BUILDING ENVELOPE IMPLEMENTATION IN A REFURBISHMENT CASE STUDY IN THE VENICE HINTERLAND

Jacopo GASPARI
Department of Architecture, Alma Mater Studiorum University of Bologna, Italy, jacopo.gaspari@unibo.it

Elena GIACOMELLO
Department of Architecture Construction Conservation, IUAV University of Venice, Italy, elenag@iuav.it

Summary

The progressive reduction of public investments in the last 20 years for the residential sector has reduced the Italian stock of social housing to less than one and half million units, which represent only 5,8 % of the residential buildings in use. This stock – built up between the ’60s and ’80s – is affected by many and relevant lacks in functionality and performances, due to its age and void of maintenance. The economic crisis burst in 2008 has produced both a dramatic intensification of affordable rental apartments request and a further reduction of the already small availability of investments to expand the social housing stock. So the evaluation of refurbishment interventions has acquired a strategic role in this sector.

A research project – which follows a research program lead in cooperation between the Faculty of Architecture of IUAV University of Venice and ATER (Territorial Agency for Residential Building) of Venice – assumed a social housing complex, built in the ’70 and placed in the Venice hinterland, as case study in order to investigate the refurbishment opportunities. The project foresees a building envelope implementation (including a new one for the first floor galleries) and a volumetric addition on the ground floor connecting the existing volumes as a “functional and commercial platform” to generate part of the financial resources to support the initiative.

The paper will outline the results of refurbishment scenarios performed on the case study describing the transformation strategy adopted, the functional and technical upgrade and the obtained energy savings.

Keywords: housing refurbishment, densification, building envelope implementation, energy savings, renewal process

1 The social housing *Triestina 68 district*: a refurbishment case study

The refurbishment project described in the paper follows a research activity on the strategies to improve the energy performance of existing buildings lead by the authors on social housing and represents a relevant case study for testing the research methodology and the proposed solutions.

1.1 General description

The Triestina 68 district is a social housing complex located in Favaro Veneto, in the hinterland of Venice city. The complex was built in 1978 by Ater (Territorial Agency for Residential Building), which is still the only owner and responsible for the management and maintenance activity on the five buildings composing the complex. The five volumes, ten storeys height with different length (see figures 1 and 2), are arranged in order to form a large polygonal inner courtyard used as green area. The complex is closed to the urban centre and well connected by the tram lines. A total of 207 apartments of different sizes (type A – 116 m^2, type B – 105 m^2, type C – 58 m^2 and type D – 27,5 m^2) are hosted in the complex. The fronts are divided by the volumes containing the stairs and lift which serve two apartments on each floor. All the ground floor is used to provide the 207 garages so the first floor is reached by several ramps connected to the courtyard. The buildings are entirely built in reinforced concrete (walls and slabs) following the beton-tunnel construction technique while the façades are completed using precast concrete panels.

1.2 Evaluation of the building

The district is one of the most successful example of social housing in the hinterland of Venice: despite its large sizes and number of dwellings, it isn't affected by social problems and this derives from the strong action of control (self supported) promoted by a resident committee in partnership with Ater. The complex offers 207 dwellings which can be defined comfortable and spacious for the social housing standards and in most cases provided of two lodges well exposed to the sun. Nevertheless, the buildings are affected by several deficits due to the physiological obsolescence of materials and to the functional obsolescence deriving from the evolution of the users' needs and lifestyle. Although ordinary maintenance activity has been periodically performed during the years this hasn't been enough in order to reach suitable comfort levels and acceptable levels of performance. The main deficits involving the building envelope can be synthesized as follows:

- the thermal insulation provided by the precast panels of the building envelope is inadequate and as a consequence the energy demand for heating is very high;
- condensation occurs, especially in the façades oriented to the east and north sides;
- condensation and water infiltration often affect the existing wooden windows;
- the waterproof membrane of the roof is seriously deteriorated and infiltrations often occur;
- acoustic bridges between the dwellings are frequent due to insulation lack.

Despite each dwelling has been recently equipped with its own heating system, the energy consumption is so high that many families are not able to face the economic expense.

