D5.2 – Manufacturing design of the multifunctional façade cladding II

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Deliverable Information Sheet

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History of changes

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0.1	04/12/2023	First draft, establishing document structure	S. García, J. García, A. Llamas, R. Menor, F. Gabaldón, A. Saráchaga
0.2	12/01/2024	First version, incorporating input from all participants	Pablo R. Outón, A. Saráchaga, A. Llamas
0.3	24/01/2024	Quality review	G. Paganin, L. Vanhoutteghem
1.0	26/01/2024	Final version addressing all further comments	A. Llamas, A. Saráchaga

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Disclaimer

1. Executive summary

This document outlines the enhancements made to the multifunctional façade cladding that was previously developed by GAR for the EU-funded HEART project to align with the requirements of the RE-SKIN project. The content presented in this document represents an advancement from the content found in D5.1 Manufacturing design of the multifunctional façade cladding I.

Since its inception for the HEART project, the façade has undergone significant changes, including the replacement of the conventional sandwich panel insulation with a bio-based alternative, and the incorporation of sustainable steel for the outer layers. Moreover, the mounting structure is further improved by incorporating recycled materials and optimising the installation process to reduce installation time.

Chapter 2 provides an overview of the façade system and its key components, while Chapter 3 includes the design of these components. Subsequent releases of this deliverable will detail aspects related to use, maintenance, end-of-life treatment, as well as a definition of the manufacturing process and production control. Supporting documents and certificates will also be included.

The optimisation process of façade components will remain ongoing throughout the project's development, with continuous updates as new information becomes available. Two additional versions of this report are scheduled for release in months 19 and 27, respectively. These subsequent deliverables will incorporate further specifications and/or modifications based on the project's progress and testing results.

2. General description

This task aims to enhance the thermal-insulation façade system designed by GAR for the H2020 HEART project, intending to match the system with the objectives outlined in RE-SKIN.
The system developed within the HEART project consists of a self-supporting thermal insulation façade that comprises panels and a substructure, and represents an enhanced version of the currently existing commercial solutions.
The RE-SKIN solution is suitable for installation on brickwork and concrete block façades, concrete load-bearing walls, and wooden structures. The new façade cladding's structure is securely anchored to the supporting vertical surfaces. All external surfaces that are not part of the supporting elements must be removed. Prior to installation, a dynamometric test (Pull-off Test) is conducted to assess the tensile strength of the walls and the load capacity of the fixings. The selection of the appropriate anchoring method, whether mechanical or chemical, is based on the results of this test.

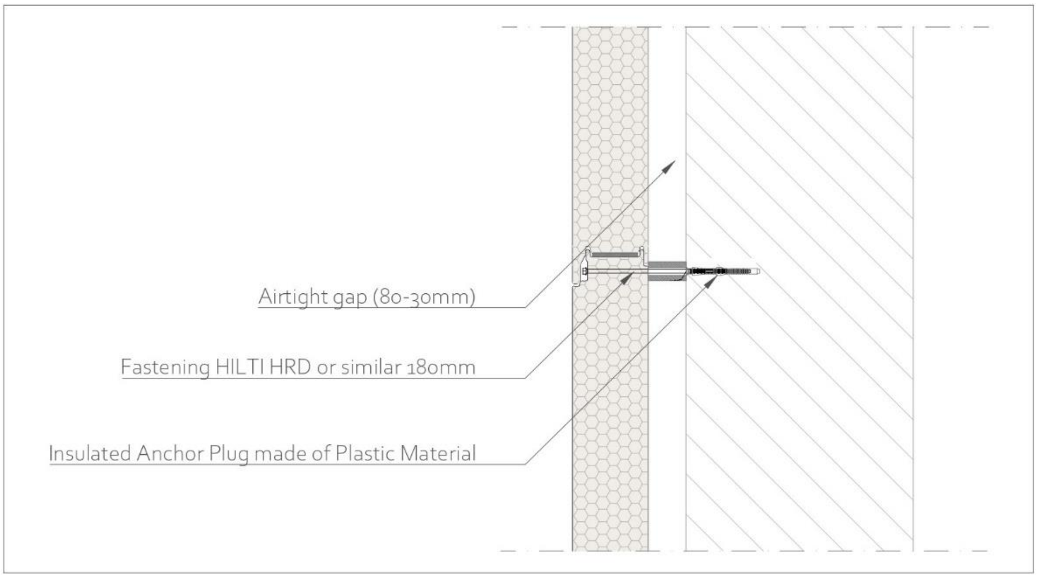


Figure 1. Panel detail (vertical) [drawing created using AutoCAD]

The panels in the HEART system are composed of a 0.7 mm outer layer of galvanised steel, a polyisocyanurate (PIR) foam core, and a 0.4 mm inner layer, resulting in a total panel thickness of 100 mm. These panels are joined together with a simple tongue-and-groove joint and then attached to the pre-existing wall through a substructure.
The substructure, which features anti-corrosion properties and galvanic protection, is assembled using supporting brackets that are attached to the pre-existing walls of the façade employing mechanical fixings and plugs. The upright structural profiles are then fixed to the brackets using self-

drilling screws. The system is completely sealed, forming an airtight cavity between the panel and the pre-existing wall. Complimentary to the system is the integration of an adaptable sealed chamber equipped with manually adjustable ventilation grilles. Depending on the seasons, the internal chamber can be fully sealed to act as thermal resistance during cold weather, or ventilation grilles can be manually adjusted to facilitate ventilation in warmer weather.

RE-SKIN builds upon the achievements of the prior H2020 HEART project, leveraging its outcomes and striving to improve them further. The project focuses on developing multi-technology and low-impact renovation solutions for the energy retrofit of buildings in critical contexts. The primary objective is to reduce the energy consumption and environmental impact of existing residential, public, and commercial buildings while adhering to the principles of life cycle sustainability and the circular economy.

Therefore, many of the materials and components used in producing the façade system will be recycled, recyclable, reused or repurposed.

To develop a sustainable and circular economy-oriented façade system, the new sandwich panels will replace the conventional thermal-insulation foam core with an innovative bio-based PUR (bioPUR) foam provided by INDRES. Furthermore, the conventional metal sheet outer layer of the sandwich panels is superseded with Greencoat BT steel from SSAB, a subcontractor of GAR. This coating incorporates a significant amount of rapeseed oil, replacing fossil oil, making it more sustainable compared to regular steel coatings. Moreover, SSAB's steel production process utilizes about 45% recycled scrap metal, further reducing the environmental impact of the material.

The mounting structure will also be improved by using recycled aluminium profiles manufactured by EXLABESA. Furthermore, the assembling process will be optimised to reduce retrofit work time and costs.

The initial phases of the project will involve testing the entire façade system. A testing mock-up, integrating all system elements, will be assembled at GAR facilities, and a demo video for installation will be produced. The mock-up and video will be dispatched to DTI for thorough testing, verification, and demonstration of the long-term reliability of the novel façade system (to be reported in D. 3.5 and D3.7).

3. System/component design

The multifunctional prefabricated thermal insulating façade of the RE-SKIN project is a self-supporting system primarily made up of sandwich panels and a substructure, designed to enhance energy performance and decrease environmental impact. This chapter provides an overview of the design process and key features of the three subcomponents of the system. Additionally, it examines the materials and technologies used in each of these subsystems to create a façade that aligns with principles of sustainability and the circular economy. All three subcomponents are studied and described in more detail in the following: the sandwich panel, the recycled aluminium mounting structure, and the finishing elements.

3.1. Sandwich panel

As previously introduced, the multifunctional façade system comprises sandwich panels and a substructure. The sandwich panels, being a key component of the system, consist of an outer layer made of Greencoat sustainable steel from SSAB, a novel bio-sourced polyurethane (bioPUR) foam core from natural oils, and an inner steel layer. These panels are interconnected through a tongue-and-groove joint and are attached to the pre-existing wall via the substructure.

The manufacturing process of sandwich panels can be categorised as continuous or discontinuous, depending on the moulding process employed. In the discontinuous process, a standardised panel is produced using a closed mould of the desired dimensions. In contrast, the continuous process involves the production of larger linear panels that are later cut according to the dimensions of the façade on which they will be installed. For RESKIN, a continuous manufacturing process is employed, which is more efficient and cost-effective for large-scale façade applications.

During manufacturing of the sandwich panels, the metal surfaces, specifically steel sheets, are spaced apart by lateral supports to allow for the injection of foam to fill the gap between them and create the insulating core. The use of steel in sandwich panels enhances their durability and strength, surpassing that of other materials.

The finishing phase of sandwich panel production includes processes such as cutting, welding, laminating, and other necessary activities to complete the product. After completing the finishing phase, a protective film is applied to the finished product to prevent scratches and dirt accumulation.

The manufacturable thickness ranges from 60 to 250 mm. In RE-SKIN, the determination of panel thickness will be based on the project's calculations for the different demonstrations to be carried out. The typical range for thickness is expected to be between 80 to 100 mm. The panel width has been standardised at 1000 mm to align with the standard width of the steel coil for the metal sheets.

However, the panel length can be adjusted based on project requirements and is expected to fall within the range of 250 to 6000 mm.

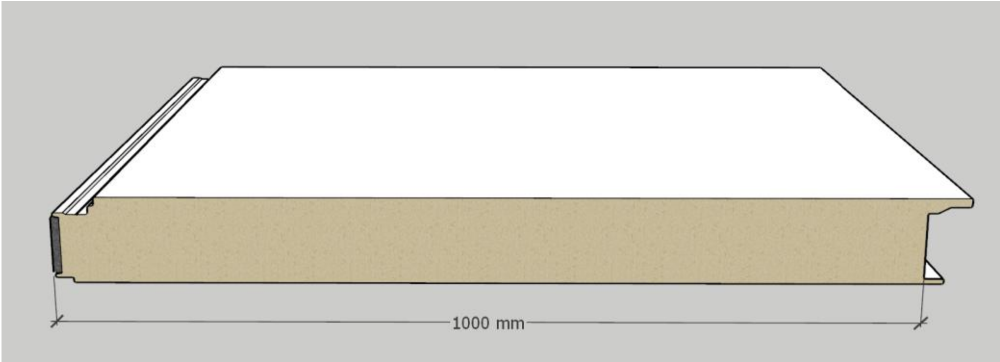


Figure 2. Sandwich panel with bioPUR and Greencoat metallic sheet [drawing created using SketchUp]

3.1.1. Outer layer

The outer layer steel coating in the sandwich panels is a critical element in building construction, providing protection and enhancing the aesthetic appeal of building façades and roofs. In recent years, the demand for more sustainable and eco-friendly building materials has led to the development of innovative coating technologies that reduce the environmental impact of building construction while maintaining optimal performance. One such technology is the GreenCoat sustainable steel outer layer, featuring a patented Bio-based Technology (BT).

GreenCoat colour coated steel products offer a sustainable coating solution for the building industry. The Bio-based Technology (BT) coating, introduced in 2012, incorporates a significant amount of Swedish rapeseed oil, a natural alternative to fossil oil. The integration of Swedish rapeseed oil in the Bio-based Technology (BT) coating contributes to a reduced environmental footprint compared to conventional coatings, establishing it as a more sustainable option for building façade applications. Moreover, it is chromate free, safe to handle, and does not emit harmful substances. With these attributes, the coating ensures long-lasting performance for buildings over several decades.[1]

Unlike petroleum-based chemicals commonly used in the building industry, the bio-based solvent in this coating becomes a permanent part of the final product. This leads to a healthier environment, reducing the release of harmful substances into the atmosphere. This bio-based coating is suitable for indoor and outdoor use, is compliant with EU REACH (‘registration, evaluation and authorisation of chemicals’) regulations governing the manufacture of chemical substances, and has a lower environmental impact compared to other coatings. This patented BT coating not only offers

[1] https://www.environdec.com/library/epd1922

environmental advantages but also improved performance for an extended product life.[1] In RE-SKIN, the specified thickness of the material to be used is 0.7 mm for the external layer and 0.55 mm for the internal layer.

