Research for Development

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Buildings for Education

A Multidisciplinary Overview of The Design of School Buildings

Fondazione Politecnico di Milano

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Preface

This book belongs to a series, which aims at emphasizing the impact of the multidisciplinary approach practiced by ABC Department scientists to face timely challenges in the industry of the built environment. Following the concept that innovation happens as different researches stimulate each other, skills and integrated disciplines are brought together within the department, generating a diversity of theoretical and applied studies.

Therefore, the books present a structured vision of the many possible approaches—within the field of architecture and civil engineering—to the development of researches dealing with the processes of planning, design, construction, management, and transformation of the built environment. Each book contains a selection of essays reporting researches and projects, developed during the last six years within the ABC Department (Architecture, Built Environment, and Construction Engineering) of Politecnico di Milano, concerning a cutting-edge field in the international scenario of the construction sector. The design of schools has been recognized as one of the hottest topics in architectural research, also for the criticalities detected in the current conditions of Italian school buildings.

The papers have been chosen on the basis of their capability to describe the outputs and the potentialities of researches and projects, giving a report on experiences well rooted in the reality and at the same time introducing innovative perspectives for the future.

With the aim of exploring the evolutionary scenario of school design as an architectural topic, the collected papers were selected according to a comprehensive and multidisciplinary overview. Researches on typology and spatial organization are enriched through the contribution of a historical and social perspective to enlarge the focus on the urban role of the school buildings. Moreover, innovative approaches and tools have been highlighted both in the design process and in the education techniques. The presented experiences include best practices of

consistent and coordinated contributions of the several disciplines involved in the design of school buildings, also implementing digital tools. Finally, the issues related to the challenges of the existing built stock triggered the development of more technical and specialized, albeit multidisciplinary, investigations and case studies' reports.

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Introduction

Background

The design of educational spaces dedicated to school is a rather recent topic in Italy, since until the end of the nineteenth century and the unification of the country,[1] children were educated exclusively in private or ecclesiastical environments; and only later, the school education was recognized for its significant role in the teaching and learning processes (Pennisi 2012). The evolution of the architectural school typology and of the primary school in particular, can be analyzed as a complex combination of political, cultural, social and urban planning issues and as a reflection of the historical situation. Through the analysis of the educational buildings erected in the different periods, it is possible in fact to detect the evolution of the legislative framework, aimed at defining hygienic and comfort requirements, and of the organization of spaces required by the different pedagogical approaches. The study of the architecture of existing schools reveals a sequence of construction systems, both traditional and innovative, from masonry walls to reinforced concrete frames and to prefabricated solutions, which were employed to better respond to changing needs (in particular, low construction and maintenance cost and construction time reduction). Finally, and with a strict connection with the above considerations, the role of the school building in the city is remarkable at the urban level also, for its ability to promote the development of entire neighborhoods of a city or for the ability to revitalize an existing portion of a city in relation to other public services and open spaces.

[1]The compulsory education was introduced in Italy with the Casati Law, issued by the Minister of Public Education Gabrio Casati in 1860. This law entrusted the central government the obligation to enact laws in relation to school education and the management of public schools and gave private individuals the possibility of founding and managing institutions, but without the right to confer educational qualifications. In this period, elementary education became free, compulsory only for the first two out of four years (i.e., for pupils aged 6–7 years) but only present in cities with over 4000 inhabitants or in secondary education institutions (Laurenti and Dal Passo 2018).

The Current Situation

The results of a more than a centenary process of school buildings' construction are significant from a quantitative point of view. The whole stock of educational buildings of all levels and dimensions amounts to 42,408 units, hosting 7,816,408 students in 370,597 classes (Miur 2017), distributed all over the national territory (see Fig. 1). However, this is an extremely heterogeneous heritage,[2] because of the aging, the functional and often physical obsolescence, which ultimately does not respond to the current demands in terms of teaching and learning methodologies, but also because of the low comfort and safety performances and of fruition and accessibility problems (lack of compliance with "Universal Design" goals).

