e-SAFE

DELIVERABLE REPORT

WP5 Demonstration activities

D5.1

DETAILED SURVEY OF THE REAL PILOT

Due date

M12 30.09.2021

e-SAFE has received funding from the European Union's Horizon 2020research and innovation programme under grant agreement No. 893135

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☐ PP - Restricted to other programme participants & EC: (Specify)
☐ RE - Restricted to a group (Specify)
☐ CO - Confidential, only for members of the consortium

TYPE

☐ R - Report
☒ DEM - Demonstrator
☐ DEC Websites, patents filling, videos, etc.
☐ OTHER
☐ ETHICS – Ethics requirement
☐ OPRP - Open Research Data Pilot
☐ DATA – Data sets, microdata, etc.

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EXECUTIVE SUMMARY

The present document is the deliverable “D5.1 – Detailed survey of the real pilot” of the **e-**SAFE project (Grant Agreement No.: 893135), funded by the European Commission under its Horizon 2020 Research and Innovation Programme (H2020).

The report describes the existing state of the real pilot building, located in Catania, which will be renovated during the demonstration activities of the **e-**SAFE project in Work Package 5. The document is the result of a survey activity that has concerned different aspects, including architectural issues, geometric issues, construction and energy issues, and structural issues. The results presented in this report are preliminary to the design of the renovation solutions that will be applied to the pilot building during the demonstration activity and allowed understanding the main criticalities that must be considered during the design and the implementation stages.

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GLOSSARY OF TERMS

ACRONYM	DESCRIPTION
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
COP	Coefficient of Performance
DHW	Domestic Hot Water
IACP	Istituto Autonomo Case Popolari
IWEC	International Weather for Energy Calculation
PC	Project Coordinator
RC	Reinforced Concrete
ToF	Time of Fly
TLS	Terrestrial Laser Scanning
TM	Technical Manager
WP	Work Package
WPL	Work Package Leader

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1. INTRODUCTION

This document describes the existing state of the pilot building, located in Catania, which will be renovated during the demonstration activities of the **e-**SAFE project.

The survey that led to this document was carried out from May to November 2021, and has included several different aspects, namely architectural issues, geometric issues, construction and energy issues and structural issues.

1.1 Deliverable structure

The deliverable is organized according to the different aspects considered during the survey.

Section 2 deals with the architectural survey. Here, the report describes the original design of the building, how it was realized, and the modifications made by the inhabitants over time. The architectural survey made use of morphological and typological analysis to place the building in its urban context and to know its architectural and distributional characteristics.

Section 3 deals with the geometric survey. Here, the existing state of the building is analyzed by means of a punctual in situ survey campaign with drone and 3D laser scanner that returned detailed plans for all floors, sections and the detailed drawings of all fronts.

Section 4 deals with construction and energy survey. This section reports on the different envelope components, their thermal features and the energy performance of the pilot building. In-situ surveys are used to determine the features of the building envelope and those of the existing technical systems for heating, cooling and Domestic Hot Water preparation. Instead, numerical analyses allowed assessing the energy performance of the building in its current configuration, while also releasing the Energy Performance Certificates of the single apartments.

Section 5 deals with the structural survey. This section investigates the geometry and the mechanical properties of the Reinforced Concrete (RC) structural elements in the building.

Finally, Section 6 makes a final recap of the main criticalities that have emerged during the survey, and that must be attentively considered during the design and the renovation stages.

1.2 Links with other tasks in the project

The outcomes of this report, carried out in the framework of Task 5.2 "Data gathering and preliminary co-design", will be the inputs for the design activities needed to start the renovation works of the real pilot in Work Package 5.

In particular, the results will feed the co-design activities in Task 5.2 and the detailed design activities in Task 5.3, leading to the renovation of the pilot building in Task 5.5.

Furthermore, knowing the geometry and the features of the pilot building will allow its simulation through the Decision Support System (**e-**DSS) that will is implemented in Task 4.2, and that will be used during the co-design activities.

1.3 Contribution of the partners

UNICT has led the activity and has performed most of the surveys in the pilot building, by combining different expertise coming from the groups of "Architectural Design" (Section 2), "Building Construction" and "Building Physics" (Section 4), "Structural Engineering" (Section 5). The geometric

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survey in Section 3 has been subcontracted to the Survey and Representation Laboratory of Kore University of Enna, due to their sound expertise in 3D laser scanning and drone survey techniques.

UNIBO contributed to the on-site survey of the technical systems. IACP facilitated all the survey activities on-site and commissioned the structural survey. SALFO supervised the whole survey activities included in this deliverable and defined the timeline.

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2. ARCHITECTURAL SURVEY

This section describes the original project, the relationship with the context, the general layout, and the architectural features of the pilot building in Catania. The knowledge of these aspects, conducted through morphological and typological analysis, is of fundamental importance for the renovation of the building. In particular, the comparison between the original configuration and the transformations that over time have been carried out on the architectural artefact, both in terms of replacements and modifications and/or alterations, is the starting point not only for interventions on the structural system and technological plants but also for the redesign of the overall architectural building image and the consequent satisfaction of inhabitant's real needs. In this way, the **e-**SAFE technology will also be tested in terms of technological versatility and architectural expressiveness.

2.1 Description of the tools used for the survey

The pilot building selected to demonstrate the innovative construction systems designed within the H2020 **e-**SAFE project is located in Catania (Southern Italy), via Acquicella Porto No 27. The building is 70% owned by the Institute for Public Housing (Istituto Autonomo Case Popolari - IACP) of Catania that designed and built the entire residential complex of which the pilot building is part.

The IACP institutes were established in Italy following the law of 31/05/1903 No. 251. They have the task of facilitating the construction of Public Housing to improve the living conditions of the population and especially of less affluent people.

The choice of the pilot building was also made considering:

- a building predominantly owned by IACP;
- a building located in a distressed suburban area;
- a large diffusion of similar buildings, at least at national scale, and therefore a repeatability of the approach and solutions.

To proceed with the design phase, it is necessary to know the building from its origins to its current state. Knowing the reasons of the design choices in terms of general layout, typology, construction technologies, materials, figurative and aesthetic structure and relationship with the place is useful not only to define the architectural features of the building, but also to understand the reasons for the real state, both material and social, of the inhabitants. They live the condition of marginality typical of the suburbs, aggravated by functional isolation compared to other residential areas of the city. They live in an area where there are mostly factories, but no residences. For this reason, they experience their housing complex as a small residential neighborhood although within a large commercial-industrial area. They have thus developed a strong sense of belonging to these places. However, they feel a strong perception of distance and isolation, which is not only due to the building location at the edge of the city but also, and perhaps above all, due to a lack of interest by the institutions responsible for their care and security, as well as the municipal administrations that have succeeded over time.

The tools to analyze and describe the original project as well as the current building state are:

- literature on the history of Public Housing and in particular that produced by IACP and published in the magazine "EdiliziaPopolare. Rivista bimestrale di studi dell'Associazione Nazionale fra gli Istituti per le Case Popolari";
- local historical literature [1, 2];
- technical documents [3];
- on-site inspections;

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- photographic survey;
- survey of changes and transformations during building construction by the inhabitants concerning the original project.

The literature on the history of Public Housing in Italy gives the phenomenological dimension of the events linked, first, to social policies for the benefit of the popular classes and then, to the post-war reconstruction of the country. Hence, the characteristics of Public Housing respond to the need of the "house for all". Therefore, these architectures are built with low construction costs and according to the principles of standardization, both in terms of construction processes and residential types. The construction of Public Housing has thus affected the entire nation with points of interest in specific realities, among them: Milan, Rome, Florence, Udine and Parma. A phenomenology strongly influenced by the economic situation, the organization of society, the sense of living, the custom at the time and local specificities. The local historical literature has made it possible to reconstruct the urban events that have affected the city and in particular the district of the pilot building.

2.2 The origins of the residential settlement

The residential settlement in via Acquicella Porto by IACP is anomalous because it was built in a part of Catania with a purely industrial and commercial vocation. This is evident from the analysis of the nearby urban fabric (Figure 1). Furthermore, this vocation is demonstrated by the design intentions at the time, which aimed at the creation of a farmers' market. Indeed, "At first, in 1946, the market was thought to be built in Via Acquicella Porto, with a project by Santi Buscema, head of the UTC [Municipal Technical Office], who studied it with a series of sheds placed close to a torrent" [1, p. 465]. Commercial and industrial sheds indeed still characterize this part of Catania: they enclose and, at the same time, isolate the residential settlement of IACP. The craft and commercial vocation of the area is confirmed and integrated in the 1964 Town Development Plan drafted by Luigi Piccinato, and still in force today (Figure 2).

Figure 1: The red perimeter represents the IACP residential settlement in via Acquicella Porto on Google maps 2021 photos.

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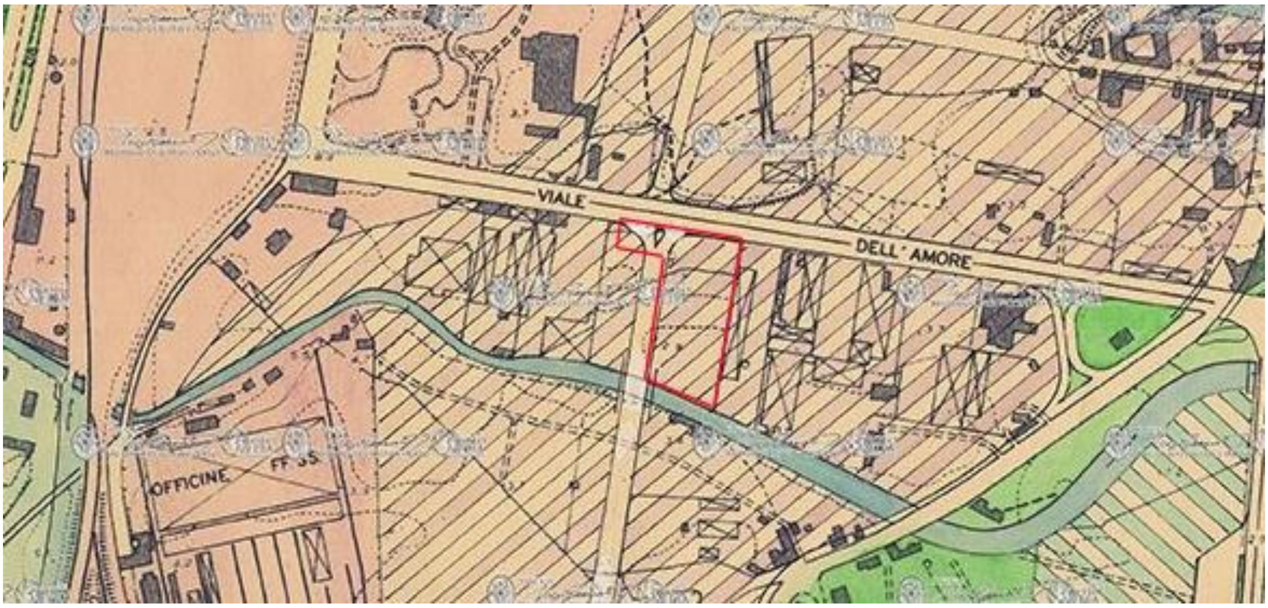

Figure 2: The red perimeter represents the IACP residential settlement in via Acquicella Porto on the 1964 urban development plan drafted by Luigi Piccinato. Namely, the diagonal hatch pattern, that affects most of the area where the pilot building is located, indicates the Industrial area.

Figure 3: The red perimeter represents IACP residential settlement in via Acquicella Porto in 1996 urban plan proposal drafted by Pier Luigi Cervellati.

However, this vocation seems to have been partly disregarded by the proposals for the urban development plan that followed Piccinato's one. In particular, the design intentions of the 1996 development plan proposal drafted by Pier Luigi Cervellati completely remove the IACP settlement in via Acquicella Porto. Indeed, Cervellati's plan replaces part of the industrial and commercial fabric, including our residential complex, with a monumental and equally unlikely residential urban fabric [2] (Figure 3).

The area is redesigned to accommodate different lined up houses. The intention was to compose a background that defined a new urban axis, already foreseen by the 1964 Town Development Plan.

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The axis should have ended with a building/door beyond the Acquicella torrent (Figure 3). However, Cervellati's proposal plan maintained part of the neighborhood's industrial sheds, used for commercial and craft activities.

The residential complex of Via Acquicella Porto is therefore a singularity in the surrounding urban fabric. Nevertheless, the project is approved and carried out even if with variations compared to the original plan. The original project included a residential complex (Figure 4) with a total of 15 blocks and 2 tower buildings. Both the lined-up and the tower buildings were built on 5 elevations and involved 2 apartments per level. The total number of apartments was 170.

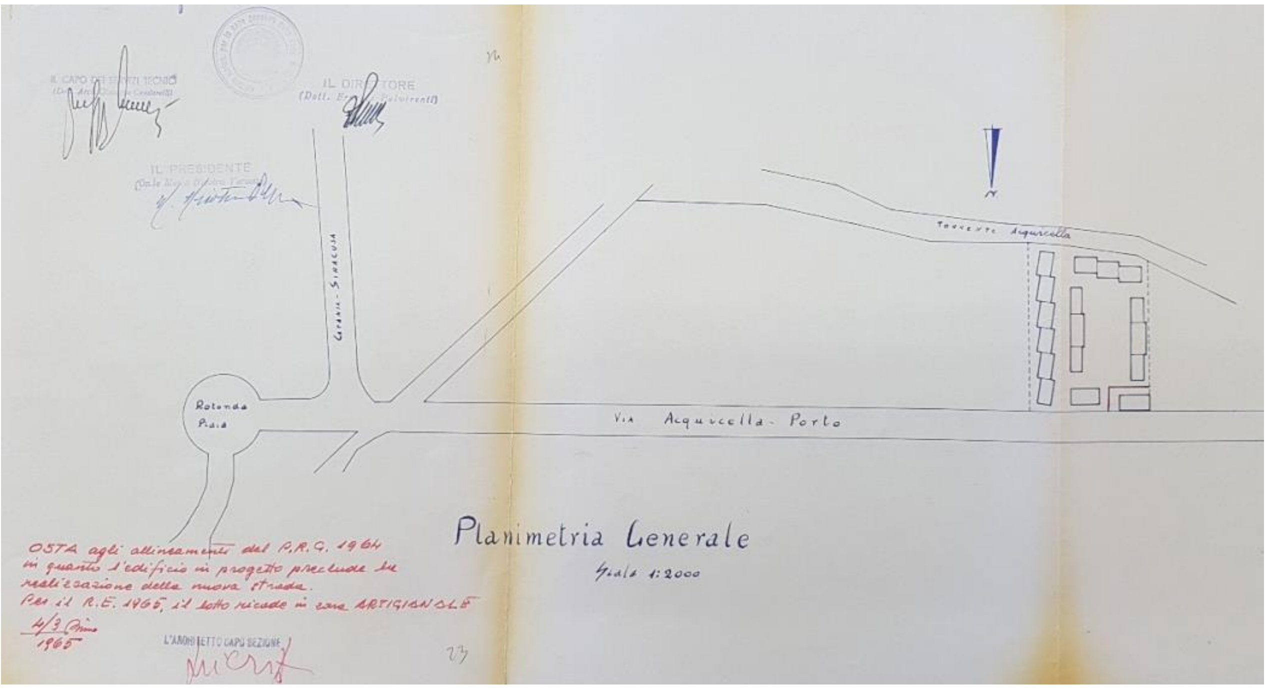

Figure 4: General plan of the first proposal project.
It was rejected because it violated the urban alignments of 1964 plan.

The original project, after vision by Technical Office, has been redesigned to respect the distances of the buildings from a road foreseen by the 1964 Town Development Plan that has not yet been realized (Figure 5). It is the same street that in Cervellati's proposal coincided with the axis that was characterized by the continuous fronts of lined-up buildings that ended with a square and the door-building (Figure 3). This version of the project, in consideration of the plan forecasts, has provided for the elimination of two lined-up blocks to leave the area free for the future road (Figure 6).

Therefore, the residential blocks located on the south side (next to the Acquicella torrent) and the residential blocks located on the west side, have been deleted (Figure 7). The final project layout thus consists of 2 lined-up buildings and 2 towers, one of which is the pilot building of the present work. All the linear blocks and the towers have five floors. Each floor consists of 2 apartments for a total number of apartments finally realized equal to 110 (Figure 8). The whole residential complex is configured as a functional and social enclave.

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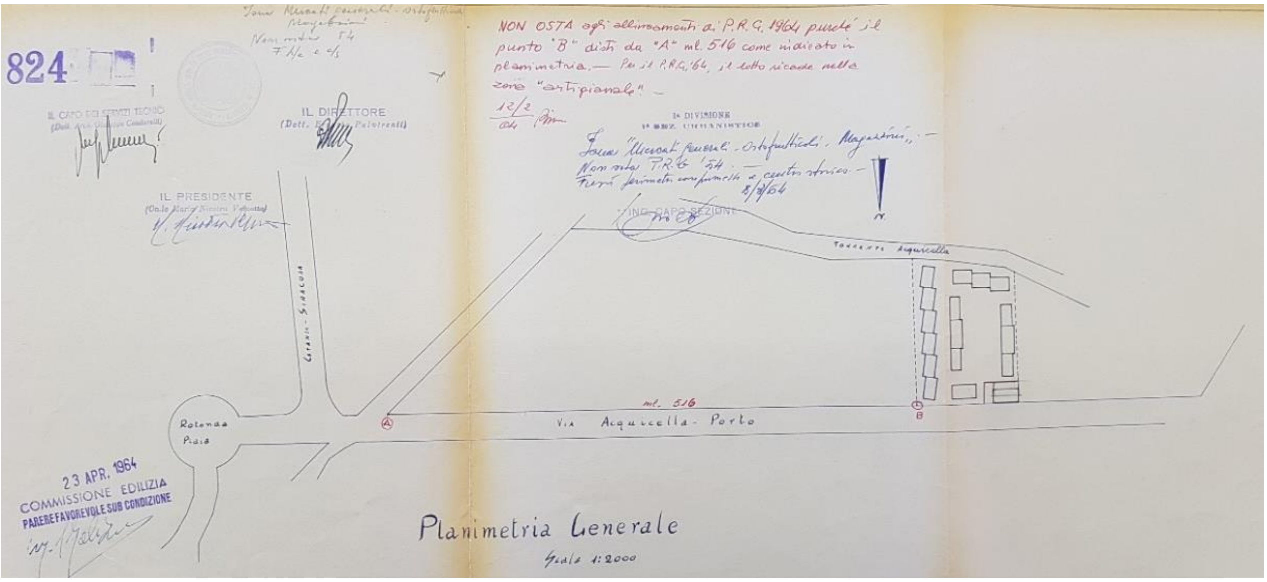

Figure 5: Map with indications of the distances planned in the 1964 plan.
The area belongs to the industrial zone.

Figure 6: Map with the road planned in the 1964 plan.

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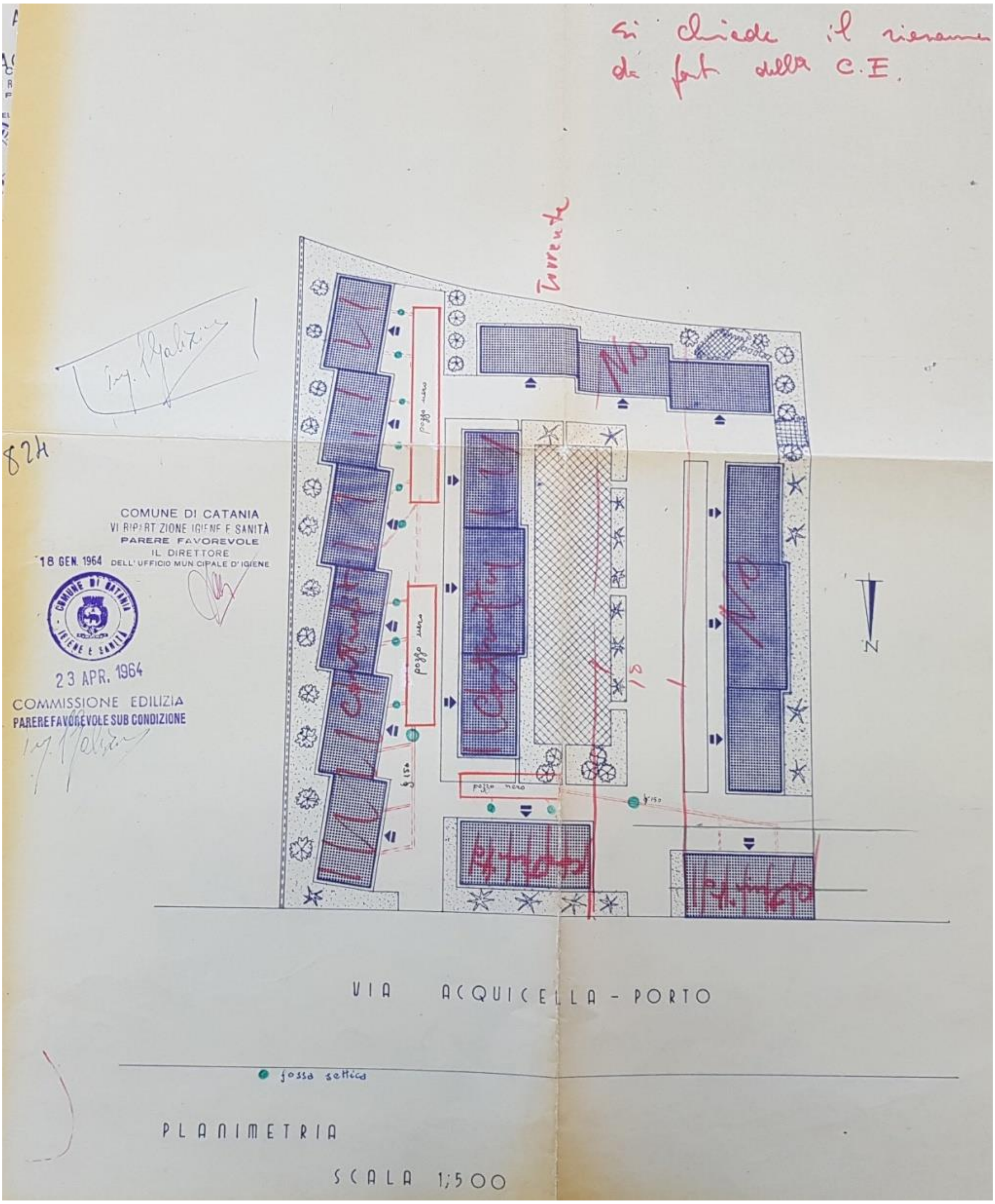

Figure 7: Corrections to the original design with the elimination of the building facing Acquicella torrent and the building on the west side.

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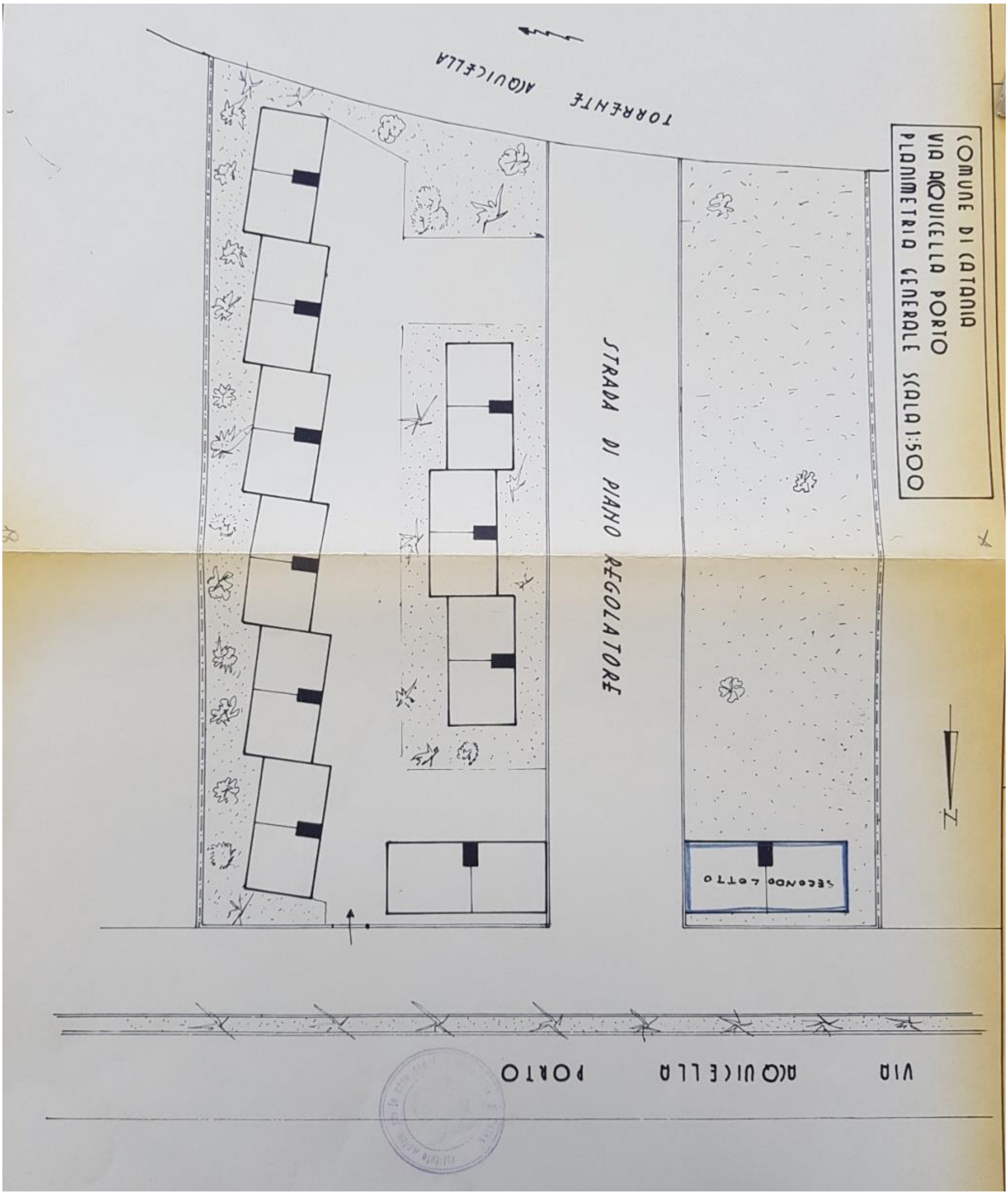

Figure 8: Map of the final project unless the town plan road not yet built.
The blue perimeter indicates the pilot building.

2.3 Morphological and typological analysis

The morphological analysis concerns the formal and dimensional aspects of the building in relation to the entire IACP residential settlement and therefore to the urban context. In this case, the pilot building in via Acquicella Porto No. 27 respects the distances and alignments required by the regulations at the time of the construction.

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The typological analysis is carried out by analogy with buildings having in common the same constructive features and layout or having the same formal, functional, and structural characteristics. The anomalous tower type, because it is low, is, in fact, present in other Italian, public and economic construction by the IACP. The reasons for the limited number of elevations are probably attributable to cost containment. A higher number of elevations would have required the use of the lifts, with consequent increase of construction, use and maintenance costs.

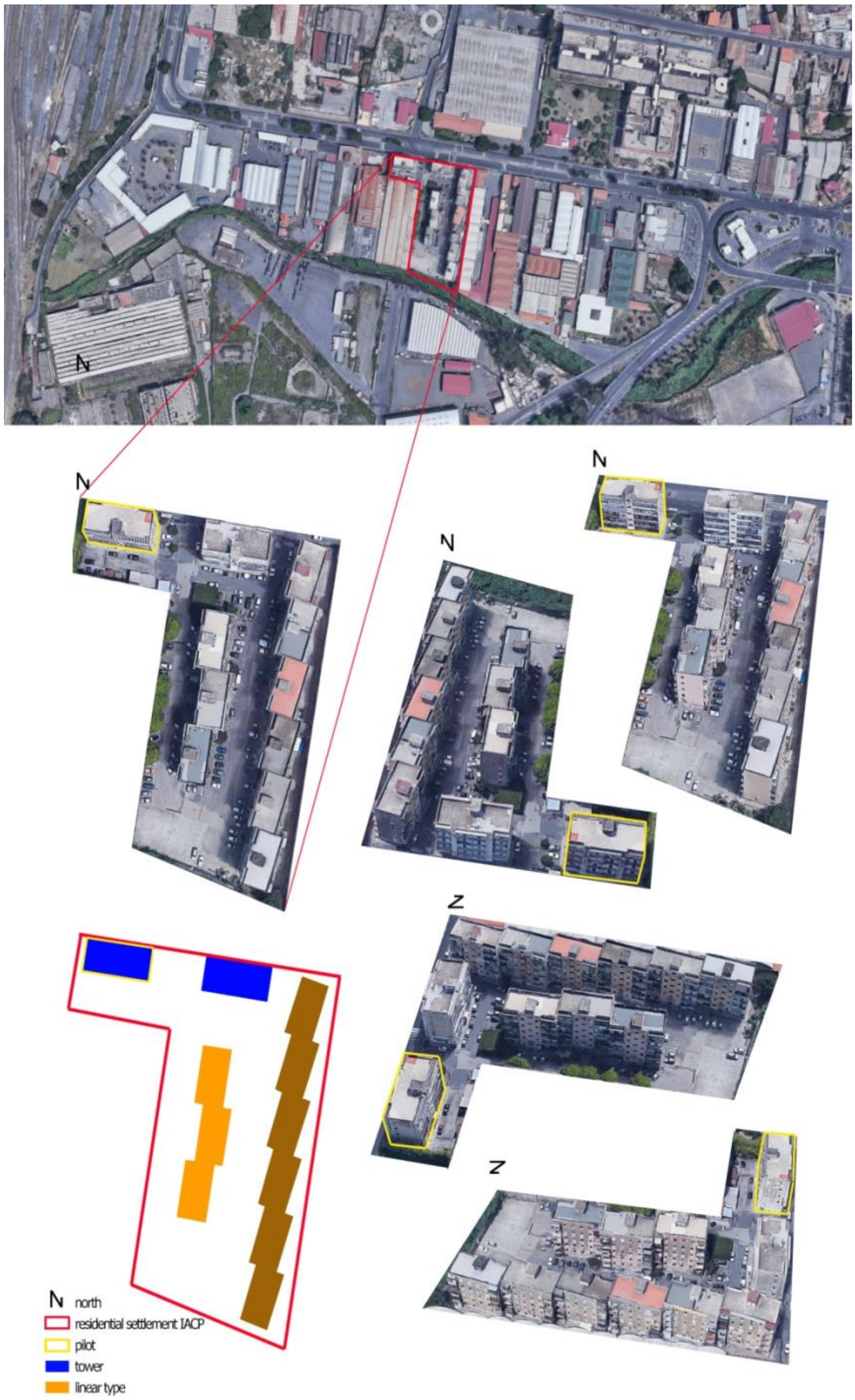

Figure 9: Territorial organization and aerial view of the residential building in via Acquicella Porto by the IACP. Yellow line shows the pilot building.

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The planimetric organization of the residential settlement in via Acquicella Porto is characterized by the relationship between the L-shape of the area, the presence of the Acquicella torrent and the building types (tower and linear type). The L-shape, which was originally a trapezoid (Figures 4 and 5), is partly due to the adaptation of the project to the requests of the Building Commission (Figures 6 and 7) concerning the road planned in the 1964 Town Development Plan.

