shapes and angles.
    b. A special corner-profile is used and installed prior to the installation of the blocks. Uses extra material but potentially saves some labour. Somewhat limited in terms of flexibility. Round openings (ventilation ducts, circular windows…) are a challenge.

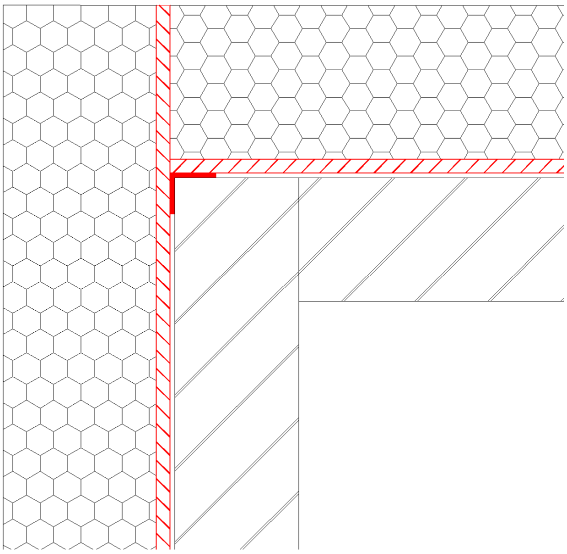


Figure 12: exterior corner, reinforcing joint for critical air tightness layer (red angle)

In any opening, another building component is going to be installed. This element will need sound connection to the air tight layer created by the EAIFS. It is thus required to provide a connecting area within the reveal of the opening. To this end, the same strategies can be employed as outlined above.

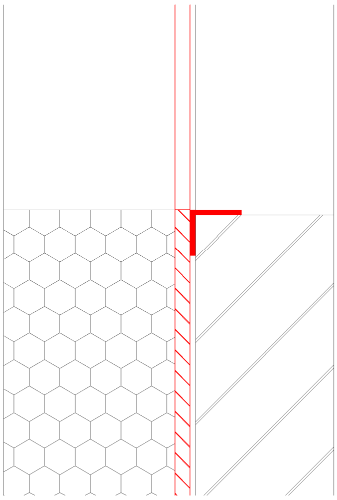


Figure 13: exterior edge at opening, reinforcing for critical air tightness layer joint (red angle) for window installation at a later date

Windows that are installed prior to the EAIFS may simply connect to the exterior surface of the wall with sealing tapes as long as they are suitable to bond with the adhesive of the EAIFS.

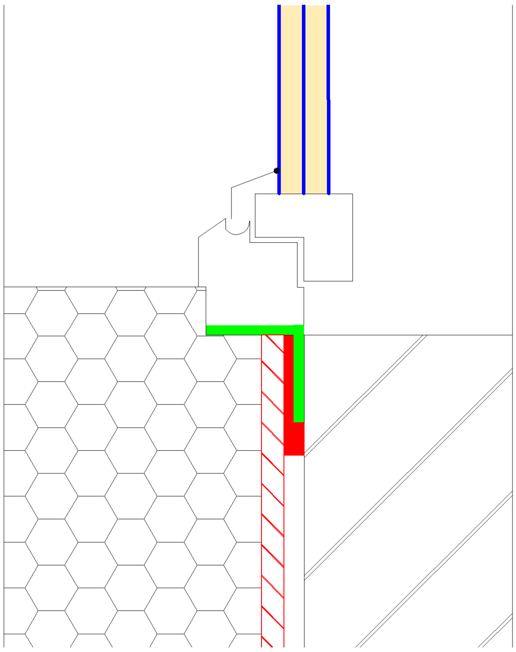


Figure 14: variation with pre-installed window, window sealing tape (green) accepts insulation adhesive

Specialised details should be provided for step-by-step refurbishments when window replacement is to follow at a later date and old windows are placed in the reveal of the structural wall, remaining for the time being. Guidelines for such details are the subject of other specialised EuroPHit papers.

For window openings in EAIFS that are generally consisting of combustible insulation materials it is often required to provide a non-combustible perimeter. Frequently, different kinds of mineral fibre insulation materials are employed for this application. Any EAIFS system not consisting of such mineral fibre insulation materials should therefore provide adequate solutions and air tight joint solutions between the different insulation materials.

2.5 Joints with other building components

Any internal corner presents the challenge of one exposed thickness of insulation material without air tightness treatment. A ready solution for this standard situation must be defined. Different paths, depending on the general approach of the system (cf 2.1) are conceivable.

1. If insulation material is air tight, no further measures need to be taken as long as the sealing block-to-block joint is maintained.

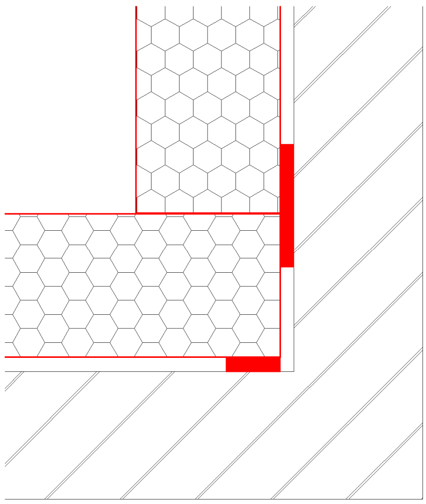


Figure 15: 2.5-1 interior corner with closed-cell insulation

2. If a dedicated air tightness layer is provided on the inner face of the blocks, special treatment of the blank cheek of the block is required to ensure an unbroken air tightness layer.
    a. Gluing on any specialised air tightness layers here would be possible but is ruled out by practical considerations.
    b. Rather it would be an option, to use a strip of closed-cell insulation with square section in such cases, which would in turn complicate logistics.
    c. More practical would be to apply a coating with adhesive material, a job easily and quickly done with readily available tools and materials and flexible to react to irregular shapes and angles.
    d. Last but not least it would be possible to overcome the problem using strips of sealing tape, treated to bond well with the adhesive and pre-installed with adhesive in all internal corners in advance.

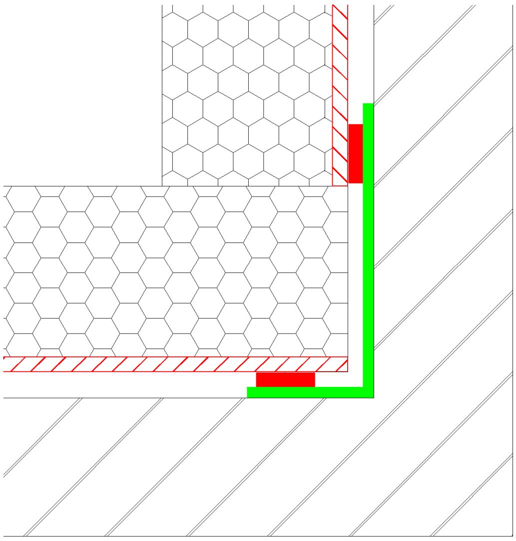


Figure 16: 2.5-2 interior corner with pre-coating/reinforcement/tape (green)

2.6 Outlook on internal applications

- Cellar ceiling insulation for refurbishment applications can benefit from the same principles as EAIFS.
- As can accompanying insulation of basement walls as it is regularly used in deep retrofits to reduce thermal bridging caused by the walls.
- Also walkable insulation systems for attic floors should be implemented with integrated air tightness layer, with the added demand for a joint seal without or at least different kind of adhesive (demand for “dry” assembly).
- Installation systems used to install roof insulation in refurbishment or new construction on top of the rafters can employ similar principles and inherit some of the new features found.