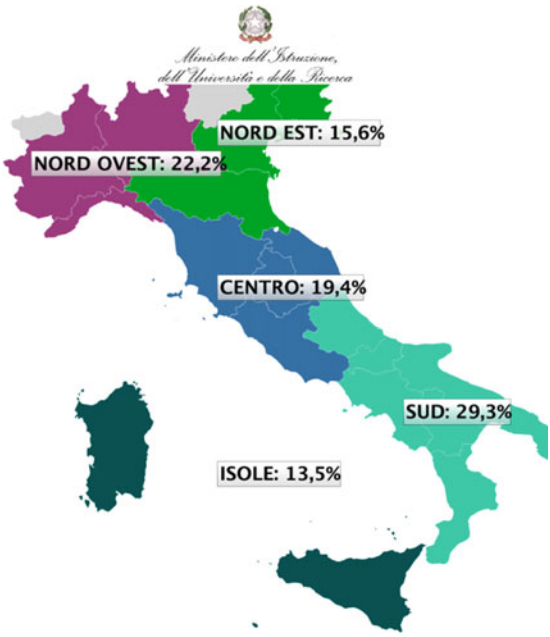

Fig. 1 Distribution of the educational buildings on the Italian territory (Source: MIUR—*Portale unico dei dati della scuola, Anagrafe scuola*)

[2] Thirty-two percent of the schools was built after 1976, 27% between 1961 and 1975, 12% between 1946 and 1960, 8% between 1921 and 1945, 4% between 1900 and 1920, 3% in the nineteenth century, and 1% before 1800. There is no information for the remaining 13% (Miur 2017).

In addition to the hydrogeological hazard that can affect some schools positioned in risk areas, one of the most urgent issues is related to the high seismic vulnerability characterizing most of the existing schools, which indeed were designed with respect to gravity loading only.

The identification of the seismic areas in Italy started at the beginning of the twentieth century, through the instrument of the royal decree, issued after the destructive earthquakes of Reggio Calabria and Messina on December 28, 1908. Since 1927, the areas hit by earthquakes have been divided into two categories, in relation to their degree of seismicity and their geological constitution. Therefore, the seismic map in Italy was nothing but the map of the territories affected by the strong earthquakes after 1908, while all the territories struck before that date (most of the seismic areas of Italy) were not classified as seismic and, consequently, there was no obligation to build in compliance with anti-seismic regulations. Only in 1974, through the law of February 2, 1974, n. 64, a new national seismic regulation was established which defined the reference framework for the seismic classification methods of the entire national territory, as well as for the drafting of technical standards. Immediately after the earthquake of October 31, 2002, that hit the territories on the border between Molise and Puglia, the Civil Protection adopted the ordinance of March 20, 2003, n. 3274, in order to provide an immediate response to the need to update the seismic classification and seismic regulations. According to the ordinance n. 3274, and unlike the provisions of the previous regulations, the entire national territory was classified as seismic and divided into four zones, characterized by different seismic hazard.

This brief history demonstrates that seismic regulations in Italy are quite recent. Indeed, according to the new registry launched by the Ministry of Education University and Research (Miur 2017), only 8% of the schools was designed in compliance with seismic regulations, 54% is in a vulnerable zone, and around 19,000 buildings are situated in high-risk seismic areas. The collapse of educational buildings in the 2009 and 2016 earthquakes in central Italy and the tragedy of San Giuliano di Puglia (2002), where 27 children died in the primary school building collapse, represent a clear symbol of the gravity of this problem.

A second major issue is related to the inadequate energy performance of the educational buildings, again due to the old construction date and to the evolution of the regulations on the energy performance of the buildings, the first being enacted only in 1976, but with very low requirements in comparison with the current situation. Although the European Energy Performance of Buildings Directive (EPBD) requires that "*the public sector in each Member State should lead the way in the field of energy performance of buildings*" and "*buildings occupied by public authorities and buildings frequently visited by the public should set an example*," almost 85% of the school buildings in Italy belongs to the bottom classes of the energy performance ranking. Only 5% (Legambiente 2018) of the stock can be classified among the first three classes, a percentage corresponding to the constructions completed after the 2001, when the first regulations requiring a high standard of energy efficiency were enacted. Hence, if the lack of sufficient structural safety can appear as a real threat, the inadequate energy performance is certainly a

waste of resources and a lost chance as well. Energy retrofit programs in fact can become lighthouse projects not only because schools are public buildings visited by pupils, their parents, and the staff, but also because the direct understanding of the behavior of the building envelope and technical systems can help children learn how to support energy savings as responsible users and transfer the knowledge to their families. A further issue to add to the serious situation of the national heritage, related to both structural safety and energy poor performance, is the significant gap between northern and southern regions; an imbalance which characterizes also the funding for ordinary repairs, let aside renovation interventions.