The area is bordered to the south by the Acquicella torrent, to the north by via Acquicella Porto, to the east and west by the area occupied by sheds. Therefore, it does not have the autonomy of an urban block, but it is instead contained in a macroblock of handicraft and commercial character. The only exception consists of the residential buildings of the IACP (Figure 9). The residential settlement consists of eleven similar blocks, easily recognizable for their shape, size, and organization of the openings. The different blocks composition defines the two used building types (the tower and the linear type). Inside the blocks, the apartments design is identical to less than small differences in size.

The base block that composes the two different building types has the shape of a parallelepiped. The base rectangle has the dimensions of 24.1 per 12.5 m (Figure 10). The height is 17.5 m. The apartments have a floor-to-ceiling height equal to 3 m. The building openings system is as symmetrical as the interior distribution. The building openings are the same for all floors and consist of glass doors overlooking balconies/loggias (Figures 12, 13 and 15), which define the residential character of the building. The short fronts in the design of the original block are blind (Figure 10 and Figure 11). The linear blocks with chain layout differ from the tower buildings due to the lack of some loggias and the presence of a larger number of windows. These slight morphological differences depend on the type of aggregation.

The pilot building is one of the two towers in the residential complex, and it is an anomalous tower, as already mentioned, given the reduced number of elevations. In particular, it is the northwest tower of the general layout (Figures 7 and Figure 9) overlooking via Acquicella Porto. The tower type is a free building on all four fronts: the pilot building is aligned to the north with Via Acquicella Porto; to the west, it borders with an adjacent area from which it is five meters away; to the south, it faces an inner courtyard and it is about eight meters from the garage (not foreseen in the original project and built later); to the east, it faces the entrance of the residential complex and it is eighteen meters far from the other tower.

The pilot building, like all other constructions in the area, consists of 5 floors with 2 apartments each. The ground floor is raised above the street level (Figure 14) and here is named 1st floor. The roof is flat. A staircase connects all five floors and the rooftop terrace. The building is built partly respecting the original design of the standard block as it can be seen from the drawings attached to the building permit (Figures 10, 12 and 13). In particular, the pilot building falls back on the second area (Figure 8) and has the following dimensional and functional design characteristics: covered area of 2330 m^2, uncovered surface area of 61 m^2;volume (from platform to gutter) equal to 3844 m^3; the height of 17 m; reinforced concrete structure; distance from boundaries 5,00 m; the floor-to-ceiling height equal to 3,00 m; the ground floor elevation from street level equal to 1,00 m; perimeter wall thickness equal to 45 cm; wooden fixtures with roller shutters; coloured plasters; inner paving with marble tiles 25 x 25 cm (majolica in bathrooms); a wastewater and sewage disposal system.

The two apartments per floor, with an identical internal distribution, are arranged symmetrically with respect to the stairwell located at the centre between them. The entrance to the stairwell and therefore to the building is to the south, on the inside front of the area. Each apartment has a gross area of 110 m^2 divided into three bedrooms, a kitchen, a living/dining room, a bathroom and a laundry room. A corridor serves all rooms. In addition, each apartment has three balconies. A continuous one on the south side overlooking the kitchen, the living/dining room and one of the

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bedrooms, and two separate ones on the north side serving: the first, a bedroom and the laundry room and the second the other bedroom. All balconies are closed on the short sides to form loggias on the long façades of the building, to the north and to the south (Figure 15). Unlike the original project, the raised floor on the northern front, on via Acquicella Porto, has only some windows and there are no balconies (Figure 15). Moreover, on the short fronts, east and west, the original design of the block did not provide any opening while in the realized building the two short fronts have a column of windows that corresponds to the second opening of one of the bedrooms of the apartments (Figures 11 and 16).

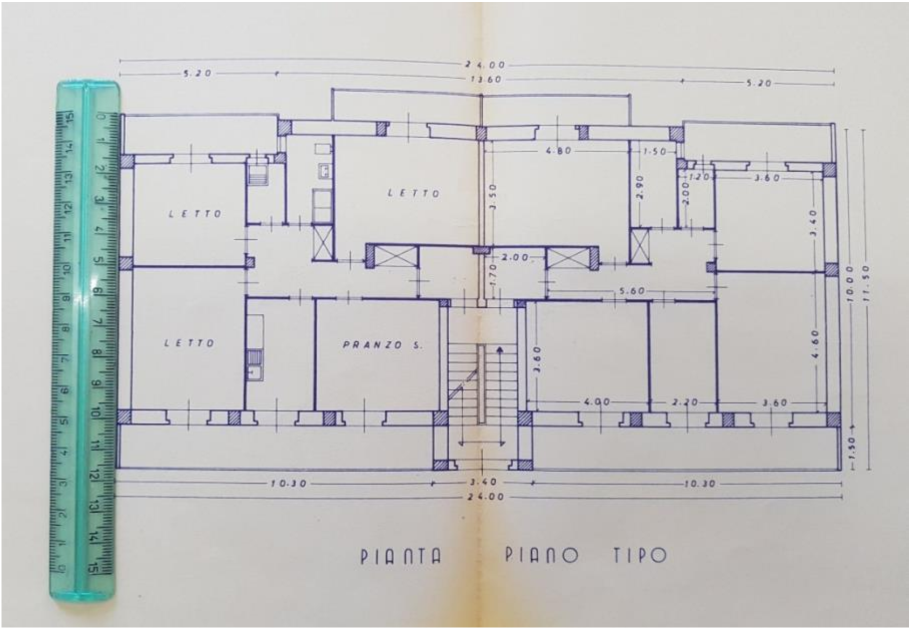

Figure 10: Plan type according to the original project designed for both tower and linear block.

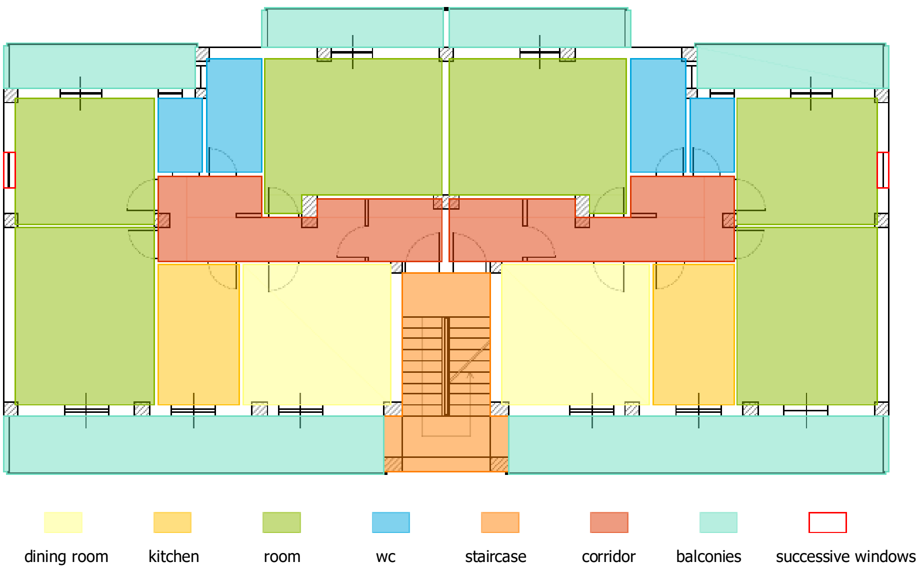

Figure 11: Plan type according to the original project. The upper right and left corner bedrooms have windows on the short fronts of the pilot.

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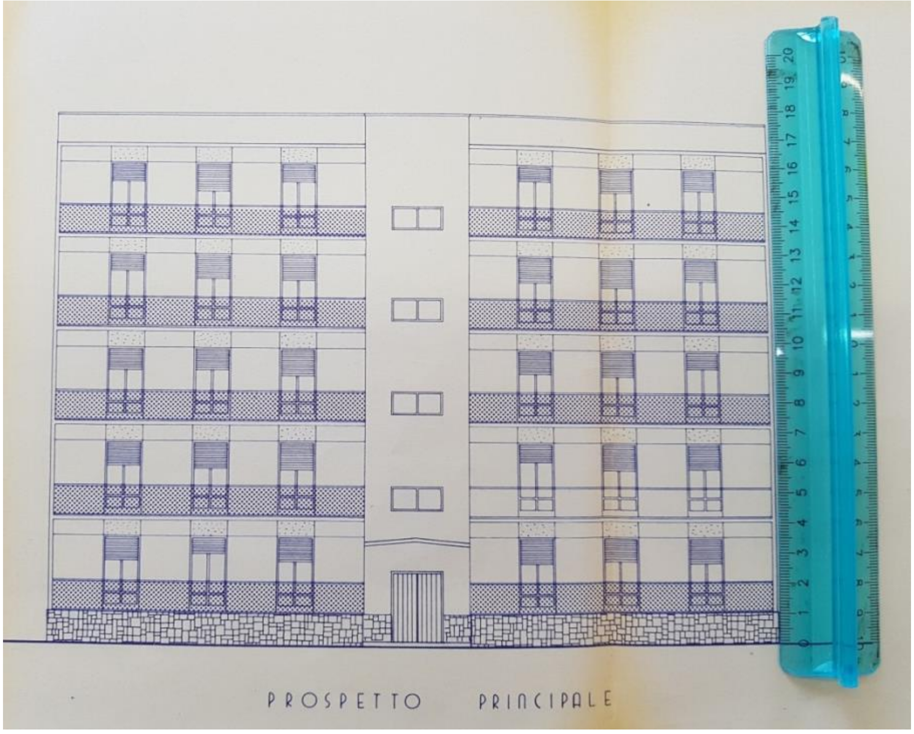

Figure 12: South side facing of inner area according to the original project.

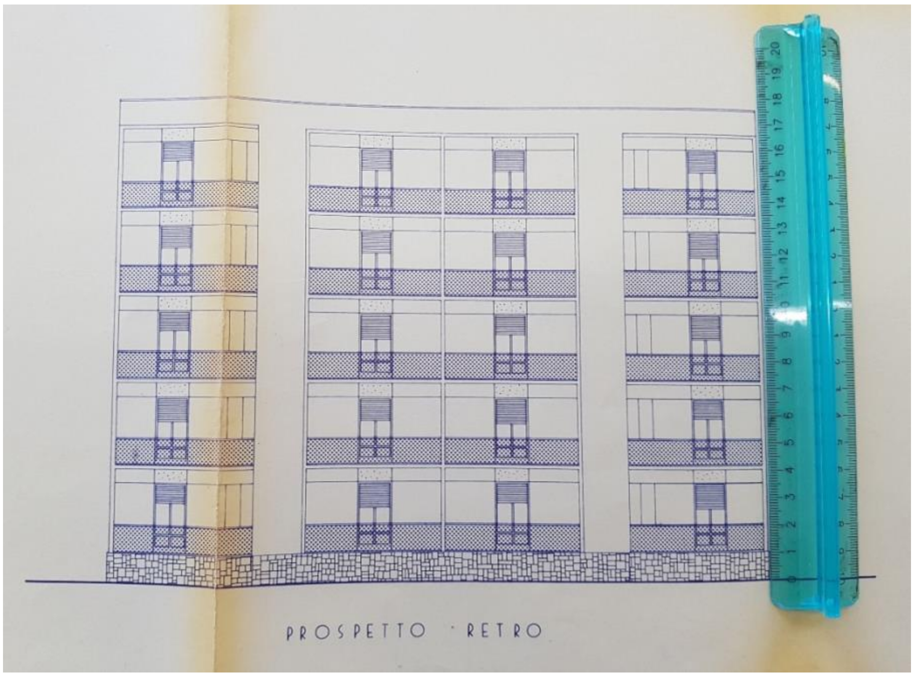

Figure 13: North side facing on via Acquicella Porto according to the original project.

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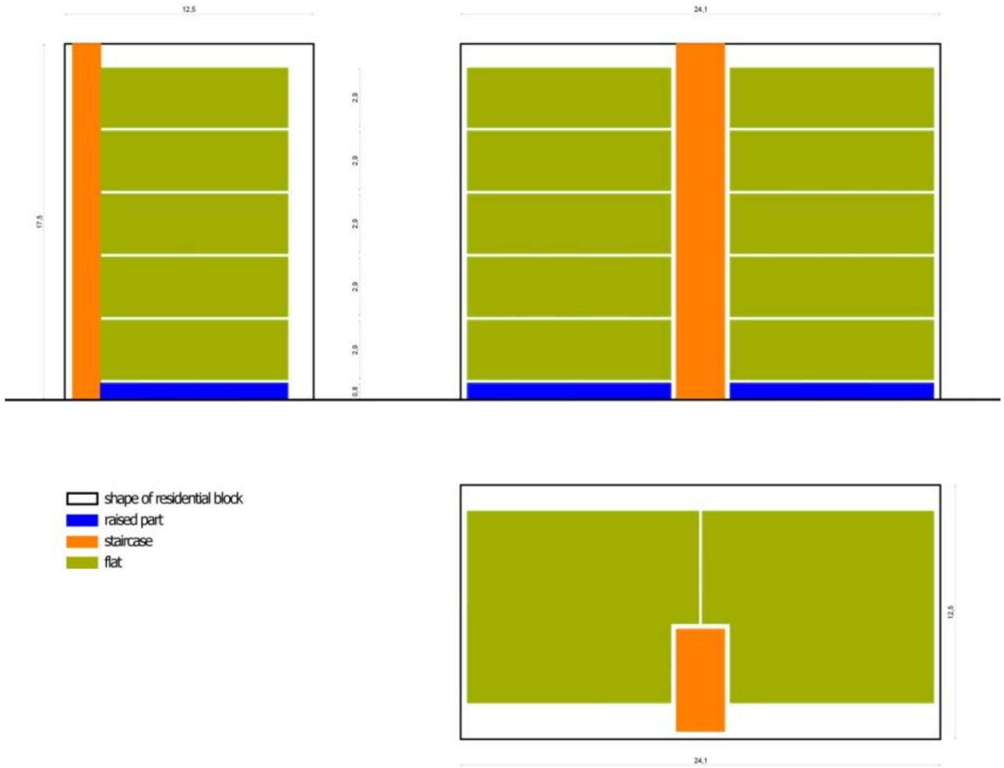

Figure 14: Pilot building block morphology.

Figure 15: Front on the north (right) and south (left) side. Red line represents loggias.

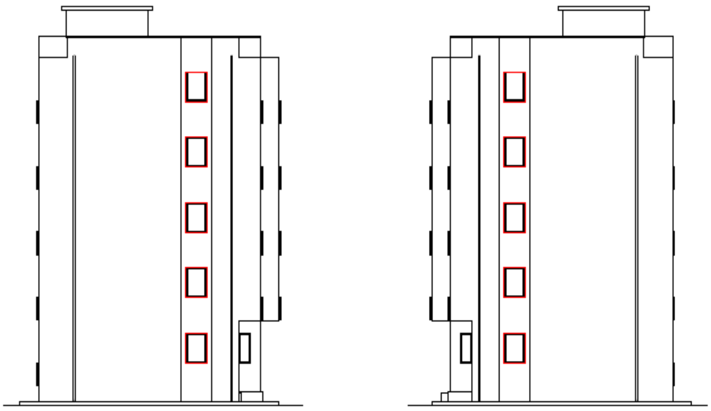

Figure 16: Front on the east (right) and west (left) side. Red line represents successive windows.

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The original technical documents compared with the surveys in situ, in addition to confirming the knowledge acquired through the literature analysis, have allowed us to draw the map of the transformations and changes made over the years by the residents.

The transformations and changes are the measure of the real needs of the inhabitants, but they do not follow an organic and unitary design idea. Indeed, each inhabitant has decided on his own apartment autonomously without considering the choices of others, and vice versa. These alterations did not affect the type of building but concerned the internal distribution of some apartments. Instead, the external building image, in particular in the southern side, is strongly characterized by the presence of many "verandas" (i.e. windows that close a balcony creating a sort of bow-window, Figure 17).

In addition, every single inhabitant has independently tried to limit the physical degradation of the finishing layer with different materials and design solutions. The uncoordinated set of all these design solutions shows, especially on the southern front – the inner one – an elevation that is like a colourful patchwork. Instead, transformations on the northern façade (via Acquicella Porto side) are minor. This is due to the type of rooms that overlook it: bedrooms and bathrooms

2.4 Changes to the original design of the pilot building

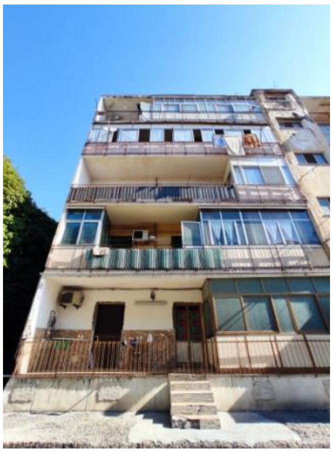

Figure 17a: Detail of southern elevation (left side).

Figure 17b: Southern elevation. Real state (2021).

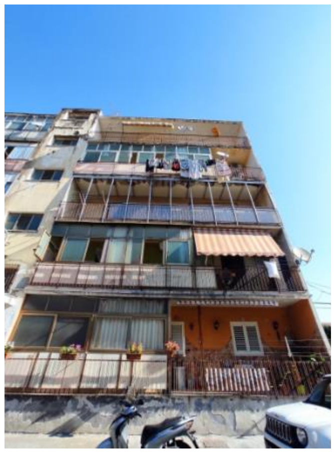

Figure 17c: Detail of southern elevation (right side).

The photos on the current state of the pilot building (2021) are a plastic representation of the transformations that the inhabitants, over time, have made (Figure 17 and 24). On the outside of the building these transformations are often reversible because they are made by temporary structures such as "verandas" or by the introduction of technological components (e.g. air conditioners, parabolic antennas).

However, some of these transformations have also involved permanent changes in the internal distribution of the apartments. In particular, on the south side, the one overlooked by the living area (kitchen, dining and living room), there are many "verandas" in almost all the apartments (Figures 17 and 18). "Verandas" are usually considered by the inhabitants as extra rooms in the balconies, and this true for most of the "verandas" of the pilot building. In some cases (Figures 19, 20, 21, 22 and 23), these "verandas" are used as kitchens, allowing to have more space inside. All "verandas" have different configuration with the same type of material (aluminium frames). Even their location on the balconies differs from one floor to another.

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Other elements affecting the overall image of the building (Figures 17, 18, 24 and 25) are: the external condenser units of the air conditioning systems, some parabolic antennas, the exhaust air extractors, gas system pipelines and electrical and telephone wiring.

Figure 18: South elevation with the transformations by the residents. The “verandas” are shown in orange. The demolitions of the interior walls are shown in red. The air conditioners are shown in blue.

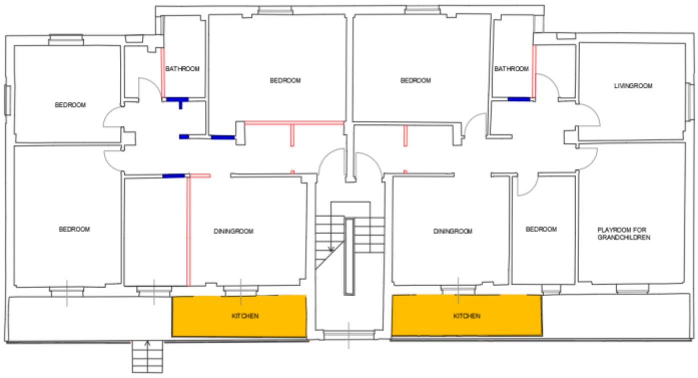

Figure 19: 1st floor transformations by the residents. The “verandas” are shown in orange. The demolitions of the interior walls are shown in red. The construction of walls in blue.

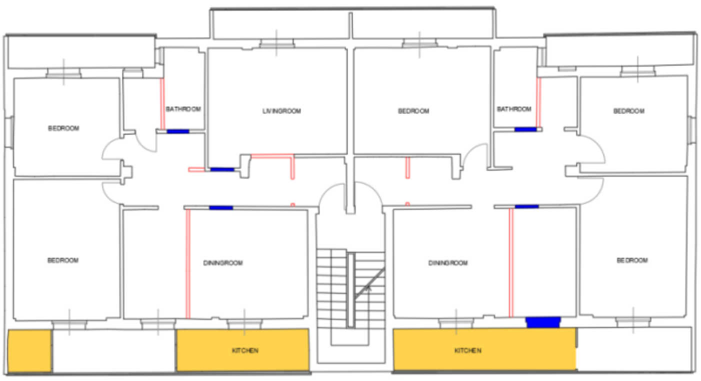

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Figure 20: 2nd floor transformations by the residents. The "verandas" are shown in orange. The demolitions of the interior walls are shown in red. The construction of walls in blue.

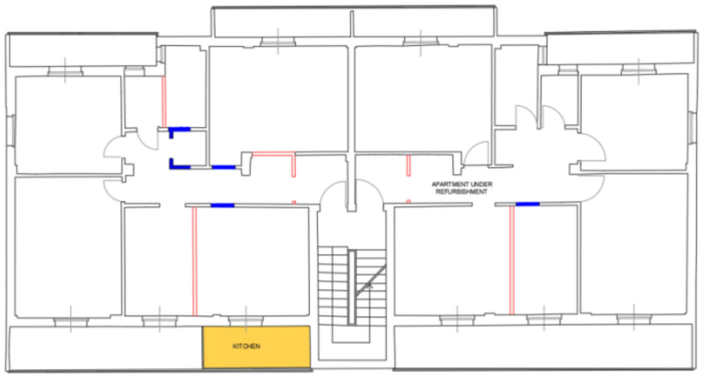

Figure 21: 3rd floor transformations by the residents. The "verandas" are shown in orange. The demolitions of the interior walls are shown in red. The construction of walls in blue.

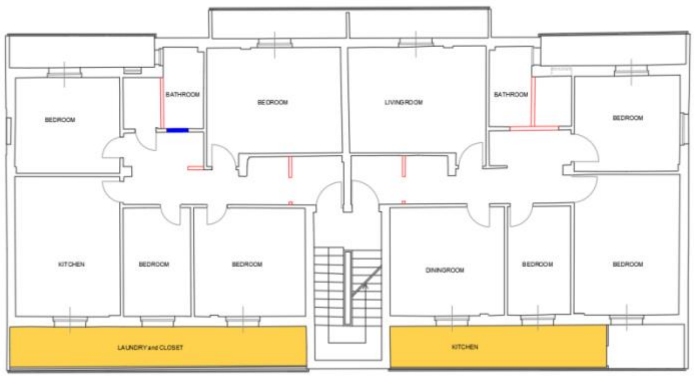

Figure 22: 4th floor transformations by the residents. The "verandas" are shown in orange. The demolitions of the interior walls are shown in red. The construction of walls in blue.

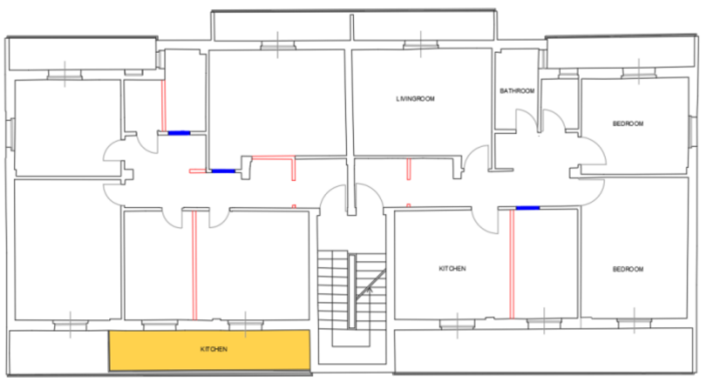

Figure 23: 5th floor (top) transformations by the residents. The "verandas" are shown in orange. The demolitions of the interior walls are shown in red. The construction of walls in blue.

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Figure 24: North elevation on via Acquicella Porto.

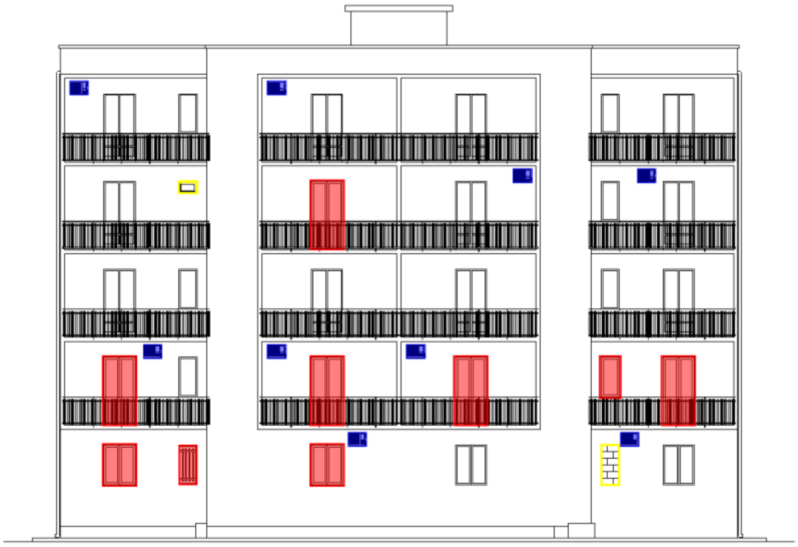

Figure 25: North elevation on via Acquicella Porto where the transformations by the residents are represented. The types of windows are shown in red.
The shapes of the openings are shown in yellow. The air conditioners are shown in blue.

Other transformations operated by the residents, to be considered as attempts to improve the façades and to customize their homes, are: the change of the façade colour (Figures 17a and 17c); the cladding with different shape and type of stone materials (Figure 17a and 17c); the addition of stairs for secondary and independent access to some balcony (Figure 17a); the walling of some openings (Figure 25); the transformation of doors in windows (Figures 18 and 25). Finally, in some cases, the inhabitants replaced the old windows, probably for their bad conditions or also to improve security, with new ones (Figures 18, 25, 28 and 29).

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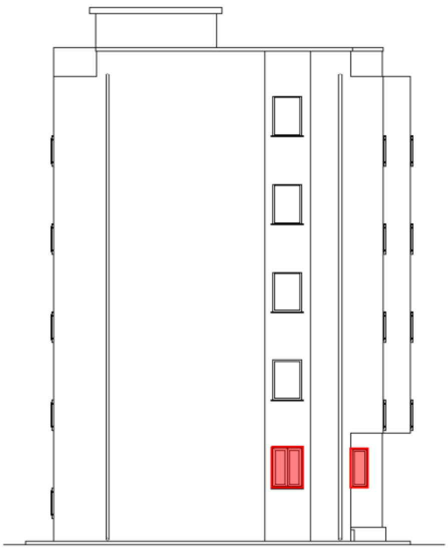
Figure 26: East elevation.

Figure 27: West elevation.



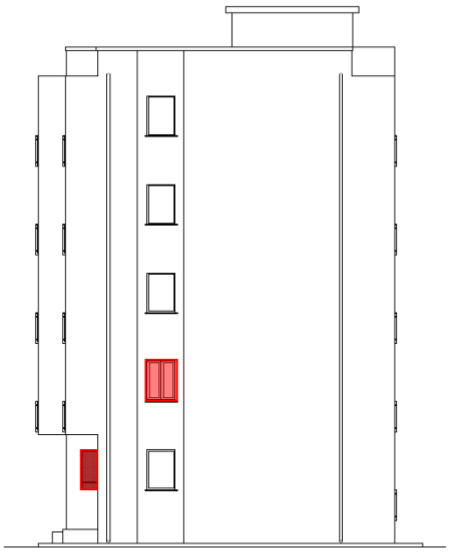


Figure 28: East elevation. The replaced windows are shown in red.

Figure 29: West elevation. The replaced windows are shown in red.

All these transformations, although of little importance if taken individually, change remarkably the original image of the building, as the inhabitants know. In fact, they would like a transformation that meets their needs (as emerging from their individual transformations) but that finds a way to be

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summed up in a harmonious and unitary building design. This is one of the challenges and tasks facing the **e-**SAFE system.

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3. GEOMETRIC SURVEY

This surveying activity was subcontracted to the Survey and Representation Laboratory of Kore University of Enna. The objective of the campaign was to collect geometric data aimed at validating the existing preliminary drawings – elaborated by UNICT combining data from the original drawings consulted by the Municipal Historic Archive of Catania and direct surveys onsite–and at representing in a very detailed way the external fronts of the pilot building.

3.1 The survey campaign phase

To this purpose, experts from the Kore University carried out a 3D survey campaign, with laser scanning technology, adopting two different instruments for the interior (first floor, top floor and roof) and for the exterior volume. For the best acquisition of the interior geometries, including the visible structural frame, the survey had to be characterized by high density point clouds and high-resolution images. To this purpose, a Faro Focus 3D scanner was used, a phase-shifting Terrestrial Laser Scan (TLS), whose features allow fast and very accurate surveys, particularly in the case of relatively small and close objects, thanks to its high range (up to 120 m), its integrated high-resolution digital camera, its acquisition speed (976,000 points/sec) and its automatic leveling option. The selected instrument enabled 93 3D scans in nearly 5 hours, with an average cloud density of about 2.5 mm/10 m and an image resolution of 24 MP.

The survey of the external volume was performed using a Time of Fly (ToF) laser scanner, a Leica C10 TLS, which has a wider acquisition range of up to 300 m, a scanning speed of 50,000 points/sec, and a camera resolution of 4 MP. Seven territorial scans were performed by setting a range of 10 mm at 20 m, which was appropriate to accurately determine the outer geometry, with architectonical details and colors, and to register it on the inner geometry. In fact, besides defining the geometry of the four fronts, another purpose of the exterior survey campaign was to merge the external and internal point clouds together, in order to derive the thickness of the structural boundary elements, which was successfully done.

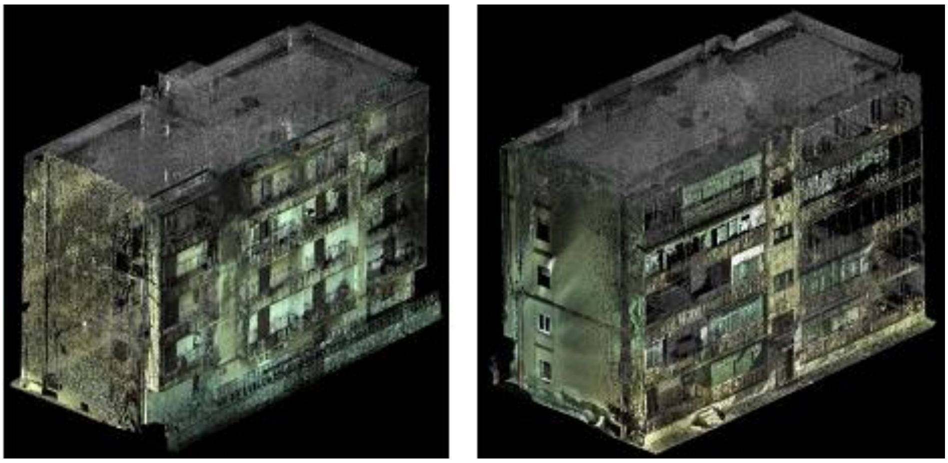

Figure 30: 3D Views of the point cloud model.

