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D7.1 – Integration of small scale components on a test façade at POLIMI

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Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
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CO	Confidential, only for members of the consortium (including the Commission Services)	

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1 Introduction

The present document constitutes Deliverable 7.1 "Integration of small scale components on a test façade at POLIMI" in the framework of the EASEE project.
This deliverable reports about the activities carried out within Work Package 7, and specifically within Task 7.1 "Integration of small scale prototypes on a test facade". As reported in the DoW; Task 7.1 has the following expectations:

"This task aims at integrating the small scale demonstrators of the single façade components developed in WP2, WP3 and WP4 (outer envelope prefabricated panels, advanced inorganic loose fillers and retrofitting solutions for the interior) on a test façade in order to assess their combined behavior and performances in real conditions. For this purpose, a test façade at the POLIMI campus in Lecco will be used, which will represent a test bench for innovative construction components and materials. A wall will be retrofitted with the different types of components available at this stage of the project. This task will allow to evaluate also the installation procedure still in the research phase, in order to minimize possible problems during the demonstration phase in the buildings. This task will be led by POLIMI and all the partners involved in the development of each component will be involved."

With respect to the above Task description, the following clarifications are provided:

- Due to the high expenditure cost of the formwork for external prefabricated panels manufacturing, it was decided to design directly the formwork for real scale panels and thus to install them at the test facade. This allowed also to evaluate the installing procedures that will be also used at the demo sites.
- Two different test facades have been identified, respectively a facade for installing WP2 real scale solutions and a wall with cavity for injecting WP3 loose fillers and installing WP4 prototypes. These test facades are located in Milan instead of Lecco (climatic conditions are the same).

The document has been mainly structured into three sections according to the retrofitting solutions installed at the test facades, taking also into account the time scheduling of activities, respectively:

- Chapter 2) related to kits installation (WP4 solutions) for interior retrofitting
- Chapter 3) related to loose filler (WP3 solution) injection for cavity wall retrofitting
- Chapter 4) related to prefabricated panels (WP2 solution) installation for exterior retrofitting

Per each section, the definition of the chosen test facade, a short overview of the retrofitting solutions installed as well as a detailed description of the installation activities are provided. Installation of WP3 and WP4 solutions was performed on schedule with respect to project Gantt Chart while some delay was encountered in the installation of WP2 solution due to the needed technical improvements to be set-up for the panels manufacturing process.

Retrofitting solutions have been installed and their thermal performances are now monitored by means of the monitoring campaign defined within Work Package 7 and in particular within Task 7.2 "Performance evaluation of the integrated facade components". The results of monitoring campaign will be reported within Deliverable 7.2 "Report on evaluation and testing of the integrated components for facade retrofitting".

2 Integration of small scale prototypes for interior retrofitting

2.1 Identification of test façade for interior retrofitting

The Test Façade choose for the installation of small scale prototypes for interior retrofitting is located in Building nr.14, at the university campus “Leonardo-Città Studi” of Politecnico of Milano (see Figure 1).

Figure 1: Politecnico di Milano Campus Maps (https://maps.polimi.it/maps)

The selected building is a eight-story building designed by the Architect Giò Ponti, built in 1965 and classified as Cultural Heritage, composed by a concrete and steel structure and non-load bearing cavity wall with finishing clinker tiles. The wall that has been retrofitted through EASEE solutions for interior retrofitting is placed at the second floor, South-East (Figure 2). The room in which the intervention has been performed is a meeting & teaching room.

Figure 2: South side of building n.14 at POLIMI for inner retrofit

2.2 Design of retrofitting intervention

The South-East part (420x270 cm) of the identified test wall has been retrofitted with the three retrofitting kits developed within Work Package 4 (see Figure 3), classified as:

- A.1 Advanced perlite board
- B.1 Permeable insulating wallpaper
- B.2 Flat laminated panel.

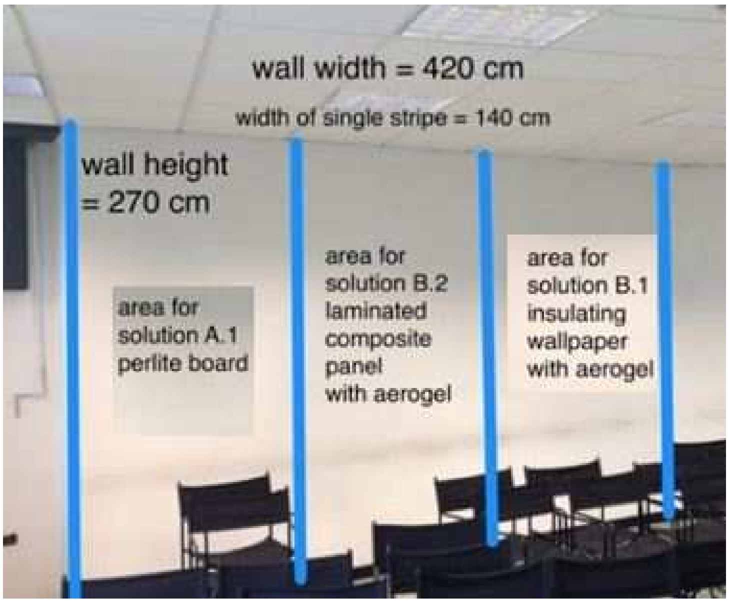


Figure 3: Inner view of the room before retrofitting with the section scheme for the three insulating solutions