In subsequent deliverables, additional specifications, such as steel grade, topcoat, dimensions, and colours, for the steel coils used in panel manufacturing will be finalised once the responsible team determines the finishing colours for all demonstration projects. Subsequently, the order for the steel coils will be placed with SSAB, who will provide the detailed specifications for the steel coils.

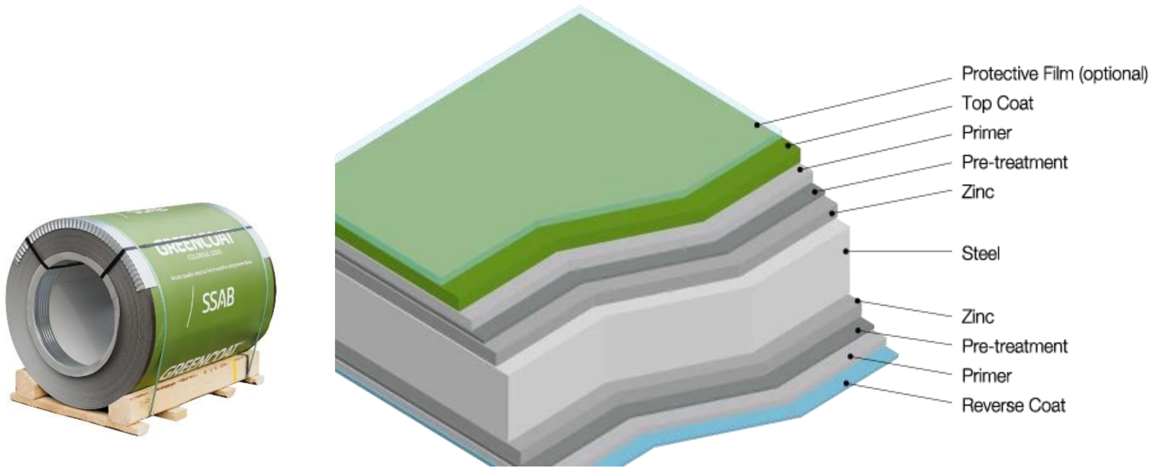


Figure 3. GreenCoat® components

Technical Properties	Matt	Regular	Satin
Gloss	< 5	40	20
Minimum inner bending radius	1 x sheet thickness	1 x sheet thickness	1 x sheet thickness
Scratch resistance	40 N	40 N	40 N
Lowest forming temperature	-15 °C	-15 °C	-15 °C
UV radiation resistance	$R_{UV}5$	$R_{UV}4$	$R_{UV}4$-5
Corrosion resistance	RC5+	RC5+	RC5+
Stain resistance	Very good	Very good	Very good
Highest operating temperature	100 °C	100 °C	100 °C
Fire classification, EN 13501-1	A1 s1 d0	A1 s1 d0	A1 s1 d0
Coating thickness, nominal (primer + topcoat)	50 µm	50 µm	50 µm

Coating structure	Structured and wrinkled	Structured	Structured
Zinc coating	S280GD, S320GD, S350GD	S280GD, S320GD, S350GD	S280GD, S320GD, S350GD
Min steel thickness	275 g/m^2	275 g/m^2	275 g/m^2
Steel width	1000 – 1500 mm	1000 – 1500 mm	1000 – 1420 mm

Table 1. Technical Properties of GreenCoat Pural BT (SSAB)[2]

3.1.2. Thermal-insulation

Aligned with project objectives, BioPUR foam has been selected as the insulation layer for the sandwich panel. BioPUR is a versatile foam suitable for insulation through methods such as spraying, injection, or use in sheets or sandwich panels.

Specifically designed for the residential sector, BioPUR foam is primarily used for energy renovation, insulation, and waterproofing in renovation activities. To ensure the sustainability of materials in the RE-SKIN project, a life cycle perspective is adopted, encompassing product contents, production, and end-of-life options like recycling or reuse. This is examined in WP7 Circular-economy support with more detail. The use of BioPUR foam aligns with this framework, offering a sustainable and environmentally friendly insulation option.

As previously mentioned, the foam in the insulation panels is based on a bio-Polyurethane foam developed by INDRES. Currently at TR 6-7, it has a density of 40-50 kg/m3, and an estimated thermal conductivity value of 0.03-0.04 W/mK. The raw materials (polyols) used are commercially available and they are derived from natural oils, making them more environmentally friendly. Furthermore, at the end-of-life, these products are approached through a circular use methodology, employing both mechanical and chemical recycling methods, see Figure 4 and 5. The integration of these products in the RE-SKIN project are an important step towards achieving a more sustainable and environmentally friendly approach to insulation.

[2] https://www.ssab.com/en/brands-and-products/greencoat/products/pural-bt

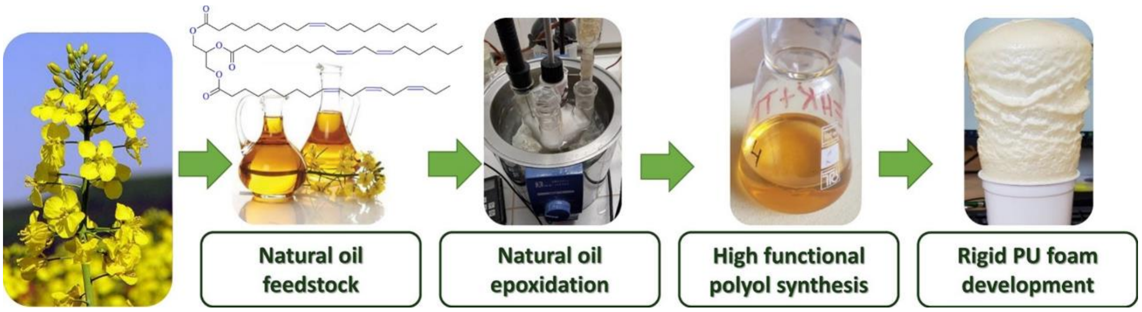


Figure 4. Process for the utilisation of natural oil-derived raw materials in BioPUR foams [3]

In general, plastic foams exhibit a higher carbon footprint compared to natural and mineral materials. However, the BioPUR insulation material boasts an estimated carbon footprint value that is lower than many other types of insulation materials.

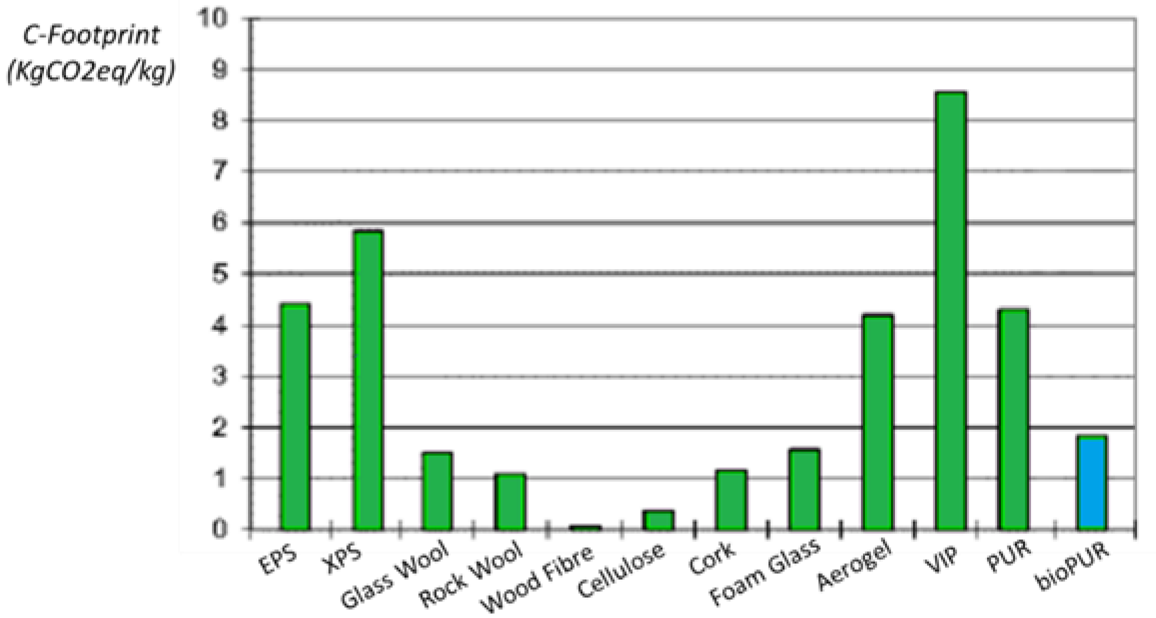


Figure 5. Comparative values of C-Footprint of insulating materials [4]

[3] https://www.sciencedirect.com/science/article/abs/pii/S0926669018305508
[4] https://www.researchgate.net/figure/Carbon-footprint-of-different-thermal-insulation-materials-per-kilogramme-mass-of-the_fig2_317934578

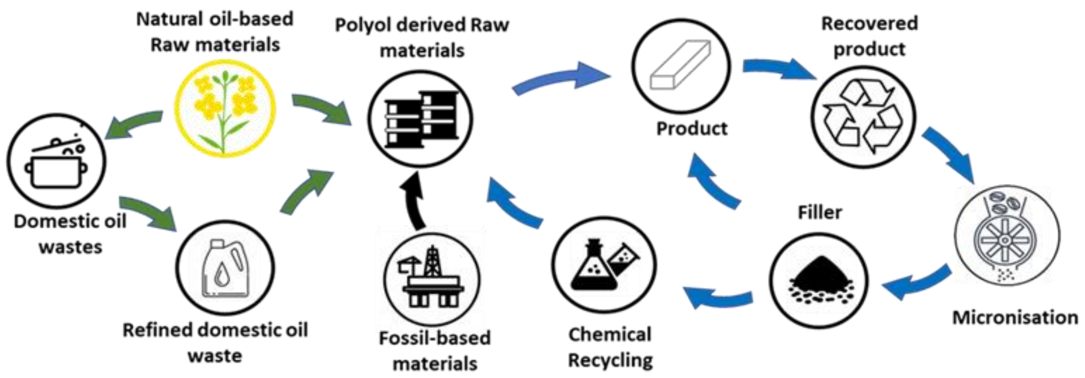


Figure 6. Schematic representation of circular approach of BioPUR materials (Source: INDRESMAT)

Figure 7. Mechanical and chemical recycling methods for Polyurethanes (Source: INDRESMAT)

BioPUR technical features for sandwich panels in RE-SKIN:

The BioPUR used in the RESKIN project is estimated to demonstrate mechanical and thermal properties similar to conventional PUR. As the product is currently at TRL 6-7, these values will be verified through additional testing throughout the RESKIN project. These thermal properties are more reliant on the microstructure of the foam (density, homogeneity, distribution of cell size, open/close cell ratio, etc.) than on the origin of the raw materials used in their formulations (bio-based or fossil-based). In this regard, INDRES has successfully developed a foaming process for BioPUR equivalent to conventional PUR, ensuring that the microstructure and properties of the foam are suitable for insulation in buildings.

