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).

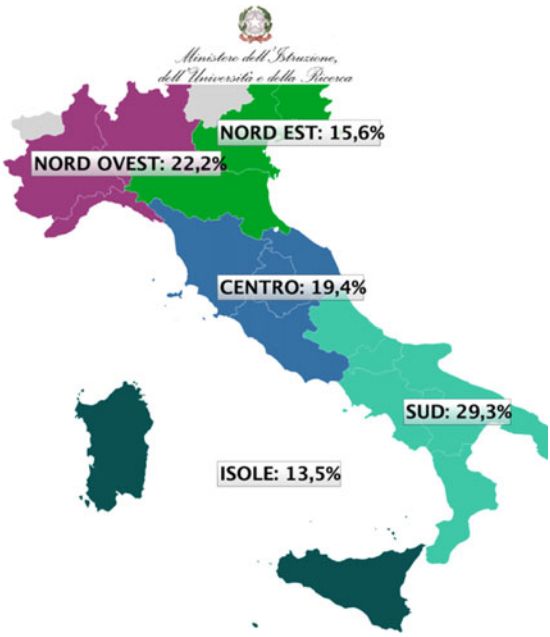

Fig. 1 Distribution of the educational buildings on the Italian territory (Source: MIUR—*Portale unico dei dati della scuola, Anagrafe scuola*)

[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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Contents

The Quality of the Project and the MIUR Standards for the Control and Funding of Buildings for Education and Training

Giovanni Castaldo, Matteo Gambaro, Elena Mussinelli and Andrea Tartaglia

Abstract This paper reports the results of an activity of scientific advice for the winning project of the national competition for the construction of a new building for the *Fondazione Collegio delle Università Milanesi*. Starting from the project submitted to the IV MIUR funding tender in 2016, the attention is focused on the issue of the quality of the project and its development up to the detailed design phase within the current regulatory and procedural models defined by the MIUR and the Public works laws for the design and construction of temporary residences for university students.

Keywords Environmental design · Temporary residences · University colleges · Public works · Dimensional standards

1 Temporary Residences for University Students

The university student residency has been progressively attracting the interests of real estate investors over the last few years, appearing as a growing market, particularly in a city like Milan, which is increasingly showing a European propensity with the growing presence of foreign students.

The offer of accommodation in facilities specifically designed to host university students is considerably insufficient compared to the real demand, both in quantitative and in qualitative terms, obligating the users to face the free housing market.

To cope with these issues, the research is developing innovative design solutions and management tools, in order to interpret changing needs and lifestyles.

In light of these considerations, with the aim of encouraging the construction of new student residences, in November 2000 the Italian Parliament passed an ad hoc law, aimed at universities, public bodies and foundations, which provides for the co-financing of specific interventions concerning existing buildings, extensions,

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new buildings and purchases of buildings to be used as residences for university students.[1] The Law 338/2000 is the first national example of an organic program aimed at encouraging interventions towards different building scales: from the removal of architectural barriers, to building improvements for hygiene and safety, to maintenance, restoration, expansion and new construction, with also the possibility of purchasing areas and buildings for residences (Del Nord 2014).

This is an ambitious and innovative program aimed at increasing the number of dormitories and at improving the design and construction quality through proper and detailed regulations focused on the "Minimum dimensional and qualitative standards and guidelines relating to technical and economic parameters concerning the construction of housing and residences for university students".[2]

Within this framework, the policy for university residence of the Milanese universities has profoundly changed and the panorama of their offer has been articulated also in relation to these building programs and their development.

The case of the *Fondazione Collegio delle Università Milanesi* is one worthy of not in this regard, a Merit College legally recognized by the Ministry of Education, University and Research—MIUR, which in the recent years has started a significant construction program aimed at increasing the number of accommodation facilities.

Precisely within these activities, an international design contest published by the Fondazione was the chance for a group of researchers from the ABC Department—who focus much of their activity on the topic of social housing and special residences[3]—to transfer theoretical knowledge and research results on techno-typological innovation, environmental quality and technical construction solutions within a design process in which these elements represent a significant added value. Analysis of trends, typologies and innovative international approaches, together with advanced tools and methods typical of the environmental technological project, as well as studies on the sustainability of building materials in a circular economy logic, have become important added values to support the project proposal which was then the winner of the competition.

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[1] Law 14th November 2000, n. 338 "Indications regarding the accommodation and the residences for university students". The implementation of the law consists of the publication of National tenders: for each tender specific decrees are published for the definition of the modalities of presentation of the co-financing requests, the required documents, the spatial and functional standards, the procedures and the constraints for the co-financed initiatives.

