School Buildings for XXI century

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Abstract

Interest in the retrofit derives from the remarkable consistency of the real estate of public schools in Italy that requires heavy and urgent redevelopment. The total estimated volume of the existing school buildings in Italy is about 230 million cubic meter, with a power consumption of about 12-13 billion kW/year. Reports continue to present the worrying scenario of a real estate portfolio for much more senescent and stalled, far away from the expected quality of users, the performance levels that both the technical regulations and the habits of a civilized society now widely required for new teaching models that are making their way, though with difficulty, in the educational landscape. The central government invested resources for improving schools without a general picture. Now it proposes to set up new funds on the basis of the assessments is the register of the school buildings, which in Italy is still far from being implemented and completed. The economic aspects of refurbishment must consider the direct costs of construction, the economies of scale of reduction in consumption and both the increase in the service life and asset value of buildings.

The crucial choices must define the best strategy for the redevelopment of an old heritage but also for adapting buildings to new issues.

Keywords: school building retrofit; performance envelope; registry; sustainability certification standard; energy retrofit; school buildings costs

1. Introduction

Nowadays, the interest towards the school retrofit requires a considerable attention to a plurality of aspects and peculiarities that must be considered, in a refurbishment or a retrofitting, to make a proper correlation between the functional, technological and system characteristics with the pedagogical ones[1]. Firstly, school buildings should be designed suitably for children, because pupils are strongly conditioned by the surrounding environment, for instance by colors and noises, imagines and experience. The quality and the structure where the educative activities take place strongly influence the being of the child and his learning ability. During the study of the project, the physical size of the child and the foresight of edges and furniture avoiding impacts and cuttings and windows that ensure a correct visibility of the external environment even when the pupil is seated, should be considered.

The importance and requirement of retrofit of these buildings is due to the poor conditions[2] and the unsuitability that are found in the today Italian schools. In Italy, a building on three was built before 1960, many of them do not own the required certifications, such as fire prevention, compliance of the electrical and fire protection water system and neither the outside safety stairs. Many Italian schools (23.000) are located in seismic risk areas and are not designed according to rules[3].

In addition, the school has an huge social, educational and economic value. Indeed, it establishes the daily relationship between teacher and student and it is often a everyday civic centre also among adults as well among children, just think of meetings carried out throughout the year such as Christmas and year-end performances, presentations, meetings etc.. The school building itself has educational value; for instance, through effective and innovative envelope and facilities it's possible to educate students, whom, detect differences between the home and the school environment, and tent to have a growing yearning of knowledge and a greater curiosity about what surrounds them. Finally, the school is a keystone of the country, a cultural and social defense, especially in small towns.

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1 On 04.07.2013 The 7th House Committee deliberated again on the necessity of conducting a survey on the state of school buildings in Italy.

2 XIV Legambiente Report sulla qualità degli edifici scolastici, delle strutture e dei servizi della scuola dell'infanzia, primaria e secondaria di 1° grado (Ecosistema scuola 2013)

3 Ministero delle Infrastrutture, 2004

The quality of environments, both internal and external, may further contribute to a reduction in costs related to hygiene, health and safety of the occupants. In fact, the increase of allergic diseases and asthma among children requires to ensure adequate thermal comfort, natural ventilation and good indoor air quality. In addition, careful and detailed analysis of illumination, in particular on the work plans, is dutiful together with the reduction of glare risk inside and outside the building.

The building retrofit must finally consider the school educational model changing that provides the use, more and more frequent, of computer, overhead projectors and tablets, and finally it must consider the change of some building features such as, the insertion of collecting space for collective activities.

During last 10 years we have designed more than 35 retrofit or new school buildings. Our activity give us huge datas about the way in which the Italian Public Administration works and what difficulties the designer can find on the way to more sustainable buildings. The hardest issue is the correct use of the few economic resources.

2. Fields of technological and functional refurbishment

The school buildings retrofit has not, only, the purpose of improving the quality of internal and external environments, change its footprint and meeting the requirement of the current regulations such as, fire prevention, architectural barriers[4], health and hygiene and earthquake proof, but, also, the purpose of optimizing the performance characteristics, in order to satisfy the current regulatory frameworks and technological solutions, and to reduce the heating and cooling primary energy demand of buildings and to respond to current functional needs and space distribution.

There are many possibilities for technological retrofit of the building. Hereinafter, several solutions related to insulation systems, ventilated façades and bioclimatic greenhouses will described in further detail.