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3.2 The data processing phase

In the following step, all the point clouds were recorded together: the internal ones, derived from the Faro scanner, were merged in the Autodesk ReCap software, thus obtaining a single registration, which was then re-registered with the external C10 one, and then optimized. For this second registration, as for the merging of all C10 clouds, the Leica Cyclone software was used. The result consists of a single registration, which was optimized with an iterative procedure, set to Max 1000 cycles, with a 60% Subsampling Percentage, and a Max Search distance of 0.01 m, whose average error, on the single point, is 0 mm, while on the vector the max error is about 4 mm. The registration procedure was implemented manually on a native Cyclone wizard that allows to select several corresponding points on each point cloud.

The last step involved the processing of the point cloud model to derive all orthogonal projections, sections, horizontal plans and hyposcopic views of each level and fronts, in order to validate the existing preliminary drawings. Through the Cyclone software it is possible to cut and slice the point cloud to obtain all the required views. These have been exported as Geotiff raster files, which can be subsequently opened in several cad software, keeping their geographical references (therefore also the location and metric scale). This methodological approach allowed to easily share the survey data with all the researchers and professionals involved in the pilot project.

Because of several discrepancies between the existing preliminary drawings and the results of this survey, especially in the position and size of certain structural elements, new 2D drawings were produced (plans, elevations, and vertical sections) by using the CloudWorks Autocad application, which enables to visualize and easily manipulate the Cyclone point cloud in a CAD environment.

All the produced drawings are included below (plans and sections of the second, third and fourth floors have been obtained combining data from the existing preliminary drawings, direct survey on-site, and the plans produced by the laser scanner survey).

Figure 31: First floor Plan.

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Figure 32: Fifth floor Plan.

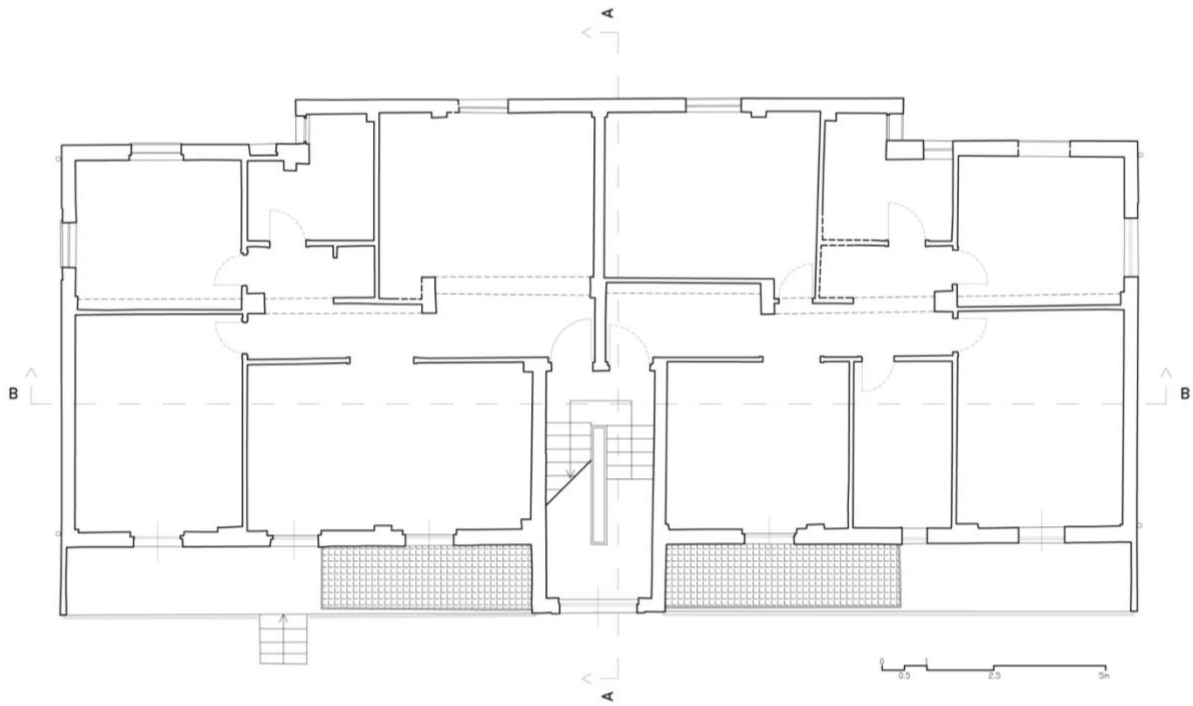

Figure 33: First floor plan (by laser scanner survey). The hatch indicates the presence of “verandas”.

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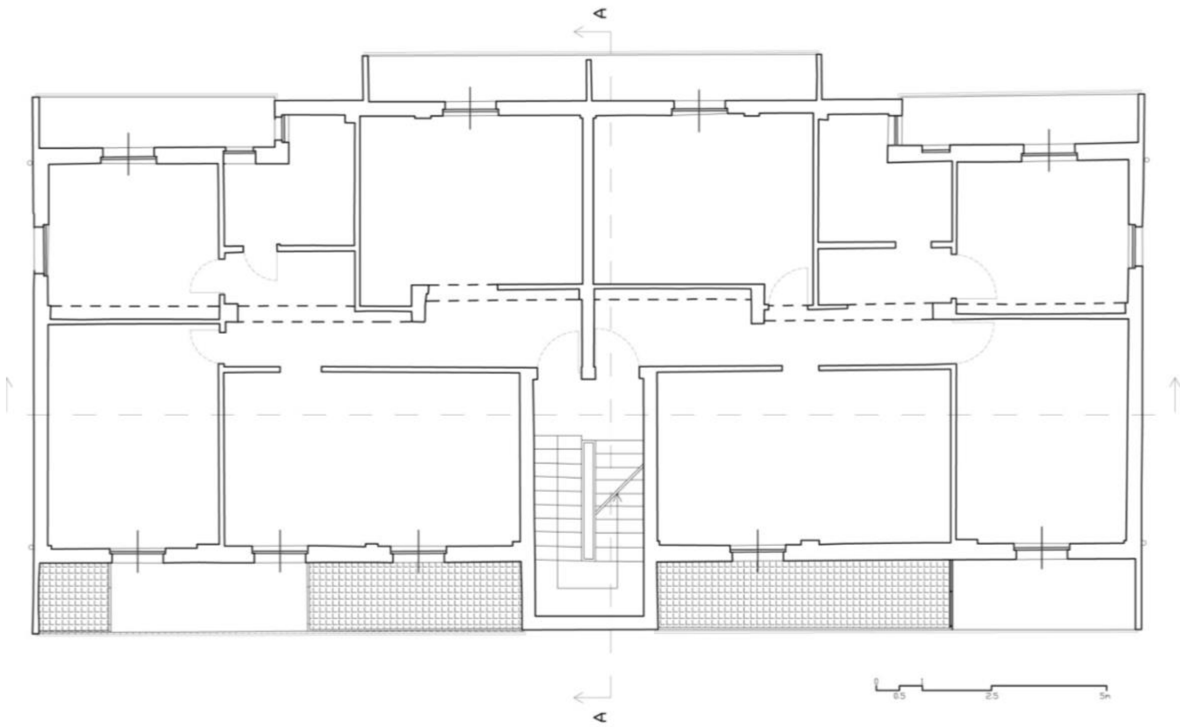

Figure 34: Second floor plan (by direct survey on-site). The hatch indicates the presence of “verandas”.

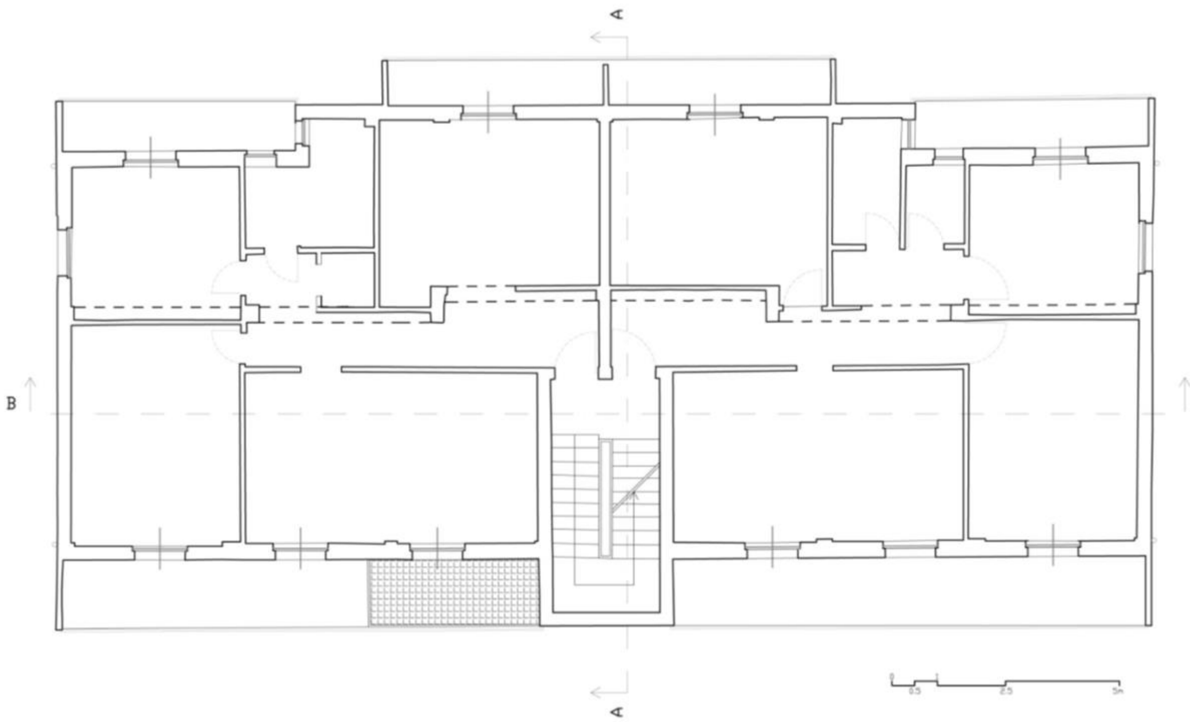

Figure 35: Third floorplan (by direct survey on-site). The hatch indicates the presence of “verandas”.

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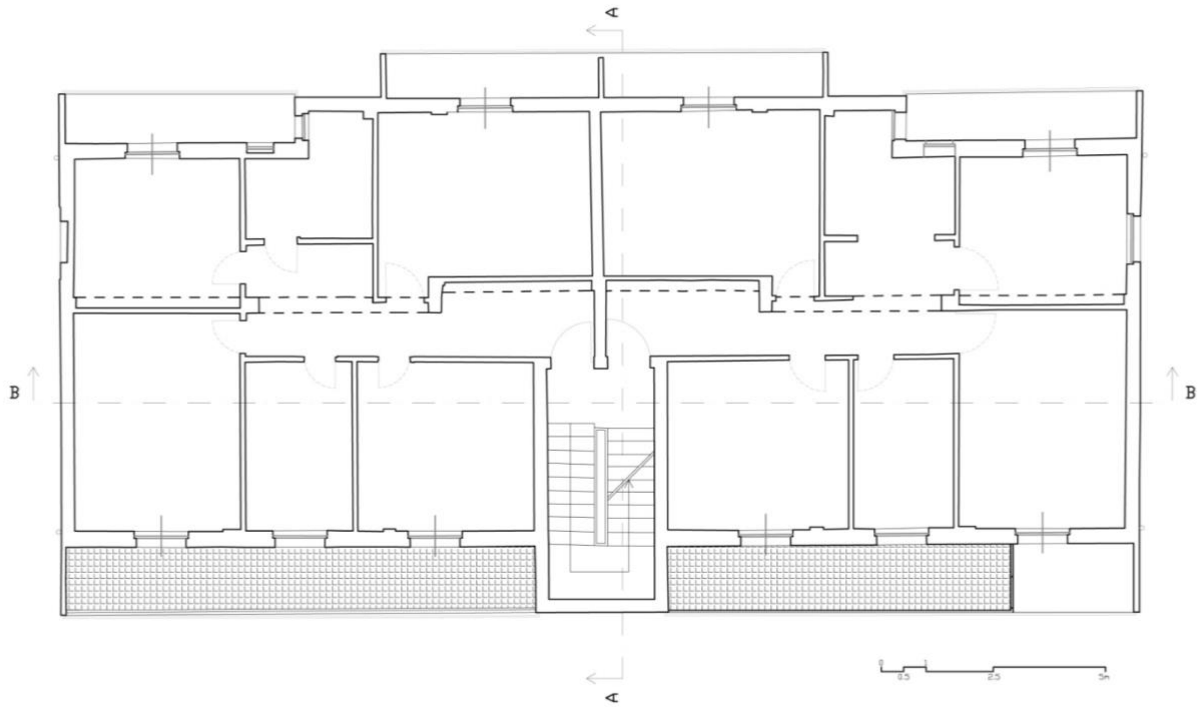

Figure 36: Fourth floor plan (by direct survey on-site). The hatch indicates the presence of “verandas”.

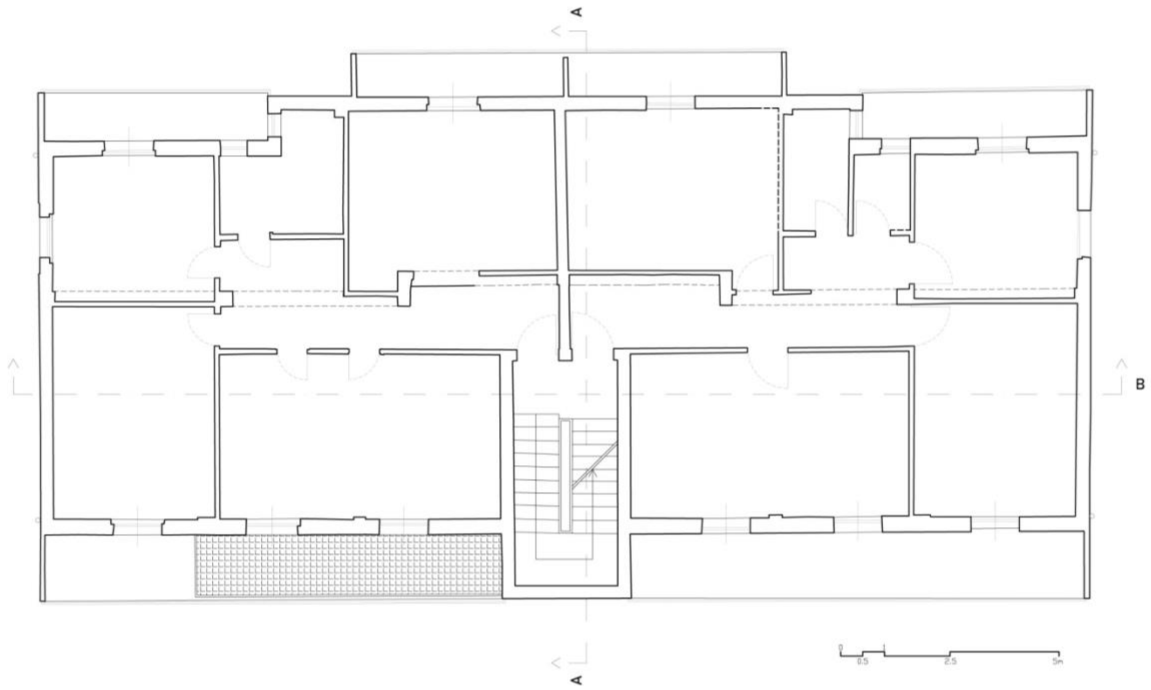

Figure 37: Fifth floor plan (by laser scanner survey). The hatch indicates the presence of “verandas”.

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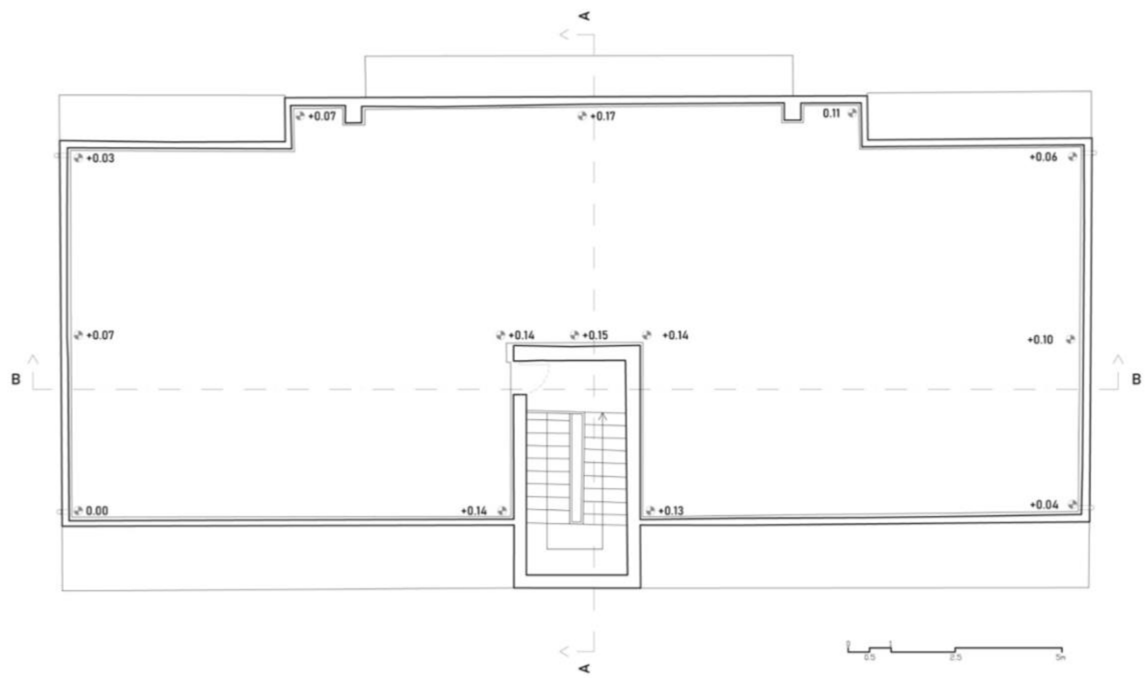

Figure 38: Roof floor plan (by laser scanner survey)

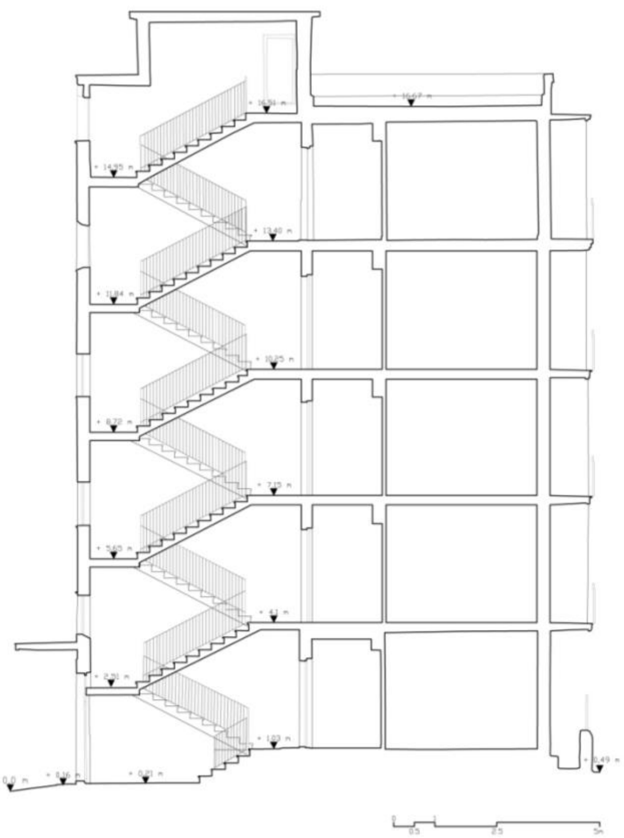

Figure 39: Section A-A (by laser scanner and direct on-site survey)

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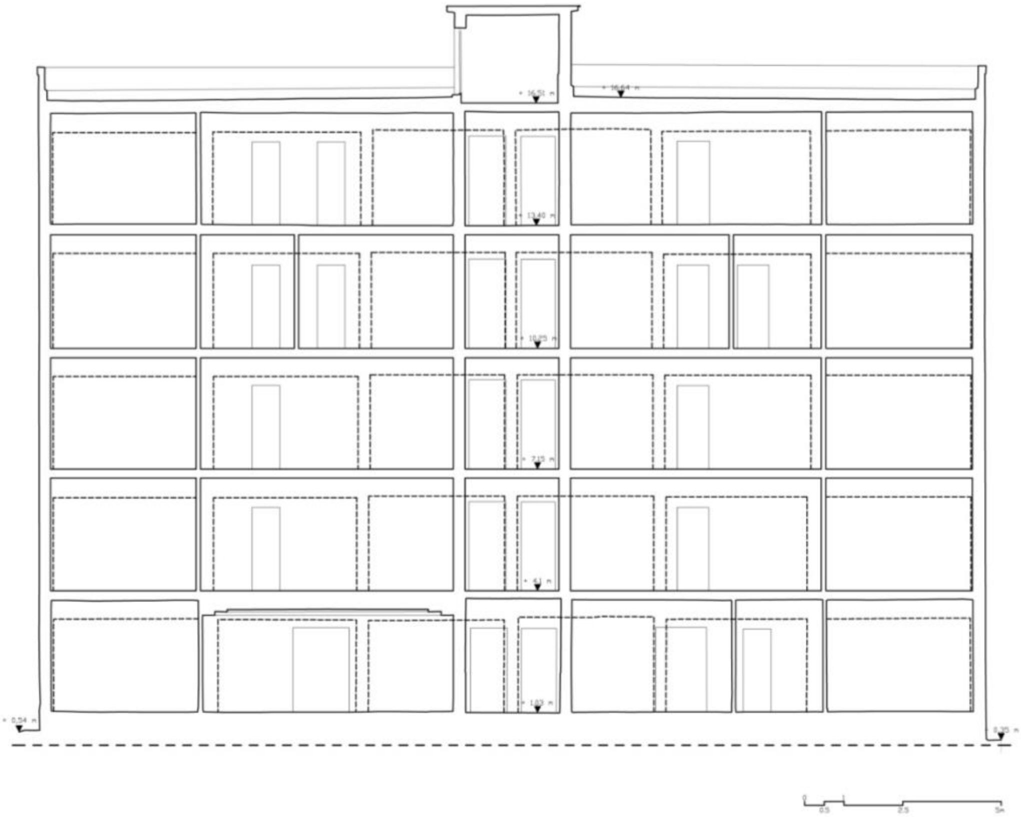

Figure 40: Section B-B (by laser scanner and direct on-site survey)

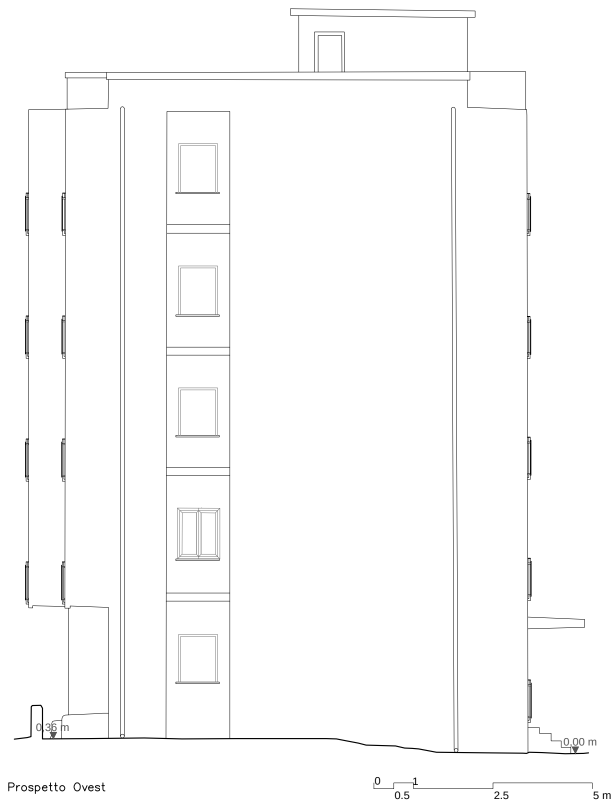

Figure 41: West front (by laser scanner survey).

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Figure 42: North front (by laser scanner survey).

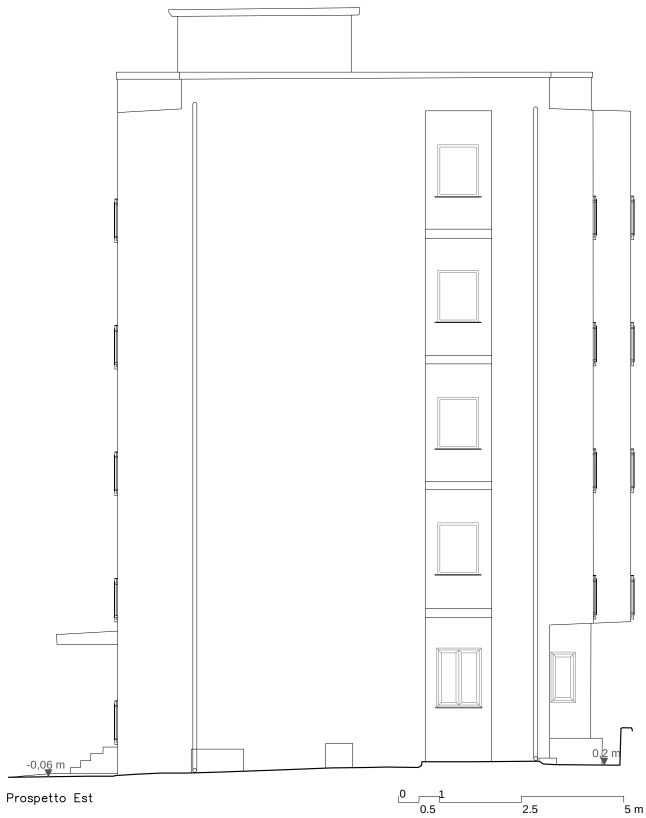

Figure 43: East front (by laser scanner survey).

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Figure 44: South front (by laser scanner survey).

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4. CONSTRUCTION AND ENERGY SURVEY

This section aims at describing the thermal performance of the building envelope and the existing technical systems for Heating (H), Cooling (C) and Domestic Hot Water (DHW) preparation. To this aim, the section is organized in three main subsections, namely:

- Section 4.1: it contains relevant information about the features of the pilot building in terms of construction assemblies, building materials and their thermal properties, type of fixtures, thermal bridges, existing thermal systems, as a result of the survey activities.
- Section 4.2: it shows the results of the energy simulations aimed at assessing the final energy needs and the primary energy demand for Heating, Cooling and DHW preparation. This analysis, carried out with the commercial software tool "Blumatica Energy v.6.2.3.2", allowed identifying the main deficiencies in the energy performance of the pilot buildings, in order to steer the energy renovation process. Furthermore, the commercial software tool generated the "Energy Performance Certificates" of all apartments in their current configuration.
- Section 4.3: here, a further energy model of the pilot building is prepared in the software tool "EnergyPlus", aimed at performing more detailed dynamic energy simulations. Dynamic simulations will be a powerful tool to investigate the effectiveness of the renovation solutions and their impact on the energy performance of the pilot building: in this stage, however, the Deliverable only describes the model and compares the results of the dynamic simulations against those provided by the commercial software tool used in Section 4.2, thus providing feedback about the reliability of the dynamic simulations. The model will then be fully exploited during the design stage of the renovation solutions.

4.1 Outcomes of the survey

4.1.1 Building components and their thermal properties

The direct survey carried out at the real pilot building allowed identifying the materials used for the various building components, along with their thickness. This information first advised on the relevant materials' thermal properties, whose values are taken from Italian Standards UNI 10351 and UNI 10355 [4, 5], in case no information can be retrieved from technical sheets of the specific material; then, this activity leads to the calculation of the stationary thermal transmittance (U-value, $W \cdot m^{-2} \cdot K^{-1}$), according to the procedures set by EN ISO Standard 6946 [6]. Further experimental analyses with a heat flux meter will be carried out during the winter season in order to check the reliability of the U-value determined in this document: indeed, waiting for the winter season is necessary to perform the measurements in suitable conditions, i.e. with a significant temperature difference (at least 15 °C) between indoors and outdoors.

Tables 1-4 summarize the assemblies' description, their thermal properties, and the resulting U-values. More specifically, the external infill walls are made of two leaves of hollow concrete blocks, made of cement and volcanic light aggregates (8-cm thick internal leaf and 12-cm thick external one), with an intermediate non-ventilated, non-insulated air cavity (9-cm thick) (Figure 45). Since there is no information about the stratigraphy of the slabs, the ground floor, the intermediate slabs and the roof are assumed made of RC and hollow clay blocks (20-cm thick) without thermal insulation, according to the construction techniques used in Southern Italy in the 1960s. The roof is flat with tiles flooring laid over a cement screed; RC parapets are also in place along the perimeter (Figure 46). Single waterproofing interventions carried out by the residents over the years evidence problems relating to water infiltration.

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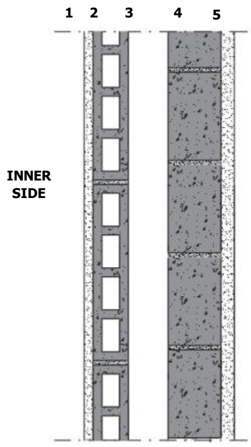
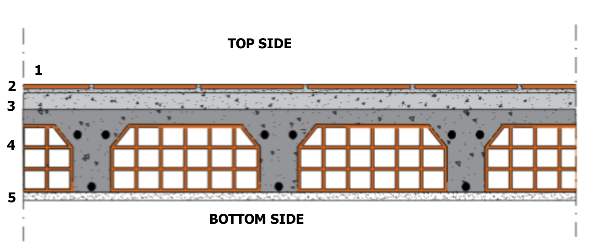


Assembly of the external wall (vertical section from the inner to the outer side)

1. Internal plaster
2. Hollow concrete block
3. Air cavity
4. Hollow concrete block
5. External plaster



Assembly of the slab (from the top to the bottom side)

1. Indoor floor tiles
2. Cement mortar
3. Cement screed
4. RC and hollow clay blocks
5. Internal plaster

Figure 45: Assemblies of the main building components: external walls (on the left) and slabs (on the right).

Figure 46: Views of the flat roof.

Table 1: Thermal features of the external walls (from the inner side to the outer side).

MATERIAL	Ref.	s (cm)	λ ($W \cdot m^{-1} \cdot K^{-1}$)	R ($m^2 \cdot K \cdot W^{-1}$)	ρ ($kg \cdot m^{-3}$)	C_p ($J \cdot kg^{-1} \cdot K^{-1}$)	μ (-)
Indoor surface thermal resistance (horizontal heat flux)	[6]	-	-	0.13	-	-	-
Gypsum plaster	[4]	2	0.57	0.035	1300	1000	6
Hollow concrete blocks with volcanic aggregates	[7]	8	0.29	0.276	845	1000	10
Non-ventilated air gap	[5]	9	-	0.180	1.3	1000	-
Cement mortar	[4]	1	1.40	0.007	2000	1000	27
Hollow concrete blocks with volcanic aggregates	[7]	12	0.39	0.307	667	1000	10
Lime and cement plaster	[4]	3	0.90	0.033	1800	840	27
Outdoor surface thermal resistance (horizontal heat flux)	[6]	-	-	0.04	-	-	-
TOTAL		35	-	1.008	-	-	-
Symbols					**U-value = 0.99 ($W \cdot m^{-2} \cdot K^{-1}$)**		
s = thickness		ρ = density					
λ = thermal conductivity		C_p = specific heat					
R = thermal resistance		μ = water vapour resistance (mu-value)					

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Table 2: Thermal features of the intermediate slabs (from the top side to the bottom side).

