INCREASING SUSTAINABILITY IN CULTURAL HERITAGE: A CASE STUDY OF SCHOOL BUILDINGS

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ABSTRACT

Environmental sustainability and cultural value preservation often appear as conflicting goals whenever regarding historical buildings; in consequence, most Italian cultural heritage institutions seem to deny any possible innovation in this field.
This paper presents an applicative work, that is a first step of a research aimed at producing methods, procedures and tools, for the sustainable rehabilitation of historic buildings. It deals with the rehabilitation design of a school and it shows the case study, the methodology and the main project elements.
The result of this work is an empirical design method, aimed at preserving building identity and improving conditions of use and environmental sustainability. It is based on the search, the analysis and the comparison of different work alternatives and on the possibility of balancing various levels of preservation and/or transformation in relation to different priorities for the various building elements.

KEYWORDS: environmental sustainability, cultural value, schools, rehabilitation.

INTRODUCTION

The environmental preservation is a principle that, even though with some difficulties, has begun to spread in Italy, both in the public awareness and in the law and tax system policies. Particularly complex appears, however, the attempt to conciliate the objectives of the environmental protection with those of the preservation of existing buildings. Although, the strategic role of building retrofit is recognized, in saving natural resources and energy, the existing buildings are believed to be the main cause of energy overuse, leading to the waste of resources and the increase of pollution.

In Italy, this conflict assumes dimensions hardly comparable, because of the quantity and dissemination of historic buildings. The problem has grown even more with the tradition of the historical studies and the restoration theories, that led us early to an extension of the preservation, over the classical monuments and the building image (Bellini, 1986), in accordance with the definition of "Cultural heritage" as “Material testimony that has a civilization value” (Commissione Franceschini, 1967, vol.1)

From this, it follows, the need to try working on existing buildings, to preserve also those elements, usually considered to be little worth, such as, flooring, doors, windows, etc.. The principles of wide preservation, agreeable at a theoretical level, often go into crisis in practice, working on non-monumental buildings. It happens for various reasons, especially: the need to adapt the buildings in use to the ever changing law requirements and users' needs; the freedom of the designer in decision-making about buildings without the protection of the building preservation institutions, etc.. In order to expand the possibility of preservation of traditional buildings, the Italian national law on Cultural Heritage (D. Lgs. 42/2004) automatically lists all public buildings over 50 year old, whose designer is no longer alive. Among the law requirements, that more recently seem to conflict with the goals of cultural heritage preservation, there are, therefore, the international energy-saving requirements

(2002/91/CE EPBD   Energy Performance Building Directory). This is a really complex problem, and the national law, at the moment, doesn't solve it but only offers an escape way. In fact, it allows the possibility not to apply the energy-saving requirements to the listed buildings, "in the event of compliance with them, it would have a consequence of an unacceptable alteration on their feature or image, especially of historical or artistic characters." (D.Lgs.192 /2005 ,D.L. 311/2006).

The lack of explicit and official criteria about what is acceptable and what is not (or about how to recognize it in the different situations) has, as a consequence, a general refusal of every works aimed at increasing sustainability, by the building preservation institutions. On the other hand, the energy requirements could further reduce the preservation of interesting elements of the non-listed buildings. There is the need to develop research aimed at supporting the design process for the rehabilitation of sustainable cultural heritage, in a proactive way; so our built environments can, at the same time, preserve their identity and improve the general conditions of life and environmental sustainability.

This paper presents a rehabilitation design of a school, and it shows the case study, the methodology and the main project elements. It was developed as an empirical activity, in research aimed at defining decision-making criteria for the evaluation of technical alternatives, for the sustainable rehabilitation of historic buildings.

THE CASE STUDY

The choice of a school building was stimulated by the fact that schools are extremely rich in terms of significance and value (due to their educational function, architecture and dimensions, etc.). Nevertheless, they are often in decay, non-complying the law requirements, misusing space and with a very low energy efficiency. Schools are, therefore, object of rehabilitation and they will be more and more; so the attention to environmental problems could assume a strategic importance for both quantity and diffusion of school buildings, and for the possibility of increasing the environmental education of children by the direct example, in order to improve their future behaviour. However, at present, the investment in the sustainability of the school buildings is tiny and differently spread throughout the Country. (Legambiente, 2007).