Technical properties of BioPUR used in RESKIN:

- Thermal conductivity (0.03-0.04 W/mK)
- Biobased content (60-70 %)
- Carbon footprint (1.8-3 KgCO2/kg)
- Viscosity (600-3000 cPs)
- Reactivity range (10–50 s)

- Density range (40-60 kg/m3)

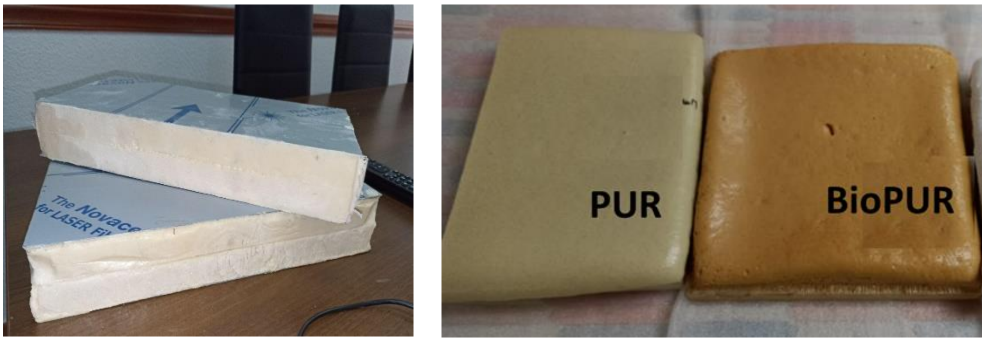


Figure 8. Demo sandwich panels made from bioPUR (left). Different varieties of PUR materials from INDRES (right).

3.2. Recycled aluminium mounting structure and fixing elements

RE-SKIN's multifunctional façade utilises a recycled aluminium mounting structure manufactured by EXLABESA to attach sandwich panels to the existing façade. The mounting structure aligns with RE-SKIN's goal to promote sustainability (more information can be found on deliverables from WP7 Circular-economy support) by using environmentally friendly materials during construction, as it is made from recycled materials and does not generate additional waste. Furthermore, aluminium is a durable material that provides long-lasting support for the panels.

EXLABESA RE-local – Recycled low carbon aluminium

Aluminium is a highly versatile material that can be recycled indefinitely without losing its quality or properties. This makes it an essential material for sustainable development. The façade profiles used in RESKIN are made with recycled aluminium, with a recycled aluminium content rate of 98%.

The recycling process includes collection, smelting, and the extrusion of new profiles. The production process generates a carbon footprint of only 2.95 kg of CO_2 per kg of aluminium produced, achieving a substantial reduction of up to 95% in energy consumption compared to the production of primary aluminium.

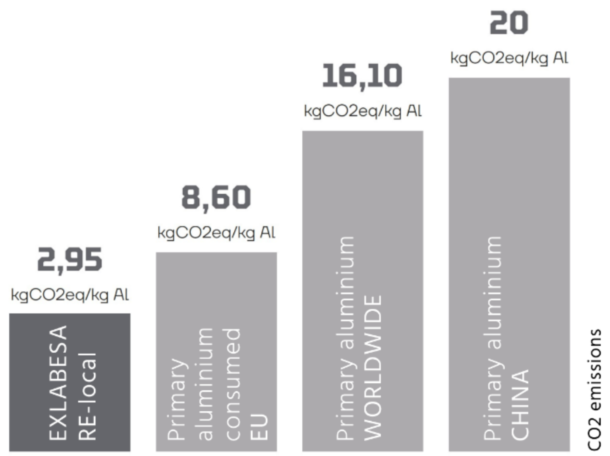


Figure 9. Aluminium Carbon Footprint (EXLABESA)[5]

Structural Profile properties and composition

In the RE-SKIN project, aluminium extrusion profiles made from AA 6063 are employed. This alloy contains magnesium and silicon as alloying elements, and its composition is regulated by The Aluminium Association. This alloy exhibits excellent mechanical properties, is heat-treatable, and can be welded. It is the most commonly used alloy for aluminium extrusion due to its capability to create complex shapes with smooth surfaces suitable for anodising.

Constituent element	Minimum (% by weight)	Maximum (% by weight)
Aluminium (Al)	97.5%	99.35%
Magnesium (Mg)	0.45%	0.90%
Silicon (Si)	0.20%	0.60%
Iron (Fe)	0	0.35%

Property	6063-T5
Tensile Strength	186 MPa | 27000 psi
Yield Strength	145 MPa | 21000 psi
Modulus of Elasticity	68.9 GPa | 10000 ksi

Figure 10. Aluminium Composition of AA 6063

The panels are affixed to the existing walls via the structural profiles, secured by self-drilling screws, the profiles are attached to the supporting brackets that are anchored to the façade. Before installation, a dynamometric test (Pull-off Test) is conducted to assess the tensile strength of the walls and load capacity of the fixings. Based on the test results, the appropriate anchoring method—either mechanical or chemical—will be determined.

[5] https://exlabesa.com/en/arquitectura/re-local-recycled-aluminium

Façade system

The system is designed in a modular and detachable way, which makes it possible to inspect specific areas when needed. To detach the panels, we first need to dismantle the vertical finishing profiles on the sides. Then, we can proceed to remove the panels one by one in the same column, starting from the top and moving downwards, until we reach the desired area that needs to be inspected.

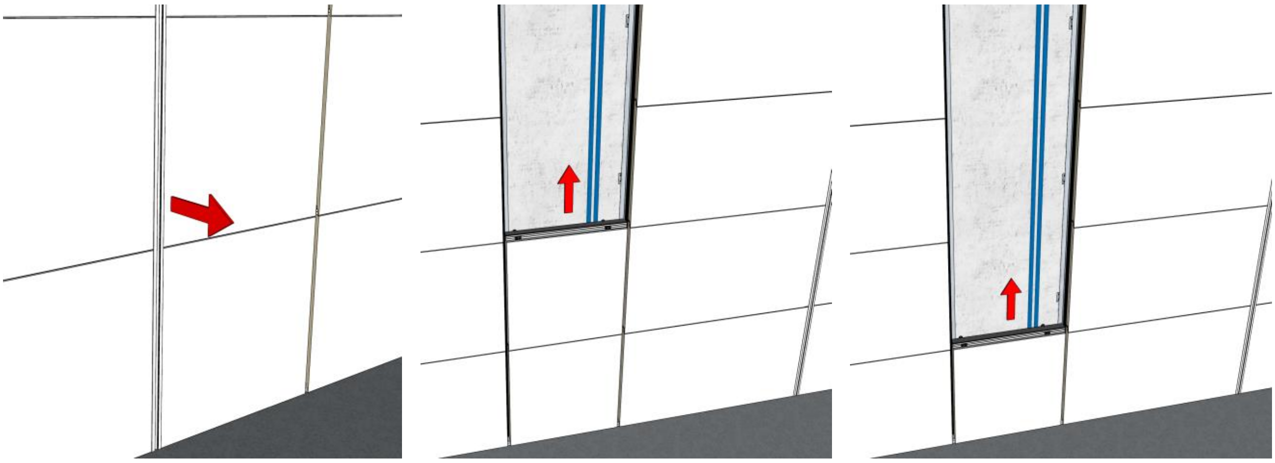


Figure 11. 3D images illustrating the sequence of panel dismantling for installation inspection [drawing created using SketchUp]

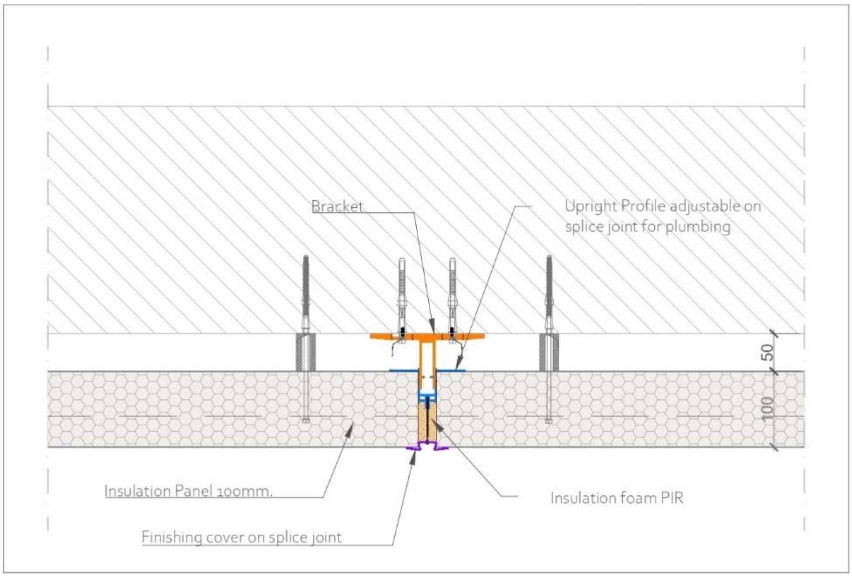


Figure 12. Detail drawing of the vertical panel connection for standard air gap (<6cm, approximately.) [drawing created using AutoCAD]

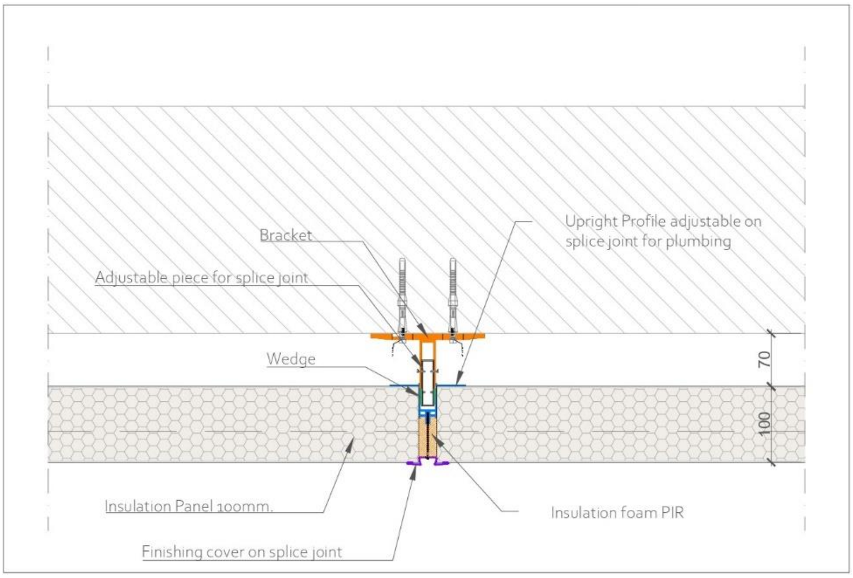


Figure 13. Detail drawing of the vertical panel connection for larger air gap (>6cm, approximately.) [drawing created using AutoCAD]

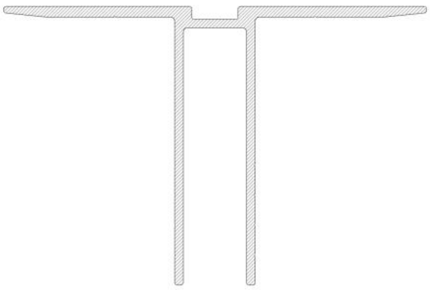


Figure 14. Detail drawing of the façade system's bracket [drawing created using AutoCAD]

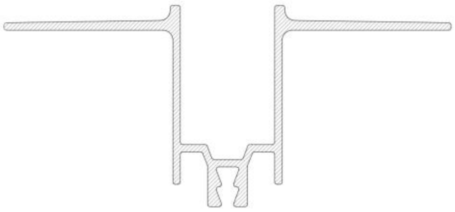


Figure 15. Detail drawing of the façade system's profile [drawing created using AutoCAD]