MATERIAL	Ref.	s (cm)	λ ($W \cdot m^{-1} \cdot K^{-1}$)	R ($m^2 \cdot K \cdot W^{-1}$)	ρ ($kg \cdot m^{-3}$)	C_p ($J \cdot kg^{-1} \cdot K^{-1}$)	μ (-)
Indoor surface thermal resistance (vertical heat flux)	[6]	-	-	0.170	-	-	-
Indoor floor tiles	[4]	1	1.47	0.007	1700	1000	200
Cement mortar	[4]	1	1.40	0.007	2000	1000	27
Cement screed	[4]	4	0.58	0.069	1400	1000	100
Reinforced concrete and hollow clay blocks	[5]	20	-	0.310	1132	840	9
Gypsum plaster	[4]	2	0.57	0.035	1300	1000	6
Indoor surface thermal resistance (vertical heat flux)	[6]	-	-	0.170	-	-	-
TOTAL		28	-	0.768	-	-	-
Symbols					**U-value = 1.30 ($W \cdot m^{-2} \cdot K^{-1}$)**		
s = thickness λ = thermal conductivity R = thermal resistance		ρ = density C_p = specific heat μ = water vapour resistance (mu-value)					

Table 3: Thermal features of the roof (from the top side to the bottom side)

MATERIAL	Ref.	s (cm)	λ ($W \cdot m^{-1} \cdot K^{-1}$)	R ($m^2 \cdot K \cdot W^{-1}$)	ρ ($kg \cdot m^{-3}$)	C_p ($J \cdot kg^{-1} \cdot K^{-1}$)	μ (-)
External surface thermal resistance (vertical heat flux)	[6]	-	-	0.04	-	-	-
Exterior floor tiles (klinker)	[4]	2	0.70	0.029	1500	1000	300
Cement mortar	[4]	2	1.40	0.014	2000	1000	27
Cement screed	[4]	14	0.58	0.241	1400	1000	100
Reinforced concrete and hollow clay blocks	[5]	20	-	0.310	1132	840	9
Indoor plaster	[4]	2	0.57	0.035	1300	1000	6
Indoor surface thermal resistance (vertical heat flux)	[6]			0.170	-	-	-
TOTAL		40	-	0.839	-	-	-
Symbols					**U-value = 1.19 ($W \cdot m^{-2} \cdot K^{-1}$)**		
s = thickness λ = thermal conductivity R = thermal resistance		ρ = density C_p = specific heat μ = water vapour resistance (mu-value)					

Table 4: Thermal features of the interior walls separating the apartments from non-heated spaces (from the inner side to the outer side).

MATERIAL	Ref.	s (cm)	λ ($W \cdot m^{-1} \cdot K^{-1}$)	R ($m^2 \cdot K \cdot W^{-1}$)	ρ ($kg \cdot m^{-3}$)	C_p ($J \cdot kg^{-1} \cdot K^{-1}$)	μ (-)
Indoor surface thermal resistance (horizontal heat flux)	[6]	-	-	0.130	-	-	-
Indoor plaster	[4]	2	0.57	0.035	1300	1000	6
Hollow concrete blocks with volcanic aggregates	[7]	12	0.39	0.307	667	1000	10
Indoor plaster	[4]	2	0.57	0.035	1300	1000	6
Indoor surface thermal resistance (horizontal heat flux)	[6]	-	-	0.130	-	-	-
TOTAL		16	-	0.637	-	-	-
Symbols					**U-value = 1.57 ($W \cdot m^{-2} \cdot K^{-1}$)**		
s = thickness λ = thermal conductivity R = thermal resistance		ρ = density C_p = specific heat μ = water vapour resistance (mu-value)					

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Still looking at Figure 46, but also at the drawings reported in Section 3.2, it is here necessary to underline that the horizontal roof provides sufficient room for placing the PV modules that are envisaged in the **e-**THERM concept. Indeed, the net roof surface amounts to 198 m^2. However, in order not to be shaded from the parapets and from the stairwell enclosure, the PV modules must be conveniently installed through an elevated supporting structure: this will also let the roof pavement available for other installations or just for leisure activities. In case further surface is needed for PV installation, the rooftop of the stairwell enclosure can be considered, which adds around 10 m^2 more.

As far as the ground floor slab is concerned, this shows the same features as the intermediate slabs reported in Table 2 except for the fact that it is suspended at a height h = 1.10 m from the soil (see Figure 47). Considering also the presence of a 10 cm thick cement screed lying on a 40 cm thick crawl space, the equivalent U-value of this construction calculated according to EN ISO Standard 6946 [6] is $U_{eq} = 0.64\ W{\cdot}m^{-2}{\cdot}K^{-1}$.

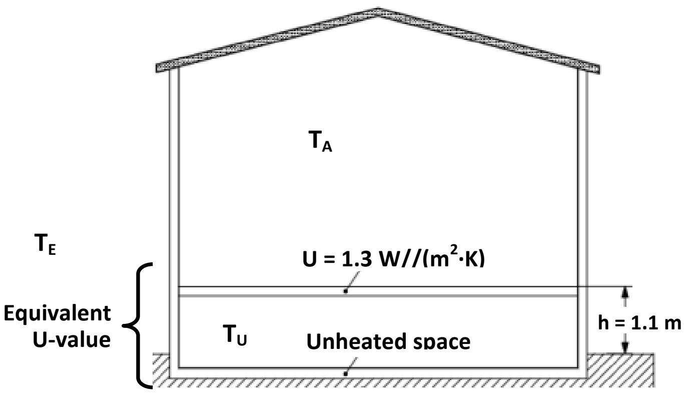

Figure 47: Schematic of the ground floor slab

It is here useful to remind that the equivalent U-values allows calculating the heat flux transferred through the slab to the unheated underground space (whose temperature is T_U) in a simplified way, as a function of just the indoor (T_A) and outdoor (T_E) temperatures:

$$q = U \cdot (T_A - T_U) = U_{eq} \cdot (T_A - T_E) \qquad (1)$$

The survey activity highlighted a great variety of external fixtures in terms of glazing, frame, and shading device typologies in the various flats. Their features are summarized in Table 5 for windows and in Table 6 for door windows. Here, the different typologies found are categorized according to: dimensions (height *h*, width *w*, average frame width *f*), frame typology (aluminum, PVC, wood), number of glazing panes (single-glazed and double-glazed), shading device (no shading, venetian blinds, interior blackout shade, plastic roller shutter) and resulting thermal transmittance U_w ($W{\cdot}m^{-2}{\cdot}K^{-1}$). The latter one is calculated also considering the presence of uninsulated window boxes with $U_{box} = 6\ W{\cdot}m^{-2}{\cdot}K^{-1}$ when roller shades are used.

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Table 5: Window typologies found in the pilot building.

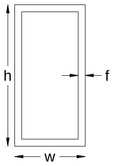
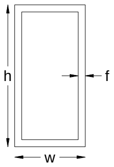
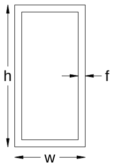
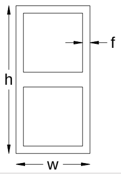
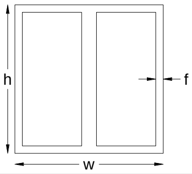
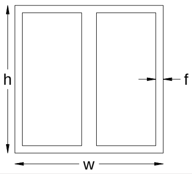
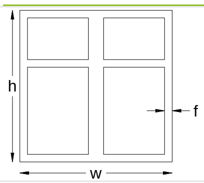
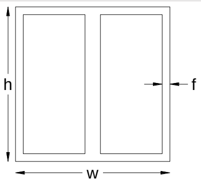
	DIMENSIONS	FRAME	GLAZING	SHADING DEVICE	U_W ($W{\cdot}m^{-2}{\cdot}K^{-1}$)
TYPE A 	w = 0.60 m h = 1.20 m f = 0.06 m	Aluminum	Single-glazed	Nothing/venetian blinds/blackout shade	6.064
TYPE B 	w = 0.60 m h = 1.20 m f = 0.06 m	PVC	Single-glazed	Nothing/blackout shade	4.664
TYPE C 	w = 0.60 m h = 1.20 m f = 0.06 m	PVC with thermal break	Double-glazed	Nothing/venetian blinds/blackout shade	2.836
TYPE D 	w = 0.60 m h = 1.20 m f = 0.06 m	PVC with thermal break	Double-glazed	Roller shutter	2.832
TYPE E 	w = 1.10 m h = 1.20 m f = 0.06 m	Aluminum	Single-glazed	Venetian blinds	6.085
TYPE F 	w = 1.10 m h = 1.20 m f = 0.06 m	Aluminum with thermal break	Double-glazed	Roller shutter	4.136
TYPE G 	w = 1.10 m h = 1.20 m f = 0.06 m	Wood	Single-glazed	Roller shutter	4.325
TYPE H 	w = 1.10 m h = 1.20 m f = 0.06 m	PVC with thermal break	Double-glazed	Roller shutter/venetian blinds	2.837

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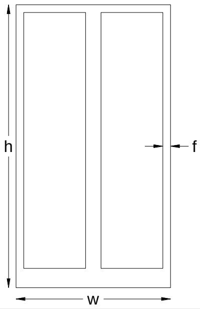
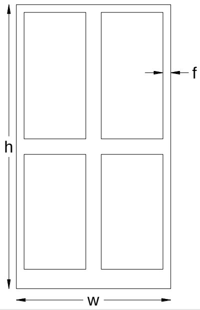
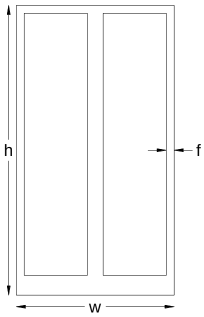
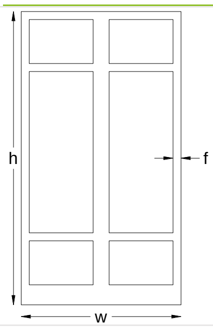
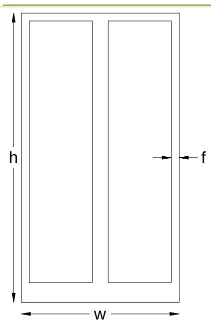
Table 6: Door window typologies found in the pilot building.

	DIMENSIONS	FRAME	GLAZING	SHADING DEVICE	U_W (W·m^{-2}·K^{-1})
TYPE I 	w = 1.10 m h = 2.20 m f = 0.06 m	Aluminum	Single-glazed	Nothing	6.081
TYPE J 	w = 1.10 m h = 2.20 m f = 0.06 m	Aluminum	Single-glazed	Nothing/roller shutter/venetian blinds	6.136
TYPE K 	w = 1.10 m h = 2.20 m f = 0.06 m	Aluminum (with thermal break)	Double-glazed	Nothing/roller shutter/venetian blinds	4.11
TYPE L 	w = 1.10 m h = 2.20 m f = 0.06 m	Wood	Single-glazed	Roller shutter	4.325
TYPE M 	w = 1.10 m h = 2.20 m f = 0.06 m	PVC (with thermal break)	Double-glazed	Nothing/roller shutter/venetian blinds/blackout shade	2.806

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Finally, Table 7 details the number of each fixture typology in every apartment. As it is possible to observe, most of the external fixtures (21 out of 72) are double-glazed door windows with PVC frame and thermal break (Type M, see Figure 48), likely indicating a rather recent replacement of older typologies such as Type J and K (aluminum frame with thermal break, see Figure 48) that are still found in various apartments.

Figure 48: Examples of door window typologies M (on the left) and K (on the right).

Table 7: Summary of fixture typologies found in every apartment of the pilot building.

APARTMENT	TYPE A	TYPE B	TYPE C	TYPE D	TYPE E	TYPE F	TYPE G	TYPE H	TYPE I	TYPE J	TYPE K	TYPE L	TYPE M
1L	2	-	-	-	-	2	1	-	1	-	2	-	-
1R	-	-	2	-	-	-	-	3	-	-	-	-	3
2L	2	-	-	-	1	-	-	-	-	5	-	-	-
2R	2	-	-	-	-	1	-	-	-	-	5	-	-
3L	-	-	1	1	-	-	-	1	-	-	-	-	5
3R	-	2	-	-	-	-	-	1	-	-	-	3	2
4L	2	-	-	-	-	1	-	-	-	-	5	-	-
4R	-	2	-	-	-	-	1	-	-	-	-	1	4
5L	-	-	2	-	-	-	-	1	-	-	-	-	5
5R	-	2	-	-	-	-	1	-	-	-	-	1	4
TOT.	8	6	5	1	1	4	3	6	1	5	12	5	23

4.1.2 Main thermal bridges

The main thermal bridges in the pilot building are classified in Figure 48, while Figure 49 identifies their position in the building. Then, Table 8 reports on their total length L_{tot} (m) and linear thermal transmittance values Ψ ($W \cdot m^{-1} \cdot K^{-1}$), the latter being calculated through the software tool IRIS 5.0 [8] according to the 2D numerical methodology set by the Standard EN ISO 10211 [9].

The last column of Table 8 reports also on the heat transfer coefficient H_e ($W \cdot K^{-1}$), calculated as the product of the external linear thermal transmittance Ψ_e by the total length of the thermal bridge (L_{tot}). This quantity will be used as an additional thermal loss term in the thermal simulations run for energy certification compliance presented in the next section.

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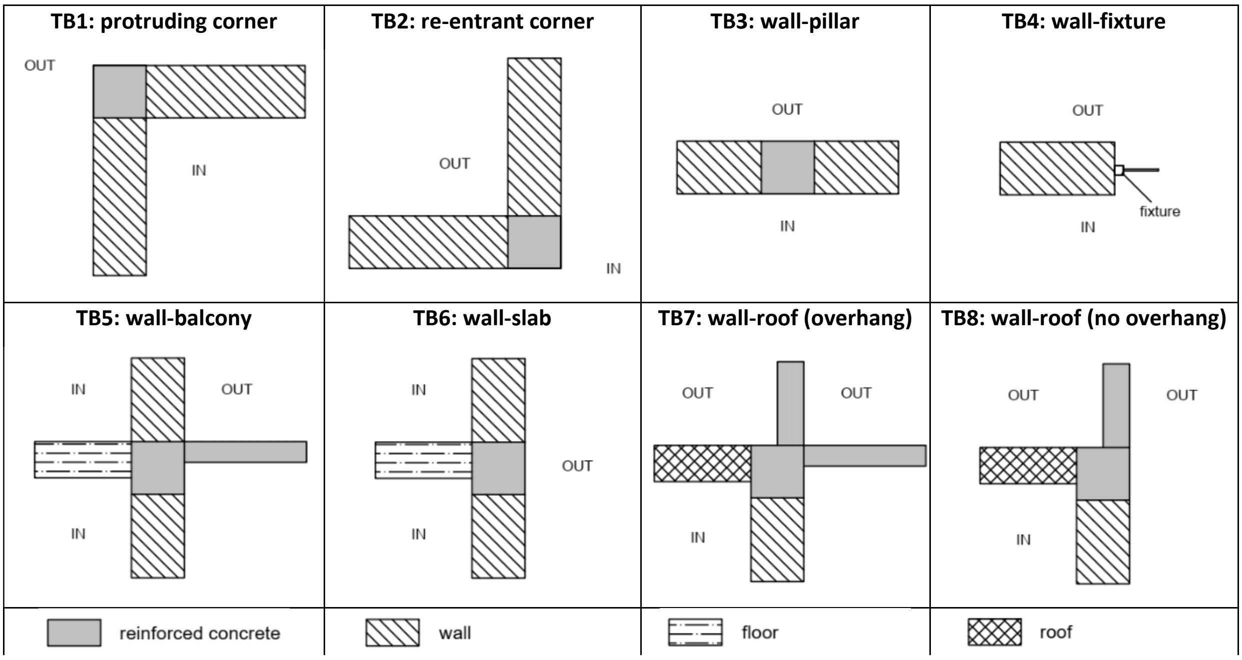

Figure 48: Type of thermal bridges in the pilot building.

Table 8: Thermal bridges: heat losses.

CODE	TYPOLOGY	L_{tot} (m)	Ψ_e ($W \cdot m^{-1} \cdot K^{-1}$)	Ψ_i ($W \cdot m^{-1} \cdot K^{-1}$)	H_e ($W \cdot K^{-1}$)
TB1	Protruding corner with pillar	84.60	-0.029	0.668	-2.5
TB2	Re-entrant corner with pillar	28.20	0.497	-0.199	14.0
TB3	Wall-pillar	126.90	0.834	0.834	105.8
TB4	Wall-fixture	438.56	0.392	0.362	171.9
TB5	Wall-balcony	191.38	1.131	1.409	216.5
TB6	Wall-slab	121.34	1.086	1.365	131.7
TB7	Wall-roof (with overhang)	42.70	0.321	1.174	13.7
TB8	Wall-roof (with parapet)	19.80	0.320	1.173	6.3

Symbols:

L_{tot} = total length in the pilot building
Ψ_i = internal linear thermal transmittance
Ψ_e= external linear thermal transmittance
H_e= heat transfer coefficient

As it is possible to observe from Table 8, TB3 (wall-pillar) and TB4 (wall-fixture) show the same internal and external thermal transmittance values ($\Psi_e = \Psi_i$) because of symmetry. The most impacting thermal bridges are TB4 (wall-fixture) and TB5 (wall-balcony), with H_e = 158.76 $W \cdot K^{-1}$ and H_e = 216.45 $W \cdot K^{-1}$ respectively. Other non-negligible thermal bridges are TB3 (wall-pillar) and TB6 (wall-slab). Minor contributions come from TB7 and TB8 (Wall-roof, with overhang and parapets respectively), mostly due to their relatively low length: it is here interesting to observe that these last two thermal bridges, despite different since the first one has an horizontal concrete-made overhang, show the same rate of heat transfer. In already very dispersing structures, adding a further overhang does not imply changes in the heat losses: however, when it comes to insulate the building, treating these two thermal bridges implies different technical difficulties.

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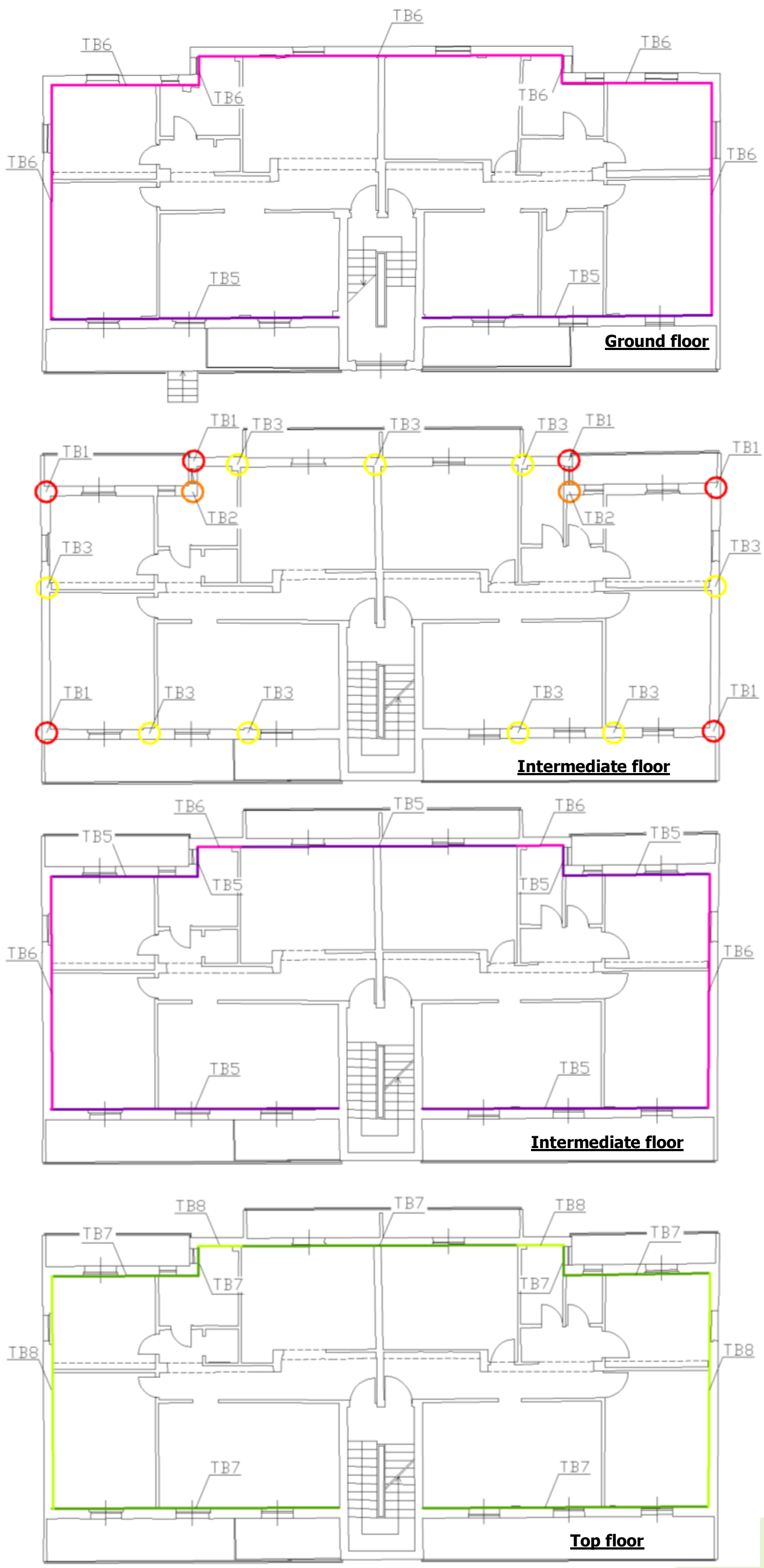

Figure 49: Identification of the thermal bridges in the pilot building.

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4.1.3 Mechanical systems

Looking now at DHW preparation, most of the apartments rely on electric boilers with different size (from 10 to 80 L) and electric power absorption (from 1.2 to 1.5 kW). Apartment 2R is the only one where DHW is prepared by a gas boiler fed by liquefied petroleum gas delivering a useful thermal power of 18.9 kW (see Figure 51 and Table 9). However, this gas boiler only serves the bathroom, whereas in the kitchen a small electric boiler is used.

It is also worth noting that apartment 3R is undergoing major renovation at the time this report is written, and as such it is not equipped with any mechanical system neither for space heating and cooling nor for DHW production. However, the owner of this apartment has stated that he is soon going to install an electric boiler too (Type A in Table 9). Energy calculations will then be based on this system also in apartment 3R.

In the current state of the building, no apartment is equipped with a heating and cooling system able to ensure thermal comfort in the entire apartment. Some apartments are equipped with one or two old split units (e.g. one in the kitchen and one in the main bedroom, see Figure 50 for an example) that could be used for air conditioning purposes (see Table 10).These split units can deliver a thermal peak power in the range of 2 kW to 2.7 kW, albeit at the expense of high electricity consumption because of their low Coefficient of performance (COP) estimated in the range of 2.2 to 2.7.

The summary of the various mechanical systems found in the apartments is reported in Table 11, while their localization within each flat is reported through plan drawings in Appendix 1.

Figure 50: External (on the left) and internal (on the right) views of a split unit in flat 2L.

Figure 51: A typical electric boiler (on the left) and gas boiler (on the right) found in the pilot building for DHW production.

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Table 9: DHW devices in the pilot building.

TYPE A – ELECTRIC BOILER

	Capacity (L)	Power absorption (kW)
	80	1.2

TYPE B – ELECTRIC BOILER

	Capacity (L)	Power absorption (kW)
	75	1.2

TYPE C – ELECTRIC BOILER

	Capacity (L)	Power absorption (kW)
	75	1.5

TYPE D – ELECTRIC BOILER

	Capacity (L)	Power absorption (kW)
	50	1.2

TYPE E – ELECTRIC BOILER

	Capacity (L)	Power absorption (kW)
	10	1.2

TYPE F – GAS BOILER (FUEL: LIQUIFIED PETROLEUM GAS)

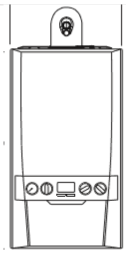
	Efficiency (%)	Thermal power (kW)
	84	18.9

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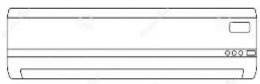
Table 10: Space heating and cooling device typologies found in the pilot building.

TYPE G – SPLIT UNIT

	Heating/cooling	Thermal output (kW)
	both	2.7

TYPE H – SPLIT UNIT

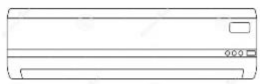
	Heating/cooling	Thermal output (kW)
	both	2

Table 11: Summary of air conditioning and DHW devices found in every apartment of the pilot building

APARTMENT	TYPE A	TYPE B	TYPE C	TYPE D	TYPE E	TYPE F	TYPE G	TYPE H
1L	1	-	-	-	-	-	2	-
1R	-	1	-	-	-	-	1	-
2L	-	-	1	-	-	-	-	2
2R	-	-	-	-	1	1	3	-
3L	-	1	-	-	-	-	-	-
3R	1	-	-	-	-	-	-	-
4L	1	-	-	-	-	-	3	-
4R	-	-	-	1	-	-	1	-
5L	-	-	1	-	1	-	2	-
5R	-	-	-	1	-	-	2	-
TOT.	3	2	2	2	2	1	14	2

Finally, the survey also allowed knowing how many people normally occupy the apartments (see Table 12): this piece of information will be useful during the design stage to assess the Domestic Hot Water consumption.

Table 12: People normally using the apartments

APARTMENT	No. of residents	N. of people frequently inside	Children	Notes
1S	5	14	2	-
1D	2	7	3	-
2S	2	5	-	-
2D	2	3	-	From May to October, they move to another building
3S	1	2	-	In summer, frequently not there
3D	2	3	-	-
4S	7	7	1	-
4D	6	6	4	-
5S	2	8	2	-
5D	2	2	-	-

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4.1.4 Rainwater drainage and water supply systems

The rainwater drainage system from the flat roof consists of four vertical PVC downpipes that drain the rainwater at ground level. The downpipes are placed on the short fronts (east and west) of the building, as shown in Figure 52.

Figure 52: Downpipes placed on the east (left side) and west (right side) oriented facades of the pilot building

On the other hand, the water supply system consists of external pipes with a diameter of 1 inch. The water pipes are located on the south façade of the building and branch off from the first storey to the top one, as shown in Figure 53. The water meters of all apartments are located at the two lateral fronts of the building (ground floor) and are accessible from the outside (Figure 54).

Figure 53: Water pipes located on the south façade of the building (from left to right: first storey, second storey, second storey, fifth storey)

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Figure 54: Water meters located at the east front of the building

One further aspect that must be underlined is that, currently, the internal distribution network for DHW does not ensure connecting all water dispensing points in each apartment under a single distribution pipe. For this reason, in many apartments two separate devices for DHW preparation are installed: one for the bathroom (and the laundry) and one for the kitchen (see Figure 55). The design of the technical systems, and more specifically the connection of the **e-**TANK to the existing distribution pipes, must take into account this peculiarity.

Still in Figure 55, one can observe that the apartments are entirely crossed, along the main direction, by a RC beam. This may pose some difficulties in connecting the two "halves" of the apartment with a single distribution pipe, in case the pipe has to be placed in the ceiling.

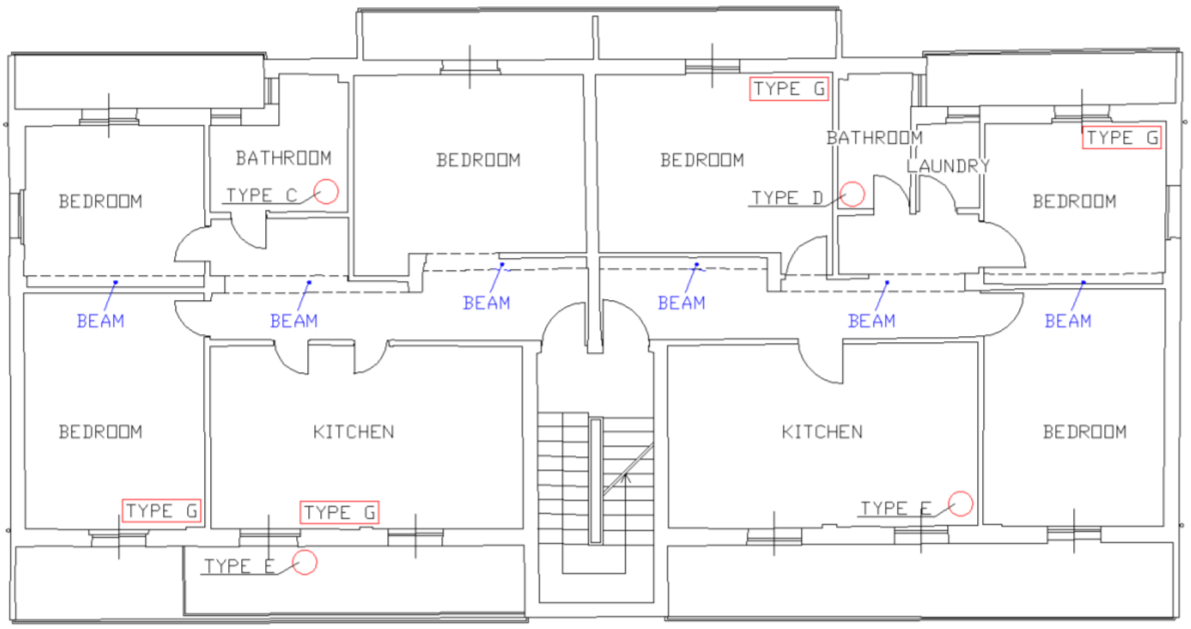

Figure 55: Position of the DHW devices in the fifth floor

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4.2 Thermal simulations for energy certification

This section reports on the energy simulations conducted for compliance with Italian laws and regulations concerning the energy renovation of buildings through the certified commercial software Blumatica Energy v.6.2.3.2 [10], based on a quasi-stationary energy balance model.

It is worth noting that the normative framework currently in force in Italy, in particular the Ministerial Decree 26 June 2015 [11] and its following updates, prescribes the drafting of the energy certificate – Attestato di Prestazione Energetica (APE, in Italian) – for each apartment in case of selling, renting, access to fiscal incentives and energy renovations. Although there is no obligation to produce the energy certificate of the building before its renovation (except when asking for some fiscal incentives), this section presents the main results of the energy simulations for the entire building in the current state. This would make it easier to evaluate the benefits achievable when the **e**-SAFE renovation solutions are applied, by comparing the energy certificates of the current state with those obtained after renovation.

Furthermore, the results of this analysis will represent a benchmark for the dynamic thermal model presented in Section 4.3.