[2] D.M. 28th November 2016, n. 936 "Minimum dimensional and qualitative standards and guidelines relating to technical and economic parameters concerning the construction of housing and residences for university students as prescribed by the Law 14 November 2000, n. 338".

[3] Cf. research projects: "Policies, projects and techniques of rehabilitation and transformation of urban suburbs" MURST 1998, operative coordination Elena Mussinelli; "Innovation and project for residential buildings", AUPREMA soc,. coop., Elena Mussinelli (2005–2010); "To live tomorrow. Technological innovation and sustainability in the residential building project", Fondazione Politecnico di Milano, coordinator Elena Mussinelli (2007–2008); "Hybrid modular architecture for emerging housing behaviours" PhD research, supervisor Elena Mussinelli, tutor Andrea Tartaglia (2015–2019); "Vivere e abitare l'università. Bilancio nazionale sulla residenzialità universitaria—Living in the university. National analysis on university residency" conference, scientific coordination Oscar Bellini and Matteo Gambaro (2019).

2 The Scenario for the Experimentation

The *Fondazione Collegio delle Università Milanesi* is a non-profit institution supported by seven universities and important public and private bodies of the city of Milan. The program of the *Fondazione* includes the provision and the management of student residence for temporary housing in a highly multicultural context, starting from the enhancement of an interdisciplinary and international method: a concept of "social intelligence" to promote life skills as well as cognitive supports such as extra-curricular course credits, which are the basis of this new educational approach. The current headquarters of the *Collegio* is in the south-west part of Milan, more precisely in a building designed by Marco Zanuso in the Seventies. This is site of great interest from both an architectural point of view—with a remarkable example of organic architecture promoted by *Cariplo* for hosting a center for financial aid to African countries—and an environmental point of view—with the presence of a high-quality garden that surrounds the area. The *Collegio*, with reference to the undergoing programs of expansion and consolidation of the campus, as well as to new development projects relating to accommodation, such as the Expo area, deals, in terms of scientific research, with the topic of university residence and of collegiality, with reference to the change of needs and to new cultural models and lifestyles. The activities of the *Fondazione* are aimed at the dissemination and at the promotion of college life, at the enhancement of the culture of merit, the internationalization of the university system and the integration of local realities. Through the study of the dynamics relating to temporary residency within multicultural contexts, it is also proposed as an incentive lever for social mobility and active citizenship.

In line with this approach, in 2008 it promoted an invitational competition for a first expansion of 53 new residential units. The winner project was by the Piuarch Studio, a choice that confirms that the *Fondazione* was well aware of the legacy of Marco Zanuso's architecture (Nannerini 1974). The work is financed with the III tender of the 338/2000 law, started in 2016 and completed in 2019.

In April 2016, the *Fondazione*, before the publication of the IV tender of the law 338/2000, promoted a "Competition for the preparation of a preliminary project for the construction of a new building for the *Collegio di Milano*" for the second expansion, which saw a large participation of architects and engineers. The theme of the competition was the construction of a new autonomous building, with access from Via Ovada, to be used for accommodation for university students, with the relative common and service spaces. The competition was organized also with the aim of participating, with the winning project, in the selection procedure called by the Ministry of Education, University and Research (MIUR) of the IV three-year program of co-financing of student residences, in the framework of the law n. 338/2000. It also required the consideration, in addition to the dimensional and qualitative constraints defined by the framework of the 2011 decree, of the volumetric, typological, functional and technological characteristics of the work to be carried out. In order to meet the objectives of the promoter, the type of accommodation to be developed was that of a "hotel", with a corridor distribution system and preferably single rooms with

private toilets. The collective residential services were to be concentrated in areas separated from the at least 50 rooms of the residents. In order to respect the qualitative standards and the functional program, the evaluation criteria for the identification of the winning project were indicated by the tender, summarized in: "aesthetic and functional aspects" with particular reference to landscape integration and the relationship with pre-existing buildings of the campus; "economic aspects" with particular reference to durability and the control of the construction and management costs; "general aspects" in compliance with the conditions of the tender and the use of advanced technological solutions.

The jury of the competition awarded the project of *Centro Studi TAT*, coordinated by Fabrizio Schiaffonati[4], stressing in the motivation the original approach related to environmental integration and the effectiveness of the techno-typological solution. The winning project, even if it was in continuity, due to its morphological and typological characteristics, with the two previous interventions, also coherently interpreting the Zanuso's legacy, to which it explicitly refered without any manneristic satisfaction, was able to implement and qualify the open public space both with enviromental and social values. It consisted of a linear building with a north-south orientation, articulated in two sections of different width, a double body and a triple body.