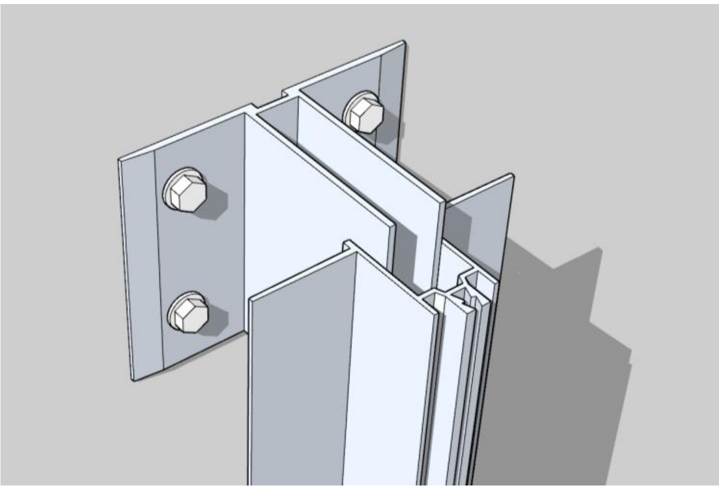
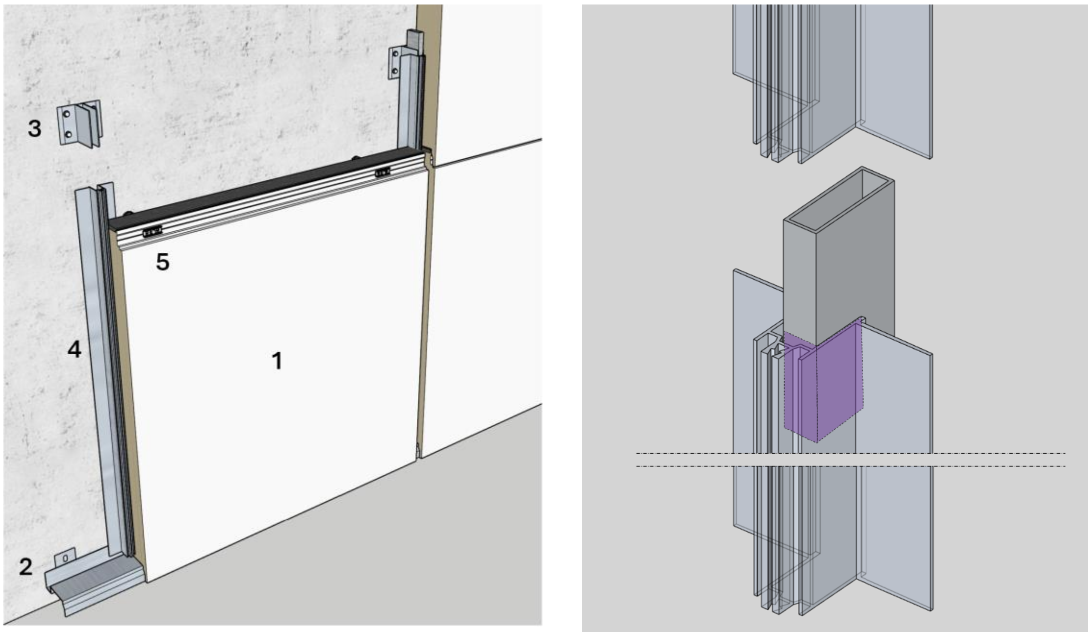


Figure 16. 3D view of the joint connection

A dedicated extrusion die has been developed to enable the subsequent production of the profiles using recycled aluminium.

Figure 17. Extrusion dies for profile manufacturing as developed by EXLABESA for the RE-SKIN façade system.



1. Insulating panel
2. System start section for internal chamber regulation
3. Vertical profile fixing bracket
4. Vertical planimetry profile
5. Insulating panel direct fixings

Detail of the planimetry profile union of the system. In purple, the fixed part of the connector to the profile. The sliding part protrudes to absorb system expansions.

Figure 18. Façade system elements

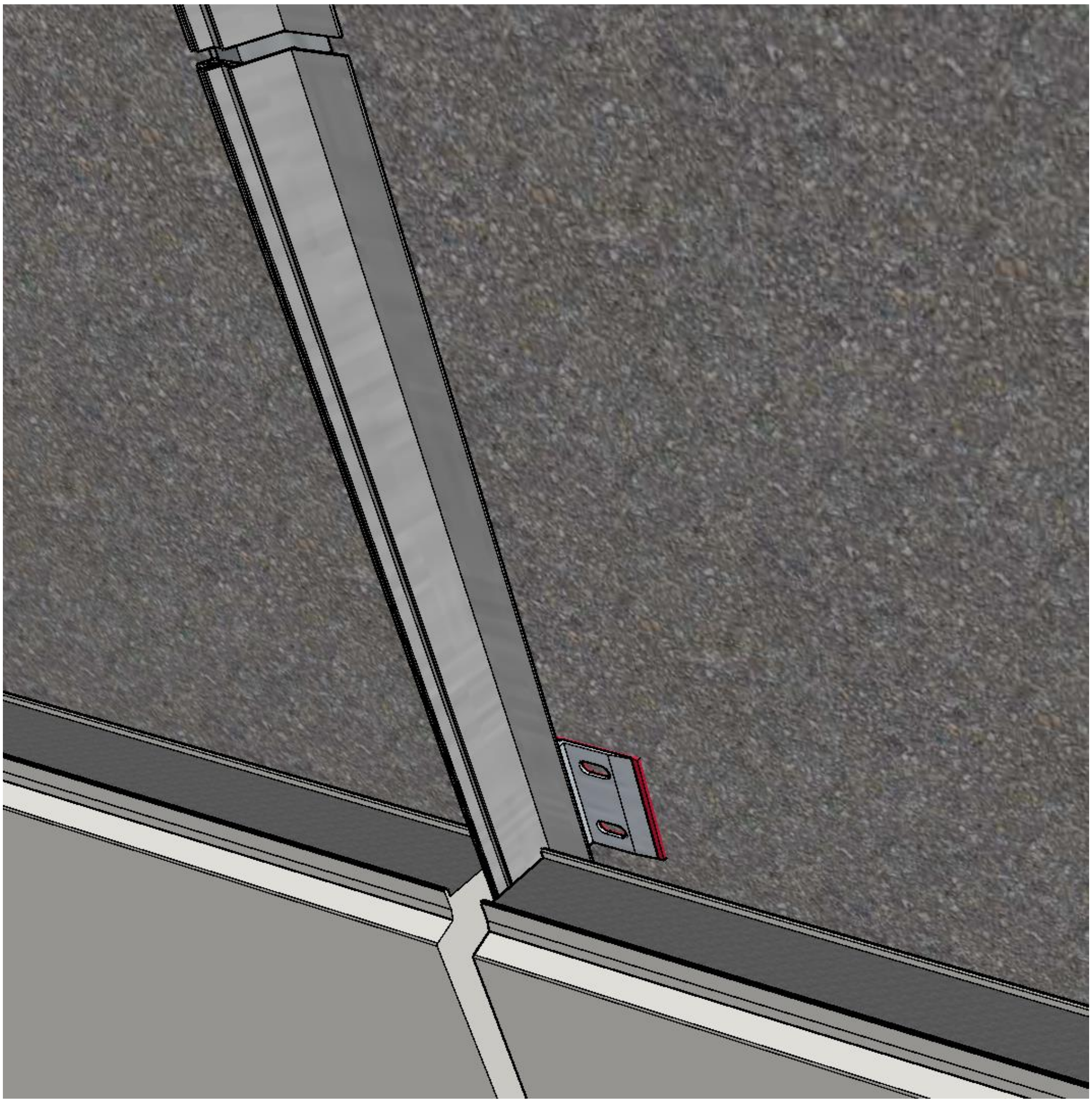


Figure 19. Sandwich panel and existing façade [image created using SketchUp]

Figure 20. Substructure elements [image created using SketchUp]

The façade system is engineered to compensate for uneven surfaces, ensuring a level installation even on non-vertical building façades. To account for these irregularities, a thorough measurement of the façade's unevenness is necessary prior to installation.

The deviation of the façade and the integration of ducts within the interior chamber influence the chamber's dimensions. If the chamber's thickness exceeds 5cm, support brackets are required to prevent anchor screws from bending excessively. These brackets effectively distribute the load, reducing screw stress.

Additionally, the system offers three types of brackets with varying dimensions, allowing for a wide range of interior chamber sizes. The appropriate bracket should be selected based on the required interior chamber size.

3.3. Finishing elements

The versatility of the machinable and modular façade system allows for the customisation of the design and configuration to meet the unique needs of a building, integrating seamlessly with new and existing elements like windows, corners, eaves and different types of ducts such as pipes, wiring, vents, or sensors. The gap required for the installation of the facade can be utilized to incorporate some of the ducts.

Moreover, the system is detachable, facilitating installations and services' inspections in designated areas.

Buildings vary in size and shape and often have different objects and facilities attached to them. To ensure that the joints between the different parts of the building are sealed with air-tightness, insulation foam is used to fill the junction points, and the overlapping of membranes and layers are also employed.

The panels used in the façade system are manufactured with the maximum lengths allowed to minimize the number of panel joints. However, connection points with other elements of the existing or new façade are inevitable. To address this issue, the RESKIN façade cladding system is designed to offer standardized solutions that can be used in various buildings, regardless of their shapes and sizes.
To ensure the proper installation of façade components, GAR has developed a catalogue of standardised technical details for constructive solutions [see Figs. 22-25, and 34-37]. This catalogue encompasses details for the installation of singular points such as windows, doors, corners, air vents, and horizontal and vertical panel connections. These technical details are necessary for the successful implementation of the façade system. By following these standardised details, the installation process can be conducted with greater efficiency and accuracy, reducing the risk of errors and ensuring the proper functioning of the façade.

Here are some examples of technical details for constructive solutions related to façade installation in singular points:

Windows

To achieve vertical alignment of window openings and ensure evenness between them, substructure profiles are installed adjacent to the windows along the entire length of the façade.