4.2.1 Main simulation assumptions

The climate data used for the energy certification of the pilot building pertains to the city of Catania (Lat. 37° 26′ 37″, Lon. 14° 4′ 8″, alt. 7m above the sea level), and are gathered from the Italian Standard UNI 10349:2016 [12]. Table 13 summarizes the average monthly values of outdoor air temperature (°C), global horizontal irradiation (MJ·m^{-2}), relative humidity (%) and wind velocity (m·s^{-1}).

Table 13: Average monthly values of the main climate variables in Catania [11]

MONTH	AIR TEMPERATURE (°C)	GLOBAL HORIZONTAL IRRADIATION (MJ·m^{-2})	RELATIVE HUMIDITY (%)	WIND VELOCITY (m·s^{-1})
January	11.9	8.3	77.1	1.8
February	10.4	11.7	66.6	1.4
March	11.8	16.8	65.4	1.1
April	15.4	18.0	76.9	0.8
May	18.8	23.1	72.1	1.3
June	23.4	24.5	61.7	0.9
July	25.8	25.8	57.1	1.0
August	26.5	22.7	59.9	1.1
September	22.9	17.4	63.8	1.0
October	19.8	13.5	77.1	0.7
November	15.1	10.2	74.1	0.9
December	12.3	7.5	71.9	1.4

The thermal modelling of the building has been carried out considering one thermal zone per apartment, thus resulting in ten thermal zones (see Figure 56).

The main geometric features of the thermal zones are detailed for the ground floor (namely 1st floor) an intermediate floor (the 3rd floor) and the top floor (namely 5th floor), respectively. Indeed, the apartments located at the second, third and fourth floor show the same boundary conditions, while the ground floor and the top floor have further heat losses through the ground slab and the roof, respectively. Table 14 summarizes the main geometric features, along with the shape factor: this is defined as the ratio between the dispersing surface of the thermal zone and its gross heated volume, and gives an indication about the compactness of the building.

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Figure 56: Thermal zoning of a typical floor in Blumatica Energy.

Table 14: Main geometric features of the thermal zones.

THERMAL ZONE	HEIGHT (m)		AREA (m^2)		VOLUME (m^3)		DISPERSING SURFACE (m^2)	SHAPE FACTOR (m^{-1})
	Net	Gross	Net	Gross	Net	Gross		
1st floor (ground floor) – apartment 1L	2.8	3.2	94	110	263	352	219.62	0.624
1st floor (ground floor) – apartment 1R	2.8	3.2	94	110	263	352	219.62	0.624
Intermediate floor – apartment 3L	2.8	3.1	94	110	263	341	117.80	0.345
Intermediate floor – apartment 3R	2.8	3.1	94	110	263	341	117.80	0.345
5th (top) floor – apartment 5L	2.8	3.4	94	110	263	374	238.80	0.639
5th (top) floor – apartment 5R	2.8	3.4	94	110	263	374	238.80	0.639
TOTAL					**2630**	**3498**	**1623.6**	**0.46**

The staircase is modeled as a non-heated space, while the air change rate of each thermal zone is set to 0.3 h^{-1} in winter (from December 1st to March 31st) and to 1 h^{-1} in the remaining of the year to simulate natural ventilation.
The internal gains in each thermal zone Φ_{int} (W) are instead calculated as a function of the net floor area A_f (m^2) through the following relation [13]:

$$\Phi_{int} = 7.987 \cdot A_f - 0.0353 \cdot A_f^2 = 439 \text{ W} \tag{2}$$

Finally, concerning DHW production, every flat is modelled considering the specific devices described in Section 4.1.3. On the other hand, no mechanical systems are considered for providing space heating and cooling because the residents declared that they mainly use portable gas stoves for heating and natural ventilation for cooling, respectively. The few split units detected during the surveys are thus used seldom, and just for cooling purposes during some exceptional hot spells; some of them are even out-of-order.

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In such circumstances, and for energy certification purposes only, a fictitious heating system consisting of a gas-fired boiler of thermal efficiency equal to 0.95 is used, as prescribed by Italian regulations when no heating system for the entire dwelling is available [11]. The heating set point temperature is set to 20 °C in any case. Consistently, no cooling system is considered in the energy certification.

4.2.2 Sources of heat losses and global heat transfer coefficient H'_T

The heat losses are due to transmission through the envelope and ventilation through the opening of the windows when natural ventilation is operated.

Figure 57 reports the breakdown of heat losses in the pilot building: the main source of heat losses is the heat transfer through the external walls, which accounts for one third of the total. The second major contributors to heat losses are thermal bridges (21% of the total), closely followed by fixtures and ventilation (15% each). Minor contributions come from boxes and ground floor slabs.

Transmission heat losses account for 85% of the total in the pilot building, but the incidence of the various components changes amongst the various floors due to the different dispersing surfaces, as shown in Figure 58.

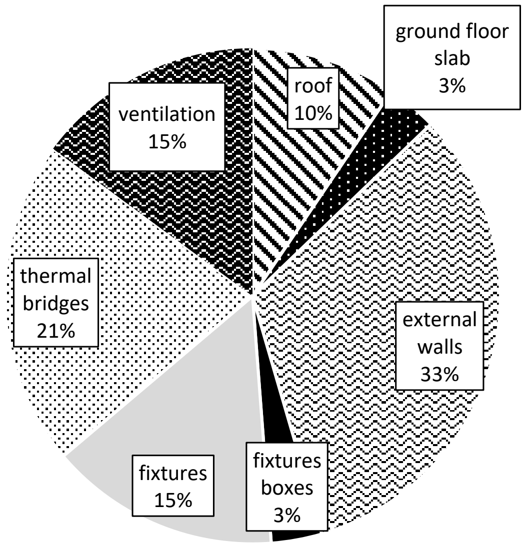

Figure 57: Breakdown of heat losses in the current state. Entire building.

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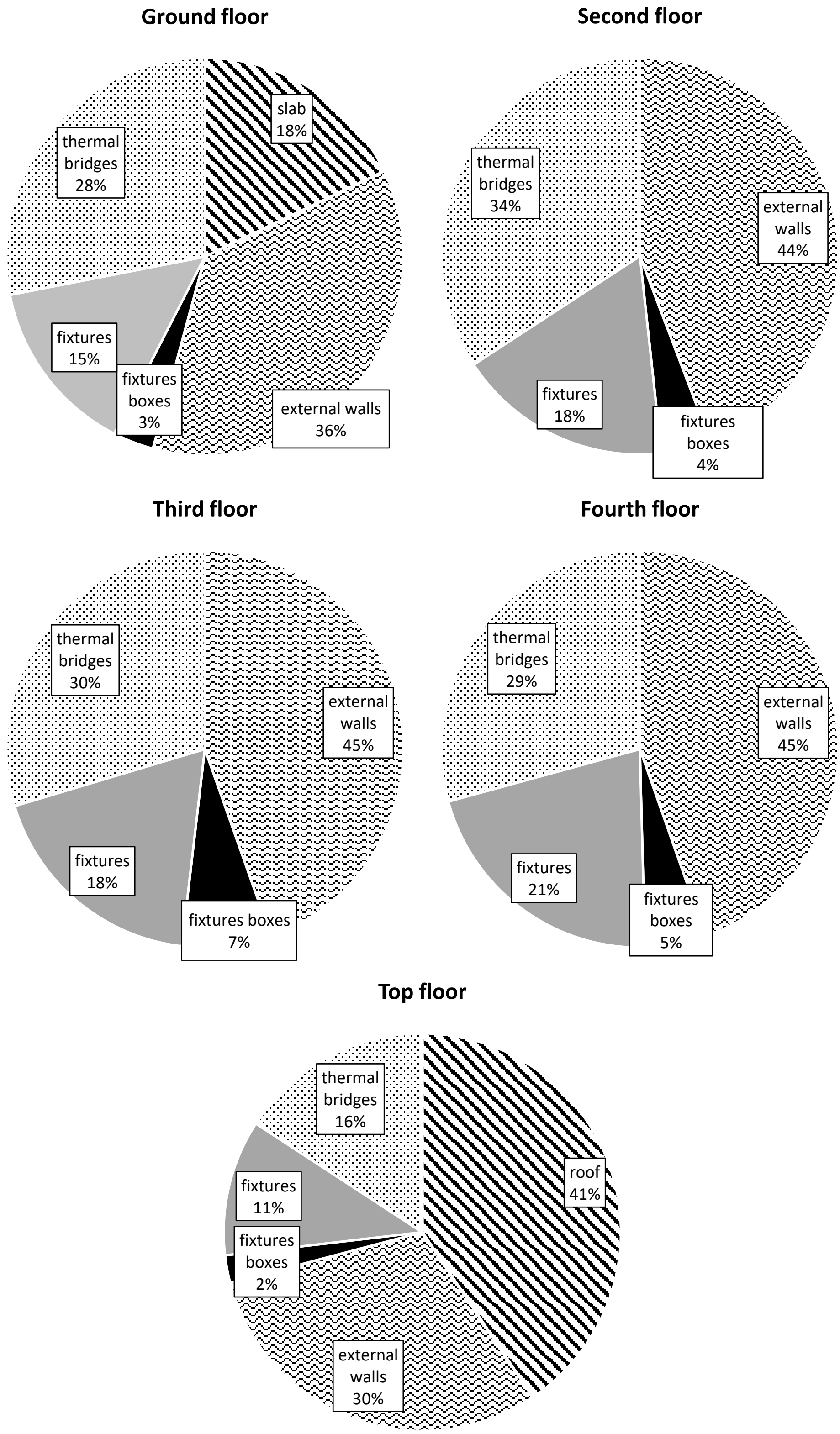

Figure 58: Breakdown of heat losses in the current state for each floor.

Because of the importance of transmission heat losses in buildings, Italian regulations prescribe the calculation of a specific index, called global heat transfer coefficient H'_T ($W \cdot m^{-2} \cdot K^{-1}$), which is defined as the weighted average of transmission losses through their dispersing surfaces:

$$H'_T = \frac{\sum_k U_k \cdot A_k + \sum_j \psi_j \cdot L_j}{\sum_k A_k} \tag{3}$$

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Here, U_k is the thermal transmittance value of the dispersing building component *k* (W·m^{-2}·K^{-1}), A_k its surface (m^2), ψ_j the linear thermal transmittance of the thermal bridge *j* (W·m^{-1}·K^{-1}) and L_j its length (m).

Table 15 reports on the calculation of H'_T for each apartment and for the entire building. These values represent a sort of mean thermal transmittance for the entire building envelope, including the effect of thermal bridges: if one considers that the Italian regulations currently in force prescribe that H'_T does not exceed 0.50 – 0.80 W·m^{-2}·K^{-1}, depending on the climate zone, it is apparent that the building currently show too high heat losses.

Table 15: Values of the global heat transfer coefficient H'_T.

APARTMENT	H'_T (W·m^{-2}·K^{-1})
1L	1.34
1R	1.27
2L	1.97
2R	1.90
3L	1.76
3R	1.83
4L	1.90
4R	1.73
5L	1.47
5R	1.47
Entire building	**1.60**

4.2.3 Energy demand and energy certification labels

The energy needs for space heating ($EP_{H,need}$) and DHW production ($EP_{W,need}$) are estimated for each thermal zone and reported in Figure 59, while the detailed energy certificates of each apartment are reported in Appendix 2.

As it is possible to observe, the energy demand for space cooling is zero, because of the absence of any cooling system, while the highest energy demand for space heating pertains to the top floor (about 67 kWh·m^{-2}) because of the higher dispersing surface. On the other hand, the predicted energy demand for DHW production is the same for each thermal zone (around 14 kWh·m^{-2}), since it depends on the net area, which is the same for all the dwellings. The aggregated energy demand figures for the entire building are 46.1 kWh·m^{-2} for space heating and 13.7 kWh·m^{-2} for DHW production, in order.

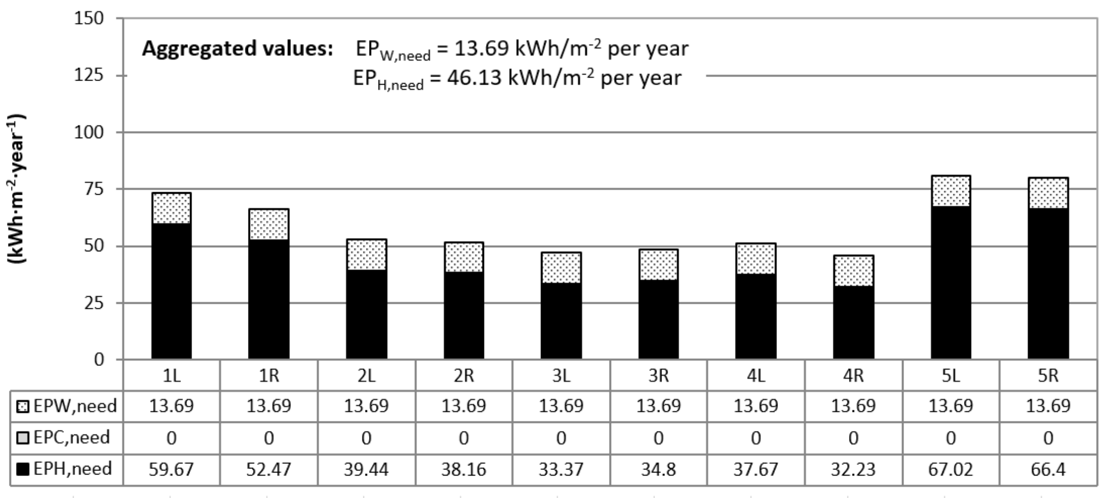

Figure 59: Energy demand of each thermal zone.

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The energy demand of each apartment is eventually converted into primary energy consumption for each building service by introducing the efficiencies of the thermal systems and the non-renewable primary energy conversion factors. For instance, electric boilers have an average annual efficiency as high as 0.75, and the conversion factor from non-renewable primary energy to final electric energy is 0.51.

The results of this calculation are shown in Figure 60. On average, the apartments show an overall non-renewable primary energy consumption amounting to 111 kWh·m^{-2} per year.

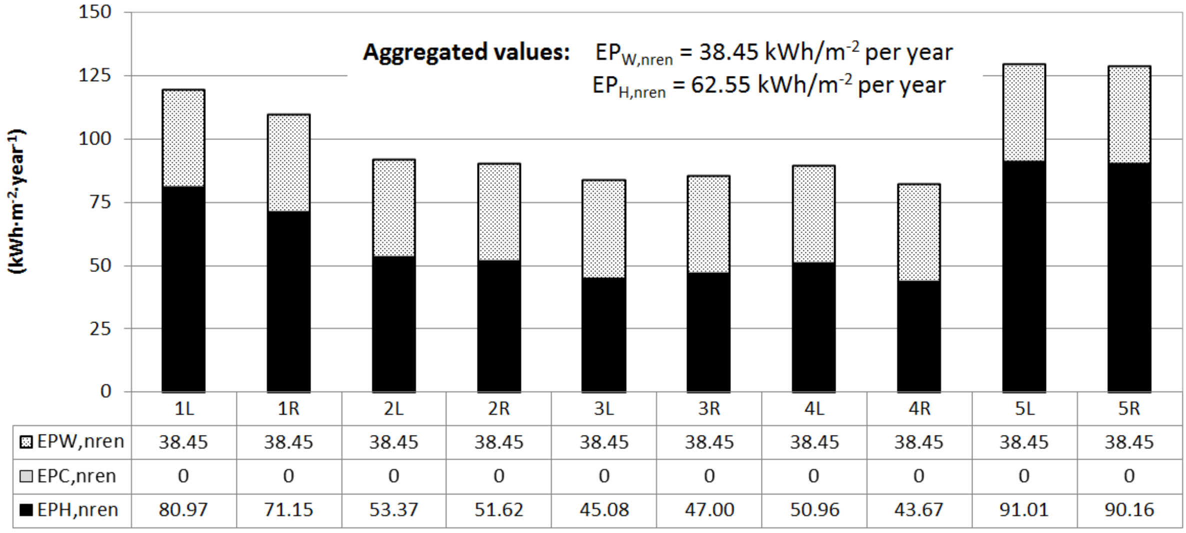

Figure 60: Primary energy consumption of each thermal zone.

Table 16: Final energy vectors and CO_2 emissions resulting from the simulations

	GROUND FLOOR (1ST)		INTERMEDIATE FLOORS						5TH (TOP) FLOOR	
	1L	1R	2L	2R	3L	3R	4L	4R	5L	5R
Electricity (kWh/year)	1853.6	1853.6	1853.6	1853.6	1853.6	1853.6	1853.6	1853.6	1853.6	1853.6
Natural gas (m^3/year)	767.1	674.0	505.5	489.1	427.1	445.7	482.7	413.7	862.1	854.1
CO_2 emiss. (kg/year)	2374.4	2190.2	1855.6	1823.6	1700.5	1737.1	1810.4	1673.2	2563.4	2547.4

Table 17: Non-renewable primary energy consumption (kWh·m^{-2}·year^{-1}) and energy class of each apartment

	GROUND FLOOR (1ST)		INTERMEDIATE FLOORS						5TH (TOP) FLOOR	
	1L	1R	2L	2R	3L	3R	4L	4R	5L	5R
$EP_{gl,nren}$	119.42	109.60	91.82	90.08	83.53	85.50	89.41	82.12	129.46	128.61
$EP_{gl,nren,ref}$	41.61	40.10	31.67	33.94	33.75	32.76	33.55	31.96	46.38	44.13
CLASS	**F**	**F**	**F**	**F**	**E**	**F**	**F**	**E**	**F**	**F**

Finally, the total non-renewable primary energy consumption $EP_{gl,nren}$ – given by the summation of the energy consumption for all building services – is calculated and compared against that of a reference building ($EP_{gl,nren,ref}$). A reference building is defined by the Italian norm as *"a building with the same localization, geometrical and orientation of that under consideration, but with predefined thermal transmittance values and mechanical systems efficiencies"*. This comparison determines the energy class of each apartment in a scale ranging from G (worst class, $EP_{gl,nren} > 3.50 \cdot EP_{gl,nren,ref}$) to A4 (best class, $EP_{gl,nren} \leq 0.40 \cdot EP_{gl,nren,ref}$), and is reported in Table 17 for all the apartments.

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4.2.4 Thermal loads for heating and cooling

The simulations in Blumatica Energy v.6.2.3.2 also allowed estimating the peak thermal loads for heating and cooling in the various apartments as reported in Table 18. Here it is easy to observe that the highest values for both space heating and cooling pertain to top floor apartments 5L and 5R because of the presence of the roof. In fact, the uninsulated roof covered by a dark waterproof membrane (see Figure 46) negatively affects the energy balance of these apartments by dispersing more energy in winter and collecting more solar radiation in summer.

The remaining flats, and in particular those located at the intermediate floors, show the lowest peak values because of the smaller dispersing surfaces, while apartment 1R shows the lowest peak cooling load because of the heat exchange with the ground.

Table 18: Heating and cooling peak loads in the various flats.

APARTMENT	HEATING PEAK LOAD (kW)	COOLING PEAK LOAD (kW)
1L	5.03	4.79
1R	4.66	3.91
2L	4.16	4.95
2R	4.03	4.55
3L	3.78	4.43
3R	3.90	4.02
4L	4.03	4.60
4R	3.72	4.27
5L	5.95	5.14
5R	5.92	4.77

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4.3 Dynamic thermal simulations

To perform dynamic energy simulations, a thermal model of the pilot building in its current state is built in EnergyPlus v.9.0 [14] as a baseline for future detailed thermal and energy analyses of the **e-**SAFE renovation solutions.

The following paragraphs describe the main assumptions made in the simulations, and the validation of the dynamic model based on the comparison with the energy demand predicted through the software tool for energy certification.

In this regard, we made the choice of assuming that all apartments in the building have the same type of windows, unlike in the real building. This allows avoiding excessive variability in the input data, while also ensuring that both models (quasi-stationary and dynamic) have the same input parameters.

4.3.1 Main simulation assumptions

Unlike quasi-steady-state simulations, dynamic simulations require hourly (or sub-hourly) weather data as an input. The simulations are thus performed using a weather file developed at the University of Catania following the standardized International IWEC procedure and based on recent observations (2002-2019) taken at the local SIAS (Sicilian Agrometeorological Service) weather station [15].

Table 19 reports the comparison between the average monthly values of air temperature and solar irradiation extracted from the weather datasets used for the simulations in Blumatica and EnergyPlus, respectively. Here, it is possible to observe how EnergyPlus weather data contain higher air temperature values in milder months and higher solar irradiation values in spring and summer months. These differences – along with those of other climate variables not reported here for the sake of brevity – may imply some deviations in the estimate of the monthly energy demand for space heating and cooling on which the validation exercise is based.

Table 19: Average monthly values of the main climate variables in Catania.

MONTH	AIR TEMPERATURE (°C)		Δ (°C)	GLOBAL HORIZ. IRRAD. ($MJ{\cdot}m^{-2}$)		Δ (%)
	Blumatica	*EnergyPlus*	*(Blumatica-EnergyPlus)*	*Blumatica*	*EnergyPlus*	*(Blumatica-EnergyPlus)*
January	11.9	10.6	+1.3	8.3	8.9	-7
February	10.4	10.4	0	11.7	11.8	-1
March	11.8	12.7	-0.9	16.8	16.5	+2
April	15.4	15.2	+0.2	18.0	19.5	-8
May	18.8	19.3	-0.5	23.1	23.5	-2
June	23.4	22.8	+0.6	24.5	26.1	-6
July	25.8	26.3	-0.5	25.8	26.8	-4
August	26.5	26.5	0	22.7	23.4	-3
September	22.9	23.8	-0.9	17.4	17.7	-2
October	19.8	20.6	-0.8	13.5	12.7	+6
November	15.1	15.7	-0.6	10.2	10	+2
December	12.3	12.3	0	7.5	7.4	+1

The thermal zoning in EnergyPlus, reported in Figure 61, is more detailed than that in Blumatica (Figure 56). In particular, every room is considered as a thermal zone (each apartment thus contains eight thermal zones), while the staircase is regarded as a unique non-heated thermal zone.

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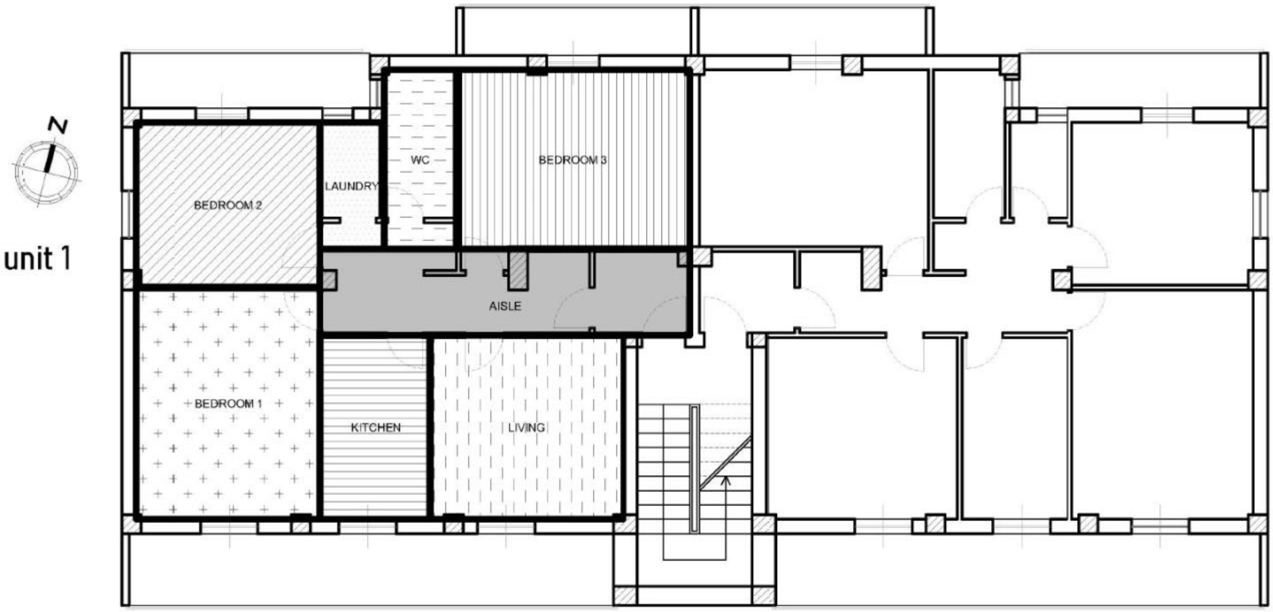

Figure 61: Thermal zoning of a typical apartment in EnergyPlus

As far as the ground slab is concerned, the heat transfer through the non-ventilated underfloor zone is simulated through the *OtherSideCoefficient* function, by assuming that the underfloor temperature is a linear combination of the outdoor air temperature (weighting factor 0.5) and indoor air temperature (weighting factor 0.5), resulting in the same equivalent U-value as that considered by Blumatica Energy. The soil has a fixed temperature of 18 °C throughout the year.

The same constructions as those applied in the Blumatica model are used in EnergyPlus so that the same U-values are retained. However, some differences occur in the case of fixtures: in particular, while shadings are always in use in summer in Blumatica simulations, in EnergyPlus they are supposed to be in place only when the solar irradiance on the glazed element is higher than 300 $W{\cdot}m^{-2}$. Furthermore, boxes are not simulated in EnergyPlus because of their low incidence (usually less than 5%) in the calculation of the global heat transfer coefficient H'_T.

Another aspect to stress is that EnergyPlus does not allow considering thermal bridges. To overcome such shortcoming, the contribution of thermal bridges to thermal loads Φ_{TB} (W) is added to those reported as an output by the simulation as follows:

$$\Phi_{TB} = \sum_j \psi_j \cdot L_j \cdot \Delta T \qquad (4)$$

Where Ψ_j ($W{\cdot}m^{-1}{\cdot}K^{-1}$) and L_j (m) are respectively the linear thermal transmittance and the length of each thermal bridge, while ΔT (°C) is the hourly indoor-outdoor air temperature difference for a representative thermal zone.

In terms of air ventilation, the same fresh air rate as in Blumatica is retained for every thermal zone (0.3 h^{-1} in winter and of 1 h^{-1} in the remaining of the year). More details are instead required for the estimate of air leakages, for which the Effective Leakage Area (ELA) method proposed by the ASHRAE is used [16]. In this method, the air infiltrations rate is determined based on the leakage area of each fixture A_L (cm^2) as follows:

$$A_L = \frac{n_{50} \cdot V_n}{3600} \cdot \sqrt{\frac{\rho}{2 \cdot \Delta p_{50}}} \cdot 1000 \qquad (5)$$

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Here n_{50} is the air change rate at pressure difference Δp_{50} of 50 Pa and assumed equal to 8 h^{-1} according to the suggestions of UNI 11300/1:2014 Standard [13] for envelopes with high permeability, while ρ= 1.2 $kg \cdot m^{-3}$ is the standard air density and V_n is net air volume of the thermal zone (m^3). The resulting A_L values for every thermal zone of a typical apartment are summarized in Table 20.

Table 20: Effective leakage area for the thermal zones equipped with external fixtures (typical apartment).

THERMAL ZONE	BEDROOM1	BEDROOM2	BEDROOM3	KITCHEN	LAUNDRY	LIVING ROOM	WC
A_L (cm^2)	128.6	91.24	127.44	60.71	24.51	107.04	39.90

Once A_L is calculated, the air infiltrations rate q ($m^3 \cdot h^{-1}$) is eventually determined through the following relation:

$$q = 3.6 \cdot A_L \cdot \sqrt{a \cdot \Delta T + b \cdot v^2} \tag{6}$$

Where ΔT (°C) is the indoor-outdoor air temperature difference, v ($m \cdot s^{-1}$) is the outdoor air velocity, a = 0.000435 ($l^2 \cdot s^{-2} \cdot cm^{-4} \cdot K^{-1}$) and b = 0.000271 ($l^2 \cdot s^{-2} \cdot cm^{-4} \cdot m^{-2} \cdot s^2$) are the stack and wind coefficients, respectively, as suggested by ASHRAE [16].

When considering internal gains, despite EnergyPlus allows considering several different sources (e.g., internal lights, electric equipment, people) and heat components (i.e., sensible and latent), the same amount of sensible internal loads as determined by Eq. (2) and adopted in Blumatica (equal to 4.67 $W \cdot m^{-2}$) have been used in every thermal zone for 24 h, for the sake of consistency.

4.3.2 Comparison with energy certification simulations

The comparison between simulations in Blumatica and EnergyPlus is carried out in relation to both heating and cooling energy demand, by assuming a heating season running from December 1st to March 31st, and a cooling season running from June 1st to September 30th, in order. The thermostat set point temperatures are 20 °C for heating and 26 °C for cooling all day long.

Similarly to heating energy predictions, also cooling energy predictions are based on the use of a fictitious cooling system with the technical features prescribed by the Italian norms because of the absence of a proper cooling system in every apartment as already mentioned in Section 4.2.1.

The simulation results shown in Figure 62 and Figure 63 for the ground floor (namely 1st floor), the intermediate floor and the top floor apartments report a very good agreement between the two simulations. In fact, the differences never exceed 10% for space heating and 11% for space cooling

If looking at the heating energy demand for the entire building, this amounts to 48.4 $kWh \cdot m^{-2}$ in Blumatica and 50.3 $kWh \cdot m^{-2}$ in EnergyPlus, which predicts higher heating energy demand by about 4%. Conversely, when it comes to cooling energy demand, EnergyPlus predicts slightly lower values than in Blumatica (27.6 $kWh \cdot m^{-2}$ against a Blumatica prediction of about 25.6 $kWh \cdot m^{-2}$), with a discrepancy below 8%.

Since the overall discrepancies are sufficiently low, the dynamic thermal model built in EnergyPlus can be considered coherent with the modeling used for Energy Certification purposes and will be used in upcoming project tasks to predict the hourly thermal behaviour of the renovated building.

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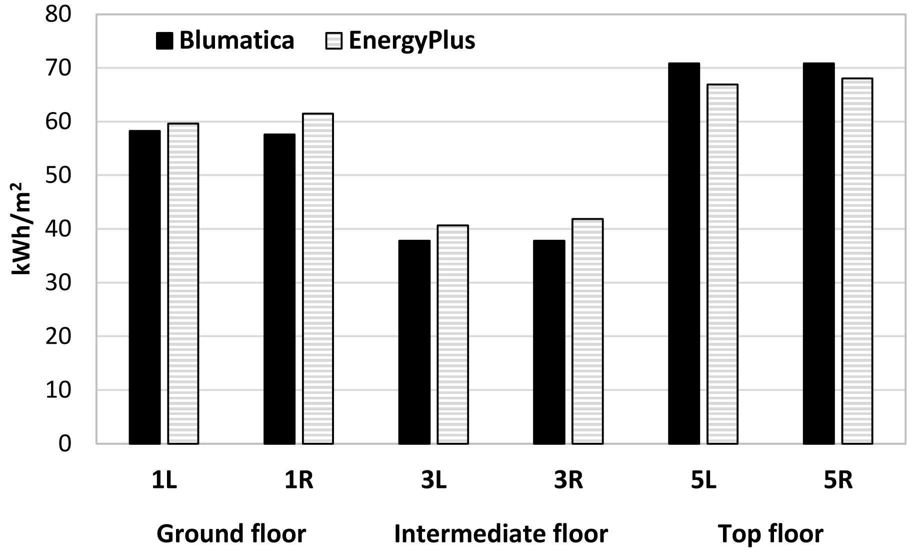

Figure 62: Heating energy demand: comparison between Blumatica and EnergyPlus simulations.