Fig. 1 *Views of the buildings in district Triestina 68*

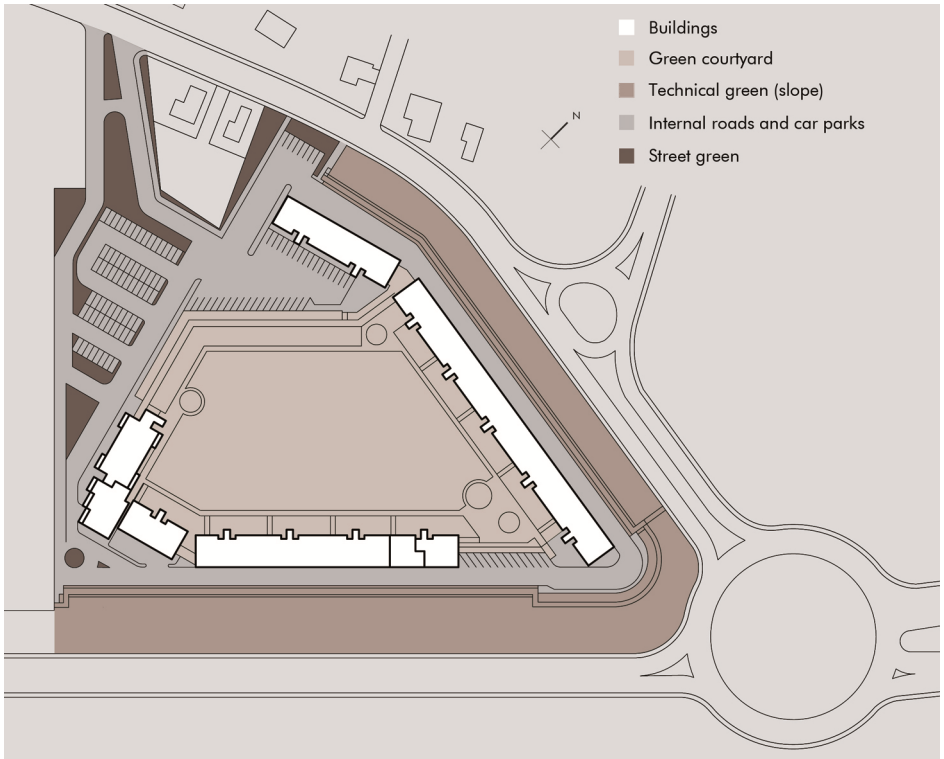


Fig. 2 *General plan of the district*

2 Refurbishment scenario

2.1 Principals of the refurbishment action

A refurbishment action has become urgent on the one hand to meet the needs expressed by the users and on the other one to avoid the economic problems connected to the heating expense (Ater covers the insolvent payments). As most part of the heat loss is connected to the building envelope deficits, a technological upgrading can produce a drastic reduction of energy demand for operating.

The refurbishment project is based on two principal strategies:

- the building envelope implementation in order to avoid thermal dispersion and to improve the performance level according to the specific climate condition of the site and to the orientation of the façades [1];
- the realization of a volumetric addition connecting the ground floor in order to obtain a platform containing new services useful to the district community and, at the same time, able to produce part of the financial resources needed to support the overall initiative.

2.2 Enhancement of public spaces and new services

The central green courtyard (approximately 13.000 m^2), which is mainly unemployed, plays a central role in the renewal process not only for what concerns the economic implications but also for the social ones connected to the life inside and outside the district. The idea is to create a great platform, connected to the buildings' ground floor, in which green courtyard of different sizes are interspersed with new volumes destined to host new public services, shops, kindergarten, etc. (see figures 3 and 4). Under the platform new parking areas and technical spaces will be provided. All the new volumes are connected by a green roof which provides paths and connections with the first floor of the existing buildings. The new volumes are designed to reach the passive standards and to be realized with dry technologies (in order to reduce the time of construction and the impacts of the building site).