Furthermore, health and indoor comfort requirements should be addressed, especially when considering that almost 10% (Legambiente 2018) of the existing complexes should be cleaned from asbestos.

Finally, the shift toward a knowledge society where information and knowledge are expanding in quantity and accessibility is introducing major changes in teaching and learning models. The information revolution has changed the way we interact with people and things. We live in a society where information is spread out in a large-scale dimension, and new technologies become new tools to change the relationship between time and space. Learning happens everywhere. The new generation of net-native pupils, with an increasingly different set of expectations about space and time, will require constant access to learning materials and resources to share within and beyond the school. Inter-disciplinary learning and collaborative peer-to-peer learning will become increasingly common. New educational models and approaches will be required to help multiple generations, belonging to diversified cultures and in different fields. This will require a general rethinking of the school layouts to overcome the actual strict zoning of the functions and to respond with a higher flexibility to the rapidly changing demand.

The barriers toward the starting of a concrete policy for the renovation or the replacement of the existing stock are varied. It is not just a problem of economic resources but also of a complex set of different issues related to both the diversity of the heritage and the heterogeneous set of institutions responsible for the construction/renovation process. The schools in fact are managed by municipalities as well as by provinces and also directly by the central state. The interventions, considering the major presence of public buildings, are very often subjected to the national public works legislation, requiring a significant effort in planning and organization. One of the challenges is thus how to support municipalities or institutions, especially the smallest ones, in the process from the design activity, to the tendering, to the site inspections and co-ordination during execution, until the final acceptance testing.

The decision for the construction or the retrofit of the school building should consider the relationship with the urban context and the possible potentials that the public building and its annexes can add to the community, for example, in terms of quality of the public spaces, additional resilience in case of emergency[3] and of lifelong learning[4] or integration with other public facilities. A new construction or a requalification can also trigger the regeneration of the surrounding neighborhoods.

The Challenge of Renovation and New Buildings Design

From 2014, in Italy a vast program[5] of construction of new schools and requalification of existing educational buildings that affect, in different ways, every level of education, from primary schools to universities, have been public financed. Different architectural design competitions were also proposed, beyond the attribution of the design task, to collect innovative proposals able to explore new solutions and approaches for the renovation of the educational facilities. Many examples and competition applications are collected in this book.

This program concerned the transformation of educational and pedagogical approaches, aimed at improving the effectiveness of learning models, as well as the requalification of the existing buildings from an energy-saving and structural safety point of view, the latter with particular regard to seismic vulnerability of the existing buildings.

These themes have long been a field of great interest, experimentation, and research, aimed at developing projects, models, and intervention strategies where different disciplines and skills are involved. The possibility of giving old places a new identity, to update buildings according to the new educational and teaching models, to develop projects that take into account the actual needs of energy savings and structural safety is deeply investigated in the following chapters.

On a broader scale, all these needs offer the possibility of redesigning complex existing buildings and developing projects that play an important role also at the urban level, by becoming reference places, opportunities for redevelopment of degraded parts of a city, new cultural, and civic centers.

This book describes the results of some of the research and consulting works, carried out at the Department of Architecture, Built Environment and Construction engineering (Politecnico di Milano), related to the design of new schools and to the

[3] A structural safe school building in seismic areas can be used, for example, as a possible emergency center or temporary accommodation in case of necessity.

[4] The often-unused spaces of a school building during the evening or weekends can host courses for adults or other continuous learning programs or different activities for the whole community.