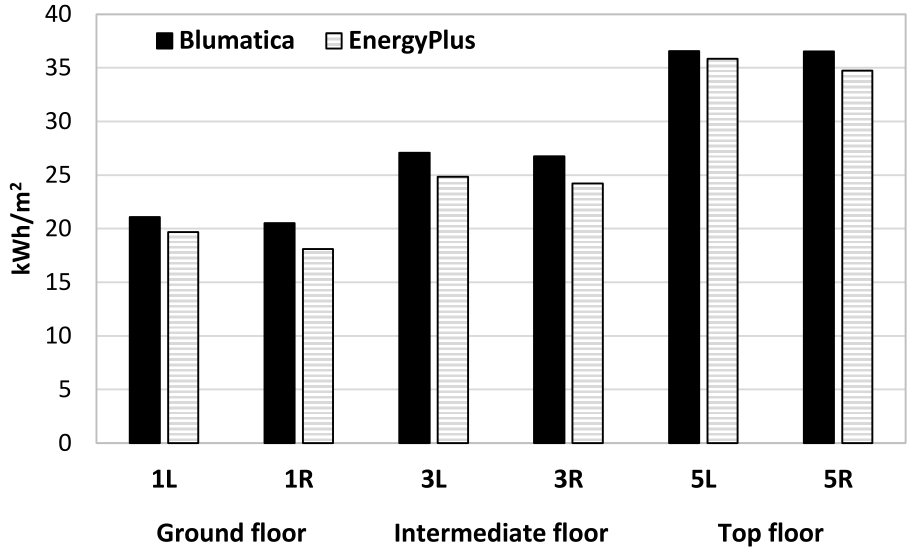

Figure 63: Cooling energy demand: comparison between Blumatica and EnergyPlus simulations.

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5. STRUCTURAL SURVEY

This chapter describes the results of the structural survey aimed at supporting the assessment of the seismic safety of the residential pilot building located in Catania. The final goal of this assessment will be the determination of the seismic safety level, according to the current Italian and European seismic codes, namely:

- DM 17.01.2018 (NTC18) [17]
- Commentary to NTC 18 [18]
- OPCM 3274/2003 [19]
- Eurocode 8 part 1-3 (EC8_1.3) [20]
- National annexes for the application of Eurocodes in Italy [21]

The investigation was based on a campaign of tests on site and in laboratory, both destructive and semi-destructive or non-destructive. The acquisition of the design documentation, the surveys carried out on the buildings to check the geometry of the original project, as well as the conducted experimental investigation led to a good level of knowledge of the pilot building, in terms of identification of geometry, construction details and materials.

In this regard, EC8_1.3 defines three levels of knowledge of the structure: KL1 (Limited knowledge), KL2 (Normal knowledge) and KL3 (Full knowledge). The achieved level of knowledge controls the admissible type of analysis and the appropriate Confidence Factor (CF) values to be used for the assessment. Since non-linear methods of analysis are advisable for the assessment of existing buildings, the structural survey aims at achieving a normal knowledge of the structure (KL2), which is the minimum level of knowledge required by the Italian and European seismic codes to allow the use non-linear analysis. In particular, this level of knowledge will permit, in the modelling phase, to conduct non-linear static analysis (pushover) for the seismic assessment of the structure. This method of analysis is widely believed the best compromise between computational burden, simplicity of interpretation of the results and accuracy in the simulation of the seismic behaviour of the structure.

5.1 Geometry of the structure

The geometry of the structure can be determined either from in-situ survey or from the original drawings. In the latter case, a visual survey is carried out to verify the actual correspondence of the building to the drawings. The data collected on the dimensions of the structural elements, together with those concerning the structural details, will allow the development of structural models suitable for linear or non-linear analysis.

In the case of the pilot building, the original construction drawings were quite limited in number and allowed only the identification of the main geometrical properties of RC structure. Figures 64.a and 64.b show plan layout of the foundation and plan architectural drawing of the floor type, which also provide a rough representation of the RC framed structure. Figures 64.c and 64.d show the elevation drawings of the north and south fronts of the building, allowing the identification of the openings in the masonry infills. No information was provided regarding the construction details and the mechanical properties of the materials. The collected data include the identification of the seismic resistant frames in both directions, the arrangement of the unidirectional slab, the size of the cross section of columns and beams.

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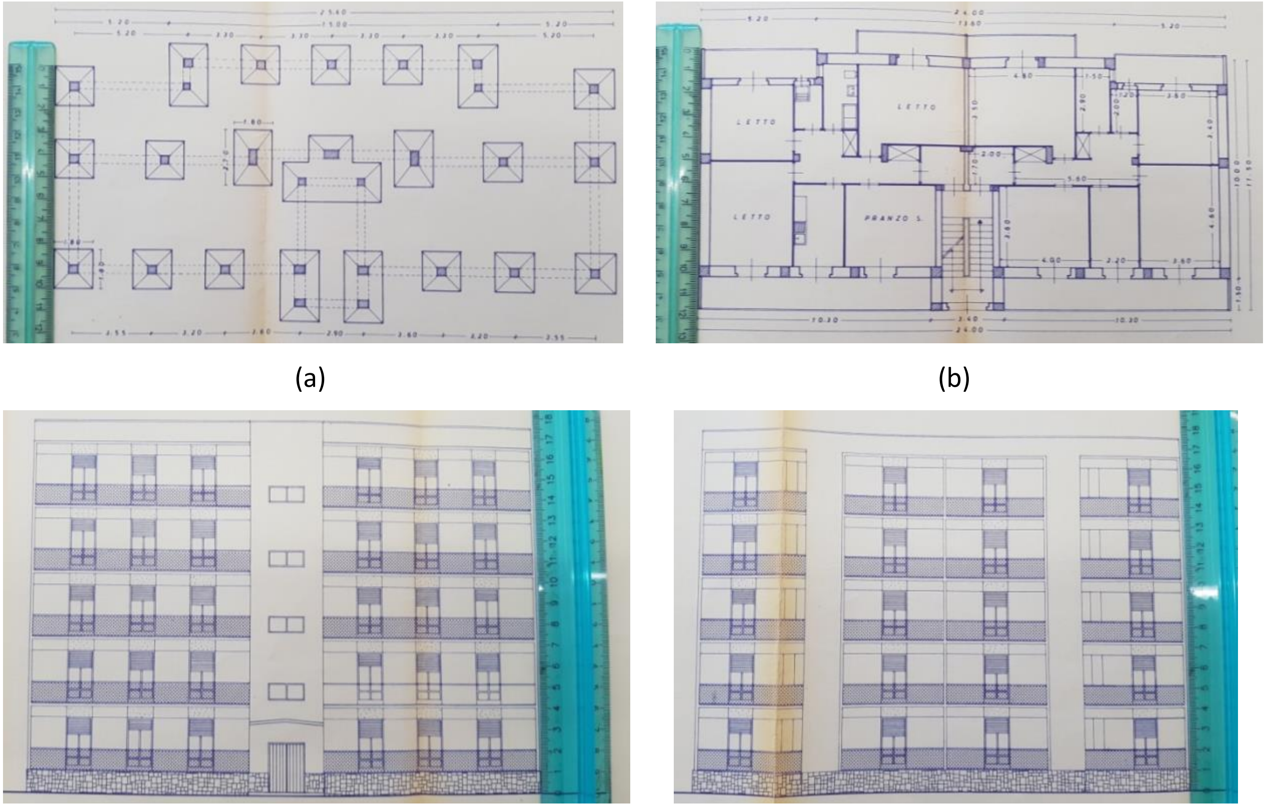

(a) (b)

(c) (d)

Figure 64: Architectural drawings of the pilot building.
(a) foundations; (b) floor type; (c) north front; (d) south front.

5.1.1 Columns

The pilot building is characterized by 28 rectangular RC columns. Figure 65 reports beams, columns and unidirectional slabs according to the original drawings. The arrangement of the structural members is replicated at each floor even though the size of the columns gradually decreases from the bottom to the top of the building. The cross sections of the columns for each storey have been determined from in-situ survey and are summarized in Table 21.

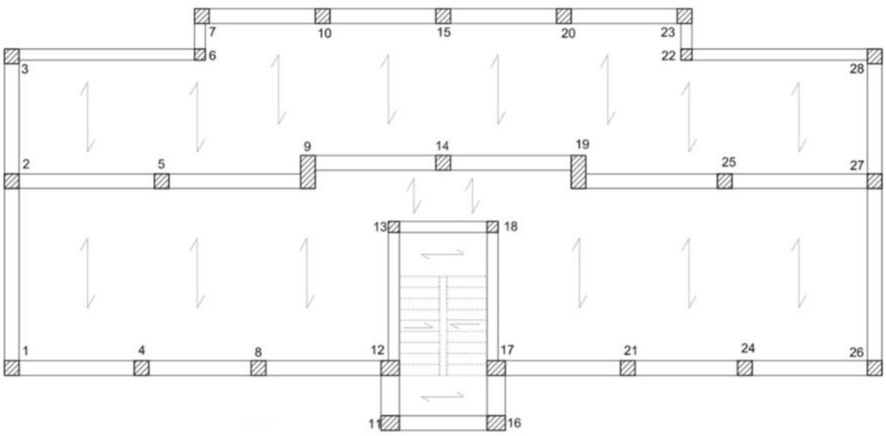

Figure 65: Beams, columns and arrangement of unidirectional slabs.

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Table 21: Cross sections of columns

COLUMN	1ST STOREY	2ND STOREY	3RD STOREY	4TH STOREY	5TH STOREY
1	35x35	35x35	30x30	30x30	30x30
2	30x30	30x30	30x30	30x30	30x30
3	30x30	30x30	30x30	30x30	30x30
4	40x40	40x40	35x35	35x35	35x35
5	40x40	35x35	35x35	30x30	30x30
6	30x30	30x30	30x30	30x30	30x30
7	30x30	30x30	30x30	30x30	30x25
8	35x40	30x35	30x35	25x35	25x35
9	25x75	25x75	25x75	25x75	25x75
10	30x35	30x30	30x30	30x30	30x25
11	30x30	30x30	30x30	30x30	30x30
12	50x50	40x40	40x30	30x30	30x30
13	40x30	25x30	25x30	25x30	25x30
14	30x40	30x30	30x30	30x30	25x30
15	30x35	30x30	30x30	30x30	30x25
16	30x30	30x30	30x30	30x30	30x30
17	30x40	30x40	30x30	30x30	30x30
18	25x30	25x30	25x30	25x30	25x30
19	25x75	25x75	25x75	25x75	25x75
20	30x35	30x35	30x35	30x30	30x25
21	35x40	30x40	30x35	30x35	25x35
22	30x30	30x30	30x30	30x50	30x30
23	30x30	30x30	30x30	30x30	30x25
24	40x40	40x40	35x35	35x35	35x35
25	40x40	35x35	35x35	30x30	30x30
26	35x35	35x35	35x35	30x30	30x30
27	35x35	30x30	30x30	30x30	30x30
28	30x30	30x30	30x30	30x30	30x30

5.1.2 Beams and slabs

The configuration of beams and slab remains constant at all storeys (Figure 65) and 28 deep beam bays are present at each floor. Twenty of these beams are arranged along the longitudinal direction and determine the three main longitudinal frames. Two longitudinal frames have 6 bays, while the third one has 7 bays as it includes the bay that sustains the staircase. The other part of the staircase rests on a single-span deep beam orientated along the longitudinal direction. In the transversal direction, 8 deep beams are present: 2 for each of the 2 outermost 2-bay frame while the other 4 are in the 2-bay frames that encase the staircase. The size of the cross sections of beams are summarized in Table 22. Unidirectional slabs are arranged along the transversal direction and rest on the longitudinal frames.

Table 22: Number of beams and their cross section

BEAM	1ST STOREY	2ND STOREY	3RD STOREY	4TH STOREY	5TH STOREY
1-4	30x55	30x55	30x55	30x55	30x55
4-8	30x55	30x55	30x55	30x55	30x55
8-12	30x55	30x55	30x55	30x55	30x55
11-16	25x50	25x50	25x50	25x50	25x50
17-21	30x55	30x55	30x55	30x55	30x55
21-24	30x55	30x55	30x55	30x55	30x55
24-26	30x55	30x55	30x55	30x55	30x55

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13-18	25x50	25x50	25x50	25x50	25x50
2-5	30x65	30x65	30x65	30x65	30x65
5-9	30x65	30x65	30x65	30x65	30x65
9-14	30x60	30x60	30x60	30x60	30x60
14-19	30x60	30x60	30x60	30x60	30x60
19-25	30x65	30x65	30x65	30x65	30x65
25-27	30x65	30x65	30x65	30x65	30x65
3-6	30x50	30x50	30x50	30x50	30x50
7-10	25x50	25x50	25x50	25x50	25x50
10-15	25x50	25x50	25x50	25x50	25x50
15-20	25x50	25x50	25x50	25x50	25x50
20-23	25x50	25x50	25x50	25x50	25x50
22-28	30x50	30x50	30x50	30x50	30x50
1-2	25x50	25x50	25x50	25x50	25x50
2-3	25x50	25x50	25x50	25x50	25x50
6-7	25x50	25x50	25x50	25x50	25x50
11-12	25x50	25x50	25x50	25x50	25x50
16-17	25x50	25x50	25x50	25x50	25x50
22-23	25x50	25x50	25x50	25x50	25x50
26-27	25x50	25x50	25x50	25x50	25x50
27-28	25x50	25x50	25x50	25x50	25x50

5.2 Evaluation of structural features by experimental testing

5.2.1 Requirements by code for KL2

The in-depth level to be purchased by tests and verifications has been determined based on the information provided by the original design documents and drawings, in accordance with Commentary to NTC18 [18] and Eurocode 8 part 1-3 (EC8_1.3) [19]. In particular, in order to achieve (target) level of knowledge KL2, the survey plan should satisfy the requirements summarised in Tables 23 and 24. The achievement of the level of knowledge KL2 allows the use of non-linear static analysis and confidence factor CF = 1.2 to assess the existing structure.

Table 23: Extracted from table C8.5.IV of the Commentary to NTC18 [18]

KNOWLEDGE LEVEL	GEOMETRY	STRUCTURAL DETAILS	MECHANICAL PROPERTIES OF MATERIALS	METHOD OF ANALYSIS	CF
KL2	From original drawings and in-situ observation	Incomplete construction drawings + Limited in-situ testing	Extended in-situ testing	Non-linear static analysis	1.20

Table 24: Extracted from table C8.5.V of the Commentary to NTC18 [18]

LEVEL OF INSPECTION AND TESTING	FOR EVERY "PRINCIPAL" STRUCTURAL MEMBER (COLUMN, BEAM)	
	IN-SITU TEST (CONSTRUCTION DETAILS)	MATERIAL TEST
Limited verification	Quantity and location of reinforcement bars have to be verified for at least 15% of members	1 concrete sample every 300 m^2 of area of the building 1 steel sample for each storey of the building

5.2.2 Selection of the structural members to be tested

Due to economic and time issues, it is unreasonable to extend the test campaign on all the structural elements of the building under investigation. So, it is necessary to select a suitable number of elements to be tested. The properties of such elements are deemed to be representative of the

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average features of the concrete castings in terms of homogeneity, quality, mechanical resistance and deterioration. In this phase it is necessary to consider different needs, such as avoiding excessive damage to the structures, reducing as much as possible costs and limiting the uncertainty margins of the test data. It should be noted that structures designed to sustain seismic actions generally have seismic resistant frames oriented along the two perpendicular directions, while buildings designed for gravity loads only are often characterized by frames oriented along one single direction. Furthermore, even in seismic prone areas, existing RC buildings may have frames arranged along one single direction and decks that are not sufficiently rigid because they were designed before the seismic classification of the area. Based on these considerations, it can be assumed that the lower storeys are those mainly loaded by both vertical loads and seismic actions. Hence, it is necessary that the concrete used especially in this part of the building respond rigorously to high mechanical resistance standards. Furthermore, among the columns of the first storey, the most loaded by seismic action are generally located at the edge or the corner of the building plan. In particular, those columns that are not included within the infill panel are more prone to develop plastic hinges at the ends, thus promoting the formation of a soft storey mechanism.

In this framework, the selection of the structural elements to be tested is done considering in principle the following issues:

- Technical-operational difficulties. It is advisable to choose elements to be investigated to limit as much as possible the damage that would be caused to the structure by an excessive number of samples and restoration operations. It is important also to reduce the costs of both investigations (number of tests) and restoration (avoid investigating elements that are difficult to access). Moreover, it is appropriate to reduce the uncertainties of the test data by operating with different methods that are comparable to each other (destructive tests are also used to calibrate non-destructive investigations).
- Priority of investigation given to columns rather than beams. Indeed, the formation of plastic hinges in columns may be more dangerous than in beams, as it might lead to the failure of the structure due to a non-dissipative collapse mechanism.
- Level of stress of the structural element. It is advisable that one chooses structural elements with an average level of stress. The stress state of the cross section of such elements has to be verified by a careful analysis of the gravity loads, in case of destructive tests, such as concrete samples to be subjected to compression test, with consequent and inevitable weakening of the resistant members.
- Arrangement of the resistant frames. It is appropriate to select sample structural elements that are located in different spans and storeys. In particular, it is advisable to carry out at least one direct (destructive) test for each floor and at least one indirect (non-destructive) test for each frame span, in order to verify the properties of the structure uniformly in the building structure.
- Plani-volumetric dimensions and presence of rigid cores. In buildings with a limited plani-volumetric development, uniformly distributed structural frame and without RC rigid cores placed in eccentric/edge/corner position, the probability of torsional effects is deemed rather low. Hence, the selection of structural elements to be investigated can be made without special precautions.
- Identification of the reinforcements. It must be carried out on the basis of the original design drawings, for both the longitudinal bars and stirrups. It is fundamental to verify the correspondence between the actual reinforcements in the building and the reinforcements provided by the original design drawings by means of covermeter tests or samples. If the drawings of structural details are missing, as in the case of the examined structure, the information collected in this phase will be used to assist the simulated design of the structure. The correct and accurate execution of these operations is also important to avoid sudden

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modifications to the scheduled investigation program, in fact it avoids unexpected presence of reinforcement bars that would be cut during the extraction of concrete samples.

Since existing RC buildings are particularly prone to collapse due to soft storey mechanisms, especially in case of presence of strong beams and weak columns, the selection of structural members to be tested tends to concentrate on columns rather than beams. Nonetheless, beams will be tested by indirect tests.

To choose which area of the columns should be tested, it should be reminded that cross sections at column ends are characterized by the highest stress states. Hence, the resistance values that can be obtained in such areas could be misrepresentative, as they might be affected by the segregation of the concrete components. Furthermore, the reduction of the resistant cross section due to extraction of samples can cause problems, particularly in cross sections with high tension levels or made with concrete with poor quality. Hence, areas adjacent to the bottom or top parts of the columns will not be taken into consideration. Based on these considerations, the area of column to be tested will be located in an intermediate area of the column height, where the moment is almost zero and concrete is expected to be fairly homogeneous.

Also for the selection of the area of the beam element to be tested, it is necessary to exclude the areas where the stresses are high. However, segregation of concrete components is rather negligible in beams, except for the base of the beam itself. For the sake of simplicity of operation, deep beams will be chosen for tests and any coring will be carried out on the side of the beam, possibly at about 1/5 of the span length. Furthermore, to avoid cutting of the reinforcing bars, the areas to be investigated will be located close to the neutral axis. In any case, a careful preliminary covermeter investigation is needed, since in these areas deformed shear reinforcement bars might be found.

During investigations, it may be necessary to update the test program due to unexpected and unforeseeable events, which may prevent or interrupt the execution of one or more investigations (such as the presence of downspouts included in the pillars, reinforcements not detectable by the instrument, system channels in the structural elements). For this reason, the preliminary program should select a larger number of structural elements to be tested than the actual one.

5.2.3 Methodology of structural investigations

Structural investigations are mainly classified into two types of tests: destructive and non-destructive tests. All types of structural tests follow the prescriptions provided by specific UNI codes and for the building here investigated the following tests were planned:

- Steel bars extraction and uniaxial tension test (Section 5.2.3.1)
- Covermeter tests (Section 5.2.3.2)
- Ultrasonic and sclerometer tests processed by SONREB method (Section 5.2.3.3)
- Coring of concrete and compression test (Section 5.2.3.4)
- Endoscopic investigation (Section 5.2.3.5)

Before each destructive test (coring of concrete or extraction of reinforcing bar samples) a preliminary covermeter test must be done of the relevant area. Once the sample has been extracted, it is advisable to promptly restore the section by adding suitable materials. Indeed, the restoration of the original cross section is of great importance to avoid the increase of stress on the structural elements.

Also for SONREB test, a preliminary covermeter test is needed, because the SONREB test could be altered by the presence of rebars. Furthermore, the area investigation is indicated on the surface of the element to allow the preliminary removal of the coating (plaster, etc).

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5.2.3.1 Steel bars extraction and uniaxial tension test

The extraction of steel bars (Figure 66) requires pulling out a sample of reinforcement bars from the selected elements in the examined structures. The goal of this test is to define the state of conservation of the reinforcement bars and the tensile strength of steels by subsequent laboratory tests (UNI EN ISO 6892-1:2020 [22], UNI EN ISO 15630-1:2019 [23]).

In the preliminary phase, the external layer of concrete and part of the concrete itself (the so-called cover) are removed. The picking of the concrete continues until the bar is reached. The reinforcement bar is thus exposed for a length of about 50 cm. Before removing the sample, the reinforcement bar is first replaced by overlapping and welding a reinforcing bar having at least the same diameter. Subsequently, the bar is removed to be subjected to laboratory tests (Figure 66). Afterwards, restoration operations are conducted to refurbish the concrete layer, usually by means of specific types of mortar for the restoration of concrete (rheoplastic, thixotropic, with controlled shrinkage and fibre-reinforced).

Once the steel samples are pulled out, they are subjected to tensile tests at an Official Material Testing Laboratories, to determine the steel yielding strength, the ultimate tensile strength and the maximum deformation capacity. In addition to this data, the steel samples are analysed to determine the type of steel used (plain or deformed rebar) and the weldability of the material.

5.2.3.2 Covermeter test

The covermeter tests (Figure 67) aim at the identification of the steel reinforcements embedded in the structural elements (BS 1881:204 [24]). In particular, the main goal of this test is to determine the presence and the diameter of steel bars and the steps within two consecutive bars. To this end, a magnetic detector of ferrous metals is used, whose measurements are based on the damping of a resonant circuit in parallel. An alternating current with a fixed and constant frequency flows through the probe coil creating a magnetic field. The shape of the probe ensures that the magnetic field stretched along the axis of the probe is distributed on the plane; the possible presence of metal objects in the area of influence alters the voltage of the coil. This alteration occurs according to a diameter-coverage ratio of the identified metal object and its value is obtained through the analogic indicator of the instrument.

Figure 66: Extraction of steel bars and steel sample.

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Figure 67: Covermeter test.

The operator observes the maximum deviation of the device, which indicates the location of the centre line of the intercepted reinforcement bar. The thickness of the concrete cover can be read in mm once the diameter of the bar is known. If the diameter is not known, it is possible to estimate quite accurately both the depth and the diameter of the bar by carrying out a series of tests at an increasing distance, interposing between the probe and the investigated element some tablets of known thickness and evaluating the consequent variation of the outcome results. Once the arrangement of the reinforcing bars is detected, the location of the reinforcement bars on the element itself is drawn by means of chalks or other. This operation must be performed, where required, on both faces, highlighting both the longitudinal bars and the stirrups.

5.2.3.3 SONREB method

The SONREB (SONic + REBound) method combines two non-destructive tests to determine the mechanical characteristics of the concrete of the examined structure. In particular, the method involves the combination of the results obtained from the ultrasonic test and sclerometer (also known as Schmidt hammer) test carried out on the same concrete element (Figure 68). The equipment used to carry out the test is composed by a digital hammer and an ultrasound device with transducers. The concrete strength R_c was estimated by means of equations that were specifically calibrated on experimental correlations between the following two parameters: propagation velocity of the ultrasound (VL) and rebound index (I).

Figure 68: SONREB method: (a) sclerometer (Schmidt hammer) and (b) ultrasonic tests.

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The effectiveness of the SONREB test stems from the complementary features of the two non-destructive tests that are involved. In fact, the humidity rate of concrete leads to an underestimated evaluation of the sclerometer index and an overestimated estimation of the velocity of the ultrasonic waves. On the contrary, with the increase of the age of the concrete, the sclerometer index increases and the ultrasonic velocity decreases.

When possible, the strength of the concrete obtained from the SONREB test is calibrated by means of destructive compression tests carried out on concrete cores extracted from the structure. The combination with the destructive test enhances considerably the accuracy of the estimate of the concrete strength. Alternatively, it is possible to use the correlations already available in literature. Preliminary to the conduction of the test, it is necessary to remove the coating (tiles, plaster, or other material placed to cover the structural element), by means of a chisel and hammer, up to the external layer of concrete (trying to leave the external concrete surface as undisturbed as possible).

For each sclerometer test, at least 12 measurements were carried out following the directives of the UNI EN 12504 [25].

5.2.3.4 Coring of concrete and compression test

The coring of the concrete (Figure 69) aims at the evaluation of the mechanical resistance of concrete by compression test conducted in the laboratory on the extracted cylindrical samples (UNI EN 12390-3 [26]). It is necessary to identify two survey areas: the first area is located within the quadrant between two consecutive stirrups and is placed at a height from the ground equal to half of the height of the column.

Figure 69 Execution of concrete coring by means of core barrel.

The second area must be inside the quadrant immediately above or below the first quadrant and in line with the previous one. It is advisable to avoid where possible eccentric cores. If the size of the structural element and the arrangement of the reinforcing bars require a second test, the second survey area can be identified within the same stirrup step of the first area. The extracted core will be marked immediately after the extraction with a marker and photographed next to the extraction hole. Transport must be carried out with the utmost caution to avoid the formation of cracks due to inflections or vibrations, protecting the core with suitable products (polystyrene balls) and placing it in rigid transport boxes. Cores will be cut and ground at an official Material Testing Laboratory.

After the extraction of concrete cores for laboratory tests, the RC structure is restored by saturating the generated cavity with mortar specifically for the restoration of concrete (rheoplastic, thixotropic, controlled shrinkage and fibre-reinforced).

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Figure 70 Execution of uniaxial compression test.

The mechanical tests conducted in laboratory on the extracted concrete samples [25] are uniaxial compression tests (Figure 70). To properly evaluate the concrete strength, it is necessary to consider the disturbance occurred during the sampling phase, according to consolidated techniques reported in literature and international standards.

5.2.3.4 Endoscopic investigation

The investigations carried out using moderately destructive samples and endoscopic investigations allow to reconstruct the knowledge of the geometry, structural morphology and construction features (materials, stratigraphy and textures) of the building. In particular, endoscopic investigation (Figure 71) is a visual inspection technique obtained by introducing a probe into an existing or specifically made hole with small diameter. The investigation exploits the property of optical fibres to transport light through subsequent reflections inside themselves. Indeed, the endoscope is made up of two bundles of fibres, one that illuminates the area under examination and the other that brings the image to the system display (the screen). The endoscope is also equipped with an optical channel that permits the view of the explored cavity through an eyepiece. By means of a high-resolution CCD sensor, the image is reproduced on a properly connected monitor and saved in memory.

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Figure 71: Execution of endoscopic test

5.3 Results of the experimental investigation

5.3.1 Survey plan

The experimental investigation was conducted by GEOservice, a company operating in the field of structural diagnostics and subcontracted by partner IACP. The following tests were executed for each storey of the building under investigation.

Foundation: Surveys on structural members of foundation are subordinated to the accessibility of the area. The survey plan includes 2 concrete cores, 1 extraction of steel bar, 8 covermeter tests, 2 SONREB tests, 1 inspection dowel and 1 exploratory sample (Figure 72.a).

Raised ground floor (slab above the foundation): The survey plan provides for the raised ground floor the following tests: 1 coring of concrete in column (column 1) and 1 coring of concrete in beam (beam 15-20); 1 extraction of steel bar in column (column 2) and 1 extraction of steel bar in beam (beam 27-26) ; 7 covermeter tests on columns (columns 10, 20, 25, 27, 8, 24, 13) and 6 covermeter test on beams (beams 2-5, 5-9, 9-14, 25-27,17-21, 17-18) (Figure 72.b). Further non-destructive tests are included. Particularly: SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

First floor (slab above the 1st floor): The survey plan provides the following tests: 1 coring of concrete in column (column 3) and 1 coring of concrete in beam (beam 12-13); 1 extraction of steel bar in column (column 27) and 1 extraction of steel bar in beam (beam 17-18); 7 v tests on columns (columns 10, 20, 5, 1, 8, 21, 26) and 5 covermeter test on beams (beams 2-5, 9-14, 14-19,25-27,11-16) (Figure 73.a). Further non-destructive tests are included. Particularly: SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

Second floor (slab above the 2nd floor): The survey plan provides the following tests: 1 coring of concrete in column (column 19) and 1 coring of concrete in beam (beam 25-27); 1 extraction of steel bar in column (column 25) and 1 extraction of steel bar in beam (beam 1-2); 7 covermeter tests on columns (columns 20, 28, 2, 5, 12, 24, 26) and 5 covermeter test on beams (beams 5-9, 9-14, 14-19, 19-25, 13-18), 1 endoscopic investigation on slab (Figure 73.b). Further non-destructive tests are included. Particularly: SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

Third floor (slab above the 3rd floor): The survey plan provides the following tests: 1 coring of concrete in column (column 26) and 1 coring of concrete in beam (beam 4-8); 1 extraction of steel

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bar in column (column 21) and 1 extraction of steel bar in beam (beam 15-20); 7 covermeter tests on columns (columns 10, 3, 28, 2, 5, 9, 4) and 5 covermeter test on beams (beams 2-5, 14-19, 19-25, 25-27, 12-13) (Figure 74.a). Further non-destructive tests are included. Particularly: SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

Fourth floor (slab above the 4th floor): The survey plan provides the following tests: 1 coring of concrete in column (column 28) and 1 coring of concrete in beam (beam 1-2); 1 extraction of steel bar in column (column 21) and 1 extraction of steel bar in beam (beam 13-18); 8 covermeter tests on columns (columns 3, 7, 15, 23, 9, 27, 24, 11) and 5 covermeter test on beams (beams 2-5, 5-9, 14-19, 19-25, 12-13) (Figure 74.b). Further non-destructive tests are included. In particular, SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

Fifth floor (slab above the 5th floor/roof slab): The survey plan provides the following tests: 1 coring of concrete in column (column 18) and 1 coring of concrete in beam (beam 17-18); 1 extraction of steel bar in column (column 15) and 1 extraction of steel bar in beam (beam 20-23); 7 covermeter tests on columns (columns 10, 23, 2, 5, 14, 8, 21) and 5 covermeter test on beams (beams 5-9, 9-14, 14-19, 25-27,11-16), 1 endoscopic test on slab (Figure 75). Further non-destructive tests are included. Particularly: SONREB tests on columns and beams and inspection dowels to verify the exact geometry and location of steel reinforcement bars and stirrups.