The case study selected is in Milan; it is a complex with a nursery, an elementary school and a professional school for adults, located in two buildings built in the '20s, and enlarged in the '50s. It is listed as a cultural object because it is a public building, more than 50 years old. Now it is in a very bad condition caused by the great decay, due to the absence of maintenance; it has very low fire-safety and comfort (thermal and acoustical) performances; its space is misused for the careless activities location and consequently, there is, at the same time, overcrowding, low utilization, and lack of location for some important user needs. The design for the building rehabilitation was commissioned by the director of the school and it will be presented to the municipal administration, owner of the buildings, which will have to decide about the work that will be carried out next year.

METHODOLOGY

This research was based on theoretical references about important issues related to existing buildings, such as: preservation and restoration (Bellini, 1986); qualification of the process

(ISO 9004, 2000, UNI 2005a, 2005b, Di Battista, Fianchini, 2005, Roders, et al. 2007); building analysis and performance evaluation (Di Battista, Fianchini, 2007)

These references allowed to define some initial hypotheses:
- It is generally better to add than to remove (materials, elements, signs of various times, etc.).
- The global performance of a building results not only by the performances of the technical elements, but also by the functional elements and by the users' behaviour.
- In order to pursue an overall increase of the different values of a building system it would be necessary to attribute different priority levels to each of the goals, related to the various building elements. In this way, it would be consequently possible to balance various levels of preservation and/or transformation, to select between different work alternatives and to evaluate them in terms of lost and benefit.

Subsequently, the following design objectives were selected, for the empirical activity:
- Global improvement of use-performances, related to the current users' needs
- Environment preservation
- Conservation and enhancement of cultural value
- Technical and Economic Feasibility
- Reliability and effectiveness of building management.

Later the information and the data on the buildings, on the users and on the activities were gathered and integrated. Some design topic goals were selected, such as: adjusting building layout, in order to fit the dimension and the location of various spaces to the needs and the activities of the various groups of users, to improve the circulation, to increase the flexibility; conforming to the law requirements (on fire prevention, on disable accessibility, on users' safety); improving thermal, acoustical and energy-saving performances; improving the conditions of use of the courtyard, and its relations with the surroundings. Then the most important spatial and technical elements and equipments were selected, and various project alternatives were considered and evaluated in relation to the level of the objectives satisfaction, by quantitative and/or qualitative criteria.

ELEMENTS OF REHABILITATION DESIGN

This part presents some examples of the project solutions and shows the comparison between the different technical alternatives, on the basis of their levels of objectives satisfaction (positive / negative / neutral).

Table 1: Legend of satisfaction levels of the objectives

Positive	Negative	Neutral
+	--	=

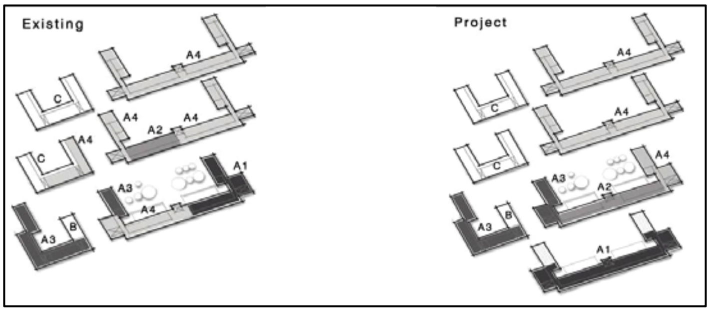
Functional Elements

✓ ***Building lay-out***

Evaluation methods: space mapping, building activities mapping; users inquiry; behaviours observation. - Diagnosis: inadequate spatial relationships of the activities (closeness

/distance); low variety of space dimensions and flexibility; disorganisation of the users' movements; overcrowding or under utilization of space. - Design solution and benefits: the lay-out design decreases the commixture of the various activities and users, by providing for different functional areas, with internal routes and separated equipment; it increases the dimensional variety of spaces, makes the area in the basement usable and makes the school completely accessible to disables; etc. This solution improves the way of use of the users, reduces waste of space and energy, makes the building more flexible and able to satisfy the ever changing needs.