[5] Of the ten billion euros invested, five have been spent by municipalities, provinces, and metropolitan cities to construct 300 new buildings and start 12,000 renovation projects. ItaliaSicura, the Council of Ministers authority created to lead and manage the renovation programme, was closed in July 2018 (https://www.corriere.it/scuola/primaria/18_luglio_05/edilizia-scolastica-ambiente-governo-chiude-italiasicura-adef7264-8017-11e8-841c-47290107a48c.shtml).

requalification of existing ones. The description of these activities has been organized into three sections, where particular emphasis is given to the effective collaboration with institutions at various levels and the synergetic combination of the different disciplines involved, needed to respond to their requests through applied and basic theoretical research works.

The chapters, organized into the three different sections, investigate central themes about the buildings for education, focusing, in particular, on the definition of multidisciplinary approaches for the design of new schools and for the upgrading of existing ones. Among the main topics highlighted, the first section focuses on the relationship between the city and the school as a civic building with a public role for the community also to possibly host different functions. Accordingly, some recent concept designs are featured, carried out within national and international competitions, and analytical and historical studies on the theme of schools and on their typology, as well as on the role of these buildings at the urban level, are reported. In the second section, innovative solutions for both the design and the construction process are analyzed, and in some applications, particular relevance is given to the building information modeling (BIM) strategy as an optimal tool to achieve a synergetic combination of the different disciplines involved. Finally, the third section focuses on the built heritage, particularly: (i) on the tools, technologies, and approaches required to upgrade the existing buildings, in order to comply with the new regulations (in terms of seismic resistance and energy performance); (ii) on the possible transformation of unused constructions into buildings for education, and (iii) on the management of the existing stock. Theoretical as well as applied research paths are reported to illustrate the topic both from the methodological point of view and through real case studies.

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About the Editors

Stefano Della Torre Graduated in Civil Engineering and in Architecture, he is a full professor in restoration at the Politecnico di Milano. He is the director of the ABC Department - Architecture, Built environment and Construction engineering. He is the author of more than 250 publications. He serves as an advisor for CARIPLO Foundation (Cultural districts) Province of Como and Lombardy Region (policies of programmed conservation of historical-architectural heritage). He is the president of Building SMART Italia - national chapter of association Building SMART international.

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of various projects for public and private buildings' new construction and refurbishment and achieved mentions and awards in design competitions.

Raffaella Neri Graduated in Architecture in 1986, she is a full professor at the Politecnico di Milano. In 1993 she gained her Ph.D. in Architectural Composition from IUAV, Venice, with a dissertation entitled, "Essay on construction. Research into the role of construction and architectural design in relation to type and decoration". In 1994–1995 she worked on organizing the exhibition entitled, "The Center elsewhere" (coordinated by A. Monestiroli), La Triennale di Milano. Since 2003 she has been a member of the teaching staff body for the Ph.D. in Architectural Composition at IUAV, Venice. Her research activities include the theory of architecture, urban design and the role of construction in design. In recent years she has studied compositional principles for residential developments and the issue of redevelopment of brownfield sites and former military zones. She participates in design contests, winning the Luigi Cosenza National Architecture Award in 1996.

"A Factory for the Future": Inveruno New School

Tomaso Monestiroli, Francesco Menegatti, Maurizio Acito, Giuseppe Martino Di Giuda, Franco Guzzetti and Paolo Oliaro

Abstract School is a rather complex issue that involves a range of different disciplines—the technical disciplines of architectural, system and structural design, along with the disciplines of training that define the educational project, as well as the disciplines of sociology and urban studies. Given such complexity, the relationship among public institutions such as City, Province and Regional administrations and the seats of scientific research such as University Departments where the above-mentioned specific expertise is developed, becomes fundamental for an innovative school project.

Keywords School · Architecture · Inter-disciplinary · Sustainability · Nzeb · Anti-seismic · Public authority collaboration · BIM

1 Introduction

Here, school is intended as a relational space open to the territory and designed to host public activities accessible to the entire urban community. The new school of Inveruno is, in this sense, the new civic center of the city, a representative building and a place of cultural integration. The school is designed to offer flexible and permeable spaces (sliding walls, movable furniture, glazed rooms, covered and open-air collective areas, etc.) where innovative education becomes the key principle to provide students with adequate skills. Therefore, the school offers in equal measure individual spaces for education and study, spaces for exploration where students may experiment and as a group practice the skills they have acquired (cross-disciplinary workshops), and group spaces where they may present and discuss the results of their work with the school and city community. Just as important are the open space between the buildings and the central square designed to host open-air events that involve the entire school community.