2.3 Installation of the small scale components prototypes for interior retrofitting

The small scale prototypes for the inner insulating kits have been provided by the partners involved in WP4 (namely RIDAN, EMPA, SCHWENK, S&B and POLIMI). The installation has been carried out in summer 2014 (8^{th}-9^{th} July).

2.3.1 Kit A.1: Advanced perlite board

Below the main steps performed for the installation at the test façade of the advanced perlite boards with inner hydrophobic layer are provided. Main technical data can be found within Deliverable 4.4 “Report on optimization of advanced insulating components”.

1 - Storage of perlite boards with frame protection before installation.

2 - Implementation of the grounding layer for the perlite insulation board installation.


3 - Application of the first line of the perlite insulation boards on the adhesive mortar.


4 – Application of the further lines to cover the wall.


5 – Application of mesh, corner protection,filler and base coat.


6 – Application of a resin overcoat – finishing layer.

2.3.2 Kit B.1: Permeable insulating wallpaper

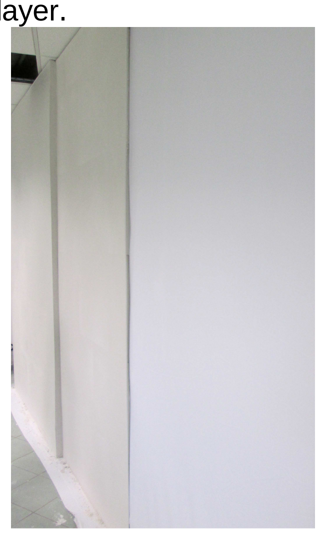
This solution is made by two different layers: a finishing textile layer and an insulating layer. These two layers are completely independent, and this helps the maintenance, the cleaning and the implementation in time. Moreover, this involves a big benefit: it is possible to replace one layer at a time and even the single portions eventually damaged. This aspect also helps the storage in the storehouse, the transport and the installation D.I.Y. (Do it Yourself), therefore all the operations, from the transport-carriage to the installation, are performed with basic tools, commonly used in every house: scissors, cutters, iron, hammer. In addition to the fast installation and simplicity (D.I.Y.), this solution provide further advantages: no need of scaffoldings or yards, minimization/elimination of occupant discomforts; elimination of typical downtime of wet assembled installations; possibility to restore the original internal façade, aesthetic features of the internal façade; new expressive potentials; respect for the existent wall and total reversibility of the system; absence of thermal bridges typical of aluminium profiles' installations; possibility to design a breathable insulating system and to improve it during the time (through the simple replacing of finishing textile that will be more or less breathable); minimization of the total thicknesses through the finishing textile; flexibility of the solution and perfect grip on all types of existing wall, even if not perfectly flat; possibility of buying the insulating kit directly in a D.I.Y. store in its standard size and further adapt it to the size of the wall to be coated with the use of simple equipment available in every home or office.
Main technical data can be found within Deliverable 4.4 “Report on optimization of advanced insulating components”. Technical details cannot be disclosed because they are part of a future patent application. The steps foreseen for the wallpaper installation at the test facade:


1 - Storage of aerogel based wall-paper before installation.


2 - Implementation of the grounding layer for the permeable insulating wallpaper installation.


3 - Application of the wall-paper on the grounding layer.


4 - Encapsulating textile glued to the aerogel.


5 – Installation of the system of tension for the finishing fabric.

2.3.3 Kit B.2: Flat laminated panel

Below the main steps performed for the installation at the test façade of the flat laminated panel are provided. Main technical data can be found within Deliverable 4.4 “Report on optimization of advanced insulating components”.

1 – Storage of aerogel based flat laminated panels before installation.

2 - Implementation of the grounding layer for the flat laminated panels installation.

3 - Application of the multi-layer solutions on the grounding layer.

4 – Fix all the panels on the wall, before applying mesh, protective corners, filler and base coat.

3 Injection of loose fillers for cavity retrofitting

3.1 Identification of the test facade for cavity retrofitting

The selected building is a eight-story building designed by the Architect Giò Ponti, built in 1965 and classified as Cultural Heritage, composed by a concrete and steel structure and non-load bearing cavity wall with finishing clinker tiles. The wall that has been retrofitted through EASEE solutions for interior retrofitting is placed at the second floor, South-West oriented (Figure 4). The room in which the intervention has been performed is a meeting & teaching room (see Figure 5).

Figure 4: West front of building n.14 at POLIMI

3.2 Design of the cavity retrofitting intervention

The South-West side (430x270) has been retrofitted filling the air cavity (depth of about 34 mm) with natural hydrophobized loose perlite provided by S&B named as:

- A.2 Hydrophobized loose perlite.