[4] According to a study conducted by S. Intravaia (L'Italia che va a scuola, Laterza, 2012) in a decade, the number of pupils with special needs in classrooms has increased by 56%, while the data Miur 2010 report that even the 60% some schools do not have proceeded removal of architectural barriers

2.1 Technological retrofitting

2.1.1 Thermal coating

The installation of an insulation system is a technological choice that involves a low economic impact on the material and on its transport and which provides quick and easy installation of façade panels, increasing energy efficiency and improving the indoor comfort of the building. Easy installation doesn't signify an easy project: windows-wall details, reduction of dismantling cost, lighting controls are all parameters that can bring to a worse building[5].

Based on the above said, the choice of intervention may become a national standard and therefore a solution of technological retrofit of the school building envelope, adoptable everywhere in the climatic zone D, E and F.

The choice relative to the implementation of this retrofit method of buildings will be described later in further detail, in the case of study of the primary school located in Pogliano Milanese, Milan, Italy.

2.1.2 Ventilated façades and bioclimatic greenhouses

The school building envelope retrofit may also include the installation of ventilated façades and the realization of bioclimatic greenhouses.

The ventilated façade system is well suited to refurbishment and redevelopment of buildings and allows, through the air ventilation along the air gap, to improve energetic, acoustic and humidity performances, as well as, aesthetic ones, of the existing envelope.

The bioclimatic greenhouses, if installed according to specific principles of orientation and with appropriate window frames and glazing, may contribute to the heating of the building and therefore .

These two possibilities of technological retrofit of the envelope, relative to the installation of a ventilated facades and bioclimatic greenhouses, should be studied and designed only by experienced professionals with specific training about. In this way, they assess the interaction between the system and the environment defining the purpose and application field, carrying out adequate analysis and evaluating the generated impact. Mandatory regulation must be considered for

[5] For information on visual and postural problems resulting from design errors, see “Dal benessere visivo al Benessere globale” R. Zannardi et altri

These two technological solutions will be described in detail in the case of study relative to the primary school located in Ossona, Milan, Italy.

2.2 Functional refurbishment

For existing schools, however, the critical design issue actually lies elsewhere: of key importance is in the functional/spatial inadequacy of the majority of school buildings that fails to accommodate evolving user needs and new didactic methods. Yet the increasing number of performance indicators required to bring an existing school "up to standard" are not enough to save this specialized building (i.e. school) from sbeing out-dated. Indeed, the overall quality of the school building is actually tied to design factors that are not directly proportional to these regolations (which are often quantitative, financial, dimensional, and physical-enviromental).

Instead, there is a close connection between construction and pedagogical standards, between layout and didactic functions that does not have to do with technical issues but rather the architectural concept, composition, and circulation. Therefore focusing on school buildings design means paying close attention to the school's architecture; a renovation project becomes above all an architectural undertaking.

In relation to the functional aspects, it appears, in some school buildings, the need for a redistribution of spaces; most school buildings date back to the Gentile Reforms of the early 1920s; and they suffer from technological constraints of the era they were built. The frontal-oriented lessons of that time were what drove the overall organization, while spatial relationships, two dimensional structural systems, and limited potential of materials, influenced the typology.

In addition, considering that the temperature difference between outside and inside very often generates flu, especially in children, may be optimal to create spaces interposed between the external environment and the school, with filter function and therefore, capable to reduce the thermal gap in the transition from outside to inside or vice versa. Such functional solution is still in experimental step and the actual efficiency of the system is studied.

Nowadays, the functional analysis must also consider the evolution of the current educational model that involves the use of technological devices, such as tablets, that require the insertion of point elements, such as sockets for recharging batteries and Ethernet cables, at each school desk, or the installation of a wireless network.

The functional analysis should also be carried out in response to the current fire prevention regulations of the school buildings, evaluating the possible need to construct external evacuation stairs, the fire resistance of structure, the reaction to fire of used materials and finishes, as well as the compartmentalization, emergency exits and escape routes.

2.3 Retrofit of mechanical plant

One of the issues under discussion relates to the increase of the role of plant during the development of energy improvement projects. The research and technology lead us to consider the possibility of using mechanical equipment to provide greater indoor air quality and reduced energy consumption.