The expansion project, which has obtained already the funding by the MIUR, is based on principles of environmental compatibility, typological and functional optimization of spaces and maximization of maintainability, substitutability and durability of materials and technologies adopted, as suggested and derived also by the preliminary studies carried out by scientific consultants.

3 The Design Experimentation

The campus of the *Collegio di Milano* has an area of 22,400 square meters, of which only 4,000 are occupied by the original intervention dating back to the early Seventies designed by Marco Zanuso and the recent expansion by the Piuarch Studio, with a total capacity of around 170 university students. In 2016, the area was expanded with a new contiguous plot measuring 4,600 square meters, already allocated by PGT to university residence, which therefore led to a total area of 27,000 square meters, with a total capacity of 220 beds (Fig. 1).

[4]The winner group consists of CSTAT, and refers to architects Fabrizio Schiaffonati, Arturo Majocchi, Giovanni Castaldo, with Elena Mussinelli, Andrea Tartaglia and Matteo Gambaro as scientific consultants for the techno-typological aspects, technical innovation and environmental sustainability, and the collaboration of Roberto Castelli, Federico Cecere, Gregorio Chierici and Francesca Scrigna. The winner was also entitled for the development of the definitive and detailed design as well as for the related commitments for the obtainement of the authorizations and permits for the construction (Tartaglia 2018), and for the definitive and detailed design phases the team included also BCMA, Broggini and Carrera Studio for the structural design and Casassa and Cigliutti Studio for the systems design.

Fig. 1.1 Aerial photograph of the campus with the first expansion highlighted in gray and the second in red

Environmental Compatibility

The intention of the project was to combine the criteria of high architectural quality with the environmental and economic sustainability of the intervention. An approach that takes into account the constraints of the context, distances from the existing buildings, heights of the surrounding buildings and orientations (Schiaffonati et al. 2011). Also enhancing the potential of the campus characterized by a remarkable amount of greenery, including a sports area, with free pedestrian and scenic paths that confirm the attention for the landscape paid by the designers of the previous interventions.

The new volume originates from the observation of the overall texture of the context, the matrix of which is represented by Zanuso's organic plant building, which Piuarch took into consideration in the morphology and alignments of their intervention, and which the new extension confirms completing a coherent articulation of the entire building complex. So the basis of the project concept is the role that the new building will play in completing this urban environment. The Zanuso building, consisting of two arms connected by a central nucleus, defines a "C" shape open towards south-west. The body of the building designed by Piuarch represents a further arm, which, with the building proposed by CSTAT completes the plant by enclosing a new space into a new "C" facing north. This morphological and functional recomposition defines the succession of two "C"s, one open towards the south (building by Zanuso) and the other towards the north (Piuarch building and the new addition) (Fig. 2).

Therefore, the project is configured as a building divided into two parts, the first with a double body in a north-south orientation with one façade facing via Ovada and the second, with a triple body, rotated of about 30° towards south-east. This choice reflects the objective of minimizing distribution spaces, particularly in the triple body, the surface to volume ratio of which is also particularly efficient from

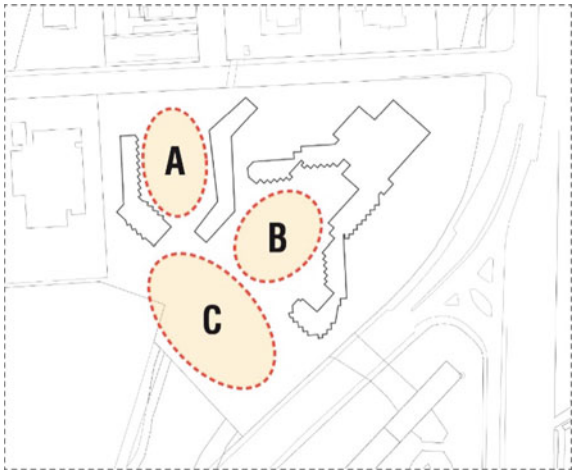

Fig. 1.2 General plan with the identification of the three open spaces defined by the buildings

an energy point of view. The building consists of 4 floors above ground: the ground floor, with shared access and services, and three residential floors with some services. The total surface area is 1,927 m^2, with a gross volume of 5,781 m^3. There are 51 rooms, including 3 for disabled use, and all the required additional services.

The environmental compatibility is the result of planivolumetric, morphological, typological, system and technological choices, as well as of alignments in terms of orientation and optimization of the sunlight (Schiaffonati et al. 2015). The soil consumption is limited, with a small footprint of the building that maximizes the permeable surface. Even the open spaces, with prevalent lawn portions, confirm the objective of limiting the environmental impact of the intervention in terms of hydraulic invariance and permeabilty. The green described above helps to mitigate and compensate for the intervention.