Figure 5: Inner view of the room before retrofitting through perlite injection

3.3 Injection of perlite for cavity retrofitting

Below the main steps performed for the cavity wall retrofitting at the test facade identified are provided. This activity was performed in July 2014 (on the 11th July). Main technical data can be found within Deliverable 3.3 “Production of perlite at laboratory and pilot scale”.

1 - Storage of the hydrophobic expanded perlite delivered by S&B.

2 - Holes were drilled at the top of the cavity prior the installation of perlite. Because of the latter’s granular characteristics, allowing the perlite to seep in the cavity simply by gravity, it was not necessary to drill additional holes at mid-height.

3 - Storage of the barrels containing hygrophobic expanded perlite delivered to Politecnico.

4 - Positioning of the blowing machine on a lorry in order to deliver the loose perlite two floors above.

5 - Filling the cavity with the granular perlite until the top and close the holes.

The vertical cross section of the test wall before and after retrofitting with loose filler and small scale prototypes for inner retrofitting is shown in Figure 6.

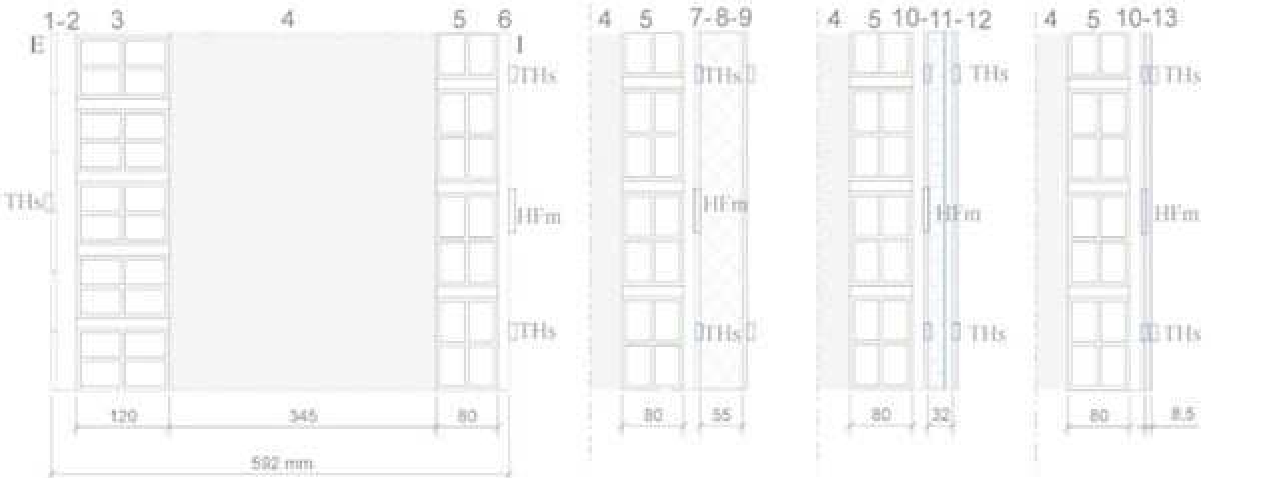


Figure 6: 1- Ceramic tiles; 2- cement based adhesive render; 3- hollow bricks 12cm thickness.; 4-air cavity; 5 - hollow bricks 8cm thickness.; 6 - lime-cement plaster with gypsum finishing; 7- cement-based glue; 8-perlite board; 9- cement based filler and resin render; 10- resin-based glue; 11- aerogel-based flat laminated panel; 12- resin based filler and resin render; 13- flexible aerogel-based blanket with fabric.

4 Solutions for external retrofitting

4.1 Identification of the test façade for exterior retrofitting

The test façade chosen for the installation of the prefabricated panels for external retrofitting was Building 21 (Figure 7), designed by Giovanni Bonicalzi and built in the early ‘70s. The buildings hosts classrooms, research laboratories and departmental offices (Figure 8). The facade that has been retrofitted through the installation of the prefabricated insulating panels is the West front facade characterized by a rough concrete finishing. That part of the building was designed considering future expansion of the wing building towards the garden (Figure 9).