Figure 1. Comparison between existing lay-out and project A: Primary school (A1 refectory, A2 direction and administration, A3 gym, A4 education); B: Nursery; C: Professional school



Technical Elements

✓ ***External masonry***

Evaluation methods: facade mapping, surveying, rapid performance evaluation (M.A.P.P.- Method for prediagnostic score evaluation, Di Battista, Fianchini 2007, pp.23-29) and energy performance calculus (UNI EN ISO 13790) - Diagnosis performance: decay of materials, risk of falling elements, low thermal insulation. - Alternatives of intervention: 1. External coat; 2. Internal coat; 3. Internal coat only on the northern side (solution adopted).

Table 2: Comparison between alternatives of intervention for external masonry

External masonry	External coat	Internal coat	Internal coat only on the northern side
Improvement of use-performance	+	+	+
Environment preservation	+	+	+
Cultural value	--	+	+
Feasibility	--	--	+
Management	=	=	=

Design solution and benefits: the intervention on external masonry consists in the installation of internal coat on the northern side to reduce energy dispersions in the most cold areas, to improve comfort in classrooms, while preserving the image of the complex.

✓ ***External Windows***

Evaluation methods: elements mapping for types and orientation, sample survey, global performance evaluation (MAPP) and energy performance calculus (UNI EN ISO 13790). - Diagnosis performance: damaged materials, closing systems malfunction, dangerous glasses, low thermal insulation. – Alternatives of intervention: 1. Improving the elements; 2.

Realizing double frames; 3. Replacing the elements (solution adopted).

Table 3: Comparison between alternatives of intervention for external window

External Windows	Improving elements	Realizing double frames	Replacing elements
Improvement of use-performance	--	--	+
Environment preservation	--	+	+
Cultural value	+	+	--
Feasibility	+	--	+
Management	=	--	=

<u>*Design solution and benefits:*</u> the solution for external windows consists in the replacement of existing elements with new ones. Both type and materials of new windows are designed to match the existing ones, maintaining the image of the complex. Installation of new elements allows a general improvement of using conditions aiming to the improvement of security performance and thermal- hygrometric comfort, thanks to the combined action of the new frames with the new mechanical ventilation system. The improvement of energy performance of new windows, combined with the choice of a natural material, contributes to environment preservation.

✓ ***Coverage***

<u>*Evaluation methods*</u>: energy performance observation and calculation (UNI EN ISO 13790) – <u>*Diagnosis performance*</u>: low thermal insulation. - <u>*Alternatives of intervention*</u>: 1. Insulation at the extrados of the attic insole; 2. Insulation at the intrados of the attic insole (solution adopted).

Table 4: Comparison between alternatives of intervention for coverage

Coverage	Insulation at the exstrados	Insulation at the intrados
Improvement of use-performance	=	=
Environment preservation	+	+
Cultural value	=	=
Feasibility	+	+
Management	--	=

<u>*Design solution and benefits:*</u> the intervention on the coverage consists in the installation of an insulating layer at the intrados of the attic insole, which allows the attic to be inspected, and reduces energy losses while improving acoustics of the below classrooms. The latter aspect increased by the combined action pf the insulating layer with the holes of modular panels of the ceiling.

✓ ***Ceilings***

<u>*Evaluation methods*</u>: direct observation and calculation acoustic performance (Sabine's equation) - <u>*Diagnosis performance*</u>: damage materials, low sound absorption. <u>*Design solution and benefits:*</u> the intervention on ceilings consists in the installation of a modular false ceiling which reduces the volume of environments, improves acoustic performance and allows to place the plants under the ceiling. The heating system, integrated with the same false ceiling, is composed of radiant perforated panels for widespread ventilation, while the mechanical ventilation system is placed between the panels and the floor. The use of perforated panels

also improves sound absorption performance, by means of the combination of perforated panels with insulating material posed on the intrados.

✓ ***Ground insole***

Evaluation methods: direct observation - Diagnosis performance: poor thermic and hygrometric capacity followed by bad indoor conditions and humidity infiltrations. Design solution and benefits: the intervention on the ground insole aims to improve the performance of the element, together with an overall improvement of the conditions of well-being and use of the recovered basement. The solution consists in the creation of a loose aired, aimed to increase the internal comfort and to allow the passage of equipments, and consequently to improve the conditions of the use of the basement. In the package of floor are housed both radiant system for the distribution of heating and an insulating layer to improve the thermal insulation on the ground and efficiency of the heating.

✓ ***Internal Windows***

Evaluation methods: elements mapping for types and sample survey - Diagnosis performance: Damaged materials, closing systems malfunction, dangerous glasses, low noise insulation. Alternatives of intervention: 1. Improving the elements (solution adopted); 2. Replacing elements.

