Intervention strategies for the energy retrofit of the built heritage: a case study in Turin

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1. The energetic enhancement of the built heritage

1.1. Energy efficiency and built heritage: a new resource

The energetic enhancement of the built heritage is one of the European intervention strategies for the reduction of energy consumption. Nowadays the built heritage is fully considered as a strategic resource both from a cultural and a socioeconomic point of view. It is important to highlight that the refurbishment and the adaptation of this heritage to energetic standards can contribute in a significant way also to the saving of cultivated soil. The 80% of the Italian housing stock has been built before the approval of the first Italian regulation concerning the control of energy consumption in buildings (L. n.373/1976). Most of these building don’t present the minimum performance level in energy efficiency as required by law.

As ‘built heritage’ we consider the whole historical building stock and not only the part which is ward of the State. Also buildings which are not to be preserved by law are depository of know-how and building modalities nowadays reproducible with difficulty, of traditional technical solutions balanced with the climate context and have a specific energetic behavior. The refurbishment intervention must enhance the value of these aspects, focusing on all the expressions of the material culture.

Within this heritage, buildings with historical and material value require an appropriate critical reflection due to the difficulties that their conservation and their requalification subject to specialists.

An effective intention for the enhancement of these buildings has to be ground to a concept of active and conscious use, in order to take away on the one hand the danger of their sterile conversion into a museum of themselves and on the other hand the risk of their degradation, due to an improper use of space.

1.2. Intervention strategies: inner insulation

The current intervention strategies for upgrading the energy efficiency of the built heritage pursue the development of the energy performance of the building acting essentially on envelope’s stratigraphy and plant management. The technical solutions which concern especially the building envelope offer the most significant contribution to the reduction of energy consumption. According to the 2011 ENEA Report on the energy savings achieved by the recognition of tax deductions, only 2% of redevelopment interventions concern the opaque envelope. It is therefore a priority to focus the research on the development of new technological solutions and on the improvement of well-established technical strategies.

In the energy renovation process of housing buildings the measures to improve the level of thermal insulation of the building envelope usually consist in
the application of insulation systems and panels on the external or the internal side of the envelope.
These technical solutions consist of a thermo-plaster work reinforced by a fiberglass mesh or of a ‘thermal coat’ made of thermal panels fixed to the envelope or made of prefabricated panels which integrate thermal insulation and coating.

In different cases it is not possible to apply effective solutions from the external side of the building: when the façade is characterized by decorations of relevant historical and material value, when the management of the site of the external intervention presents logistic difficulties or when the prevalent energetic retrofit interventions concern single housing units rather then the whole building.

A significant option is to put the insulation in the internal side of the building envelope.

Inner shell insulation is still a developing and improving intervention field, both at a technical and a commercial level. In many cases the internal insulation solutions borrow techniques and products from the most consolidated solutions of outer shell insulation, often revealing difficulties in execution and in control of the results.

The current inner insulation interventions consider passive solutions, based on traditional techniques, as insulated drywall, pre-finished insulated panels, double wall envelope. Currently these solutions present some disadvantages: an high commitment of human resources (designers, enterprises, operators), timetable and procedures of a traditional site, incompatibility of some processing techniques with the permanence of the users in the building (dust, noise, etc.).

These solutions produce additional costs and often don’t offer an effective reduction of the thermal bridges in the building enclosure.

2. The I.I.I. project
The Innovative Inner Insulation (I.I.I.) project started in September 2011 with the aim to look for new solutions to the need to improve the thermal performance of existing buildings, with a special attention on constructions with an historical value.

The project is financed by Regione Piemonte through the European Regional Development Fund (ERDF). It is part of a regional initiative called “Industrial research projects and/or experimental development” launched to support Small and Medium Enterprises (SMEs).

The attention of the research is focalised on the envelope of the buildings and on the possibilities to reduce, or avoid, thermal bridges.