Figure 7: Aerial view of the building (Fonte: https://maps.google.com)

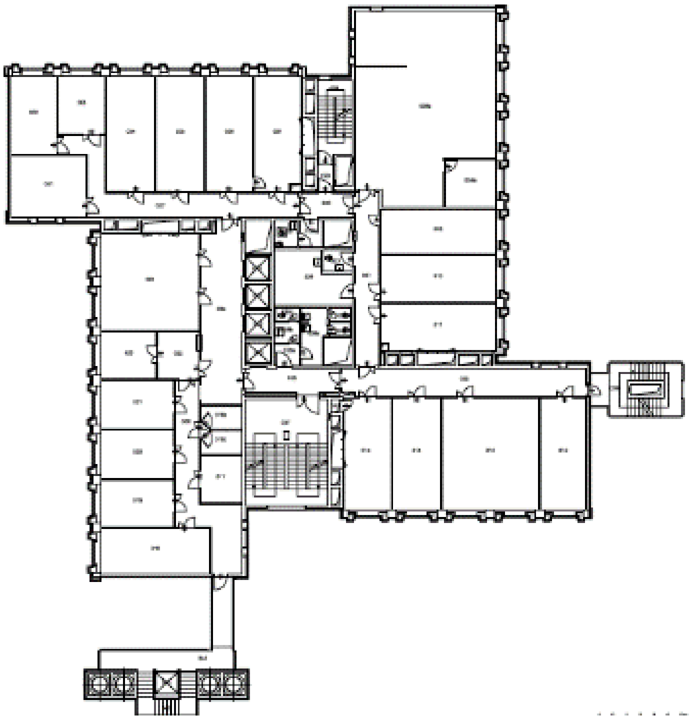


Figure 8: Floor distribution of the building 21

From the structural point of view, the building is a prefabricated pillars and beams building. The pillars, 70 x 60 cm size, are joined in height with a simple superposition of the steel bars. The beams are connected to the pillars with prestressed steel cables. The beams have a section "pi greek " and were completed on site with concrete casting. The wall between the pillars is made with concrete.

Figure 9: Picture of the test façade

4.2 Design of the exterior retrofitting intervention

4.2.1 Geometrical survey

A geometrical survey was carried out by means of topographic, photogrammetric and laser scanning relief. The relief was based on a local reference system by means a permanent nails fixed on the ground and different reflective tape targets installed on fixed elements of the building.

The measurement of the network placement was carried out with a total station (Leica TS30) of the first order. The accuracy on the measurement of the distance was equal to ± 0.6 mm and ± 0.15 mgon on measures azimuth and zenith angles. A peculiar characteristic of this type of total station is the distance sensor able to perform measurements without a prism up to a maximum of about 1000 m distance depending on the type of target surface. This allowed the direct measurements of some points of the building that could not be easily reached. The final accuracies were of the order of 1.5 mm.

The laser scanner survey was carried out by the terrestrial sensor Faro Focus 3D, having a nominal accuracy of ± 2.2 mm with sensor-object distance of 25 m and 10% reflectivity of the surface. Totally, three scans were performed with high coverage by acquiring a total of about 80 million points. The accuracy of recording scans was approximately ± 2-3 mm. The data of this survey campaign were thus used as base drawings for the test façade design.

In addition, orthophotos RGB and thermal imagines were also cretaed in order to combine metric and photo-realistic information. A digital calibrated camera Nikon D700 (pixel size 0.0084 mm) was used for orthophoto RGB acquisition.

The thermal orthophoto was made with a thermocamera FLIR T 640 (19 mm focal length) installed on drone Asctec Falcon 8, equipped with automatic navigation system (GPS, inertial and high sensors) and stabilization of the room. The images are photogrammetrically oriented and is produced with a resolution of 2 cm.

Figure 10: Scheme of the geometrical and orthophoto relief campaign

4.2.2 Materials survey

An analysis of the façade materials status was carried out to highlight the presence of weak points. Figure 12 and Figure 13 shows the results of the survey underlining the presence of anthropogenic degradation at the base of the façade due to the water presence as the main material that compose the facade is exposed concrete-coated on prefabricated panels. In particular for the portion of the facade were detected the following aspects:

- The coating made of prefabricated panels covers only a portion of the test façade (last 2 floors) (Figure 11, a);
- There are a system of outdoor lighting and a burglar alarm system for the computer room on the ground floor (Figure 11, b);
- The metal frame door on the right side of the façade is an emergency exit of the inside classroom and it is raised above the ground surface of about 5 cm (Figure 11, c);
- On the left side of the test façade there is a presence of a big tree that must be taken into account during the installation phases (Figure 11, d).

a) b) c) d)