From our point of view it is appropriate to concentrate efforts to reduce the role of mechanical systems: it is known that in Italy the system of maintenance of the buildings has never been effective, even for the average costs, and plant systems for mechanical ventilation may result in severe respiratory illness. However the moderate temperature of days in October, March, April, May and June, simply bring us to open doors and windows. For this reason, frequently seek to use spaces buffer as solar greenhouses, use of vegetation for the reduction of pollutant concentration more than MVS.

In our experience, during the analysis of energy consumption of the existing buildings, air ventilation rate is never as mandatory regulation. On the other end the qir quality varies during the lesson period, while windows are closed.

3. Examples

We present below two different projects already finished: the first concerns a primary school in Ossona (MI), the other a primary school in Pogliano Milanese (MI). Both projects date back a few years ago and have made it possible in recent years to be able to observe the behaviour of real property than expected. Our firm apply always the typical approach for analysis and design:

Activities	*Interaction*
Acquiring construction drawings or testing	Municipality
Acquiring energy consumption data	Municipality
Processing model of the status quo	
Needs	School technical staff, parents, students
Development model of the project	
Choice of retrofit measures	Municipality, school technical staff
Realization intervention	
Post-intervention data collection	Municipality

This method has guaranteed to obtain important information both as regards the costs of intervention and the time of return of the investment, and as regards the behaviour of users in buildings. It must be noted that many communities of people are hardly represented by legislative assumptions, especially in a nation as diverse as the Italian one.

3.1 Ossona

The envelope was made by curtain wall consisting of single glazing and sandwich panels with polyurethane interposed of thickness 5 cm. The thermal transmission is 5.3 W/m^{2}k and the acoustic insulation of the façade is 29 dB. The original data[6] (2005) reported by about 36,000 €/year for energy consumption

Illustrazione 1: View of the existing façade - 2005

The needs illustrated by teachers and municipality are:

- better thermal and lighting comfort;
- reduction of the energy bill;
- reduction of maintenance cost;
- new image to the building.

The total amount is 1,127,169.30€. The project has provided for the redefinition of the relationship between walls and windows, the realization of a new masonry with thermal transmittance less than 0.23 W/m^{2}k, the construction of control systems of external sunlight in substitution to the inner one. As a result of the interventions consumption drop to 6,500€/y with significant savings on the ordinary expenditure of the Municipality.

[6] Data acquired from Municipality

The project involved the construction of a ventilated facade with brick elements, XPS thermal insulation with a thickness of 10 cm. and construction of new brick masonry. In this way it was possible to change the image of the building itself, in addition to improving the performance of the technical elements.

The new performances of the buildings are:

Wall thermal transmittance: 0,231 W/m^{2}k

Windows thermal transmittance: 1,7 W/m^{2}k

Acoustic insulation of the façade: 48 dB

The original project also includes the installation of solar greenhouses with solar shading which have photovoltaic standard features. This lot has not yet been realized, but hopefully will be funded from existing financial instruments made available by the Region and the State.

3.2 Pogliano Milanese

The school is a three floor building of the beginning of the 70's. Some destructive tests were made to understand the wall is realized with double layers of bricks with air gap. The control of the natural lighting is realized by external blinds while the windows present a single glass of 4 mm. and wood frames.

The thermal transmission is 1.8 W/m^{2}k for wall and 5.3 W/m^{2}k for windows.

The needs illustrated by teachers and municipality are:

- better thermal and lighting comfort;
- reduction of the energy bill;
- new image to the building.

The total amount is only 633,900.47€; after a cost-benefit analysis the decision was to use an XPS insulation coating, ventilated facade only at first level, new solar control system and to change windows.

The new performances of the buildings are:

Wall thermal transmittance: 0,22 W/m^{2}k

Windows thermal transmittance: 1,7 W/m^{2}k

Acoustic insulation of the façade: 49 dB

The project has focused on details to address potential thermal bridges derived from the need to reduce the costs of demolition and arrangement of rooms architectural window