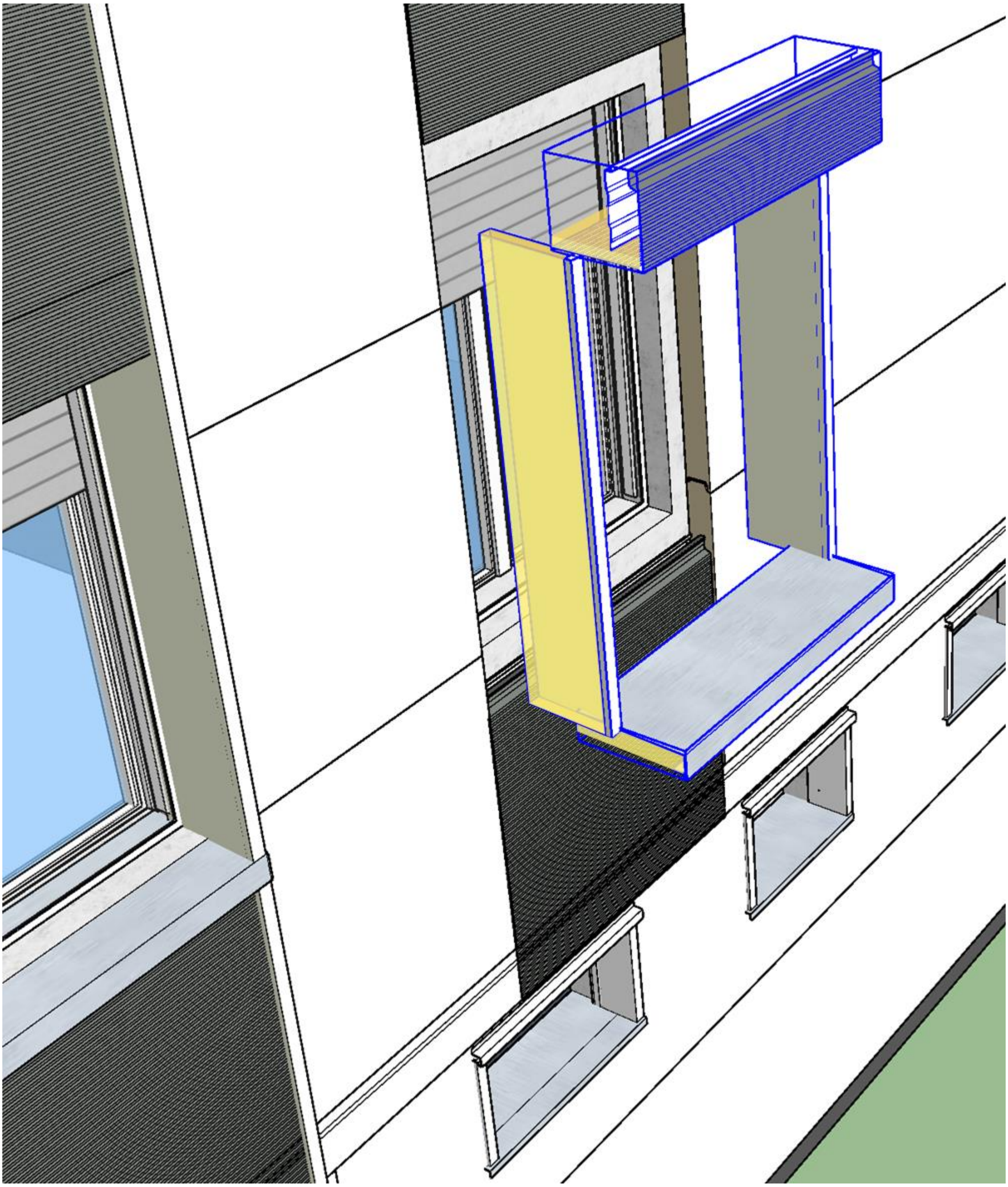


Figure 21. Finishing elements for insulated and sealed window frames [image created using SketchUp]

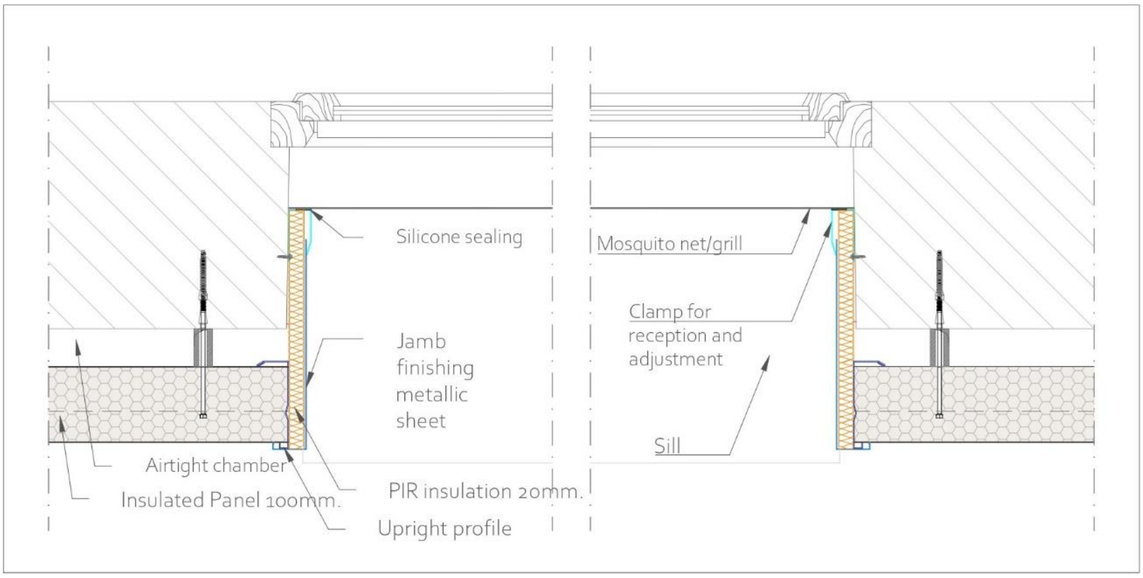


Figure 22. Window detail drawing (horizontal) [drawing created using AutoCAD]

The lintels, jambs, and windowsills are sealed using silicone and a rubber strip along the frame to create an airtight cavity. For insulating the jambs, BioPUR panel insulation is used, while the windowsills are insulated with PUR insulating foam. However, to avoid obstructing the visibility from indoors, it is essential to assess the dimensions of the window frame before determining the thickness of the insulation to be applied to the jambs and lintel.

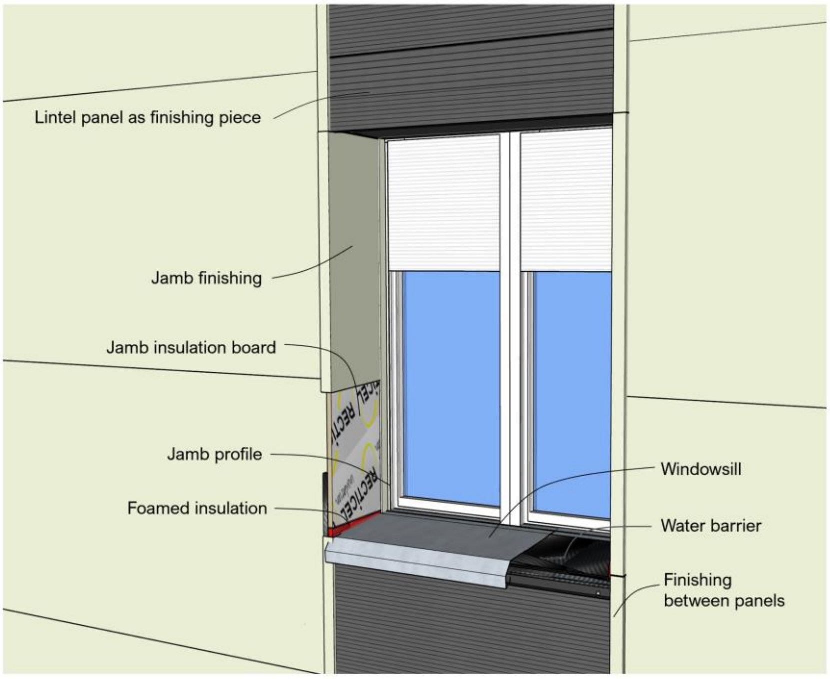


Figure 23. Components, membrane and window sealing [drawing created using SketchUp]

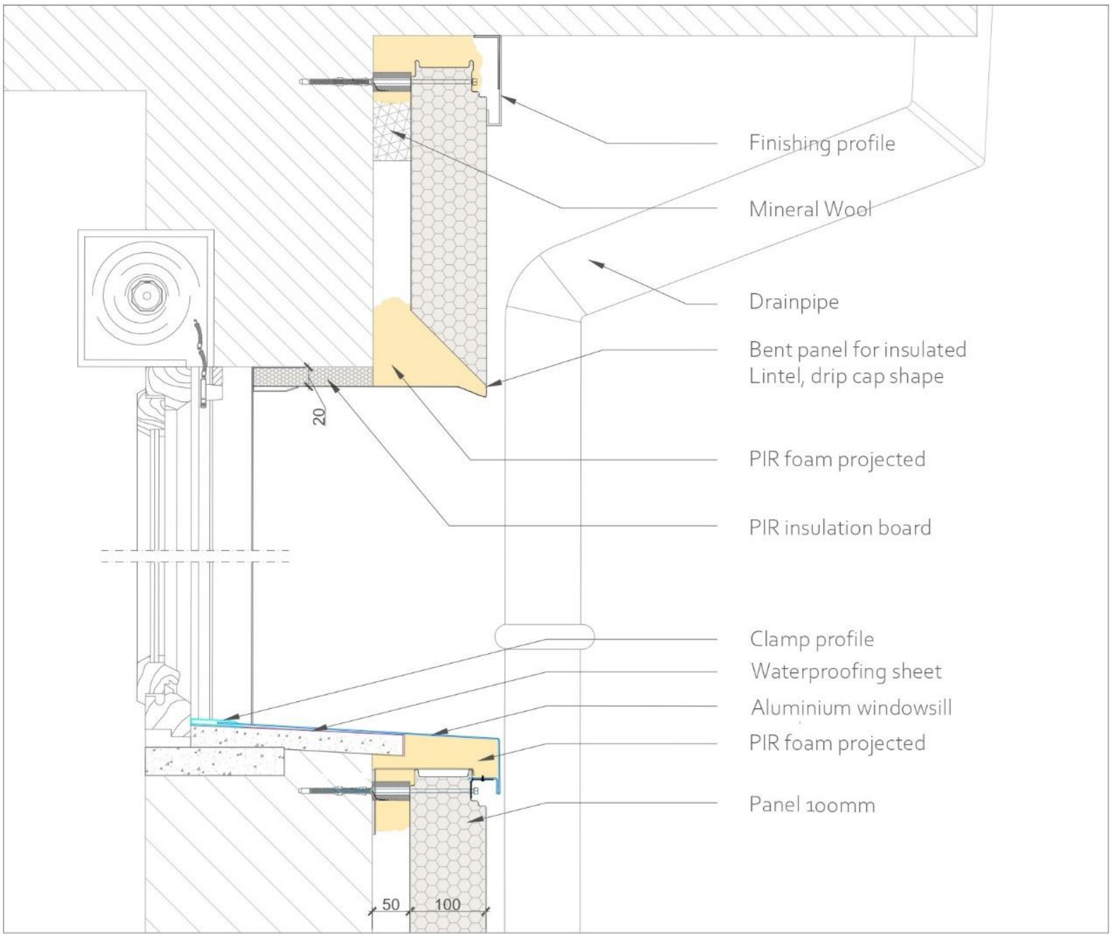


Figure 24. Window detail drawing (vertical) [drawing created using AutoCAD]

As illustrated in Figure 24, the panel used to cover both the façade and lintel is bent at a 90-degree angle to maintain airtightness and minimise thermal bridging. Additionally, the aluminium windowsill finishing must reach the window frame to avoid water penetration and ensure complete sealing. Finally, when insulating the windowsill, it is important to determine the dimensions of the window frame, as well as the location of the drainage points, to avoid obstructing them.

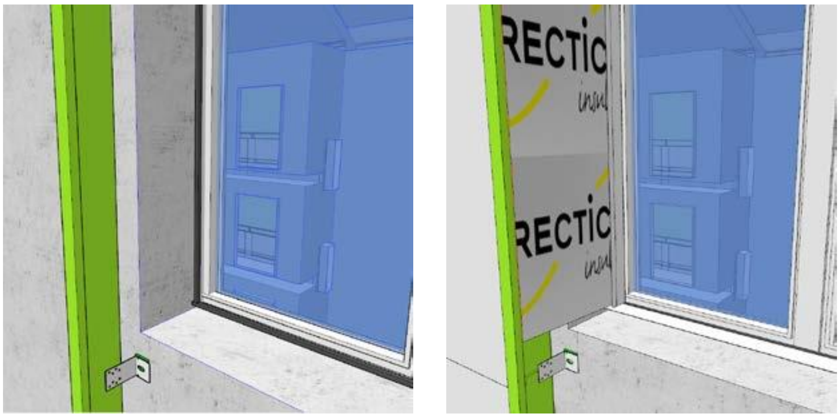


Figure 25. Window frame elements: rubber strip and insulation in jambs [images created using SketchUp]

Figure 26. Image depicting the current condition of the ground floor windows in the Milan demo case.

