The promotion of energy efficiency of the building envelope in the rehabilitation process. Case study: a minor centre in Abruzzo

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Abstract

Any life forms organized on earth have always set up a biunique relationship with the surrounding environment, and even if they have changed slowly their habits to adapt themselves to the surrounding context, on the other side they have changed the environment to make it more suitable to their needs. Today most of the building heritage of the historical centres does not meet the users’ needs, in terms of functionality and efficiency, and is mostly in a state of physical decay. So we can understand the need to promote a rehabilitation process of the historical buildings that must take into account the present topics of sustainability.

It is not easy to promote the concept of energy efficiency in the design of the building envelope because, besides the energetic, technical and plant engineering aspect, we need to consider the cultural problems arising when the architectural and environmental values do not allow any invasive actions. Therefore, the introduction of sustainability into the building design of the historical envelope is more complex, as the process of compatibility involves the interaction between the environmental context, the local resources, the building techniques of the past but also the innovative ones. For this reason, on one side we found the recovery of the principles of the past and on the other one the introduction of project solutions that are technologically advanced and compatible at the same time.

Keywords: energy efficiency, building envelope, compatibility, values, rehabilitation building process.
1 Introduction

The energy efficiency of a system can be defined as its capacity to use the energy provided to meet an end need. The less energy required to meet the end need, the higher the efficiency. Although this definition is easily applied to heating systems, fridges etc, it is only quite recently that this concept has been applied to building in terms of building performance and more specifically to the building envelope. The origins for the transfer of this concept can be traced back to a series of events in the second half of the last century which led to a significant re-evaluation of the relationship between buildings and their environment, bringing to the forefront the principles of sustainability that were fundamental in the pre-industrial era. In fact, built fabric of times past reflect the fact that building was conceived as an ecosystem and man’s work, developed experimentally over time, resulted in a series of systems capable of relating the building to its environmental context. Notable examples of this are the Trulli in Alberobello, the Dammusi in Pantelleria, Bulla Regia, Hyderabad Sind etc., fig. 1.

Following the industrial revolution, the blind trust in technology and affirmation of the supremacy of the concept of the “machine à habiter” led to the total exclusion of the environmental context from the building project. This led to the construction of buildings that could have been positioned anywhere [1] as the designer relied on the plant engineering systems to provide internal comfort. Hence it was only two hundred years later, around the time of the petrol crisis in the 1970s, that designers started to reverse this trend. This change was characterized by a growing environmental awareness aimed not only at improving internal comfort but also reducing pressure on the soil, the use of fossil fuel, water, dust and gas pollution, etc. Hence there was a shift in attention to a theme that today would come under the term of environmental sustainability.

In construction, envelope was originally conceived to absolve a series of functions, from structural to protective, but its massive constructive system underwent a modern dematerialization process during the two centuries after the industrial revolution. Moreover in construction today envelope has acquired a more sophisticated role than that of a simple ‘skin’.

Figure 1: “Torre del vento”, “Trulli”, “Bulla Regia” as examples of connection between building and environmental context.
In fact many studies have looked at ways of increasing its performance levels in full recognition of the fact that envelopes represent the main source of building dispersion but at the same time potentially the most efficient one. Hence the building envelope is now expected to create an equilibrium between the interior and the exterior in terms of temperature, the purity and humidity of the air, the management of energy fluxes etc.

In this sense contemporary envelopes differ from the traditional definition of a ‘closed’ system, in that they are able to exchange energy but not material, and embrace the definition of a ‘complex’ system, with its own metabolism that varies in relation to the stress that it is subject to and to the use it is put.

Hence the building, from a designed element for containing plants, becomes a function integrated “envelope-plant” system at the disposition of society.

Figure 2: “Sieeb Building” MCA, “Museo dei Bambini” Italplan, “Ex Acciaierie Falk” R. Piano, as examples of sustainable projects.

Figure 3: The minor centres of “Santo Stefano di Sessanio” and “Civitaretenga”, as examples of places with environmental, historical, spatial, architectural values.

This line of research has been implemented in a number of technological applications such as the double skin, the shadovoltaic system, the ventilated wall, the pixel and the interactive wall etc., and state of the art studies show how these energy systems can be applied with success to construction of new buildings and to re-qualification of buildings, fig. 2.