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2 Urban Context

Inveruno, a town with 8600 residents, is part of the metropolitan city of Milan in the Lombardy region.

Its urban structure mainly resulted from the prevailing agricultural activity that experienced a renewed impulse after the opening of the Canale Villoresi in the second half of the nineteenth century.

The modification of the territory after the construction of the canal resulted in a new system of smaller canals and in the innovation of the agricultural activity and brought remarkable transformations in the history of the town. During the modern age, Inveruno owed its urban expansion to the creation of industrial activities such as the Muggiani textile mill, the Officine Elettriche Colombini and more recently the Belloli oil-mill.

The development of industrial activities resulted in a gradual decline of agriculture with remarkable consequences on the urban structure of Inveruno. Later on, the decommissioning of most industrial facilities has left several sites now requiring adequate redesign and redevelopment as they play a strategic role in the urban structure.

The urban fabric of Inveruno comprises a first and oldest core connected to the establishment of the rural hamlet and featuring linear buildings that follow the morphology of the territory. Their layout defines closed blocks with interior courtyards. This oldest core is complemented by sections of residential fabric comprising low houses within which the landmarks of the town community, starting with piazza San Martino bordered by the parish complex, emerged. A third evolution followed this second development, which appears more relevant in terms of quantities rather than for settlement reasons. This is a disjointed and patchy fabric made of one- or two-family houses built during the phase of industrial development. This expansion resulted in an uncontrolled sprawl within which, however, the old structure defined by orthogonal hydrographic canals that shape a road network that still organizes the actual expansion of the town's urban boundaries is still recognizable.

Within this heterogeneous context, the industrial site of the decommissioned Belloli oil-mill, now undergoing a design rehabilitation, is located in the northeastern part of the town and the urban void that defines it plays the role of a cornerstone between two kinds of road tracing of the urban expansion. Therefore, the rehabilitation of this decommissioned site, in terms of its location and contextual features, is strategically important for the urban transformation of Inveruno.

3 The Site

The decommissioned Belloli site is a large urban void bordered by via Brera, via Fratelli Bandiera, via IV Novembre, and the provincial road 129. Built in 1919, the Belloli industrial facility increased its activity in the post-WW2 period and closed

down in 1979. The large void of the decommissioned factory within the town was surrounded along the perimeter by industrial facilities demolished in 2009 for safety reasons and still features a towering reinforced concrete silo used to store seeds. Built in the 1960s, the silo is a reinforced concrete structure supported by "V"-shaped pillars that emerges as an actual landmark in the town and over the years has almost become a historic monument in the life of its residents. The site is currently in a state of disrepair and heavy deterioration. Its rehabilitation is necessary because it occupies a central spot along a green axis established by the park across from the Town Villa overlooked by the town library that extends along viale Piemonte, connects the areas of the Inveruno Sports Union and further on, the green areas of the Luigino Garavaglia Town Stadium. This green axis is particularly important for the Town of Inveruno as it connects the areas that traditionally accommodate the old San Martino Fair, the main agricultural fair of the region for over four centuries.

4 Architectural Design

The principle underlying the design of the new school complex results from the belief that the current buildings fail to meet some fundamental requirements as a good quality educational facility. The two primary schools have small classrooms and lack collective spaces and workshops, without mentioning the fact that their cafeterias are in the basement. The secondary school building is hardly functional in terms of the standards of a modern secondary school: the building is not properly insulated and therefore underperforming on an energy level and the implementation of safety measures from the static point of view would require a significant investment.

The project results from the belief that the school represents a place of primary importance and recognition for the town community within the urban structure. For this reason, the project addresses multiple levels in the rehabilitation of the decommissioned Belloli oil-mill site. The core of the project is an open public space created for the gathering of the entire community. The two schools with their sports facilities and a small auditorium that closes the perspective from via IV Novembre overlook this new green square. The school complex is conceived as a small campus where open space is prevailing and the layout of the individual buildings acquires a particular importance. Indeed, in order to respect the vocation of this large urban void, the buildings are recessed from the boundary of the roads so that they create widenings and resting spaces for the town.