Table 5: Comparison between alternatives of intervention for internal windows

Internal Windows	Improving elements	Replacing elements
Improvement of use-performance	+	+
Environment preservation	+	--
Cultural value	+	--
Feasibility	+	+
Management	=	+

Design solution and benefits: The improvement of the elements by sealing the frames and replacing the existing panes with safety glasses enables to improve conditions of use as entails an immediate increase in the soundproof windows, reducing air infiltration as well as an improving security conditions for its use. The recovery of elements makes it possible to contain the waste of natural resources, fundamental value for environment preservation. From the cultural value point of view the solution allows the memorial building techniques, inherent in the original frames, to be maintained.

✓ ***Heating system***

Evaluation methods: assessment of consumption by the analysis of the historic reported of the last 5 years, inspection with technicians. - Diagnosis performance: low efficiency of production system and of distribution and regulation one. Alternatives of intervention: 1. maintenance of existing plant; 2. replacement of existing plant with an high efficiency plant, integrated with renewable sources (geothermal heat pump integrated with photovoltaic plant) + replacement of distribution and emission system with a low temperature system for increase efficiency of production system + increased efficiency of control system by positioning new thermal probes.

Table 6: Comparison between alternatives of intervention on heating system

Heating system	maintenance existing plant	replacement of production system	cutting plants	replacement of emission and distribution system
Improvement of use-performance	=	+	+	+
Environment preservation	--	+	+	+
Cultural value	=	=	=	=
Feasibility	=	+	+	+
Management	=	+	+	+

Design solution and benefits: the intervention on the heating system consists in replacing the existing plant with a geothermal heat pump. With this solution, the primary energy used from the plant will become electricity. If electricity is produced through the installation of photovoltaic plant, it will be totally clean, thanks to the exploitation of renewable energy. At the last, the other interventions are: firstly, the replacement of emission and distribution system, with the installation of a floor radiant system at the basement floor, and a radiant ceiling for the other floors; and secondly, cutting plants through a division building in compatible areas in activities and timetables.

Table 7: Comparison between all design solutions adopted for make a qualitative assessment of the level of satisfaction of the project

Solution adopted	stairs	external masonry	external windows	coverage	ground insole	internal windows	ceilings	heating system	ventilatio n system
Improvement of use-performance	+	+	+	=	+	+	+	+	+
Environment preservation	=	+	+	+	+	+	+	+	+
Cultural value	+	+	--	=	=	+	=	=	=
Feasibility	=	+	+	+	+	+	+	+	+
Management	=	=	=	=	=	=	+	+	+

CONCLUSION

The work on the case study allowed us to carry out the empirical development of the method supporting the sustainable rehabilitation design of cultural heritage, and, at the same time, to verify its outcomes in progress.

The introduced rehabilitation design of the school seems to satisfy the initial objective of improving the performances and avoiding the identity loss of the buildings. That was thanks to this methodological approach, which stimulated the search for solutions capable of satisfying the most number of goals, by the analysis and comparison of various work alternatives. Moreover, in the cases where it was not possible to pursue all the goals at the highest level, it allowed to select the works in relation to the different priorities for each element, so the satisfaction levels of the various goals could have been balanced in the global project. It is the case, for example, of the decision of moderating the thermal resistance improvement of the external walls, in order not to disfigure the facades; this limitation has been compensated by the replacement of the external windows (which could not be preserved because they would be too dangerous for users). The loss of the external windows was compensated, at the same time, by preserving the similar windows placed in the internal space, which could be made safe; and so on.

Regarding the general issue on the sustainable rehabilitation of cultural heritage, this work has been a useful methodological test. In fact, the objective of the application on the case study was not the production of project models to be automatically reproduced on similar buildings, but to support conscious decisions in the different cases. However, it is only a first step of research that requires further development, to move from the experimental level to a more precise theoretical elaboration, oriented to a generalization of the method.

In particular, in this work, the evaluation criteria and the goal priorities for the various building elements have been set up in a synthetic way; following research developments should focus on their analytical definition with the aim at laying the bases for a procedural standard, for the qualification and control of design for the sustainable rehabilitation of cultural heritage. In fact, in order to spread these principles in the work practice, it seems absolutely necessary to provide operators (designers, property owners and public administrators) the methodological and procedural tools for their application.

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