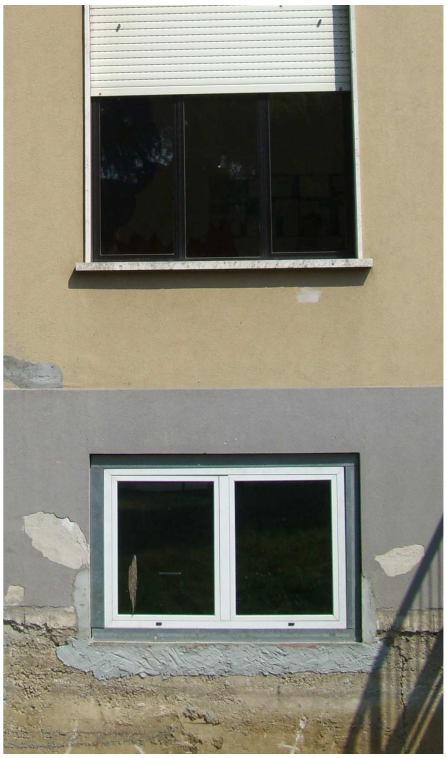

Illustrazione 2: Solar control

Illustrazione 3: New solar control system and ventilated façade

The change of the windows with higher noise insulation performances gives a great improvement in noise control. This improvement gives to the students a better capability of understand lessons and in this way we ensure to students more possibilities of success.

The extarnal sun control system was chosen to:

- better control on the south façade;
- better protection from direct light;
- reduce the glare effect inside the schoolroom.

4. Cost

The main issue of large-scale interventions for the public real estate assets or private is always the cost. In particular, in these years of economic crisis we found ourselves having to debate, with greater or lesser success, the theme of the public function of the building for the community. In particular convince the authorities that the building is not just an envelope in which you perform the functions school, but must itself be an educational element.

We can take inspiration from reality in South America, where the building does not perform a limited function at school, but retains the same role that absolved the school buildings in Italy until 1990.

Interventions must therefore possess characteristics of innovation in the management of lighting, reduced energy consumption, in the correct evaluation of the seismic vulnerability of buildings.

Our experience shows that this approach for improving the building envelope can be applicable for a limited number of buildings that already have suitable functional spaces. Or limiting the type of intervention, for a large number of buildings, knowing that the buildings themselves will be the subject of future interventions to ensure adequate standards and functional flexibility. Given that today the state funding in that area can not cover all the needs of the heritage building, architects and engineers will find themselves having to apply scarce resources wisely to improve the technological performance more in deficit. Only in the future, with a new political strategy for reconstruction of school buildings, we will have high-performance buildings throughout the Country and not only for a few pilot interventions.

We can summarize these 10 years of field experience in the following way:

- Cost per square meter for limited interventions casing: 203,08€/sm
- Cost per square meter for interventions also on plant parts: 503,37€/sm
- Typical intervention on the external walls for municipalities under 3,000 inhabitants: insulation coating
- Typical intervention on the external walls for municipalities with more than 3,000 inhabitants: ventilated facade;

5. Conclusion

Consider also the hypothesis that someone advances: a conception of "common school", according to which the places of learning and knowledge are brought into the network, but also places where the specific culture of the city themselves become active school: of the rest , the Greeks wished the school the same way as an "educating city."

In this context, the concept of mere functionalism is exceeded: the spaces are generated by the activities that you will have to exercise, but most are occupied by persons in continuous evolution.

The school, revised in this way, is understood not only as an institution, witness of civilization but also as a vehicle useful and beautiful, due to the quality of the buildings: through walls, shapes, objects, colors, spaces, so through architecture must stimulate the sense of belonging and identity and at the same time should facilitate the conditions for physical and mental wellbeing in the students and the school staff.

The school buildings, through their expressive language but also through the materials and technological equipment, the space complexity, the articulation distribution, the degree of flexibility, the level of interaction with the context, the correlation between inside and outside, the propensity to 'integration with the community including non-school, become a strong tool of visibility and communication with the city and with the generations that follow and in what represents an essential educational moment.

The school is a place to live, is a living space in the wholeness of the feelings, it is a place of welcome, it is a place of satisfaction, is a place of growth and therefore evolution is the only space in which the same subject in the same environment with the passage of a short time, changing one's being as a person physical and cognitive, as an individual and as a "social animal". The school, through walls, shapes, objects, colors, spaces, then through the architecture must foster a sense of belonging and identity.

The architecture of schools, perhaps more than any other place built to serve mankind, must be able to express the maximum synergy between form, function and comfort: architectures poor are poor schools and poor schools lead to poor results.

Interesting and innovative experiences of advanced design for the construction of new schools exist in Italy, but especially abroad, where the previous one built is not as binding (culturally and psychologically) as in our country: comes from these ideas

virtuous the belief that, perhaps , we should rethink the design of the school and, especially, the approach with existing schools.

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