The argument becomes more complex however when the context is historical and hence dotted with a cultural identity, with the presence of historical values.
protected by building restrictions, and with technical and structural limitations, fig. 3. Therefore a new line of research has developed to find a way of using technological and sustainable innovations in the rehabilitation of the historical envelope, taking into account both new technological changes and the limited transformability imposed by the desire to conserve values and building restrictions.

2 Analysis

The willingness to introduce the principles of sustainability into the rehabilitation process opens up a scenario of great complexity given that the object of intervention possesses an innate historical value and design is restricted by certain structural, technological and building features. The rehabilitation process must therefore take into consideration the historical, aesthetic, technical, spatial and environmental values that have been handed down by past generations. In the light of this it is easy to understand how the theme of ‘building on buildings’ raises complex questions and differing solutions on the basis of varying theoretical viewpoints.

The answer offered by the project to requirements of a functional and formal nature and performance, translates the technological features in the forms of expression of a prevalent strategy. Several strategies can be identified in the light of this [2].

The ‘integration’ strategy is characterized by an increase in performance levels of the envelope through the integration between new constructive and functional elements and the existing structure, fig. 4.

Figure 4: On the left an example of “integration”: Attics in Vienna, ZWZ; on the right an example of “substitution”: Reichstag, Fostern & Partners.

The ‘insertion’ strategy tends to limit as much as possible change to the external image and configuration of the original structure; the pre-existing building is considered the containing element into which new technological elements can be inserted (Reichenberg Tower, Tscholl W.). The ‘addition’ is a design strategy that entails adding one or more complete elements to the original
building that are defined and distinguishable from the pre-existing element (Museum in Wurzburg, Brukner & Brukner).

“Substitution” of one or more building elements is a strategy that is most used in cases of serious degradation or for improving the performance of a building, fig. 4. “Overlap” consists of totally or partially encompassing the original element with a new envelope maintaining unaltered the original structure (Wohlfahrt-Laymann house, Meixner Schlüter Wendt architekten). Lastly, “interposition” entails insertion of a new envelope adhering to the pre-existing, that interposing totally or partially to the existing one does not affect the original structure but allows a significant improvement in its performance levels (Il borgo di Pianezzo, M. Arnaboldi).

Independently of the specific strategy identified, state of the art studies show that the common thread is research into compatibility which arises from an in-depth awareness of the environmental context and a case by case sensitivity.

Moreover, further study has shown that the examples cited above are a clear expression of the theoretical position that contemporary debate has assumed with respect to the theme that ties the building envelope to the question of energy efficiency. In fact over the last decades many Italian and international studies as well as norms and regulations have developed along two lines of research: the first concerning the conservation of energy and the second the production of energy by envelope [3].

In real terms, although there can be a leaning towards one theoretical position rather than other, it is not possible to identify a net separation. Envelopes were not conceived exclusively as “passive elements” for thermal comfort or “active elements” to enable self-sufficiency of the building. In fact in view of the above reflections, the envelope design can be considered the result of a synthesis process, the result of research into compatibility with new performance requirements, environmental context and traditional values.

It is not simply a question of meeting standards or applying rules but rather thinking more carefully, keeping an open mind and maintaining a certain flexibility so each case can be evaluated on its own merits, in an appropriate manner.

This theoretical position is valid for the examples analyzed which mainly concerned the single historical building for which grants and information are normally readily available. In real terms the aim of this research is to investigate the criteria to adopt when wishing to introduce the principles of sustainability into the rehabilitation process of the historical envelope of the built fabric. Hence a case of rehabilitation on the historical urban fabric of the minor centre of Civitaretenga is illustrated.

3 Case study – methodology

The underlying basis for the methodology outlined below was the conservation of the identity of the place which is only possible through an awareness of those characteristics that lend ‘value’ and which any planned action must preserve. This objective can only be achieved through action that is the fruit of an in-depth
knowledge of the environmental context, and traditional building structures and materials; action that is compatible without being invasive or in conflict with the surrounding environment.

The study of features of decorative, cultural and historical value, or in other words, of all the elements that a planner should protect and conserve so that they can be passed down to the next generation, fig. 5, allows us to draw up a map of “values” for the envelope of the buildings in Civitaretenga.

Figure 5: Examples of values in the minor centre of Civitaretenga: on the left a roof truss, on the right an ancient door.