Both buildings, a primary school and a middle school, feature an open courtyard overlooking a central square with a slight rotation that follows the layout of the context in order to create articulated and differentiated volumes around the central square as well as to distinguish their sites and accesses.

The middle school complex lies to the north-west from via IV Novembre and comprises the classrooms and the sports buildings, while the open-air sports facilities and the cafeteria directly connected to the school's building lie in the back from the square.

At the southeast, there is the primary school complex comprising, from the entrance, the indoor sports facilities followed by the actual school building in a recessed position from the road. Like the first building, this complex has its green open spaces and the cafeteria at the back. The buildings are autonomous and independent volumes also in terms of their potential of use by the citizenship. The school offers sections others than the educational facilities that can be used in different ways as well.

5 The Single Buildings and Their Interior Spaces

The middle school building includes four classes with attached workshops and special classrooms, while the primary school includes three classes and an additional Montessori Method program for one class of the school of Furato, a hamlet of Inveruno.

The middle school has a courtyard layout with a system of load-bearing columns that define its inner and outer perimeter. This solution allows treating the elevations in a differentiated manner by opting for either glazed walls or opaque infills according to the needs. This construction system also offers additional advantages in terms of transparency and visual openness as it optimizes the potential of natural lighting. The school is accessible through the green courtyard overlooking the square. At the ground floor, a large lobby connects the interior courtyard and the garden in the back, a large collective space designed to host temporary exhibitions of the students' works. All the classrooms at the ground and first floors along with the associated workshops overlook the large central courtyard according to a layout that benefits from the best sun exposure. The generous distributive system becomes an informal space (a fundamental element in the guidelines of innovative educational facilities) where alternative education- or study-related activities may be organized. The staircase cores and services are located at the sides of the courtyard so that they are immediately visible and accessible. One of such cores provides access to the locker rooms of the gym through an underground passage.

The class-B gym is designed to host junior league provincial and regional sports games. The facility relies on load-bearing walls and features two entirely glazed and shielded elevations overlooking the courtyard. The gym's main elevation directly overlooks the new green square so that the building may be accessible independently from the school. Spectators and users may reach the gym directly from a lobby in order to get either to the stands on the field's sides or to the locker rooms and ancillary services at the underground level. From the northern elevation, instead, it is possible to access directly the outdoor sports courts in the school's large garden.

One last small building accommodates the cafeteria directly connected with the school building from one of the distribution cores through a covered and heated passage. The cafeteria is entirely glazed and openable towards the exterior.

The primary school has the same features as the middle school except for the necessary distinctions related to the latter facility. Classrooms and workshops are similar in terms of size to those of the middle school, except for the selection of specific furniture that guarantees high flexibility in the subdivision of spaces. The gym is smaller than the one of the middle school and designed to accommodate motor activities for children. It is likewise independent and directly accessible from the green square even for after-school programs such as sports activities that require smaller courts—martial arts, yoga or dance classes.

The cafeteria is larger in this case and divided into smaller "rooms" in order to avoid overcrowding strongly discouraged by the scientific community of educators.

A civic hall completes the square in the terminal part as a facility designed to operate independently from the school and host activities for both students and the entire town community.

6 Technical Design Choices

The technical choices reflect the compliance to the following main criteria: reduction of energy consumption, reduction of the building's environmental impact, reduction of construction times, construction and use flexibility, simplified maintenance and management.

7 Building Life Cycle

The project relies on the use of construction technologies based on the dry assembly of single components. Vertical prefabricated concrete structures are mounted on a concrete basement for the construction of the load-bearing frame and are completed by floors and interior laminated wood walls designed to guarantee a fast and efficient construction on the one hand, and dimensional precision and flexibility of spaces on the other hand. Prefabrication allows for a high quality level due to the possibility of selective dismantling and replacement of parts in case of maintenance. The absence of the seasoning times required by concrete and the installation of completed components allow for a shorter construction phase. A particular care was devoted to the distributive flexibility of classrooms, which have no structural elements dividing them and therefore may be repurposed in case of changed use requirements simply by dismantling and moving the wood dividing walls. The two courtyard layouts allow for an optimal distribution network of systems, the connection ridges of which are in the readily serviceable false ceiling and in the raised floors in order to guarantee flexibility of use and an easy maintenance.