In the context of the Milan demonstration case (see Fig. 26), the existing stone sills and mouldings covering the jambs will be dismantled as they appear to be in poor condition and may not be securely attached to the wall. The deterioration of the sills and mouldings pose a risk to the proper attachment of new jambs. Removing these sills and mouldings will allow for the installation of thicker insulation, enhancing the efficiency of the insulation system, further reducing potential thermal bridges, see Figures 21-29.

However, it is paramount to avoid covering the drainage holes in the windows during this process. These openings are crucial for the proper functioning of the windows and ensuring effective drainage for the window frame.

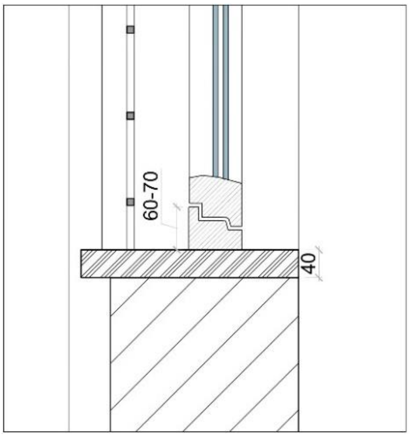


Figure 27. Vertical section of existing window detail

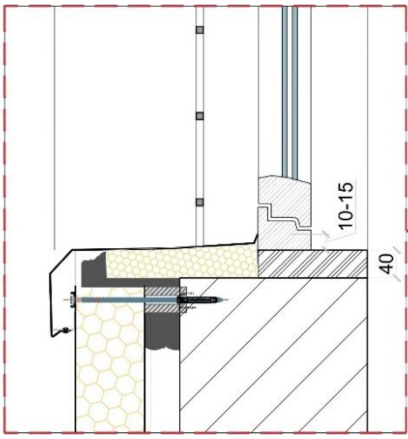


Figure 28. Vertical section of proposed windowsill design

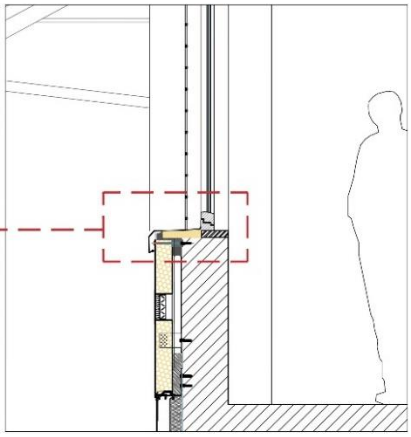


Figure 29. Vertical window detail section – Key plan

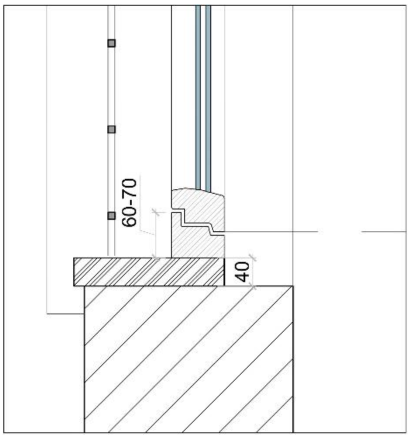


Figure 30. Horizontal section of existing window detail

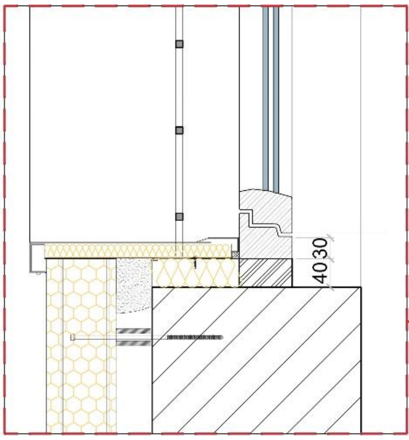


Figure 31. Horizontal section of proposed jamb design

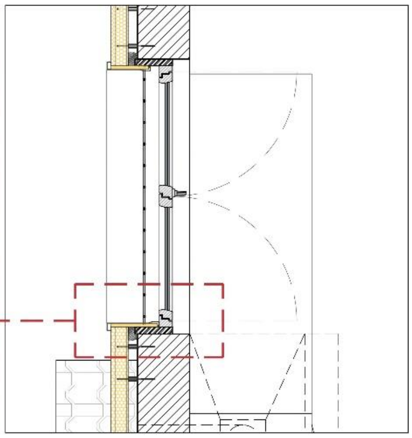


Figure 32. Horizontal window detail section – Key plan

When installing insulation in elements such as lintels and jambs, the presence of mosquito nets or window grills in the balcony windows should be considered.

For the Milan demonstration building, existing grilles and mosquito nets will be removed temporarily to allow for improved insulation and minimisation of thermal bridges. Subsequently, new mosquito nets and metal grates will be installed after the renovations.

Figure 33. Image showcasing the specific case of the first-floor windows in the Milan demo, featuring blinds and a mosquito net

On the first floor, all windows feature vertical shutters with a recessed vertical rail in the wall. The insulation will extend up to the shutter track in the jambs, given the presence of the vertical rail. The existing shutter rail is closely positioned to the window frame. As a result, the new jamb will terminate at the rails without covering them.

<u>Balconies</u>

Residential buildings frequently encounter space constraints in certain areas that need to be insulated. This is the case for balconies, which require a different construction approach compared to the rest of the building due to space limitations. The solution for balcony insulation involves incorporating a Bio-based PUR foam and a finishing layer of aluminium composite panel affixed using brackets and profiles.

In the areas where installing the sandwich panel is not feasible, an alternative BIO-based material will be used for the 50 mm insulating layer.

The construction solution for insulating the balconies aims to minimise thermal bridges while using the balcony space efficiently. Lintel and jambs are insulated wherever feasible, similar to window frames.

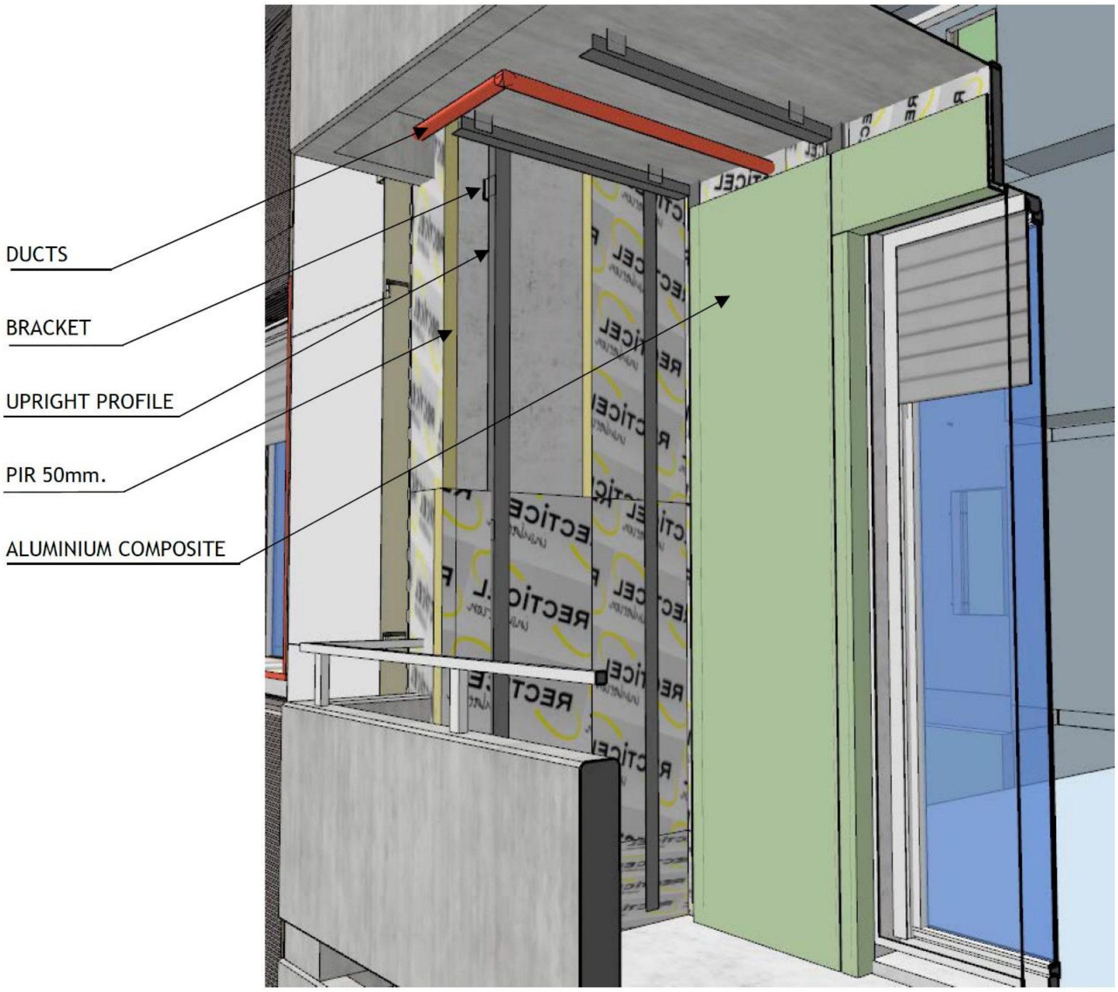


Figure 34. Balcony 3D [image created using SketchUp]

When the balconies are open, the balcony ceiling does not require insulation; therefore, the gap between the ceiling and the composite panel attached to the balcony's façade is used to accommodate different ducts and wires. Thermal bridges at the connection with the facade are minimised using insulation boards or foam for sealing points.