The aim is to find insulating solutions as much as possible compatible with the existing building: they have to reduce their impact on it both in terms of physical transformation of the spaces and of discomfort for the users during the installation. To target this objective the system developed during the research has to be assembled in factories and integrates the insulation, the radiant hydraulic elements and the finish panels.

The insulating and radiant system proposed is thought to be used in the inner
side of the vertical walls of existing buildings. This solution can be used also in those cases in which heating plants can’t be located under the floor, or in other cases in the ceiling of the room because of their value and in order to avoid the use of external components like fan-coil or radiators.

The different solutions studied have been found not only in the traditional file of the building constructions, but also looking at other industrial worlds: in this case a specific attention is given to the refrigerated transport.

2.1. Partnership

The project is coordinated by professor Gianfranco Cavaglià of the Politecnico di Torino and involves three university departments and three SMEs: Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico di Torino; Department of Energy (DENERG), Politecnico di Torino; Department of Science and Technological Innovation (DSIT), Università degli Studi del Piemonte Orientale; Boschis S.p.A; NTS Group S.r.l.; Cluster S.r.l.. This partnership has been created to answer to the Regional call aimed to make working together the research world with Small and Medium Enterprises (SMEs). The cooperation is useful to promote the exchange of competences among the partners: researchers can work on real problems arisen in the communities or in the market, the owners of SMEs have the chance to be involved in researches they generally haven’t the economic and logistic strength to develop alone.

2.2. Activities developed

The study of the state of the art has been focused both on the different solutions proposed by the marked to improve the thermal performance of the buildings, but also on the restriction given by the need to work in existing buildings with specific physical and geometrical characteristics.

The analysing phase of the project has been concentrate on the study of different residential case studies to be able to give concrete answers to improve their thermal performance. To go deeper in this direction metric surveys and tests of their thermal performances have been done. In some cases thermographic images have been used to identify the critical parts of the external walls of the building.

Another part of the research has involved all the partners of the project in the achievement of prototypes of insulating and radiant panels: different products have been assembled until a shared solution has been found.

Thermographic survey of one of the analyzed case studies
All the components of the new insulating and radiant system have been made to be installed in the main case study of the project: an hotel in the historical centre of Turin. One of its rooms has been chosen to house the experimental part of the project. The aim of this final part of the experience has been to verify the insulating and radiant system performance in a real case study. The analysis has been concentrate to the thermal data, but also on the real possibility to integrate the system in a specific location.

2.3. The insulating/radiant system

The insulation system assembled and tested during the I.I.I. project is based on the dry laying of a pre-assembled panel, which combines structure, thermal and acoustic insulation, heating system and finish. The system integrates in a single component, to be used in the inner vertical part of walls, the high performance of insulating products with low temperature radiating elements. The connection between the insulating/radiant panels and the walls is made by a dry anchoring system with characteristics of reversibility and inspectability. The system is made of two types of panels: one integrates the insulation and the heating coil, the other, used as coating, can be pre-finished or finished on site. The insulating/radiant panels are made of a rigid insulation material coated on its back and front faces by two plastic glued laminates.

Exploded view drawing of the insulating/radiant system

The front side of the panel is milled with numerical control machines in order to produce the vertical conduits necessary to wedge the heating elements of the system and the structure useful for the anchorage of the covering panels. Two differ kinds of millings are used: those with a circle section, where are housed the radiant coils and the glued aluminium bent sheets used to guarantee an homogeneous distribution of the heat towards the inner part of the heating room, the other with square section which contain the aluminium structure for the anchorage of the covering panels. These hanging racks are connected with the insulating panel through self-tapping screws, which reaches the back of the insulating/radiant panel where are fixed wooden horizontal slats. They are part of the anchoring system which includes other slats screwed in the wall. The wood elements are connected through a mechanical dry joint. The covering panel, prefinished or finished on site, completes the insulating
and radiant system. It can be made of wood, aluminium, glass, ceramics or using traditional or innovative products according to the formal chooses defined in the project. Nevertheless it is important to pay attention in not compromising the transmission of the radiant heating through it. The covering panels is connected with the insulating/radiant panels with screwed metallic hooks.