The open space facing the building is configured as a new square, partly paved and partly green, which visually and functionally connects the different buildings; this space is characterized by the presence of plants and trees, with the function of mitigating and increasing the environmental quality, as well as by the presence of chairs. The compact building shows on the facades the regular rhythm of the windows of the rooms and of some wider openings for common services. A number of volumetric additions and subtractions aim to maximize the energy performance of the building, as well as to express spatial relations with the context and to characterize the building in terms of recognizability. In this sense, the arcade on the ground floor operates as a covered connection between the new pedestrian entrance of via Ovada and the atrium of the building (Fig. 3).

Building Typology and Distribution Characters

The "hotel" building typology distributes the (single) rooms partly along the double body and partly (24 rooms) along the triple body with a central corridor. This

Fig. 1.3 Perspective view from the south of the new building

"hybrid" distribution system aims to optimize the corridor space, to enhance the orientation and to harmonize the new building within the pre-existing morphological and environmental context. Thus, the new volume seeks to dialogue with existing and under-construction buildings through its alignment and dimensions. The articulation of the distribution system also offers optimized views to the rooms: the corridor is in fact located on the west side in the double-body portion and centrally in the triple-body portion. The correct orientation of the rooms contributes to increase the quality of the spaces of the residence, as well as the overall energy efficiency of the building.

The distributional rigor and the optimization of the relationship between served/servant spaces are also sought at the accommodation scale. Each room has an area of 17.9 m^2, including a bathroom of 3.9 m^2. All the rooms have a 4 m^2 balcony and an entrance that serves the bathroom and the room. The arrangement of the furnishings, even if with a certain degree of flexibility, is designed to guarantee high levels of rationality and usability of the spaces. The wide windows of each apartment allow for a correct solar gain and the visual fruition of the context. The window is smooth, packable on one side, with a maximum opening of more than 2.40 m. When fully open, the balcony becomes an extension of the interior space. On the privileged fronts for sun exposure (east and south-west) there are 39 rooms, only 12 facing north-east (Fig. 4).

The residential spaces are completed by the services prescribed by the National tender and by the decrees. The environmental units for services envisaged by the project are: cultural and educational services (study rooms, multi-purpose spaces

Fig. 1.4 Type floor plan of the new building

for conferences and educational activities: 265.9 m^2); recreational services (multipurpose spaces, lounge spaces: 96.5 m^2); support, management and administrative services (laundry, warehouses, office space: 118 m^2); access and distribution functions.

Material Alternatives, Maintainability, Substitutability, Durability of Materials and Construction Technologies

The material simplicity and the volumetric rigor of the facades are a salient feature of the image of the new building, also to ensure a high degree of maintainability, durability, substitutability of the various components. The external envelope is characterized by the provision of a ventilated façade, of which the last layer is made up of large vertical GRC panels, which, in addition to guaranteeing adequate energy performance, are optimal for conservation and maintenance issues. The large translucent vertical closures of the rooms and of the common spaces provide for the adoption of doors and windows with profiles with a thermal break.

Another key-element of the facades is the triangular-shaped balconies of the rooms, which represent an expansion of the living space and an important view on the surrounding greenery. The "jagged" image of the balconies of the rooms is an explicit reference to the architecture of Marco Zanuso. The parapet of these balconies is partially opaque, realized with a GRC panel and partially transparent grate of metal rods.

On the west elevation there is an external safety staircase designed with a central reinforced concrete core that supports cantilevered ramps, stairs and horizontal connections, with transparent metal parapets.

Overall, material choices have been made in harmony with the main colors identifiable in the surroundings, without any sophisticated contrast. The elevated structure

is in reinforced concrete. In the competition, the proposal included also the possibility of using concrete blocks made with aggregates, produced with the use of the waste from recycled glass processing: solutions developed by the research "Ethical concrete" which also saw in 2015 the participation of a number of researchers from the ABC Department (Tartaglia et al. 2016).

Standards and Laws Legge 14 novembre 2000, n. 338 Disposizioni in materia di alloggi e residenze per studenti universitari.

D.M. 28 novembre 2016, n. 936 Standard minimi dimensionali e qualitativi e linee guida relative ai parametri tecnici ed economici concernenti la realizzazione di alloggi e residenze per studenti universitari di cui alla Legge 14 novembre 2000, n. 338.

D.M. 7 febbraio 2011 n. 27 Standard minimi dimensionali e qualitativi e linee guida relative ai parametri tecnici ed economici concernenti la realizzazione di alloggi e residenze per studenti universitari di cui alla Legge 14 novembre 2000, n. 338.

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