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RESEARCH ARTICLE

An Innovative School Building Design in the Town of Montemiletto

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Abstract:

Background:

This paper presents an innovative design for a school building, awarded in the concourse “Scuole innovative”, published by the Italian Ministry of Education, University and Research. The new school building is located in a newly built urban area of Montemiletto (Avellino, Italy), at the south-east of the Leonessa castle and the ancient nucleus of the town. The Comprehensive Institute that includes a kindergarten, a primary school and a secondary school, is proposed as a Civic Center, an “urban place”, characterized by new spaces of relationship and aggregation.

Objective:

The main idea of the project design is the creation of an innovative school with respect to the architectural, structural and plant system aspects and to the energetic efficiency and characterized by the presence of new environments of learning and openness to the territory.

Materials and Methods:

The project proposals can be summarized in the different points: a) unit of the morphological-settlement solution and the articulation of the Civic Center, to be identified as new reference point in the city; b) adherence of the characters of the school to the landscape and visual connection with the castle; c) urban and architectural role of the system of the paths and connections, which surround and enter in the intervention area; d) extension and permeation between the natural and artificial environments assigning to the roof the task of increasing open spaces; e) accentuation of the public and multi-functional character of the different spaces, so that the school can be a place for meeting and comparison, in which it is possible to test new ways of teaching; f) use of different types of green open spaces as gardens, flowerbeds, educational vegetable gardens that change with the seasons, sporting fields, cycle-for-gate routes among the green. Moreover, with respect to the structural aspects, seismic isolation at the basis of the building is proposed. This paper focuses mainly on the aspects related to energy and environmental sustainability and life cycle cost with reference to the case study design. The goal is to reduce the impact on the ecosystem, trying to make the school building organic to the existing environment. The containment of energy consumption for the air conditioning of the rooms is done through the isolation of the massive walls of the façade, covered with local stone (Irpina breccia) and polycarbonate. Water-saving is obtained by reusing rainwater for the irrigation of vegetable gardens, vegetation and sanitary use.

Results and Conclusion:

The use of recycled materials and components is proposed: the Irpinia breccia covering the façade and, with different grain sizes, the external roofing and flooring; the polycarbonate; the polyester insulation; the outdoor furniture in recycled wood. In addition, dry reinforced concrete construction technologies are chosen. Definitely, the main concept is to have “a school in the park”.

Keywords: Innovative schools, Sustainability, Civic center, School in the park, Flowerbeds, Educational vegetable gardens.

Article History

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1. INTRODUCTION

The “Innovative Schools” concept competition was launched as implementation of the Decree of the Minister of Education, University and Research November 2, 2015 (n. 860) [1], with the aim of acquiring design ideas for the creation

of innovative schools from an architectural, plant, technological, energy efficiency and structural and seismic safety point of view, characterized by new environments of learning and openness to the territory. The concept has been conceived as a single major competition, divided into 52 territorial areas, identified by each region on the basis of a specific procedure initiated by decree of the Minister of Education, University and Research. A massive participation has been recorded. It allowed to set up interesting thematic comparisons and

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analyses, placing itself as a strong reference in the design of new schools in the Italian reality.

The new school, whose project won the competition for the Montemiletto town, in the province of Avellino, is located in the south-east of the castle and of the ancient core of the town municipality, in an urban area of recent formation, already characterized by school functions and urban equipment.

The new school building is designed as a Civic Center, an urban place characterized by spaces of relationship. There is an articulated system, in which the nursery school is in immediate contact with the garden and the educational gardens, but also connected to a large atrium, where the auditorium, the canteen and the laboratories are located. This unitary space is both a space for great events and domestic space, sub dividable and usable in everyday life. At the same altitude, the system of open and covered spaces is connected to the existing gymnasium, incorporated into the new system. From the atrium it is possible to descend towards the library and to go up towards the elementary school and then to the middle school. The rotation of the superimposed levels makes possible to create terraces and outlooks, which, together with the inclined roof, define the characteristics of an articulated building immersed in the green spaces, which recalls the castle and the hill. The idea is to have a building in the park. This fundamental goal is pursued in relation to the general aims of the "Innovative Schools" competition with respect to which specific answers have been elaborated and summarized in the proposed solution. However, these specific answers can be explored, identifying some specific themes [2 - 10]. Figs. (1 and 2) propose front views of the school building under consideration.



Fig. (1). Front view of the school building.



Fig. (2). Front view of the school building with the adjacent area.