The platform roof is covered with intensive green (that can be considered as a low--emissive surface) [2, 3] to guarantee plants' presence to the new artificial soil. Pavements are designed to organize the paths for the new functions. The platform roof, the surfaces of the existing banks and the first free floor of the blocks are equipped with furniture, such as shaded seating, bike racks, parking spaces for motorcycles, games equipment and vegetable garden for inhabitants.

Fig. 3 *Cross sections of the courtyard platform connecting the buildings*

Fig. 4 *General plan of the courtyard platform connecting the buildings*

This part of the project is aimed at increasing both the environmental quality as well as the availability of services and at producing some financial benefits to feed the renewal process, while the one involving the façades is aimed at reducing the cost deriving from energy consumption [4]. So no refurbishment actions are foreseen inside the dwellings: all the available budget is used for the implementation of the building envelope.

Therefore the principal interventions are aimed to reduce thermal dispersions, to contrast the thermal bridges and to modify the energy demand trend for operating.

3 Thermal behavior and energy demand

3.1 Evaluation of starting conditions

The building is affected by severe deficits concerning the thermal performance mainly related to the geometric configuration and technological choices made at the time of its construction. The building envelope is composed of precast concrete panels used to close the structural modules and designed to speed up the construction phases. Although the panels are provided of an integrated insulating layer, they are unable to guarantee an adequate thermal behavior of the wall section. Moreover, the main sources of dispersion are derived from the widespread presence of thermal bridges connected to the mode of junction the panels to the structural elements or due to the geometry of the façade. The

recurring presence of lodges on both the main fronts implies substantial dispersions (also difficult to be faced) affecting the edge beams and the slabs. The other major source of dispersions is given by the existing wooden windows (single glass layer) and by the thermal bridge resulting from the housing of the roller shutters.

The current heating system is far from the high efficiency standards, and therefore the energy demand for operating is very high. Added to this, during the hot summer period cooling systems are adopted by the users in order to reduce overheating. Simulations showed the total EP index for each building is around 170–190 kWh/m^{2}y in relation to the quota of energy required for cooling system.

3.2 Design criteria

Due to budget constraints which always characterize interventions on social housing (especially in the current economic situation) some strategic decisions have been taken in order to maximize the effects of retrofit action and to face the principal deficits affecting the building [5].

First of all, the idea of providing a new insulation layer following the original shape and geometry of the main façades was excluded because it'd be very difficult to find a cheap technological solution to reduce the thermal bridges on the lodges' slabs (a thermal cut would be very expensive and insulating all the surface of the lodges would increase the costs as well). Second, a new insulated skin for implementing the existing envelope was investigated. The use of a ventilated façade would certainly be useful to mitigate the excess of solar heating during the summer period, but the presence of the lodges on each floor interrupts the vertical continuity of the façades (also becoming a marked formal feature of the building) decreasing the effectiveness of the solution [6]. Furthermore this option was considered too expensive in relation with the available conventional cladding system.

So the design strategy adopted the following criteria:

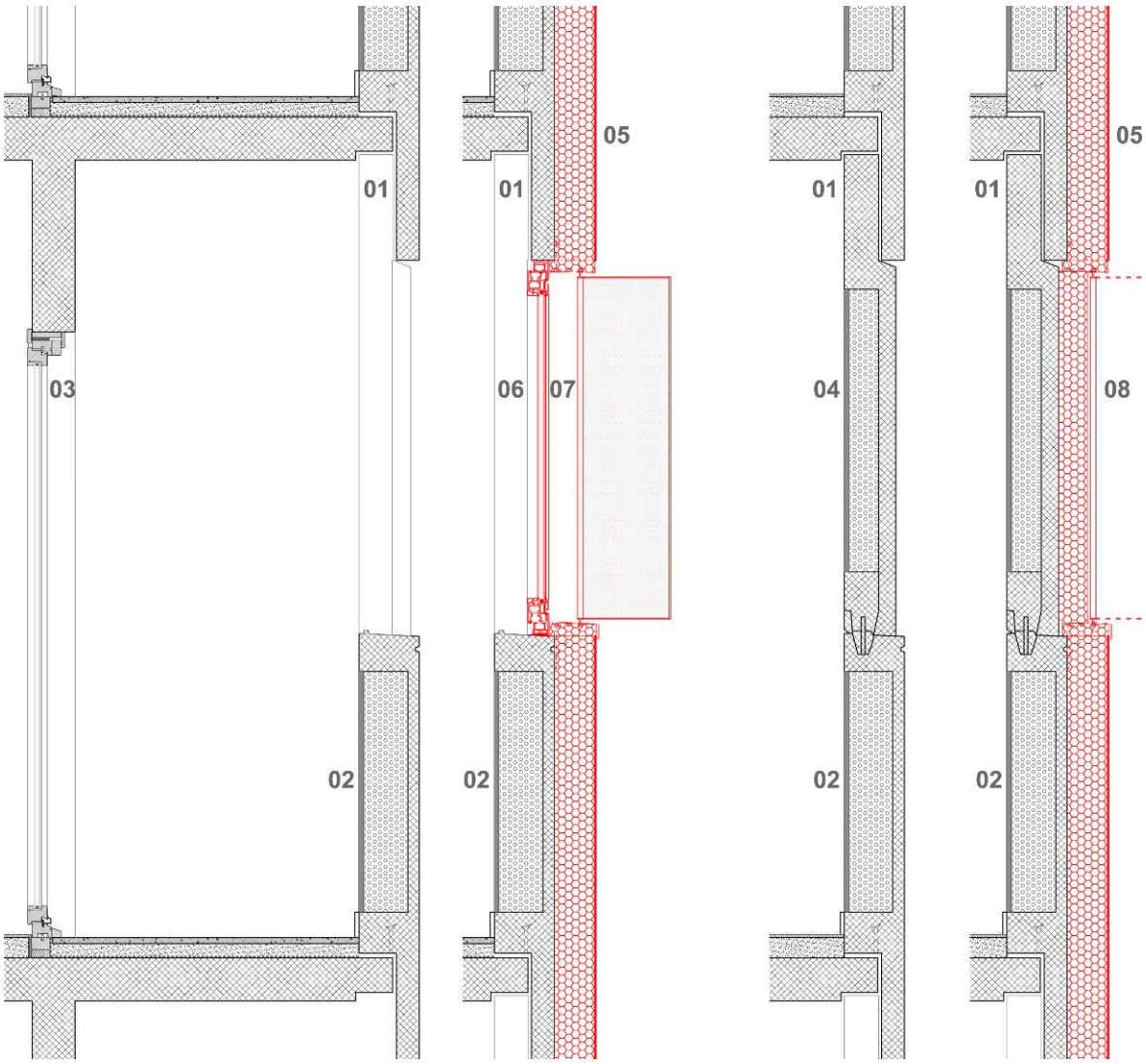
- To consider the lodges as a relevant character of the building to be stressed in terms of formal layout as well as in terms of quality improvement.
- To convert the lodges in solar greenhouses to get the benefits of the passive gains incoming during the winter period.
- To provide shading system on the glass surface in order to reduce overheating during the summer period.
- To implement the thermal behaviour through a new insulating layer which completes the new glass surface of the lodges.
- To implement the insulation of the roof and to integrate solar and photovoltaic system between the emerging volumes of the vertical connections.

The final aim of the retrofit action is to reach a global EP value around 20–30 kWh/m^{2}y. This range partially depends on the quota of energy deriving from solar systems which are financially supported by a national program.

4 Building envelope implementation

4.1 Performance levels

The vertical closure of the building can be distinguished between two separate conditions (as figure 5 shows): on one side the closure of the lodges which is placed one meter behind the main front of the building and on the other the typical closure of the main façade.



01- existing bearing structure
02- typical precast concrete panel
03- glazed element of the lodges
04- precast concrete panel for closing openings
05- EPS insulating layer with plaster finishing
06- new glazing closing the lodges
07- new shielding elements
08- EPS insulating module

Fig. 5 *Cross sections of the lodges and of the typical building envelope on the main façade before and after retrofitting interventions*

The existing closure on the lodges is mainly composed of glazed element and a small part of concrete wall without insulation. The main façade consists of two typologies of precast concrete panels with an integrated insulation layer of expanded clay.