3. Inner Active Insulation: a case study in Turin
The insulating and radiant system developed during the project has been installed in a room of an historical building in Turin where a construction site is in progress. The old building is made of various constructions with different physical and architectonical characteristics. It occupies a whole court with a façade on the square called Carlo Emanuele II. The thermal performance of small parts of the envelop of the building has been monitored both in summer and winter conditions. One room has been selected to install the insulating and radiant system to verify its contribution in the reduction of thermal bridges and in general in the improvement of the external walls thermal protection.

3.1. Energetic enhancement in an historical building
The case study represents the chance to verify the real possibility to use the insulating and radiant system in an existing construction with specific geometrical characteristic and physical restrictions. One of the aims of the project has been to transform them from limits to opportunities to design and realize architectonical solutions. As usual happens the critical points are, for example, the window frames, the corners, the floor and ceiling connections, the plants integration. In the limit of the objective needs of the installation the impact on the existing structure has been reduced. The connection has been thought as mechanical reversible solutions and the inspectionability of the hydraulic parts is guaranteed by openable systems.

Study of panels connections and corner solutions
3.2. In site experimentation

The experimentation in site has been divided in different parts: thermal monitoring of the performance of the external wall of the selected room and of others chosen as comparison examples in summer and winter conditions; installation of the different parts of the system: the anchoring wood strips, the insulating panels with their radiant coils and aluminium bent sheets, the finish panels; thermal monitoring of the insulated wall without the use of the heating pipes contained in the panels; test of the thermal performance of the system with hot water passing in the pipes.

Each partner has collaborate to the different actions developed: DIST has followed all the aspects related to the technological solutions (design of the system and its components, connection among them, anchoring systems, etc.); DENERG has been responsible for the modelling of the thermal performance of parts of the existing buildings and of the insulating and radiant system and with DSIT is involved in the thermal monitoring on site thermal and in the analysis of the data; Boschis S.p.A., was charged to design and to produce the wooden parts of the system and the mechanical components of the insulating and radiant system; NTS Group S.r.l., has provided know-how and components related to the active radiant part of the system; Cluster S.r.l., has given the manufacturer’s point of view and has made available as case study a part of one of its construction sites, giving the chance to have a real experimentation in the field.

4. Conclusion

One of the purposes of the I.I.I. project is to subsidize the retrofit intervention developing a simplified and flexible technical solution.

From a technical viewpoint the added value of the insulated/radiant panels, compared with the market’s offer, consists of several aspects:
- possibility of a complete dry-laying on the internal vertical surfaces of the envelope;
- integration of thermal insulation, heating plant, structure and finish coat in a single panel;
- possibility to adapt the system in many different sites reducing the use of “special” elements, working with standard modules of small dimension and giving the possibility to cut them if necessary.
- possibility to connect the heating radiant plant to an existing general heating plant;
- reduction of laying time to the 50%;
- more compatibility of the refurbishment intervention with the human permanence in the building;
- possibility to design a finish coat according different options of matter and texture;
- possibility to disassemble the finish coat panel in order to facilitate the management and maintenance of the heating radiant plant.

This solution managed to ride out some disadvantages of the inner insulation practice, but some others are still left, as the reduction of the inner floor area or the indifference of the system toward the positive effect of the thermal inertia of the existing envelope.

Besides these tangible results, there are other intangible ones, which are relating to interesting opportunities of collaboration between the partners and to a new perspective for the future energetic refurbishments.

The work done has been a great chance to put together around a table, but especially in the same construction sites, actors of the building sector that very often don’t communicate and collaborate each other. At the same time it has been the occasion to meditate on the different approaches between the interventions on new or existing buildings.

It is important for the technicians involved to understand that in our contest the future of the building sector goes in the direction of the generally enhancement of the existing heritage. Special attention must be done to the energetic upgrade of the building performances because of the new awareness on the sustainable themes.

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