Figure 11: Pictures of the test facade site

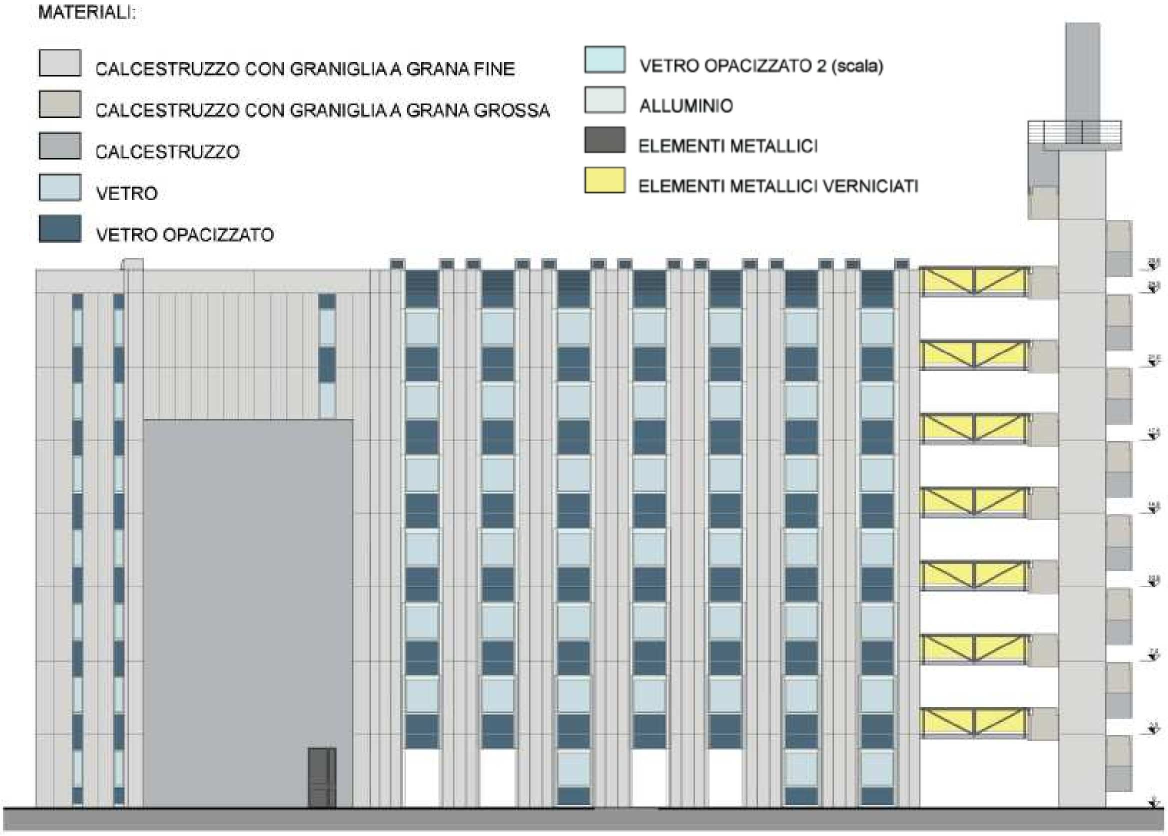


Figure 12: Material survey– west side elevation

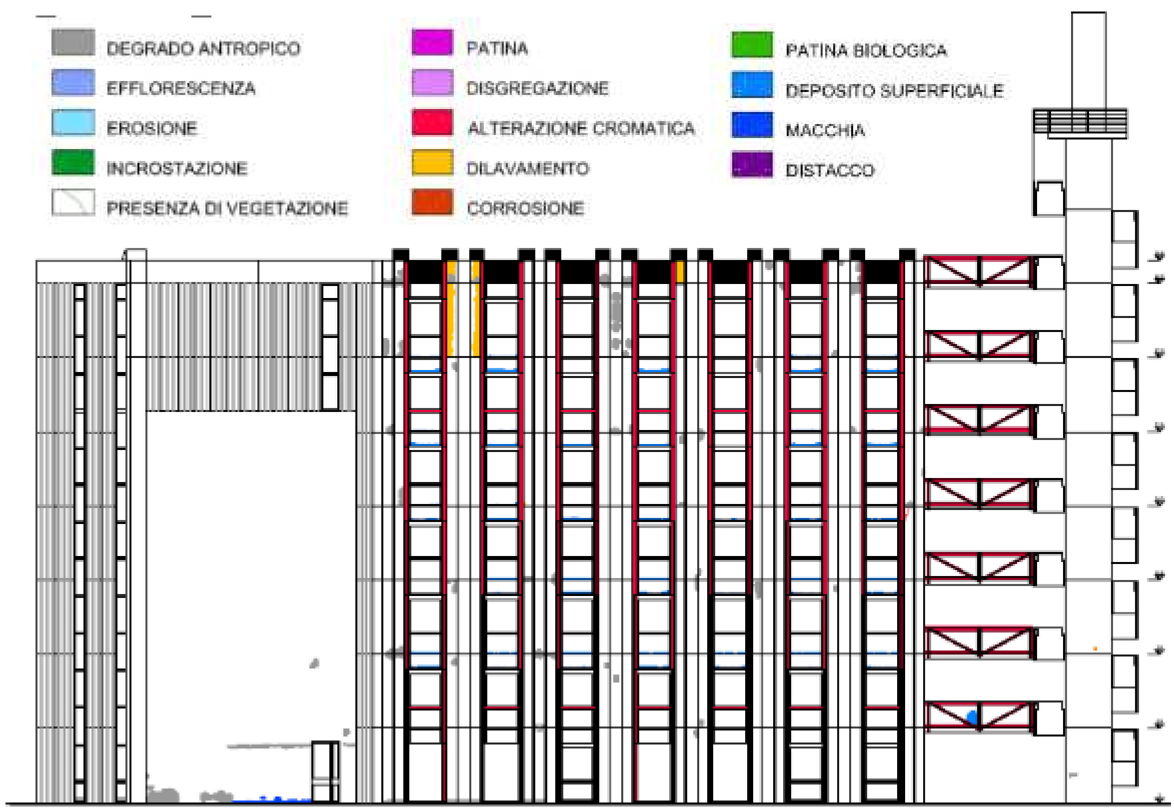
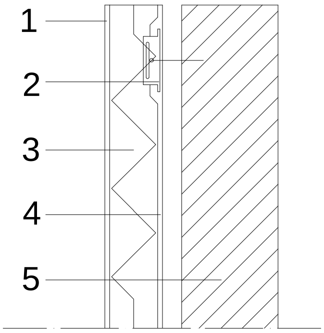