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Cp Concrete coring on column	Ep Steel bar extraction –column	Mp Pacometry - column	E Endoscopic investigation
Ct Concrete coring on beam	Et Steel bar extraction –beam	Mt Pacometry - beam	

(a)

(b)

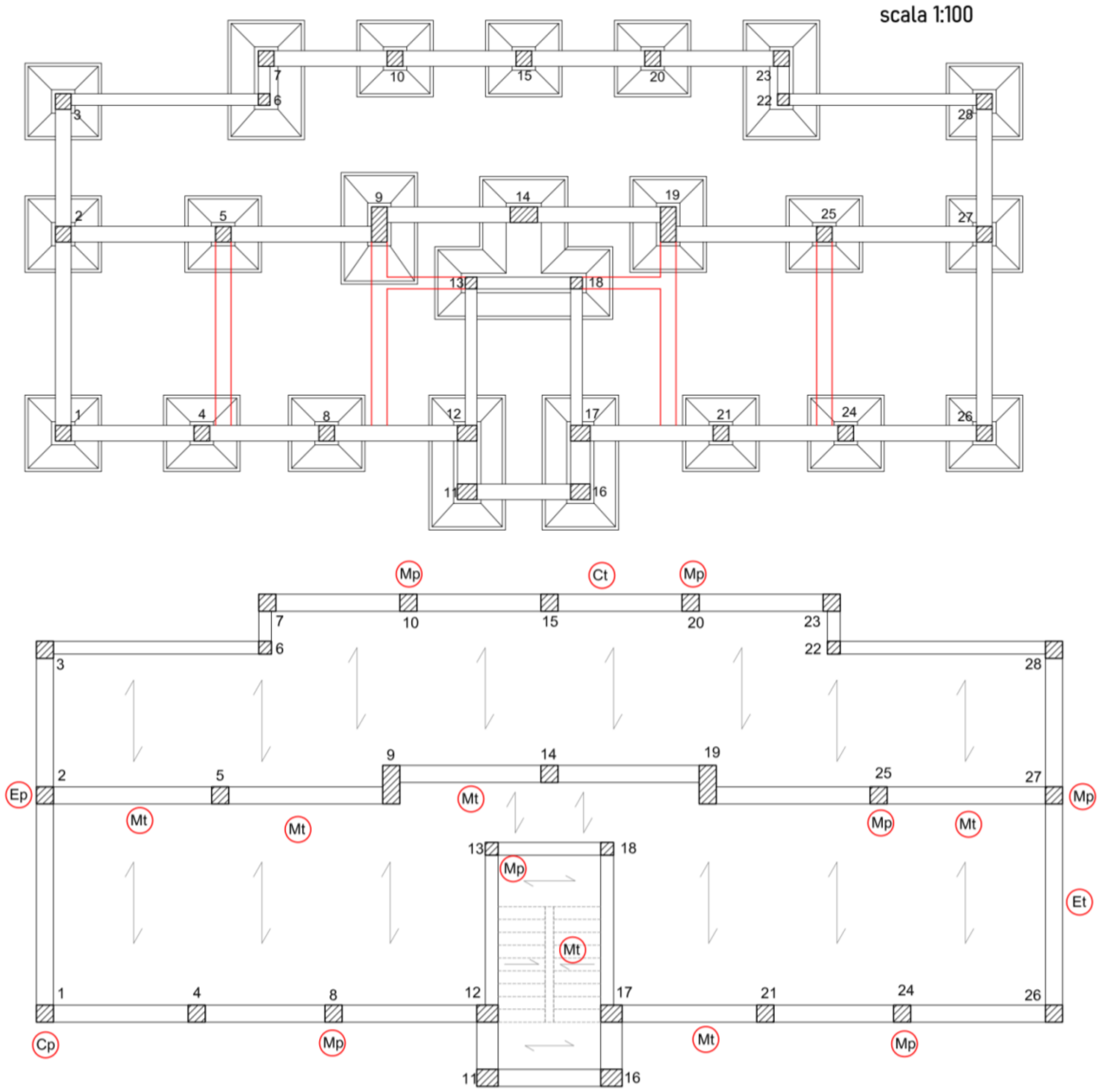

Figure 72: Survey plan – (a) Foundation, (b) Raised ground floor.

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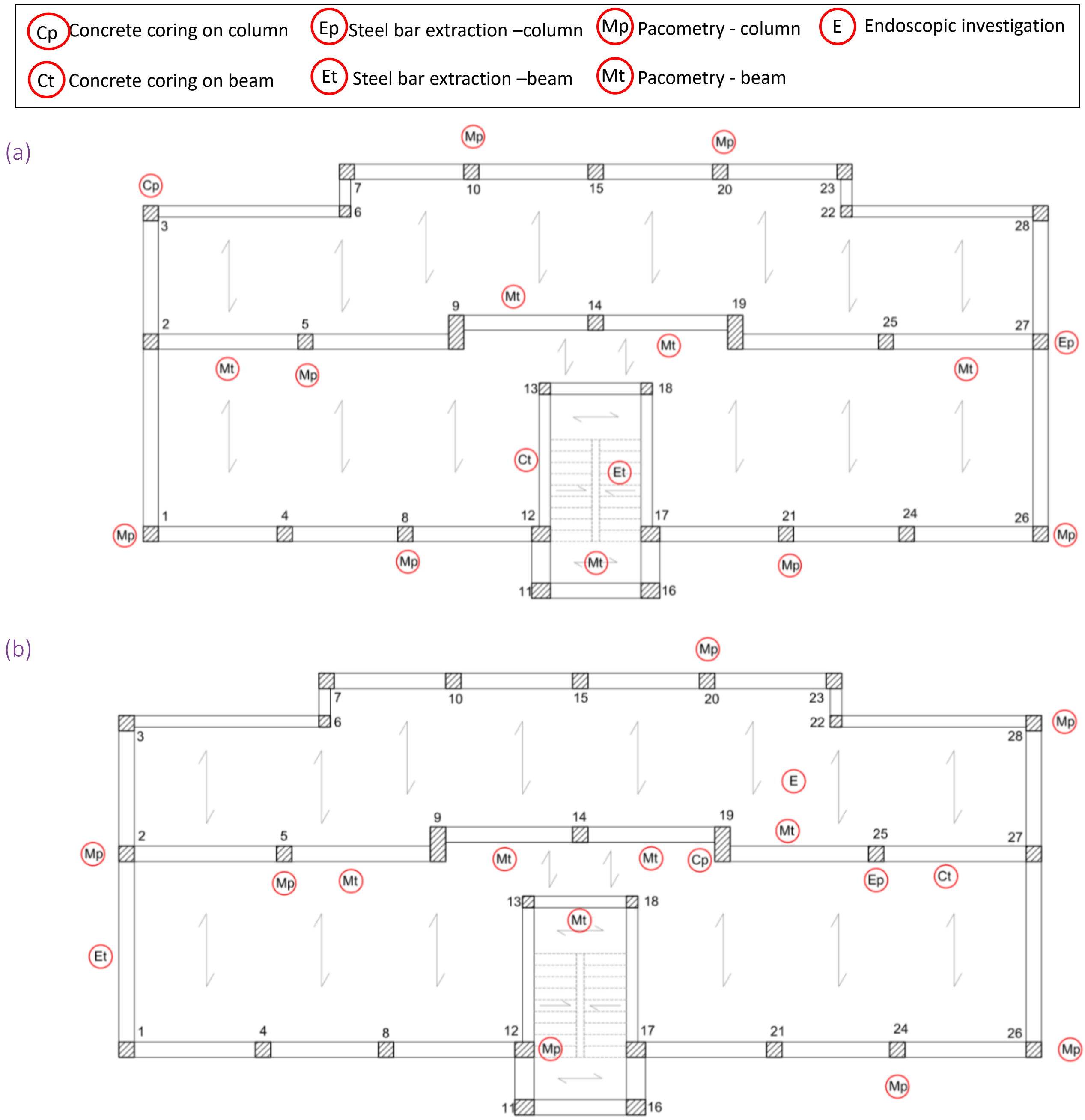

Figure 73: Survey plan – (a) First Floor, (b) Second floor.

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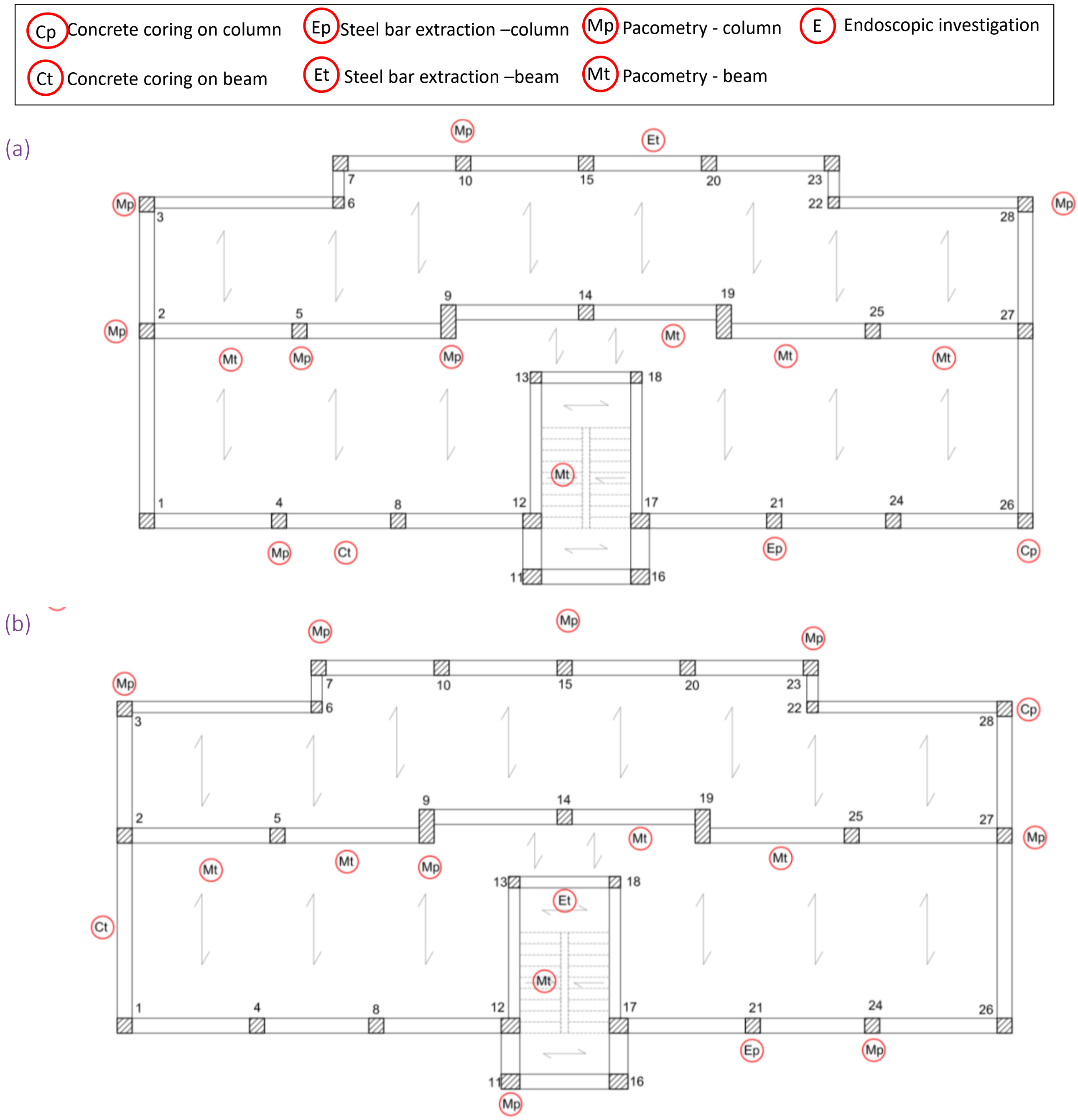

Figure 74: Survey plan – (a) Third Floor, (b) Fourth floor.

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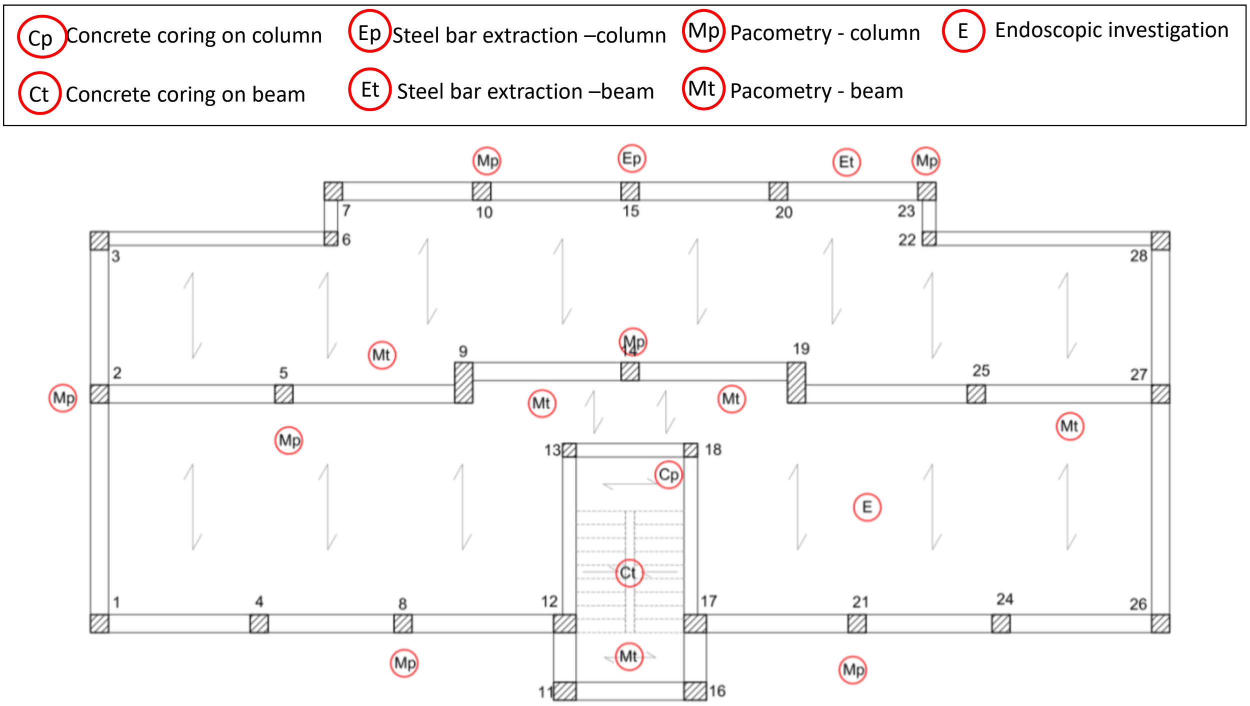

Figure 75: Survey plan – Fifth floor.

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5.3.2 Construction details of the structure

From the analysis of the results provided by covermeter tests (also called pacometry), it is possible to determine the location of steel reinforcement bars, their diameter and concrete cover. Table 25 and Table 26 summarise for each investigated member the number of longitudinal bars detected, their diameter (ϕ_L) and cover thickness, the diameters of the stirrups (ϕ_{ST}) and their spacing (s). As a general consideration, it emerges that a very small diameter (8 mm) is used for almost all the rebars in the beams, and sometimes also for columns.

The two endoscopic investigations also allowed the definition of type and thickness of two slabs. A mixed slab with hollow clay block and concrete (total thickness 20 cm) is found at the 5th floor. Instead, the one of the basement is a concrete slab 15 cm thick.

Table 25: Details of the rebars in the beams.

ID TEST	FLOOR	N. OF REBARS	ϕ_L (mm)	COVER (mm)	ϕ_{ST} (mm)	s1 (cm)	s2 (cm)	s3 (cm)	s4 (cm)
M06	Foundation	2	8	33	8	20	23	24	23
M07	Foundation	2	8	33	8	23	22	24	24
M08	Foundation	2	8	32	8	23	22	22	22
M16	Basement	2	10	33	8	22	22	24	20
M17	Basement	2	10	38	8	22	23	23	24
M18	Basement	2	10	33	8	24	22	23	23
M19	Basement	2	10	36	8	23	23	21	20
M20	Basement	2	10	31	8	21	22	23	21
M28	1st	2	8	33	8	22	22	21	21
M29	1st	2	8	34	8	24	22	24	23
M30	1st	2	8	33	8	23	23	22	24
M31	1st	2	8	34	8	23	23	22	22
M32	1st	2	8	36	8	23	22	21	20
M40	2nd	2	8	37	8	23	23	23	21
M41	2nd	2	8	33	8	21	20	24	20
M42	2nd	2	8	32	8	21	22	21	23
M43	2nd	2	8	33	8	22	22	21	22
M44	2nd	2	8	37	8	23	23	20	20
M52	3rd	2	8	36	8	20	22	21	21
M53	3rd	2	8	33	8	23	24	24	20
M54	3rd	2	8	33	8	23	23	20	21
M55	3rd	2	8	38	8	22	22	23	24
M56	3rd	2	8	32	8	22	21	21	24
M64	4th	2	8	33	8	22	22	21	21
M65	4th	2	8	34	8	22	24	21	24
M66	4th	2	8	30	8	23	23	22	24
M67	4th	2	8	32	8	23	20	20	20
M68	4th	2	8	33	8	22	23	23	21
M76	5th	2	8	33	8	23	22	21	23
M77	5th	2	8	38	8	21	21	21	23
M78	5th	2	8	39	8	20	22	22	23
M79	5th	2	8	34	8	24	20	21	20
M80	5th	2	8	36	8	23	23	20	21

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Table 26: Details of the rebars in the columns.

ID TEST	FLOOR	N. OF REBARS	ϕ_L (mm)	COVER (mm)	ϕ_{ST} (mm)	s1 (cm)	s2 (cm)	s3 (cm)	S4 (cm)
M01	Basement	2	14	35	8	18	20	18	-
M02	Basement	2	14	35	8	19	19	20	-
M03	Basement	2	14	35	8	18	20	20	-
M04	Basement	2	14	35	8	20	19	18	-
M05	Basement	2	14	35	8	19	19	20	-
M09	--	2	14	39	8	18	18	18	-
M10	--	2	14	36	8	21	20	18	-
M11	--	2	14	35	8	21	19	19	-
M12	--	2	14	30	8	18	19	19	-
M13	--	2	14	37	8	19	19	18	-
M14	--	2	14	37	8	18	18	19	-
M15	--	2	14	39	8	19	20	18	-
M21	1st	2	14	35	8	21	20	20	-
M22	1st	2	14	34	8	18	19	18	-
M23	1st	2	14	31	8	18	20	20	-
M24	1st	2	14	32	8	19	18	19	-
M25	1st	2	14	38	8	21	21	20	-
M26	1st	2	14	35	8	19	19	18	-
M27	1st	2	14	36	8	19	18	19	-
M33	2nd	2	14	35	8	19	19	18	-
M34	2nd	2	14	35	8	18	19	21	-
M35	2nd	2	14	37	8	20	20	19	-
M36	2nd	2	14	38	8	18	18	19	-
M37	2nd	2	14	32	8	19	19	20	-
M38	2nd	2	14	37	8	19	18	19	-
M39	2nd	2	14	38	8	20	18	18	-
M45	3rd	2	14	38	8	18	19	20	-
M46	3rd	2	14	35	8	20	19	19	-
M47	3rd	2	14	31	8	19	21	18	-
M48	3rd	2	14	33	8	18	20	18	-
M49	3rd	2	14	33	8	20	19	18	-
M50	3rd	2	14	35	8	19	18	21	-
M51	3th	2	14	34	8	20	18	18	-
M57	4th	2	14	30	8	18	21	18	-
M58	4th	2	14	31	8	18	20	20	-
M59	4th	2	14	32	8	20	28	18	-
M60	4th	2	14	34	8	19	21	19	-
M61	4th	2	14	35	8	18	19	18	-
M62	4th	2	14	37	8	20	19	19	-
M63	4th	2	14	38	8	20	20	18	-
M69	5th	2	8	35	8	19	20	18	-
M70	5th	2	8	39	8	18	19	19	-
M71	5th	2	8	32	8	20	18	18	-
M72	5th	2	8	34	8	19	19	20	-
M73	5th	2	8	35	8	18	18	19	-
M74	5th	2	8	37	8	19	18	19	-
M75	5th	2	8	38	8	19	20	19	-

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5.3.3 Mechanical properties

5.3.3.1 Steel properties

Yield (f_y) and ultimate (f_u) strength and of the rebars were determined by uniaxial tension tests on the 13 samples extracted from the structure. The results of the tests are reported in Table 27 together with diameter (ϕ) and type of the rebar. The results are quite homogenous: the mean values are f_y = 371.07 MPa and f_u = 530.37 MPa, respectively. The scatter of the two distributions of values is negligible.

Table 27: Steel properties determined by uniaxial tension tests.

ID TEST	MEMBER	FLOOR/STOREY	ϕ (mm)	TYPE	FY (MPa)	FU (MPa)
A01	Beam	1st	10	Plain	370.26	532.88
A02	Column	1st	14	Plain	374.83	530.50
A03	Column	1st	8	Plain	375.43	536.28
A04	Column	1st	14	Plain	365.10	522.16
A05	Beam	3rd	8	Plain	370.07	527.43
A06	Column	3rd	14	Plain	370.95	522.59
A07	Beam	2nd	8	Plain	372.14	528.96
A08	Column	2nd	14	Plain	367.39	520.48
A09	Foundation	Foundation	8	Plain	383.51	548.48
A10	Beam	4th	8	Plain	373.30	531.65
A11	Column	4th	14	Plain	370.35	525.73
A12	Column	5th	8	Plain	356.27	533.37
A13	Beam	5th	8	Plain	374.30	534.27
				MEAN VALUES	**371.07**	**530.37**

5.3.3.2 Concrete properties

The concrete compressive strength has been investigated by compression tests executed on the 14 cylindrical cores extracted from the RC structure. A cylindrical sample with height-diameter ratio H/D = 1 is obtained and tested for each core. Table 28 reports for each test, diameter (D) and height (H) of the sample, specific weight (γ_c) and compressive strength (R_c).

Table 28: Compressive strength of concrete determined by compression test.

ID TEST	MEMBER	FLOOR/STOREY	H (mm)	D (mm)	RC (MPa)	FC (MPa)	HC (mm)
C01	Column	1st	94.2	94	24.44	20.29	32
C02	Beam	1st	94.3	94	30.17	25.04	52
C03	Column	1st	94.1	94	31.09	25.80	--
C04	Beam	1st	94.4	94	26.10	21.66	--
C05	Column	3rd	94.1	94	25.17	20.89	--
C06	Beam	3rd	94.2	94	22.67	18.82	67
C07	Column	2nd	94.5	94	24.27	20.14	--
C08	Beam	2nd	94.3	94	26.99	22.40	30
C09	Foundation	Basement	94.4	94	31.19	25.89	--
C10	Column	Basement	94.4	94	25.25	20.96	22
C11	Beam	4th	94.2	94	33.21	27.56	--
C12	Column	4th	94.1	94	21.78	18.08	--
C13	Column	5th	94.3	94	27.20	22.58	21
C14	Beam	5th	94.2	94	25.97	21.56	35
				MEAN VALUES	**26.82**	**22.26**	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

Since compression tests are executed on samples with H/D = 1, the measured strength is representative of the cubic compressive strength, while the corresponding cylindrical compressive strength (f_c) is determined according to NTC18 [17] by the following relation:

$$f_c = 0.83\ R_c \tag{7}$$

For some cores, the carbonation depth (h_C) of the concrete core was determined. Table 28 resumes also the values of R_c and f_c, as well as h_C when available.

A total number of 20 sclerometer plus 20 associated ultrasonic tests were executed in an non-destructive way for the evaluation of the concrete compressive strength by the SONREB method. The calculation of the compressive strength was done also for 4 members for which compression tests were available. The results of these compression tests are used to calibrate the SONREB method. Table 29 reports the values of compressive strength determined by compression test and SONREB method and the ratio between the two values. On average, the actual compressive strength determined by compression test is 36.9% larger than the one returned by SONREB test. Hence, all the results of the SONREB tests are updated according to this ratio and summarised in Table 30, which reports for each test the mean rebound index determined by the sclerometer test (I_m), the propagation velocity of the ultrasound waves determined by the associated ultrasonic test (VL), the related cubic compressive strength of concrete $R_{c,SRB}$ estimated by the SONREB method and $f_{c,SRB}$ calculated from R_c by Eq. (7) and, finally, the updated values of R_c and f_c.

The mean value of the concrete cylindrical compressive strength calculated considering both the values obtained by compression test and SONREB method is 20.1 MPa. This value is rather lower that that expected. Indeed, considering the time of construction of the building, it was expected a C20/25 concrete with characteristic and mean values of fc equal to 20 and 28, respectively. Furthermore, the distribution of values of fc is very scattered and ranges from a minimum of 14.72 MPa to a maximum of 27.56 MPa.

Table 29: Calibration of the SONREB method.

COMPRESSION TEST			SONREB METHOD			COMPRESSION TEST-SONREB RATIO
ID TEST	RC (MPa)	FC (MPa)	ID TEST	RC,SRB (MPa)	FC,SRB (MPa)	
C01	24.44	20.29	S19	15.75	13.07	1.552
C09	31.19	25.89	S20	23.62	19.60	1.320
C13	27.20	22.58	S02	21.42	17.78	1.270
C14	25.97	21.56	S01	19.44	16.14	1.336
					AVERAGE RATIO	**1.369**

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

Table 30: Compressive strength of concrete determined by SONREB method.

ID TEST	MEMBER	FLOOR/STOREY	IRM	VS (m/s)	RC,SRB (MPa)	FC,SRB (MPa)	RC (MPa)	FC (MPa)
S01	Beam	5th	31	3560	19.44	16.14	26.62	22.10
S02	Column	5th	31	3695	21.42	17.78	29.33	24.35
S03	Column	4th	31	3237	15.18	12.60	20.79	17.26
S04	Beam	4th	33	3509	20.44	16.97	27.99	23.24
S05	Column	4th	31	3201	14.75	12.24	20.20	16.76
S06	Beam	4th	33	3507	20.41	16.94	27.95	23.20
S07	Column	3rd	31	3265	15.53	12.89	21.27	17.65
S08	Beam	3rd	33	3310	17.56	14.57	24.05	19.95
S09	Column	3rd	31	3210	14.86	12.33	20.35	16.89
S10	Beam	3rd	33	3205	16.15	13.40	22.12	18.35
S11	Column	2nd	32	3101	14.20	11.79	19.45	16.15
S12	Beam	2nd	31	3200	14.74	12.23	20.19	16.75
S13	Column	2nd	33	3280	17.15	14.23	23.49	19.49
S14	Column	2nd	31	3251	15.35	12.74	21.02	17.45
S15	Beam	2nd	33	3220	16.35	13.57	22.39	18.58
S16	Column	2nd	33	3205	16.15	13.40	22.12	18.35
S17	Column	1st	31	3150	14.14	11.74	19.36	16.08
S18	Beam	1st	31	3045	12.95	10.75	17.73	14.72
S19	Column	1st	32	3227	15.75	13.07	21.57	17.90
S20	Beam	1st	33	3710	23.62	19.60	32.35	26.84
						MEAN VALUES	**23.02**	**19.10**

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

6. CONCLUSION: CRITICAL ISSUES

This Deliverable describes the results of a multi-disciplinary survey of the pilot building located in Catania that will be renovated during the demonstration activities of the **e**-SAFE project. The document highlights the different features of the building in its current state, including architectural issues, geometric issues, construction and energy issues, and structural issues

As a conclusion to this Deliverable, it is then useful to underline the main criticalities emerging from the survey, that is to say those delicate issues that must be attentively considered (and possibly overcome) during the design stage.

- Thermal bridges: they currently contribute significantly to the heat losses in the pilot building (21% of the total for the entire building). Hence, the **e-**SAFE renovation solutions must be able to correct thermal bridges. While this is not a difficult task for some thermal bridge typologies (wall-pillar, wall-slab), the correction of other typologies is a particularly complex task: for instance, this is the case of the balconies and the parapets/overhangs at the top floor. Detailed 2D simulations are needed during the design stage to assess the impact of these thermal bridges in the renovated building, and to provide suitable technical solutions.
- Thermal systems: no apartment is equipped with a heating and cooling system able to ensure thermal comfort in the entire dwelling. Some residents have installed one or two old split units, mainly used for air conditioning purposes, while heating is provided mainly through portable gas stoves. The few split units detected during the surveys are thus used seldom; some of them are even out-of-order. Thermal comfort in the apartments is not satisfactory.
- "Verandas" need to be removed before installing **e-**SAFE façade components (**e-**CLT and **e-**PANEL).
- The RC structural elements have mechanical characteristics that on average are below the limit imposed by law at the time of their construction (1906s).
- All the apartments are crossed, along their main direction, by a RC beam. This may pose some difficulties in connecting the two "halves" of the apartment with a single distribution pipe, in case the pipe has to be placed in the ceiling. Placing internal distribution pipes inside the floor is not recommended, since this would mean disruption for the residents.
- Pipes and cables attached to the outer walls, that need to be removed or relocated.
- Roof and PV modules: the roof is suitable for placing the PV modules that are envisaged in the **e-**THERM concept. However, the parapets and the stairwell enclosure are possible shading objects, meaning that the PV modules must be conveniently installed through an elevated supporting structure.