This ties in closely to the study of the environment in that the continual presence over time of given critical conditions may be at the root of certain forms of degradation. Furthermore, the study of the state of conservation of the historical envelope is essential for establishing what the element itself can offer,
in terms of performances, and for establishing possible uses. Following the
drawing up of the map of ‘values’ and in the light of the degradation observed, a
transformability map can be prepared defining variables and areas for
intervention.

When encompassing sustainability within a project, local climate conditions
must also be evaluated and they will be a new element in the compatibility
process. In fact, in parallel to these studies aimed at identifying values and
transformable elements, an environmental investigation was also realized.

This investigation consisted of: a bioclimatic study looking at the degree of
sunshine, fig. 6, and ventilation and any relationships between the urban fabric
and climate; and biophysical analyses of the land, vegetation and water basins.
These were then used to draw up a map of “critical conditions” for winter and
summer highlighting “zones at climate risk”, fig. 7. This type of map can be
made more detailed by evaluating the degree of severity of the risk or by drawing
up plans for intervention in one of the two seasons without compromising the
other [4].

Figure 6: Study of the degree of sunshine in the minor centre of
Civitaretenga on the 22nd December (above) and on the 21st June
(below) – Ecotect software.

These three maps, the map of critical environmental aspects, the map of
‘values’ and the transformability map, provide the designer with a context for the
project. It is important to underline at this point, that the rehabilitation process
must ensure that the building brought back to “life” meets the needs of today’s user which are completely different to those of past occupants.

So re-qualification of historical envelope must entail reflection on new uses and needs also in terms of lighting comfort, hygrothermal comfort and acoustic one.

These general environmental requirements can be met through the definition of determined planning strategies and a method based on a comparison between requirements and performances. Further climate analyses allow the identification of specific objectives highlighting criteria to be met through technological and sustainable solutions, compatible with the historical context.

Figure 7: Map of the winter critical conditions in the minor centre of Civitaretenga.

The drafting of these technological solutions provides an overall picture of the options available however the approach to adopt can only be established after a further phase of investigation, fig. 8, which represents the last phase of the methodological process and which incorporates all of the previous analyses. The last phase, in fact, looks at the complex process of compatibility. The identification of a solution is achieved through the study of compatibility grids covering intended use, environmental requirements, climate aspects, values and transformability. The designer uses these grids to identify compatible, conforming technological solutions that take into account the values to be conserved in line with intended use and environmental standards in process of synthesis, fig. 9.
The introduction of the climatic component increases the number of variables in the compatibility process and constitutes a further level of investigation, adding to the knowledge of the system but it is by no means exhaustive. The wider the compatibility study and higher the number of variables, the more compatible and contextualised the intervention.

4 Conclusion

The application of the methodology previously illustrated has led to the elaboration of different types of intervention on the envelopes of buildings in Civitaretenga, in the section of the minor centre referred to as the “ghetto”.

Figure 8: The methodological process.

Figure 9: The process of compatibility has brought to the respect of the values.
The compatibility process has led to the promotion of systems aimed at improving the thermal performance of the envelope of building used as both a home and work place (telework), avoiding technological solutions that would have led to a loss of perception of the historical structure. Thermal solar panels were introduced into the historical wooden roof so that renewable energy could be used provide hot water, and solar tube systems were installed to allow natural lighting in the darkest parts of the inhabited unit, fig. 10.

Figure 10: Examples of compatible solutions: the solar-tube and the ventilated roof.
Figure 11: The process of compatibility has brought to the use of the renewable energy through systems introduced on the building historical envelope.

Obviously bioclimatic study allowed for the optimum positioning of these systems in relation to the degree of sunshine and the identification of roof that, being the most exposed during the summer, was necessarily of a ventilation type. It was felt that a public building should also show sensitivity towards the energy issue and given the deterioration in the state of the museum’s roof, a new roof was introduced incorporating a system using solar energy to produce electric energy.

The new roof is a window type with a shadovoltaic system which uses silicon cells inserted between panes of glass which has the added advantage in this case, of creating shadow and therefore soft diffused lighting in the museum, fig. 11.

A further aspect worth highlighting is the fact that the project also included the recovery of ventilation channels under the roofs which in the past ensured the dispersion of thermal loads thanks to summer breezes.

This example underlines how design must arise from a process of synthesis that is based on a deep knowledge of the local urban fabric, the environmental context and recent technological innovations. Hence it is clear how the synthesis process must be in context with the object of intervention through an in-depth knowledge of the reality of its situation.

References