8 Materials, Safety and Comfort

The wooden elements of the floors allow for a perfect reaction in case of earthquake as they perform as a monolithic plate unbounded to the concrete frames. The now consolidated use of both elastomeric and sliding seismic isolators guarantees a high resistance to earthquakes. Aside from technological aspects, we tried to provide the building with features that would guarantee maximum efficiency to emergency escape routes in case of danger.

The insulation materials we chose are of natural origin and recyclable; they provide a high stability of performance across time and maximum fire resistance. The wooden floors are completed by cork suspended ceilings, which are highly efficient in reducing noise reflection.

In order to ensure the natural ventilation of spaces, the pivoted windows are equipped with vertical opening leaves. Low-emissivity glass and rolling blinds complete the equipment of windows in order to guarantee high levels of comfort.

The geometry of the façade, which is recessed from the floors, allows for a satisfying control of solar radiation, while the stringcourse beams perform as brise-soleils in order to protect the elevations.

The walls are enclosed in ventilated walls equipped with interior insulation and a particular care was devoted to the elimination of cold bridges.

Green roofs concur to the control of solar radiation. If sown with low-water requirement plants such as succulents, they will guarantee a further thermal insulation to the surface.

The rooms are equipped with underfloor radiant heating panels; each room is equipped with temperature control calibrated on crowding and solar radiation. A ventilation system channels filtered, hot and humidified air into the rooms through airflow vents and high induction diffusers with air intake vents and grills in toilets and corridors.

9 Environmental and Energy Sustainability

The widespread reliance on prefabrication, the careful design of the shell and the use of natural materials, efficient glazing and solar shields complement energy-efficient air conditioning systems.

The production of domestic hot water is centralized and fueled by heat pumps. Winter/summer air conditioning exclusively relies on renewable power sources.

The geothermal system fueled by reversible heat pumps is the only source of thermo-refrigeration. The system we propose relies on a station with two heat pumps, one of which functioning in a polyvalent reversible mode. Both concur to cover the winter energy supply, while the polyvalent heat pump covers the summer energy supply of the building, as well as the yearly production of domestic hot water (DHW) with a total recovery of heat during the summer period.

A system of photovoltaic panels would be installed on the roof of the gym.

The school is as a relational space open to the territory designed to host public activities for the entire town community. In this sense, the new school of Inveruno is intended as the new civic center of the town, a representative building and a place of cultural integration. The school provides flexible and permeable spaces (sliding walls, movable furniture, glazed classrooms, covered and outdoor collective spaces, etc.) where innovative learning methods become the key element in helping the students acquire the right skills. For this reason, the school equally offers individual spaces for learning and study, exploration spaces where students may experiment and practice as a group the skills they have acquired (cross-disciplinary workshops), and group spaces where they may present and discuss their works with the school and town community. Just as important are the open space between the buildings and the central square where open-air events that involve the entire school community may be organized (Figs. 1, 2, 3 4 and 5).