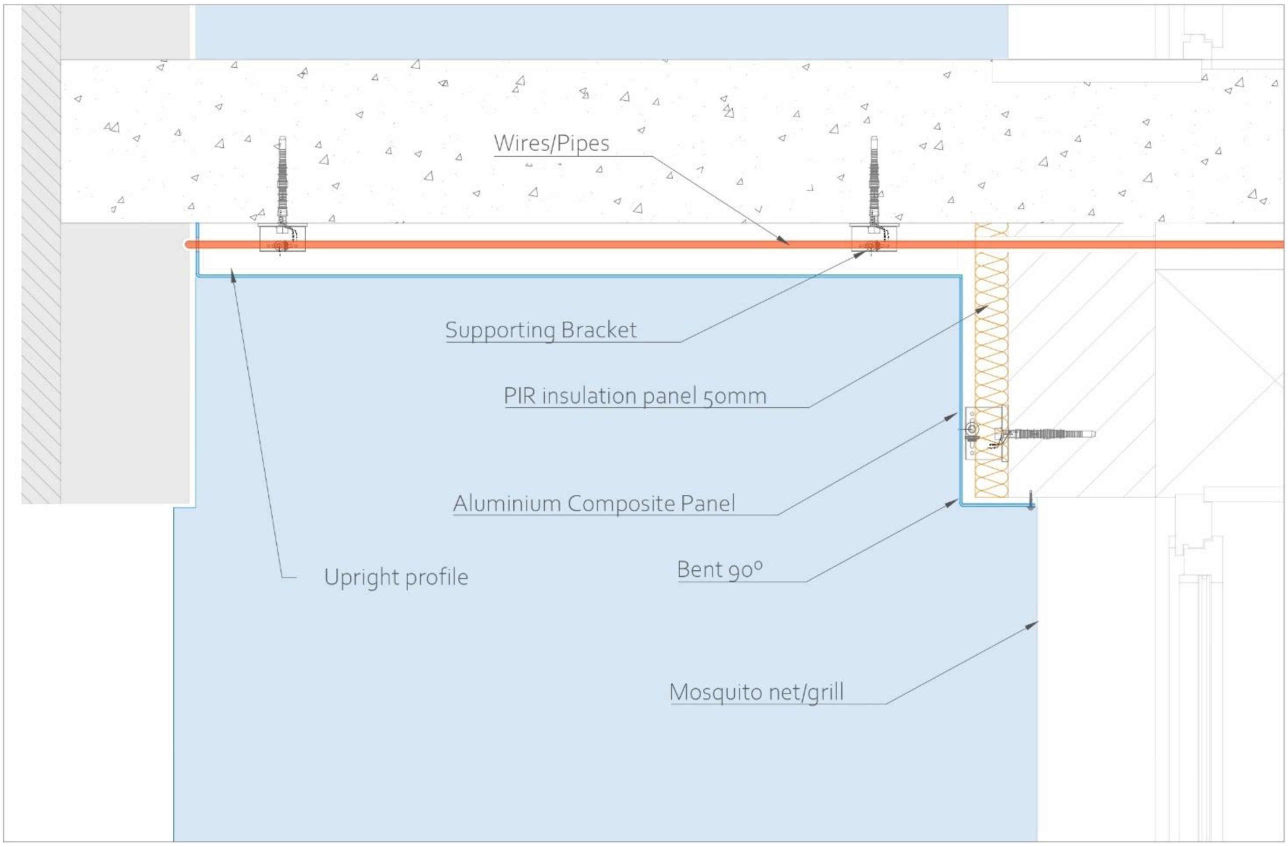


Figure 35. Balcony detail (Vertical) [drawing created using SketchUp]

Integration of utility elements

Other elements found in existing residential buildings that require specific design solutions to adapt to the new façade system are gas metres, drainpipes, vents, and gas pipes. Drainpipes will remain on the exterior of the new façade, and before the installation of the new façade, require dismantling to allow the fitting of the substructure and panels. Once the new building envelope is in place, the drainpipes will be assembled again, readjusting the pipe elbows to adapt to the new façade's width. Gas pipes and meters remain in their original locations, and the insulation of the façade is briefly interrupted when its application overlaps with these elements. The composite panels will be modified to facilitate inspections of gas meters and pipes.

Adaptations for air vents involve removing the outside grid and connecting a new ventilation duct to the existing one, ensuring compatibility with the new façade system, see Figure 30.

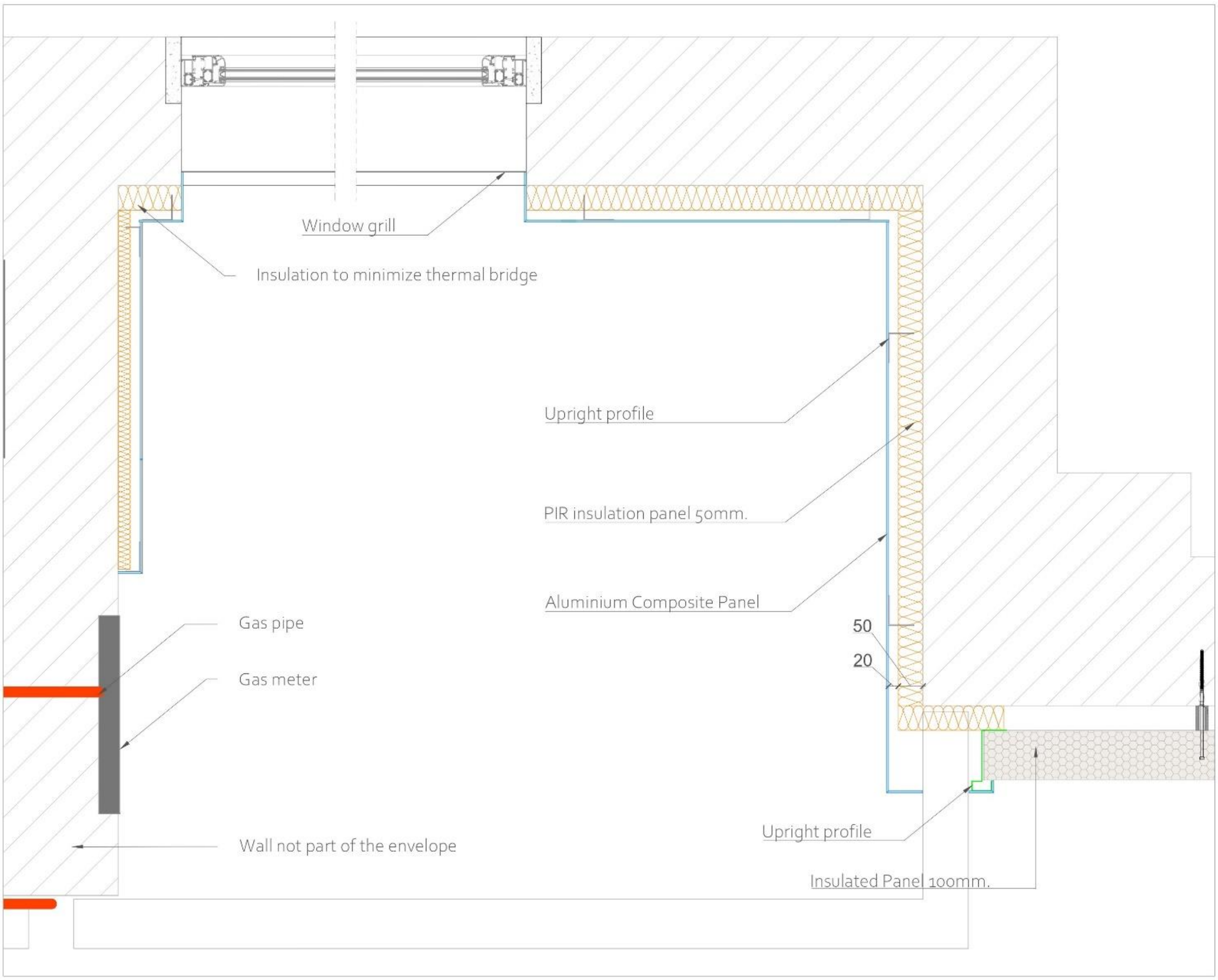


Figure 36. Balcony section (Horizontal) [drawing created using AutoCAD]

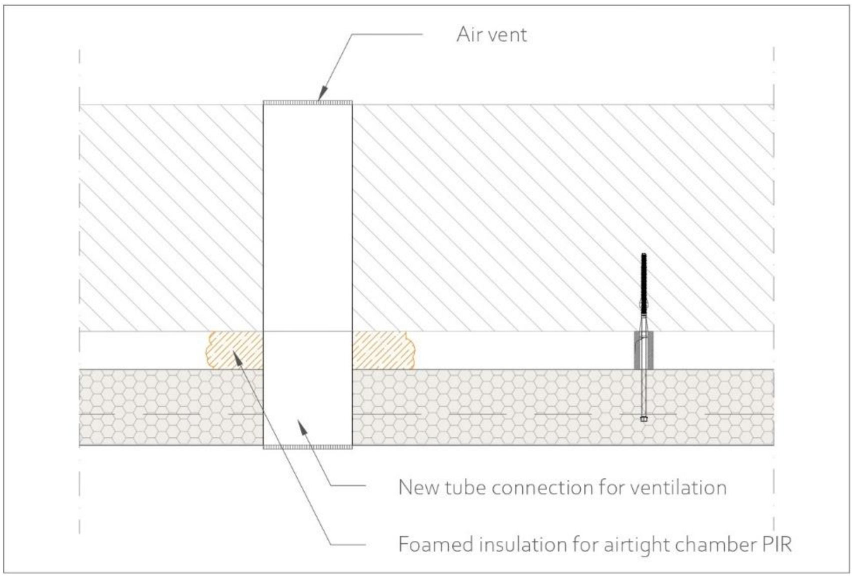


Figure 37. Air vent detail [drawing created using AutoCAD]

A valuable addition to the system involves incorporating an adaptable sealed chamber equipped with manually adjustable ventilation grilles (see Fig. 37). Depending on the seasons, the internal chamber can be completely sealed to provide thermal resistance in cold weather. Alternatively, ventilation grilles can be manually adjusted to enhance ventilation in warmer weather.

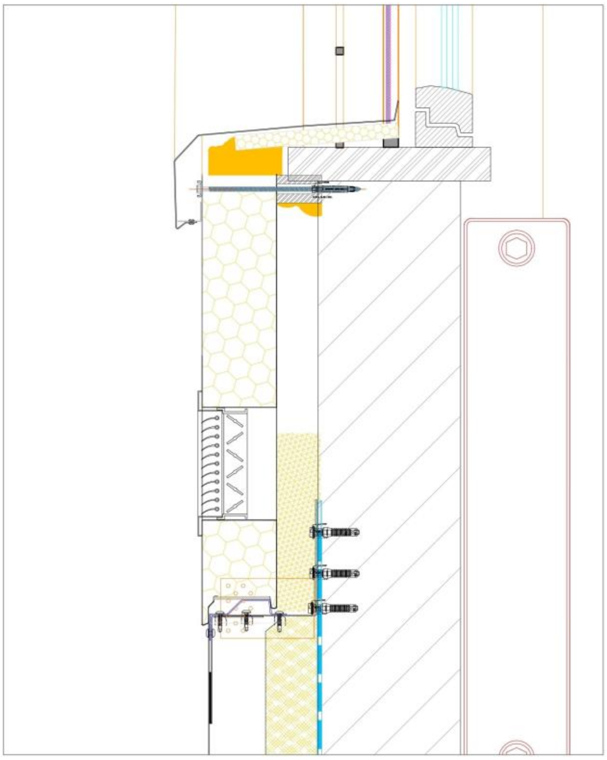


Figure 38. Preliminary design of ventilation grilles dependent on the final manufactured façade panel.

4. Installation

4.1. Transportation and storage

The material is transported in batches of pallets. The pallet dimensions are approximately (6x1x1.3) m, weighing each one about one ton. These figures vary depending on the building itself (square meters of façade, morphology, etc.) as the material and dimensions are defined when all areas of the building have been analysed and resolved. The material is sent on a truck. A pallet jack is necessary on-site to unload the material.

Regarding the storage, the material should be kept indoors, to avoid any type of degradation. It is recommended to use fencing material and regular construction site safety measures.

Figure 39. Transport and unloading of materials on-site for the HEART project. (Source: GarcíaRama)

4.2. Selection of auxiliary equipment

The selection of an installation system by the installer depends on the complexity of the façade and the existing accessibility conditions. For instance, in the case of a highly intricate façade, the installer may opt for general scaffolding systems, while crane platform installation systems may be employed in less complicated situations due to the versatility of the machinable and modular façade system. The RE-SKIN facade system allows for the use of crane platforms, thereby reducing installation time, labour requirements, and eliminating the need for scaffolding.

In the case of the Milan demonstration building, given that it is a two-storey building, using a compact lifting platform in such a structure facilitates the installation of larger panels while minimising the risks associated with their handling. This approach allows for the maximisation of panel length, leading to a substantial reduction in installation time due to the decreased number of panels requiring placement. Therefore, employing a lifting platform in a two-storey building is the optimal choice for enhancing the efficiency of the installation process.