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ACKNOWLEDGEMENTS

This deliverable was carried out in the framework of the *Energy and seismic affordable renovation solutions* (**e-**SAFE) project, which has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

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[24] BS 1881:204

[25] UNI EN 12504

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[26] UNI EN 12390-3

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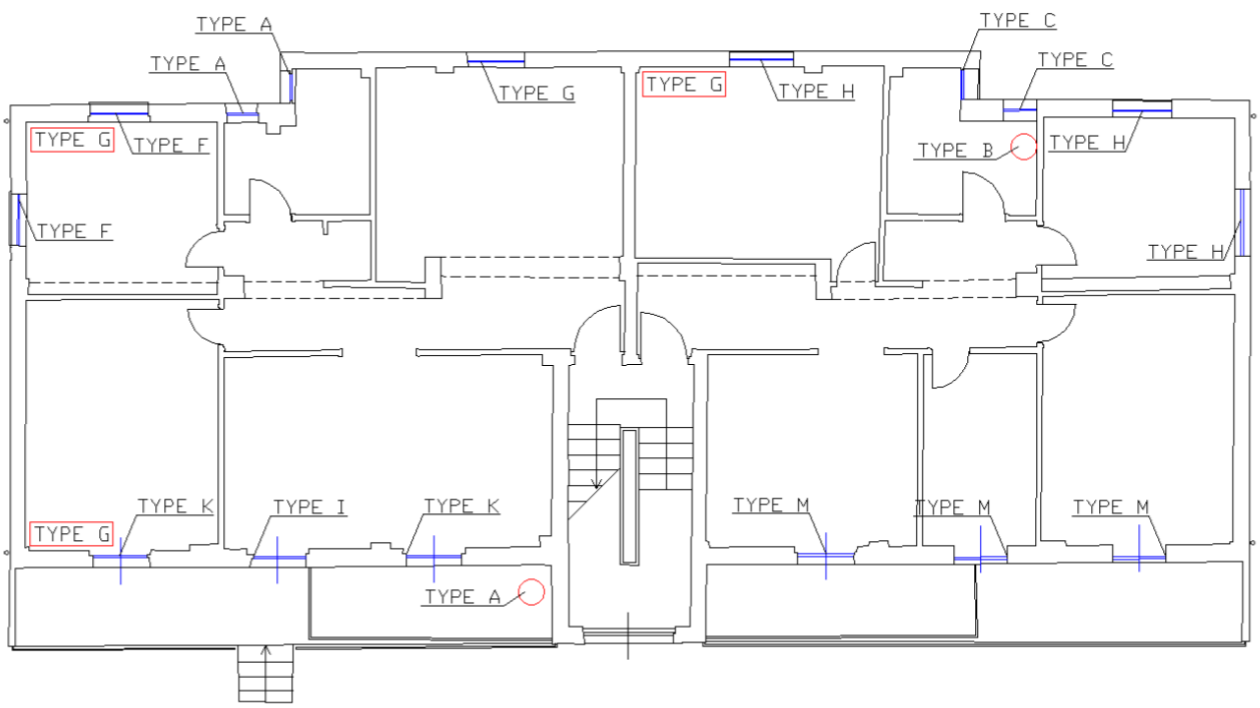
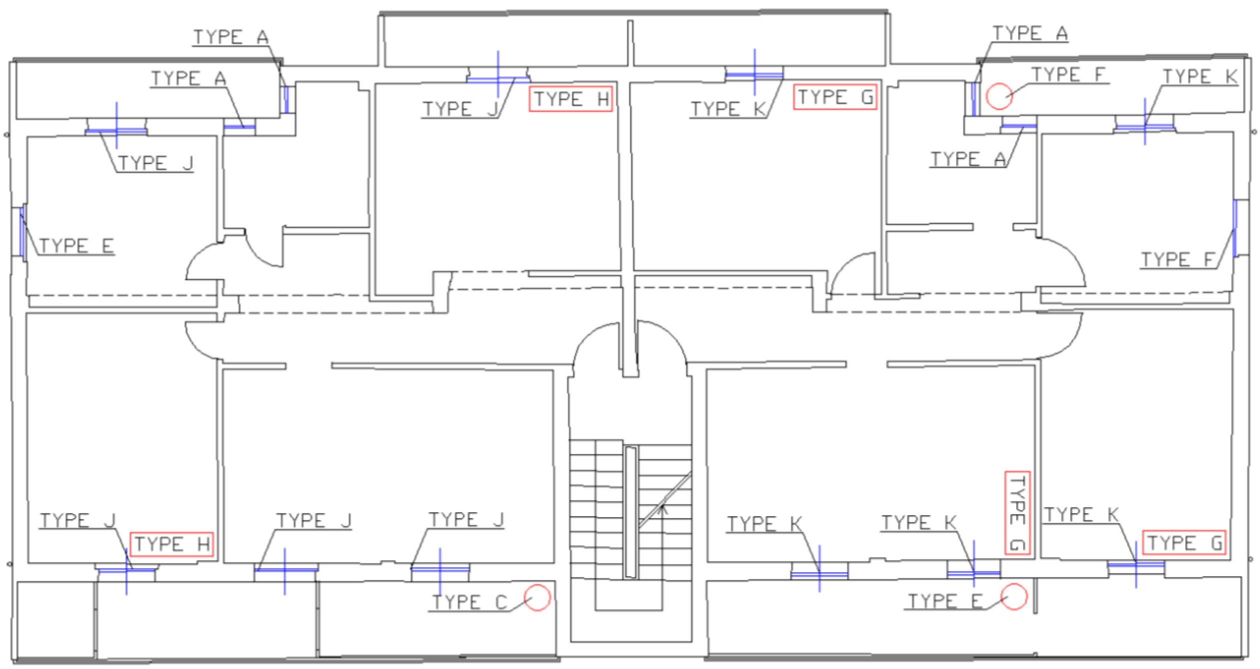
APPENDIX 1: LOCALIZATION OF EXISTING MECHANICAL SYSTEMS AND FIXTURE TYPES

Ground floor (1st floor)

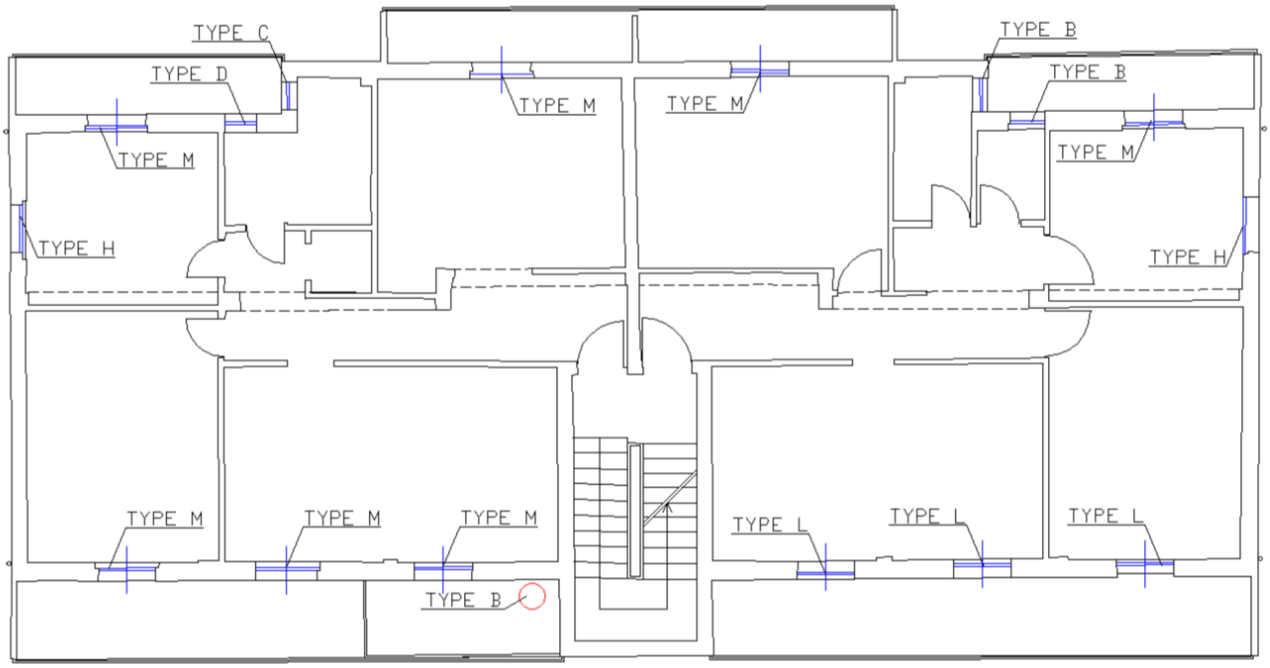


Second floor

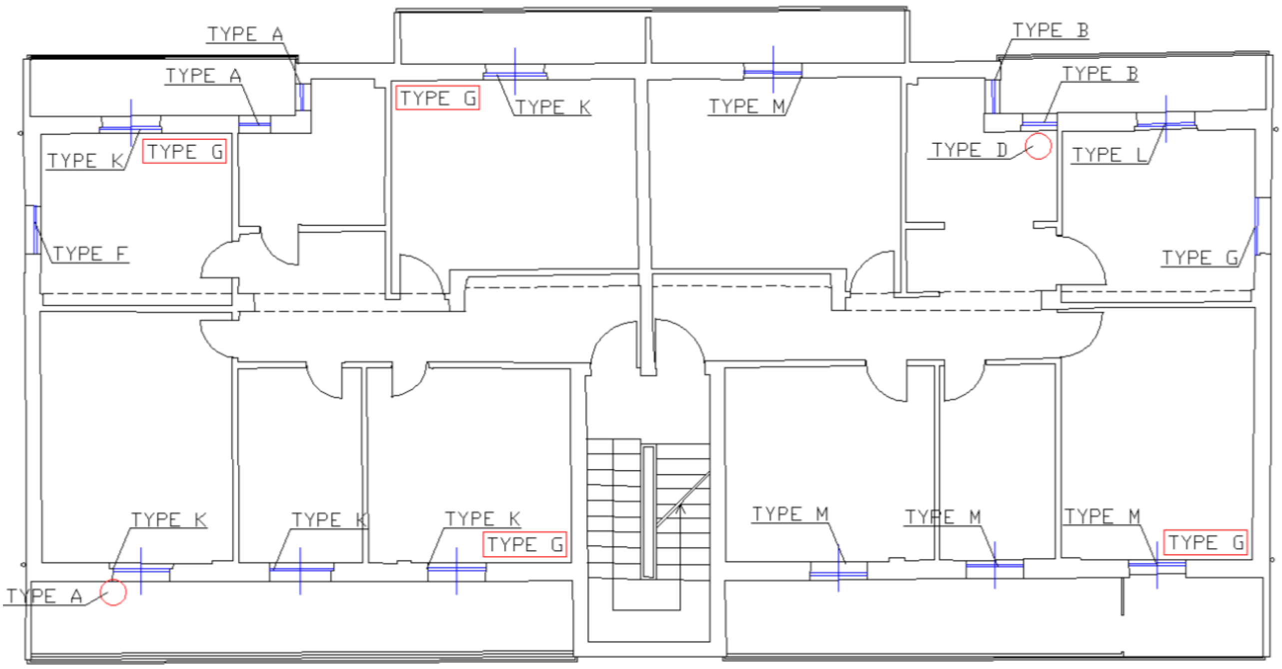


e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

Third floor

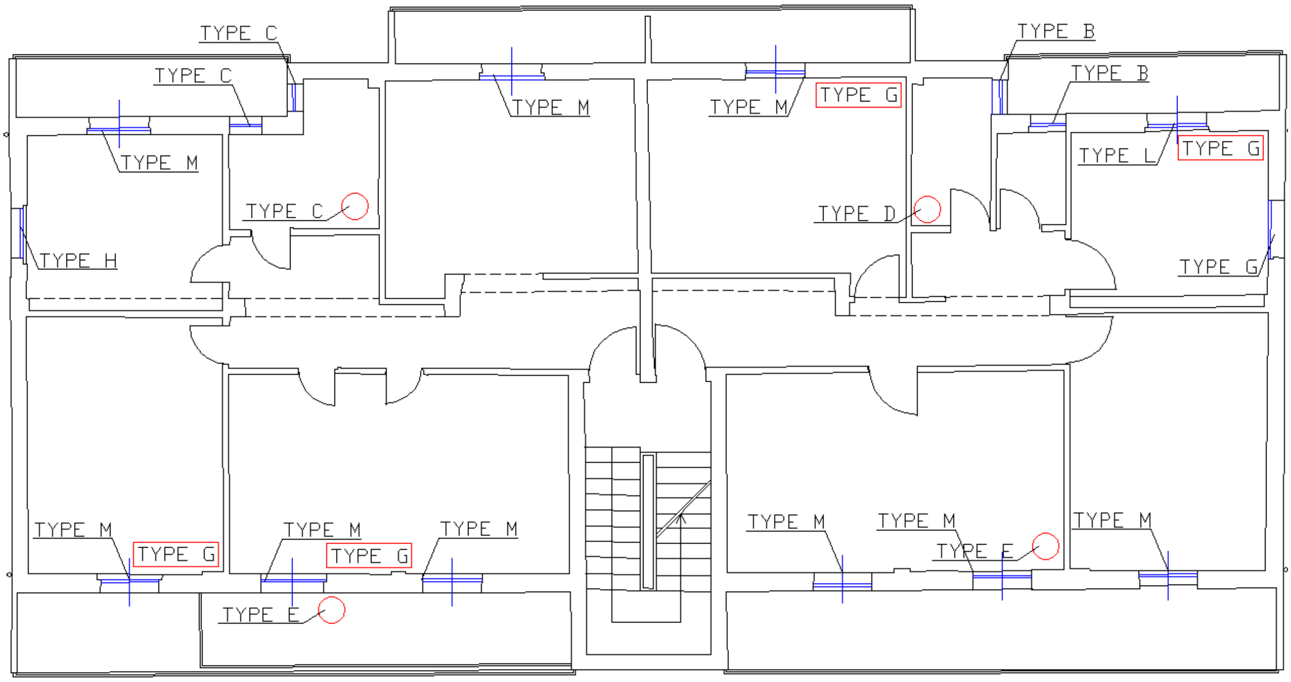


Fourth floor



e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

Top floor (5th floor)



e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

APPENDIX 2: ENERGY PERFORMANCE CERTIFICATES

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 1L

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia
Comune:	CATANIA
Indirizzo:	via Acquicella Porto, 27, n.
Piano:	
Interno:	
Coordinate GIS:	

Zona climatica:	B
Anno di costruzione:	1964
Superficie utile riscaldata (m^2):	94,00
Superficie utile raffrescata (m^2):	0,00
Volume lordo riscaldato (m^3):	352,00
Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni							

Servizi energetici presenti

- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

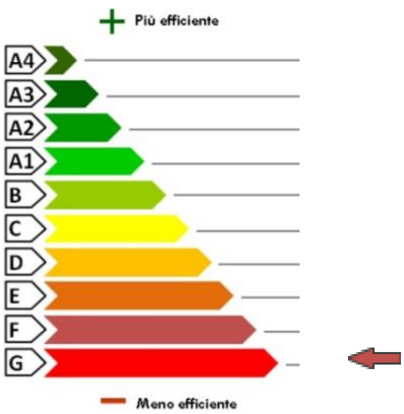
PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

L

Prestazione energetica del fabbricato

INVERNO	ESTATE

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

119,42 kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

41,61 kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno **119,42**
X	Gas naturale	767,06 m^3	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m^2 anno **25,26**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	352,000	m^3
S - Superficie disperdente	219,620	m^2
Rapporto S/V	0,624	
$EP_{H,nd}$	59,7	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,02	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,737	η_H	0,0	81,0
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 1R

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia	Zona climatica:	B
Comune:	CATANIA	Anno di costruzione:	1964
Indirizzo:	via Acquicella Porto, 27, n.	Superficie utile riscaldata (m^2):	94,00
Piano:		Superficie utile raffrescata (m^2):	0,00
Interno:		Volume lordo riscaldato (m^3):	352,00
Coordinate GIS:		Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni							

Servizi energetici presenti

- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
☹	😐

Prestazione energetica globale

EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

109,60
kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

40,06
kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno **109,60**
X	Gas naturale	674,00 m^3	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m^2 anno **23,30**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00	kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	352,000	m^3
S - Superficie disperdente	219,620	m^2
Rapporto S/V	0,624	
$EP_{H,nd}$	52,5	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,01	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,737	η_H	0,0	71,1
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

e-SAFE

FLAT 2L

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia
Comune:	CATANIA
Indirizzo:	via Acquicella Porto, 27, n.
Piano:	
Interno:	
Coordinate GIS:	

Zona climatica:	B
Anno di costruzione:	1964
Superficie utile riscaldata (m^2):	94,00
Superficie utile raffrescata (m^2):	0,00
Volume lordo riscaldato (m^3):	341,00
Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da a
Altri subalterni							

Servizi energetici presenti

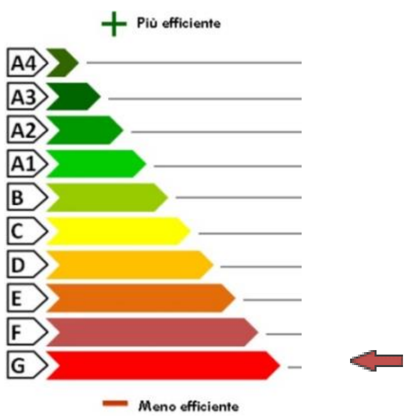
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

91,82 kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

31,67 kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m² anno **91,82**
X	Gas naturale	505,55 m³	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m² anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m² anno **19,74**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	39,4	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,01	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,739	η_H	0,0	53,4
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,5	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 2R

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia	Zona climatica:	B
Comune:	CATANIA	Anno di costruzione:	1964
Indirizzo:	via Acquicella Porto, 27, n.	Superficie utile riscaldata (m^2):	94,00
Piano:		Superficie utile raffrescata (m^2):	0,00
Interno:		Volume lordo riscaldato (m^3):	341,00
Coordinate GIS:		Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni								

Servizi energetici presenti

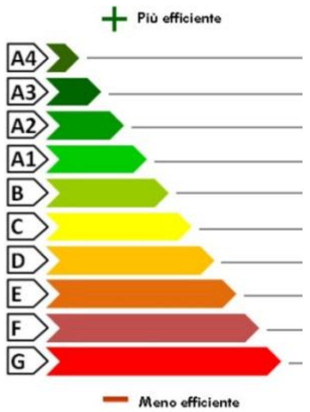
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO [ ]

CLASSE ENERGETICA

F

90,08

kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

33,94

kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m² anno **90,08**
X	Gas naturale	489,06 m³	
☐	GPL	-	
☐	Carbone	-	
☐	Gasolio	-	
☐	Olio combustibile	-	
☐	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m² anno **9,27**
☐	Butano	-	
☐	Kerosene	-	
☐	Antracite	-	
☐	Biomasse	-	
☐	Solare fotovoltaico	-	
☐	Solare termico	-	Emissioni di CO_2 kg/m² anno **19,40**
☐	Eolico	-	
☐	Teleriscaldamento	-	
☐	Teleraffrescamento	-	
☐	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

e-SAFE

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	38,2	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,02	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,739	η_H	0,0	51,6
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler Gas Boiler			Elettricità GPL	1,2 18,9	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 3L

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari
di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia	Zona climatica:	B
Comune:	CATANIA	Anno di costruzione:	1964
Indirizzo:	via Acquicella Porto, 27, n.	Superficie utile riscaldata (m^2):	94,00
Piano:		Superficie utile raffrescata (m^2):	0,00
Interno:		Volume lordo riscaldato (m^3):	341,00
Coordinate GIS:		Volume lordo raffrescato (m^3):	0,00

Comune catastale			CATANIA					Sezione				Foglio					Particella						
Subalterni	da		a			da		a			da		a			da		a					
Altri subalterni																							

Servizi energetici presenti

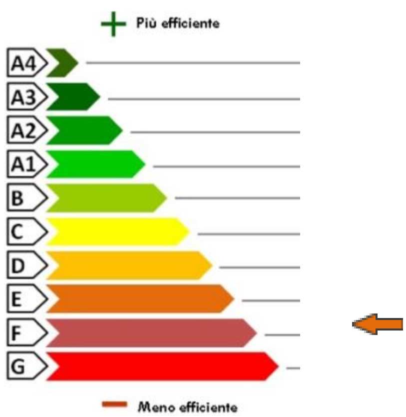
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
	

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO [ ]

CLASSE ENERGETICA

E

83,53
kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

33,75
kWh/m^2 anno

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ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard
X	Energia elettrica da rete	1.853,61 kWh
X	Gas naturale	427,08 m^3
	GPL	-
	Carbone	-
	Gasolio	-
	Olio combustibile	-
	Propano	-
	Butano	-
	Kerosene	-
	Antracite	-
	Biomasse	-
	Solare fotovoltaico	-
	Solare termico	-
	Eolico	-
	Teleriscaldamento	-
	Teleraffrescamento	-
	Altro	-

Indici di prestazione energetica globali ed emissioni
Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno **83,53**
Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno **9,27**
Emissioni di CO_2 kg/m^2 anno **18,09**

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00	kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	33,4	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,01	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,740	η_H	0,0	45,1
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 3R

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia
Comune:	CATANIA
Indirizzo:	via Acquicella Porto, 27, n.
Piano:	
Interno:	
Coordinate GIS:	

Zona climatica:	B
Anno di costruzione:	1964
Superficie utile riscaldata (m^2):	94,00
Superficie utile raffrescata (m^2):	0,00
Volume lordo riscaldato (m^3):	341,00
Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da / a	da / a		da / a		da / a	
Altri subalterni							

Servizi energetici presenti

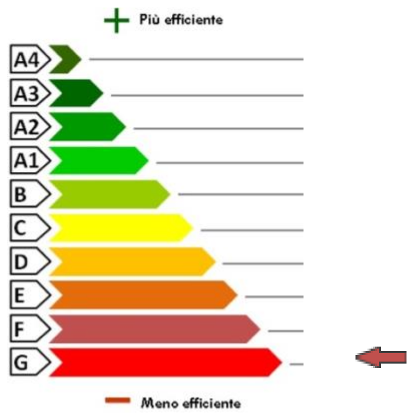
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
	

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

85,50

kWh/m^2 anno

Riferimento

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

32,76

kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno **85,50**
X	Gas naturale	445,66 m^3	
☐	GPL	-	
☐	Carbone	-	
☐	Gasolio	-	
☐	Olio combustibile	-	
☐	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno **9,27**
☐	Butano	-	
☐	Kerosene	-	
☐	Antracite	-	
☐	Biomasse	-	
☐	Solare fotovoltaico	-	
☐	Solare termico	-	Emissioni di CO_2 kg/m^2 anno **18,48**
☐	Eolico	-	
☐	Teleriscaldamento	-	
☐	Teleraffrescamento	-	
☐	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00	kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	34,8	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,01	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,740	η_H	0,0	47,0
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 4L

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia	Zona climatica:	B
Comune:	CATANIA	Anno di costruzione:	1964
Indirizzo:	via Acquicella Porto, 27, n.	Superficie utile riscaldata (m^2):	94,00
Piano:		Superficie utile raffrescata (m^2):	0,00
Interno:		Volume lordo riscaldato (m^3):	341,00
Coordinate GIS:		Volume lordo raffrescato (m^3):	0,00

Comune catastale				CATANIA				Sezione				Foglio				Particella							
Subalterni	da		a			da		a				da		a				da		a			
Altri subalterni																							

Servizi energetici presenti

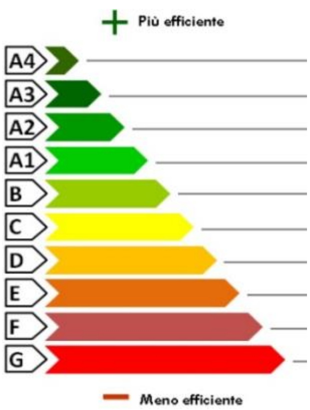
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
	

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

89,41
kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

33,55
kWh/m^2 anno

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m² anno **89,41**
X	Gas naturale	482,74 m³	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m² anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m² anno **19,26**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	37,7	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,01	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,739	η_H	0,0	51,0
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

e-SAFE has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 893135.

FLAT 4R

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia	Zona climatica:	B
Comune:	CATANIA	Anno di costruzione:	1964
Indirizzo:	via Acquicella Porto, 27, n.	Superficie utile riscaldata (m^2):	94,00
Piano:		Superficie utile raffrescata (m^2):	0,00
Interno:		Volume lordo riscaldato (m^3):	341,00
Coordinate GIS:		Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni								

Servizi energetici presenti

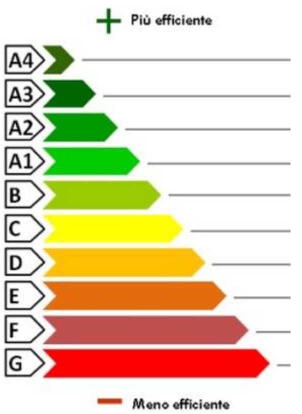
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
	

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

E

82,12 kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

31,96 kWh/m^2 anno

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ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m² anno **82,12**
X	Gas naturale	413,67 m³	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m² anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m² anno **17,80**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

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ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	341,000	m^3
S - Superficie disperdente	117,800	m^2
Rapporto S/V	0,345	
$EP_{H,nd}$	32,3	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,02	-
Y_{IE}	0,53	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,740	η_H	0,0	43,7
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

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FLAT 5L

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia
Comune:	CATANIA
Indirizzo:	via Acquicella Porto, 27, n.
Piano:	
Interno:	
Coordinate GIS:	

Zona climatica:	B
Anno di costruzione:	1964
Superficie utile riscaldata (m^2):	94,00
Superficie utile raffrescata (m^2):	0,00
Volume lordo riscaldato (m^3):	374,00
Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni							

Servizi energetici presenti

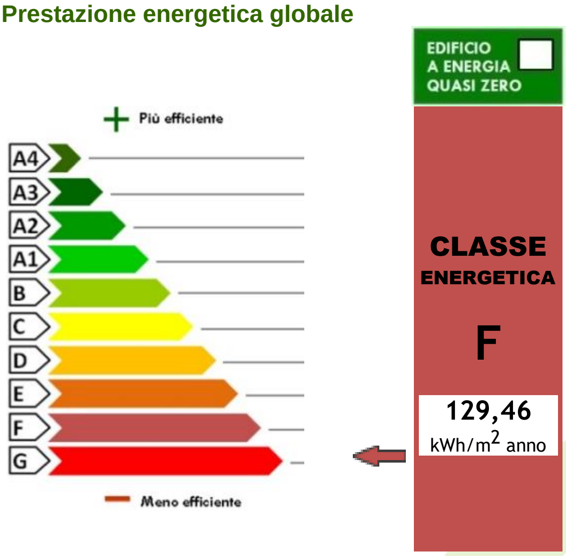
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE

Prestazione energetica globale



Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

46,38

kWh/m^2 anno

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ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard
X	Energia elettrica da rete	1.853,61 kWh
X	Gas naturale	862,14 m^3
	GPL	-
	Carbone	-
	Gasolio	-
	Olio combustibile	-
	Propano	-
	Butano	-
	Kerosene	-
	Antracite	-
	Biomasse	-
	Solare fotovoltaico	-
	Solare termico	-
	Eolico	-
	Teleriscaldamento	-
	Teleraffrescamento	-
	Altro	-

Indici di prestazione energetica globali ed emissioni	
Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno	**129,46**
Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno	**9,27**
Emissioni di CO_2 kg/m^2 anno	**27,27**

e-SAFE has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 893135.

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00 kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	374,000	m^3
S - Superficie disperdente	238,800	m^2
Rapporto S/V	0,639	
$EP_{H,nd}$	67,0	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,02	-
Y_{IE}	0,38	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,736	η_H	0,0	91,0
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

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FLAT 5R

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

DATI GENERALI

Destinazione d'uso

- [X] Residenziale
- [ ] Non residenziale

Classificazione D.P.R. 412/93: E.1.1

Oggetto dell'attestato

- [ ] Intero edificio
- [X] Unità immobiliare
- [ ] Gruppo di unità immobiliari

numero di unità immobiliari di cui è composto l'edificio: 10

- [ ] Nuova costruzione
- [ ] Passaggio di proprietà
- [ ] Locazione
- [ ] Ristrutturazione importante
- [ ] Riqualificazione energetica
- [ ] Altro:

Dati identificativi

Regione:	Sicilia
Comune:	CATANIA
Indirizzo:	via Acquicella Porto, 27, n.
Piano:	
Interno:	
Coordinate GIS:	

Zona climatica:	B
Anno di costruzione:	1964
Superficie utile riscaldata (m^2):	94,00
Superficie utile raffrescata (m^2):	0,00
Volume lordo riscaldato (m^3):	374,00
Volume lordo raffrescato (m^3):	0,00

Comune catastale	CATANIA	Sezione		Foglio		Particella	
Subalterni	da	a	da	a	da	a	da	a
Altri subalterni							

Servizi energetici presenti

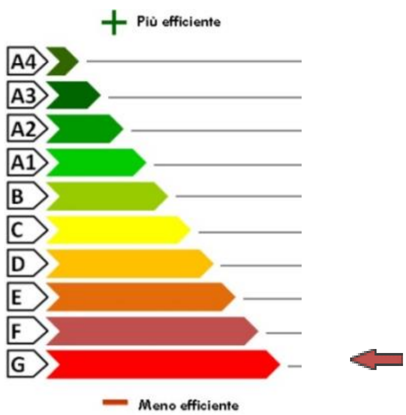
- [X] Climatizzazione invernale
- [ ] Ventilazione meccanica
- [ ] Illuminazione
- [ ] Climatizzazione estiva
- [X] Prod. acqua calda sanitaria
- [ ] Trasporto di persone o cose

PRESTAZIONE ENERGETICA GLOBALE E DEL FABBRICATO

Prestazione energetica del fabbricato

INVERNO	ESTATE
	

Prestazione energetica globale



EDIFICIO A ENERGIA QUASI ZERO

CLASSE ENERGETICA

F

128,61
kWh/m^2 anno

Riferimenti

Gli immobili simili a questo avrebbero in media la seguente classificazione:

se nuovi:

A1

44,13
kWh/m^2 anno

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e-SAFE

ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

PRESTAZIONE ENERGETICA DEGLI IMPIANTI E CONSUMI STIMATI

La sezione riporta l'indice di prestazione energetica rinnovabile e non rinnovabile, nonchè una stima dell'energia annua consumata annualmente dall'immobile secondo un uso standard.

Prestazioni energetiche degli impianti e stima dei consumi di energia

	FONTI ENERGETICHE UTILIZZATE	Quantità annua consumata in uso standard	Indici di prestazione energetica globali ed emissioni
X	Energia elettrica da rete	1.853,61 kWh	Indice della prestazione energetica non rinnovabile **EPgl,nren** kWh/m^2 anno **128,61**
X	Gas naturale	854,09 m^3	
	GPL	-	
	Carbone	-	
	Gasolio	-	
	Olio combustibile	-	
	Propano	-	Indice della prestazione energetica rinnovabile **EPgl,ren** kWh/m^2 anno **9,27**
	Butano	-	
	Kerosene	-	
	Antracite	-	
	Biomasse	-	
	Solare fotovoltaico	-	
	Solare termico	-	Emissioni di CO_2 kg/m^2 anno **27,10**
	Eolico	-	
	Teleriscaldamento	-	
	Teleraffrescamento	-	
	Altro	-	

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ATTESTATO DI PRESTAZIONE ENERGETICA DEGLI EDIFICI

CODICE CERTIFICATO: VALIDO FINO AL:

APE 2015

ALTRI DATI ENERGETICI GENERALI

Energia esportata	0,00	kWh/anno	Vettore energetico: -

ALTRI DATI DI DETTAGLIO DEL FABBRICATO

V - Volume riscaldato	374,000	m^3
S - Superficie disperdente	238,800	m^2
Rapporto S/V	0,639	
$EP_{H,nd}$	66,4	kWh/m^2 anno
$A_{sol,est}/A_{sup,utile}$	0,02	-
Y_{IE}	0,38	W/m^2K

DATI DI DETTAGLIO DEGLI IMPIANTI

Servizio energetico	Tipo di impianto	Anno di installazione	Codice catasto regionale impianti termici	Vettore energetico utilizzato	Potenza Nominale kW	Efficienza media stagionale		EPren kWh/m^2 anno	EPnren kWh/m^2 anno
Climatizzazione invernale	SIMULATO IN QUANTO ASSENTE					0,736	η_H	0,0	90,2
Climatizzazione estiva							η_C		
Prod. acqua calda sanitaria	Electric Boiler			Elettricità	1,2	0,287	η_W	9,3	38,5
Impianti combinati									
Produzione da fonti rinnovabili									
Ventilazione meccanica									
Illuminazione									
Trasporto di persone o cose									

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