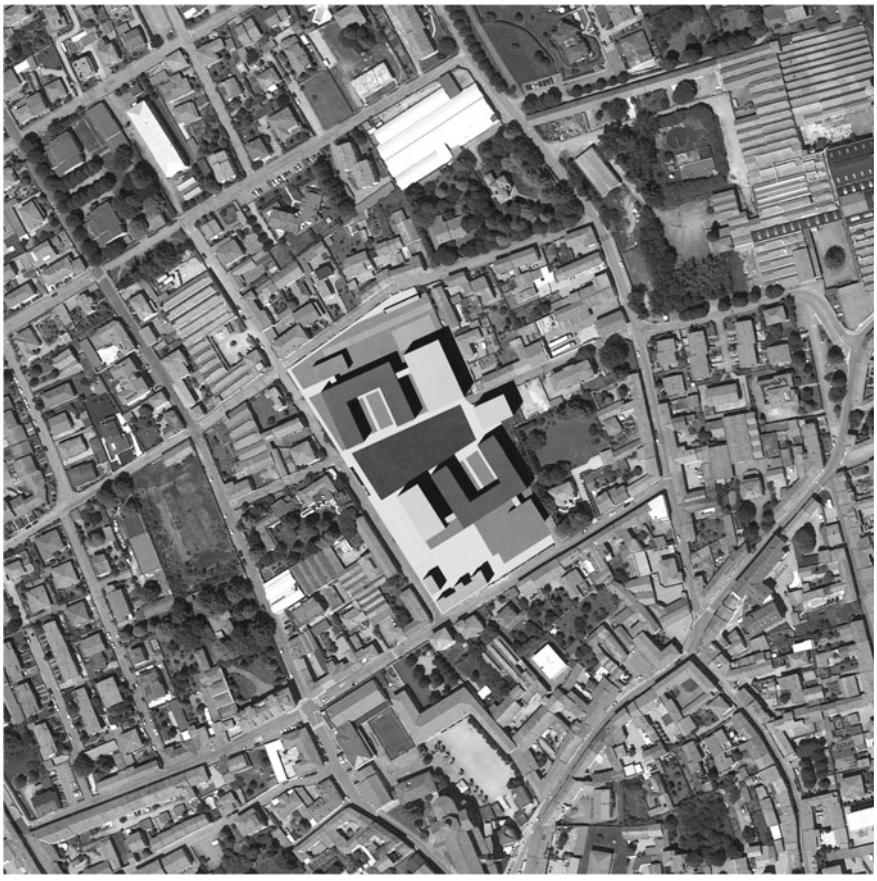

Fig. 1 Aerial photography photomontage

Fig. 2 View of the main courtyard garden

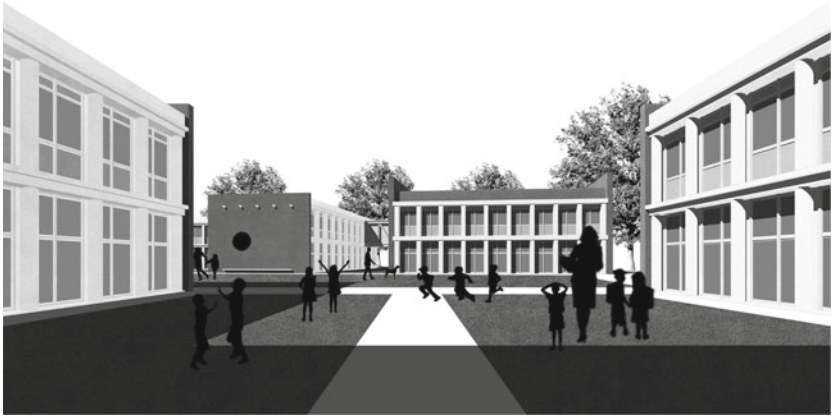

Fig. 3 View from the high school courtyard

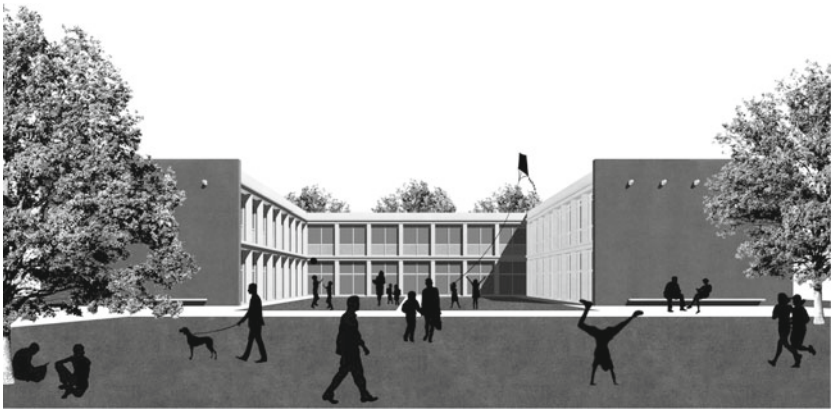

Fig. 4 View from the high school courtyard garden

Fig. 5 General plan