An additional EPS insulating layer is needed to reach the transmittance limits by low. The principal characters of the typical technological section of the building envelope before and after interventions are summarized in table 1.

Tab. 1 *Synthesis of the principal characters of the typical section of the building envelope*

Vertical closure	**U**	**|Yie|**	**φ**	**fd**
	W/m^{2}K	W/m^{2}K	h	-
Existing building enevlope	2,09	0,960	6. 59’	0,457
Implemented building envelope [A]	0,28	0,044	10. 28’	0,157
Implemented building envelope [B]	0,21	0,031	11. 03’	0,150

Implementation option [A] is obtained with a 10 cm thick EPS layer [λ = 0,033 W/mK, c = 1350 J/kgK, ρ = 30 kg/m^3] which allows to respects the limits by low, while implementation option [B] is obtained with a 14 cm thick EPS layer which is needed in order to reach the expected level of performance according to the final EP goal.

The panels are used to insulate all the external surface of the building envelope, avoiding the existing thermal bridges, and they can be directly placed on the concrete panels for being completed with a plaster finishing.

In order to reduce the surface to be insulated (and consequently the deriving costs) the lodges are converted into greenhouses using double glazed aluminum frames with thermal break. Their transmittance is equal to 1.5 W/m^{2}K (the limit by low is 2.2 W/m^{2}K).

4.2 Technological choices

The new glazed modules can be installed on the precast concrete panels which compose the main front. The same modules used for closing the lodges are adopted for replacing the other existing windows on the main fronts. The existing windows and doors in the lodges become internal partitions so the users are free to decide if a replacement is needed or not, without influencing the thermal behavior of the building envelope and allowing to reduce the overall costs.

This option is aimed at increasing the passive solar gain and at providing an additional space for the dwellings. Furthermore it is designed to act as a buffer zone during winter and summer seasons [7].

With the goal of reducing the overheating of the lodges during the summer period a shading module is installed in front of the glazed one. The shielding system consists of a series of perforated metal plates which can rotate on their own axis respect their metal supporting frame, in order to optimize the shading effect in relation with the exposure. The shielding modules are supported by metal clamps connected to the concrete panels.

The openness factor of the perforated plates can be varied in relation with the orientation of the front. These elements create a metal stripe for each level which envelops the lodges and the windows creating a variable configuration of the elevation (see figure 6 and 7). The supporting frame of the shielding system is used as a guide for placing the insulation panels aimed at implementing the thermal behavior of the building envelope.

As no heating and cooling are currently available, no implementation interventions are foreseen for what concern the volumes containing the stairs and lift. The design approach is oriented towards the insulation of the internal walls bordering with these volumes in order to reduce the overall costs.

The solar systems placed on the roof are design to cover the energy demand for hot water production, and the combined effect of new heating system and the building envelope implementation allow to reduce the EP value around 20–30 kWh/m^{2}y.

Fig. 6 *View of the south-east façade before interventions*

Fig. 7 *View of the study – elevation considering the overall transformation of the south-east façade: new shading stripes connect the lodges and the windows*

5 Conclusions and final remarks

The described case study offered the chance to test some of the intervention strategies pointed out during a research activity concerning the retrofitting of several social housing buildings. After a methodological approach for providing diagnostic tools and design criteria was set up, this test required to match technological options and severe budget constraints. Simulations supported the design activity for what concerns the evaluation of the performance level as well as for what concerns the final layout of the solution adopted.

The project is based on two main principals: on one hand to improve the quality of the dwellings and on the other to increase the density of the ground floor introducing new services and functions through volumetric additions in order to generate part of the economic resources to feed the retrofitting process.

The principal results of the test activity can be summarized as follows:

- The simulations run prove that a balanced design approach in terms of building envelope implementation allows to reach good performance levels (low energy building) respecting the low budget available.
- The conversion of the lodges is the key factor of the project: on one side it limits the investment needed for insulating and on the other side it allows passive gains extending the usable area of the dwellings.
- The shielding system adopted allows the lodges to maximize their effectiveness during winter season while shading them during summer season in order to avoid overheating

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