Figure 40. Crane platform and scaffolding installation system

4.3. Preparation of walls that will support the new façade

To ensure the strength and endurance of the existing wall structure supporting the façade system, conducting multiple test samples using a dynamometer is essential. GAR has developed a Pull-Off Test Guide (dynamometric test) with comprehensive instructions and indications to identify the appropriate type of anchoring needed. The Pull-Off Test Guide can be found as Annex I in this deliverable.

The objective of the test is to ascertain whether mechanical anchoring alone is adequate or if chemical anchoring is required, especially in instances where the façade walls exhibit weaknesses, deterioration, or poor construction. This process guarantees the stability and safety of the façade system.

Figure 41. Dynamometric test (Pull-Off Test Guide in Annex)

4.4. Substructure installation

The installation of the façade system requires the coordination of at least two operators working simultaneously. These workers are tasked with the layout and distribution of components, aided by laser measuring and guiding equipment. The installation process begins by fixing the brackets, followed by the lower base profiles. Subsequently, the remaining substructure is installed, using the appropriate fixings depending on the condition of the existing wall.

Step 1: Using a laser and measuring tools, holes are made for the brackets that will support the starting point of the façade.

Step 2: The brackets are then screwed onto the façade.

Step 3: The starting profile is placed, anchored to the brackets. This starting profile will guide the panels that will later be screwed onto the façade.

Step 4: The laser assists in ensuring the profiles are perfectly vertically aligned, even if the façade is not flat and exhibits irregularities and slopes.

Figure 42. Demonstration of substructure installation

4.5. Insulating panel installation

The façade panel is attached to the substructure and subsequently to the wall using screws, which are concealed due to the tongue-and-groove system.

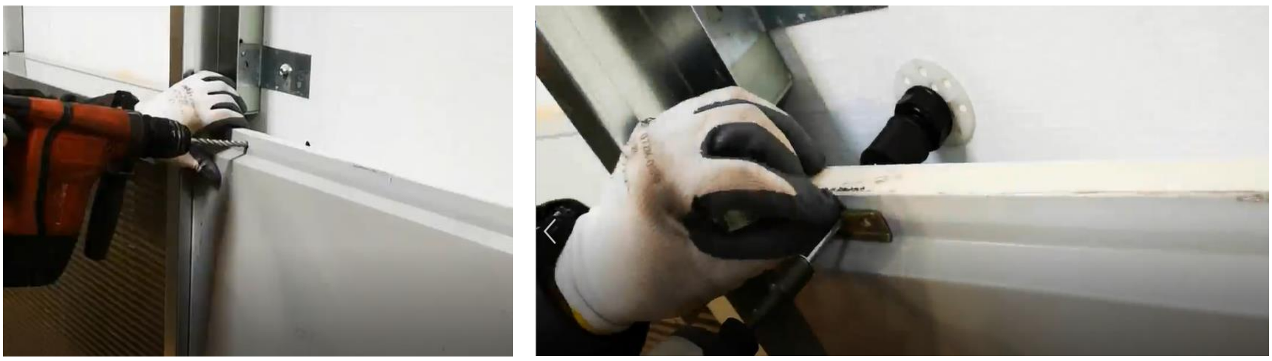


Figure 43. Demonstration of insulating panel installation

4.6. Installation of finishing elements

Similar to other façade cladding systems, such as ETICS (External Thermal Insulation Composite System) or ventilated façades, finishing elements are essential to complete singular elements like window frames, jambs, rain gutters, and gables. The use of aluminium sheet components is recommended for these purposes. Specifically, for window frames, it is advisable to incorporate an insulating sheet on the inner layer to prevent thermal bridging.

Figure 44. Completed façade installation by GarcíaRama (Image source: GarcíaRama)

5. Operation mode

5.1. Adaptable sealed chamber

The objective of the installation system in RE-SKIN is to incorporate an adaptable sealed chamber with manually operable ventilation grilles. The internal chamber is devised to function as thermal resistance and can be created by sealing an airtight gap, offering an effective insulation solution during cold seasons. The transmissivity of the chamber can be manually adjusted using the ventilation grilles, allowing for ventilation in warmer seasons. This approach ensures energy efficiency, cost reduction, and easy adjustments in response to seasonal variations.

Depending on the climatic zone and the existing wall structure, the airtight seal during colder seasons helps maintain the internal temperature of the building. In warmer seasons, the cavity can be opened to facilitate air circulation, preventing moisture and heat accumulation. Strategically placed ventilation grilles enable fresh air intake and exhaust stale air, establishing a continuous flow. In this preliminary design stage, the grilles are positioned at the base and top of the façade to facilitate air intake and exhaust. These grilles, made from stainless steel or aluminium, will be sourced from existing market designs, ensuring they prevent water ingress and debris.

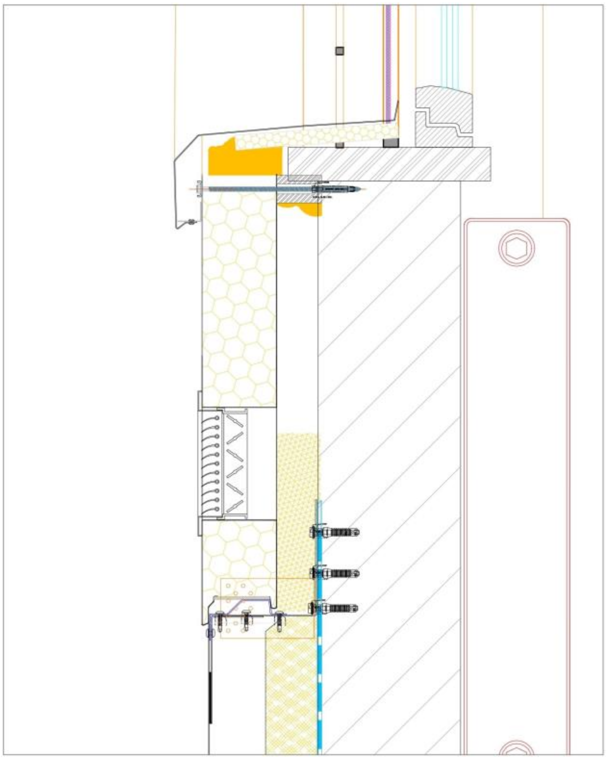


Figure 45. Preliminary design of ventilation grilles dependent on the final manufactured façade panel.

5.2. Maintenance

Regular cleaning and maintenance are essential to keep the Greencoat steel sandwich panel facade in good condition and extend their lifespan.

Cleaning

The most effective way to clean the facade is with a pressure washer. However, it is important to use the pressure washer carefully to avoid damaging the panels. The pressure should be set to a maximum of 20 bars.

The frequency of cleaning will depend on the location of the facade and the level of pollution in the environment. In general, it is recommended to clean the facade at least once every 5 years. If the facade is located in an urban area with heavy traffic, it is advisable to clean it more frequently.

It is important to use specific cleaning products. These products are designed to be gentle on the surface of the panels and will help to prevent damage.

Inspection

In addition to cleaning, it is also important to inspect the façade regularly for any signs of damage. This proactive approach helps to maintain the safety and integrity of the façade, extending its lifespan and reducing the risk of costly repairs or premature replacement.

Annex I: Pull-out Test Guide

DYNAMOMETRIC TEST

Funded by
the European Union

Table of Contents

1. GENERAL

This guide is made based on the recommendations included in the European Technical Approval Guideline, **ETAG 20**, in reference to:

PLASTIC ANCHORS FOR MULTIPLE USE IN CONCRETE AND MASONRY FOR NON-STRUCTURAL APPLICATIONS

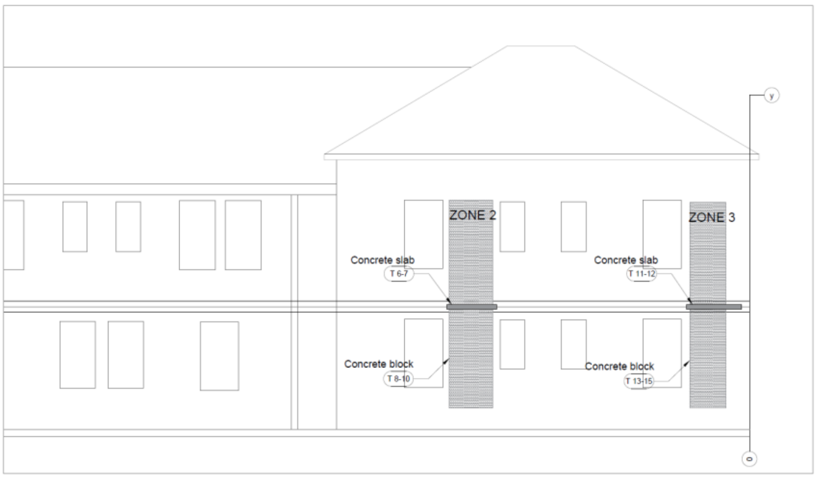
Specifically, in its annex B:

RECOMMENDATIONS FOR TESTS TO BE CARRIED OUT ON CONSTRUCTION WORKS

In the section for determination of resistance and according to the criteria of the ETAG:

*This characteristic resistance to be applied to a plastic anchor shall be determined by means of at least **15 pull-out** tests carried out on the construction works with a concentric tension load acting on the plastic anchor. These tests may also be performed in a laboratory under equivalent conditions as used on construction works.*

For each case study, a sampling plan is provided to guide the selection of representative areas for analysis. While the marked areas in the plan are considered to be critical due to their increased susceptibility to fatigue caused by expansion forces, the technician may identify additional regions that require evaluation to improve the accuracy of the characterization process.



Example of elevation with areas for testing

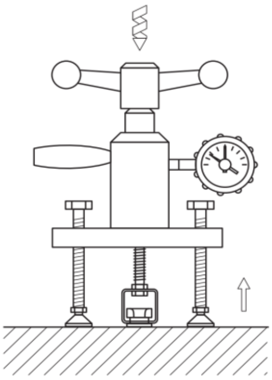
2. TEST EXECUTION

The test rig used for the pull-out tests shall allow a continuous slow increase of load recorded by a calibrated measuring equipment (dynamometer):

Tool recommended: HILTI AT 28 pull-out tester.

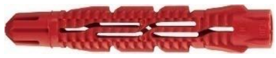
Pull-out tester

The load shall act perpendicular to the surface of the base material and be transmitted to the plastic anchor via a hinge. The reaction forces shall be transmitted to the base material such that the possible breakout of the masonry is not restricted. This condition is considered as fulfilled if the support reaction forces are transmitted either in adjacent masonry units or at a distance of at least 150mm from the plastic anchors.



The load shall be progressively increased so that the ultimate load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

Recommended anchors:

IMAGE	ANCHOR NAME	SCREW LENGHT
	HRD-HR 10	Concrete: L >120 mm Brick: L 60 to 80 mm
	HUD-L 10 X 70	Brick: 100 mm
	Fischer plug UX 10 x 60 R	Brick: L 80-100 mm

Recommendations:

- When testing on brick, we will search for knot in two holes (for the plug to get more expansion inside the brick).
- A longer plastic plug does not necessarily give better results.

Plug on brick

3. RESULTS REPORT

		PLACE					
		Street, number. Postal Code XXXXX - Region. Country					
WP5		**Pull-out Test guide**					
DATE	xx/xx/2024		Construction works Metal Panel				
		Anchors					
Nº TEST	Masonry (*a)	Ø	L (screw)	L (Plastic plug)	Crack	Pull-out	Results (KN)
1	C	8	120	120	Y/N	**Y/N**	18,7KN
2	BH	8	---	---	---	---	---
…	---	---	---	---	---	---	---
15							

(*a) 1. **C** *Concrete,* 2. **BH** *Brick (hole zone),* 3. **BM** *Brick (mortar zone).*