Figure 13: Degradation survey – west side elevation

4.2.3 Design of the external retrofitting

Technical details on the prefabricated insulating panels that were installed at the test façade in Milan can be found within D2.4 “Testing and LCA evaluation of prefabricated shapeable panels through lab scale prototypes”. The panels installed at the test-façade were produced by Magnetti Building by means of the formwork designed by STAM and assembled at Magnetti premises. This formwork allows the realization of different types of panels finishes in terms of colors and texture. Pigments of colors can be add to the TRM before the formwork concrete injection and a form liner can be applied to the internal side of the formwork in order to obtain a desired finishing.



1- Textile reinforced concrete (TRC) sp.10 mm
2- Halfen body anchor
3- EPS Insulation sp. 100 mm
4- Textile reinforced concrete (TRC) sp.10 mm

Figure 14: Scheme of the outer insulation panel.

The design of the prefabricated panels started form the following concept:

- Time minimization and mistakes reduction for the building retrofitting, by implementing prefabricated panels components and by performing an accurate survey of the building;
- Availability of wide range of different finishing layers of the retrofitting panels;
- Easiness of local replacement in case of damage of a single panel;
- Possibility to retrofit the building without burdening occupants and users as well as normal activities inside the building during the intervention;
- Energy performance improvement with the achievement of the thermal transmittance targets (in terms of U value).

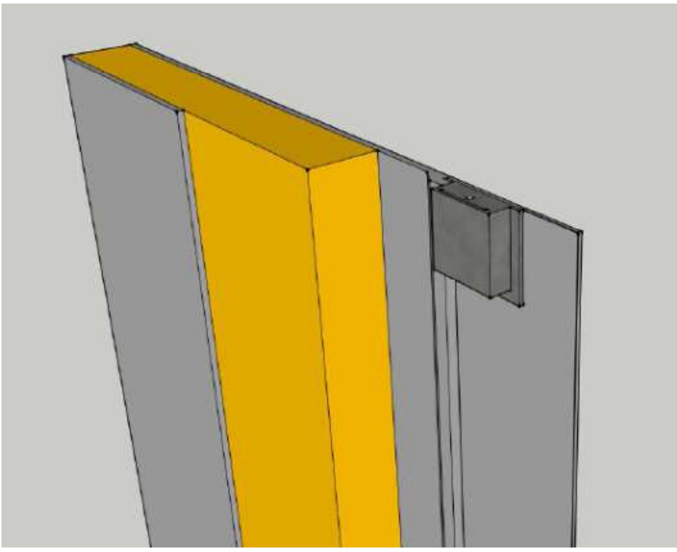


Figure 15: Axonometric view of the panel

From the structural point of view the panels were connected with the existing facade by means of specific anchoring systems (developed by Halfen), which are connected with the "TRC boxes" located in the four corners of the perimeter of the panel.

Figure 16 provides the test façade design, consisting in 13 panels with three different dimensions and color (light gray, gray and charcoal). In particular:

- 10 panels 302,5 x 150 cm
- 1 panel 302,5 x 142,5 cm
- 2 panels 302,5 x 55 cm

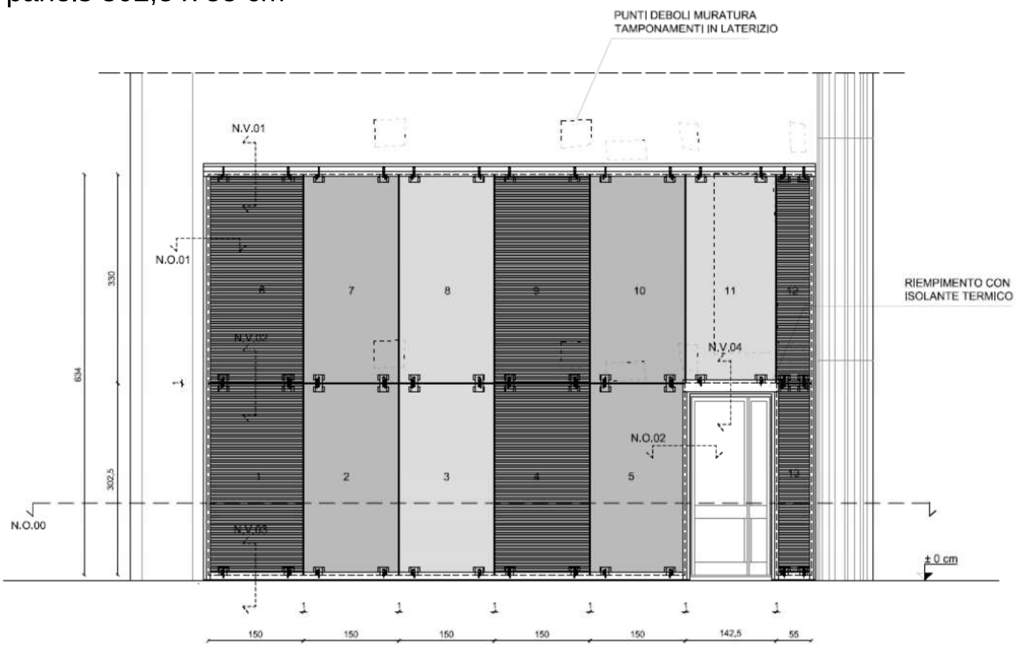


Figure 16: Drawing of the tests facade

This was chosen in order to study the joints between the different panels.
Moreover, two of the panels with the dimension of 302,5 x 150 were produced with a vertical lines texture on exposed surface (Figure 17).

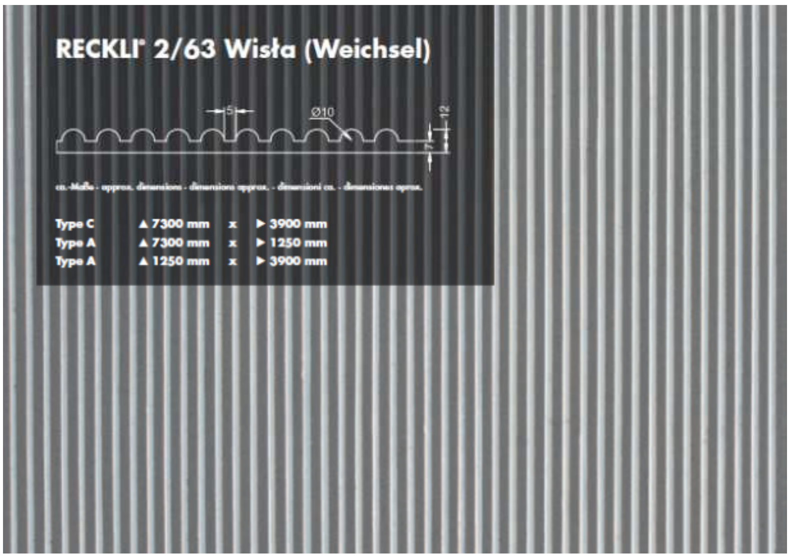


Figure 17: Texture applied to two panels of the test façade

The monitoring systems to evaluate the thermal transmittance of the retrofitted façade have been installed in correspondence of the second level of the panels.

4.3 Installation of the prefabricated panels for exterior retrofitting

All the bureaucratic procedures for the site opening and for the construction companies identification and verification as well as for the sanitary notification (ASL notification) and security protocols (PSC preparation) were duly accomplished (see Figure 18).

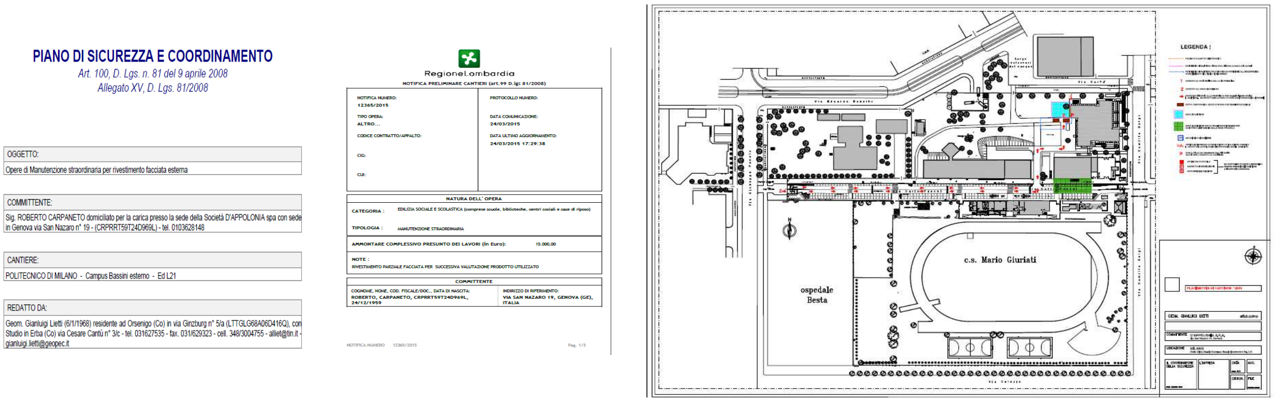


Figure 18: Examples of bureaucratic documents provided for the test facade opening

The prefabricated panels has been transported by truck from Bergamo (where they were produced) to Milan where they were delivered at the test site and unloaded by the crane of the truck. Indeed, all the panels were equipped of a dedicated fixing system within the anchoring boxes, allowing the insertion of a ring slot for the lifting system (see Figure 19).

Figure 19: Panels storage and handling

Figure 20 shows the panels before the installation and stored near the test façade site.

Figure 20: Panels before installation stored in the test facade site

The following two pictures show the typologies of the anchoring systems used for the test facade. The first one (on the left of the Figure 21) is called Halfen DT suitable for large stand-off distances between 140 and 300 mm with and high loads up to 1300 N.

Figure 21: Halfen body anchor type DT. Right side Halfen body anchor type BA

The pre-assembled anchor consist on the body and horizontal bracket. The adjustable wedge plate and a clamping bolt is supplied ready to be installed. The stand-off distance is adjusted using the spade bolt. The second typology of the anchor is called BA (right of the figure 17). This type is designed for small stand-off distances from 60 to 120 mm with a maximum load of 1300N. The anchor consist of a sturdy base element, a serrated palate and a spade bolt. The bracket has a vertical 8.5 x 28 mm slot and a serrated plate for easy height-adjustment.Some of the anchors has been fixed to the existing wall with mechanical anchor, some others, in the portion of the wall less resistance with chemical anchor.

Figure 22: Left side: Mechanical anchor. Right side Chemical anchor

The panel's installation has been made without scaffoldings. A small crane vehicle trucks was used for both, body anchor and panels installation.

Figure 23: Pictures of the installation phase

Below some pictures took during the installation phases:

Figure 24: Some pictures of the installation process

The joint between the panels has been made using a low elastic modulus neutral-curing silicone sealant with outstanding ageing resistance. The silicon has been placed on polyurethane backfill material in order to reduce the danger of cracking. The elasticity remains constant at temperatures ranging from -50°C to +100°C. The high resistance to UV rays and atmospheric agents foresees that after 20 years of service under normal conditions, the joints shows no trace of superficial cracks.
In the test two different color has been chosen, gray between the light gray panels and black between the charcoal color.

Figure 1 – The grey silicon sealant between the panels and the polyurethane foam

Around the whole perimeter of the test façade, the cavity between the panels and the existing wall, has been close using a polyurethane foam sealant. With this the air permeability is drastically reduced and a close air cavity is created.

5 Conclusions

This document aimed at providing evidence of the performed activities performed within Task 7.1 related to the integration of small scale prototypes at the test facade as preliminary step towards the implementation of the developed retrofitting solutions at demo buildings (in Italy, Spain and Poland). At the current stage is provided info on the fully accomplished demo installations:

- Interior retrofitting (Kit A.1, Kit B.1, Kit B.2) at the Building nr. 14
- Filling for cavity wall at the Building nr. 14
- Exterior retrofitting at the Building nr. 21

A description of the test facades chosen for the activities, a short overview of the solutions applied and of the intervention design as well as detailed description of the installation process as technical showcase have been provided as also shown in the figure below.

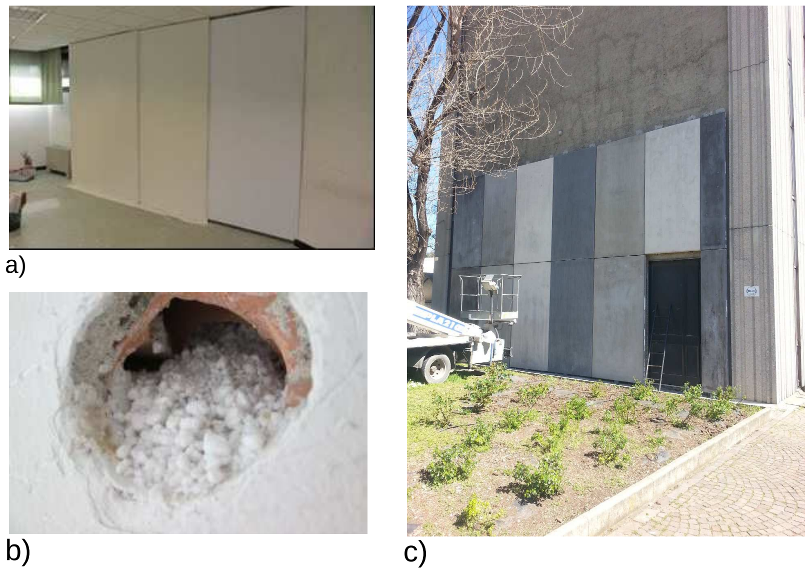


Figure 25: View of the interior façade (a) and cavity (b) retrofitted at Polimi Building nr. 14 and view of the test façade externally retrofitted at Polimi Building nr. 21 (c).

Insights of the thermal behaviours of the solutions installed will be provided within D7.2 “Report on the evaluation and testing of the integrated components for façade retrofitting” due at Month 43.