2. MATERIALS AND METHODS

2.1. Innovative Themes for the School Design

A first theme proposed by the announcement is the relationship that the design solution establishes with the natural

environment, with the landscape and with the reference context also as a didactic function, *i.e.* in other words the theme of the presence of usable green spaces that enrich the habitability of the place. Based on such premise, the project for the new school is conceived as a landscape project, intended as the construction of an architecture strongly related to the specific site, to the topography of the area, and to the vegetation aspects of the place. In this perspective, three fundamental choices are presented: A perceptive connection is established with the castle, whose connection with the site and the articulation of volumes is reinterpreted; an extension and an interpenetration of the natural and artificial soil is done, assigning to the full and/or inclined roofs the task of enhancing the quality of open spaces; different types of green open spaces are planned: gardens, flowerbeds, educational vegetable gardens that change with the seasons, sports pitches, cycle-pedestrian paths through the greenery, with a view to obtaining "a school in the park" (Fig. 3).



Fig. (3). The school in the park.

A second theme identified by the concourse is related to the opening of the school to the territory, an aspect that concerns the participatory path and that has been interpreted in the proposed project solution as a continuous and varied interrelationship between the school building and the city. In fact, all the environments, including not only the atrium and the open spaces, but also the classrooms, can become collective spaces, making the school a place for meeting and comparison, involving all the community.

A third theme concerns the correspondence of the design of the spaces with the pedagogical needs and with the instances of didactic innovation. The school is intended as a pedagogical place where learning takes place not only in the classrooms, but in all available spaces. The school environment becomes a living environment, a home in the school, a place where you can experiment with new ways of learning. All the environments are delimited by a flexible and modular closing system, designed to be adapted to a future evolution of the structure. It is possible to define multiple configurations that can be achieved with flexible set-ups: one-to-one learning, group activities, group discussions are moments different of the teaching, which impose the overcoming of the traditional classroom, which can be interpreted only as a possible answer to the different needs. In this context, the school building is imagined as an architectural element capable of stimulating collective growth (Fig. 4). The atrium is not only a representative space, but also an educational space. In addition, the connecting spaces are no longer traditional corridors, but are animated by lights, seats and settings that create spaces for aggregation, work areas and rest. In parallel, even other apparently more rigid schools spaces have been redefined on

the basis of a new approach. The library and the laboratories are incorporated into the system of connections and conceived as places of research and study, equipped with innovative technological devices and sized to perform a role of service for the entire community (Fig. 5). Moreover, spaces designed to guarantee the presence of common areas for the interaction and development of sociality can be at the same time subdivided into small environments for individual concentration and well-being. Also the professional spaces for the teachers are designed with a view to spatial dislocation between the levels of the schools; this position is detached from the idea of a single and closed administrative block and allows a greater integration of the teachers' activity with that of the students. Definitely, the school space is designed as a safe space, easily accessible and usable by everyone: the access routes for urban, pedestrian and cycle-pedestrian needs and those for parking are clearly identifiable and without any barrier.

A fourth theme, related to many interconnected aspects, regards the sustainability of new schools, in structural, environmental, energy and economic terms. It is important to highlight that it makes sense to talk about sustainability with reference to the specific objectives of the project ideas and not in general terms. Based on such premise, some proposals are presented, able to enhance the contents of the school, encouraging their feasibility, but also compatible with the spatial concept introduced in the school.

2.2. Sustainability of the Design

2.2.1. Structural and Technological Aspects of the Design

The structural behavior of the structure is one of the most challenging topics in high seismic regions as Campania [11 - 19]. With respect to the innovative solutions for the structural aspects, a seismic isolation at the basis of the building is proposed. Also in this topic, the traditional conception of the fixed base structure is overcome. In fact, it is possible to go beyond the classic structures, characterized by low main periods, by the interposition of a deformable element in a horizontal direction, which allows achieving higher periods, reducing the demand spectral acceleration. If the structural innovation allows having the safety of the building, in an area with a high degree of seismicity, this can represent a fundamental condition of the new school in terms of collective well-being, interpreted in a broad sense. Moreover, the technical and technological solutions are designed in such a way as to guarantee environmental comfort and thermal-hygrometric, visual and acoustic well-being. The presence of vegetation and the continuous osmosis of internal and external spaces allow contributing to the achievement of significant results, through techniques and consolidated experiences. In particular, the design choice to create "narrowing openings" at the windows favors passive ventilation, a proper lighting and an adequate shading of the rooms. At the same time, the choice of glass thermal break frames with low emissivity allows the fulfillment of the objectives of safety, well-being and sustainability. The thermo-acoustic insulation is obtained through the introduction of the massive walls of the facades, covered with local stones ("*breccia irpina*"). In this way, energy consumption can be contained, coherently with the

broad issue of the use of renewable sources. Water-saving is obtained by collecting and using rainwater for irrigation of vegetable gardens, vegetation and for sanitary use. In this context, it is to note that the project is based on the use of recycled materials and components: the local stone (*breccia irpina*) used with different sizes to cover the façade and to build the coverings and the external perimeters; polycarbonate on the façade; polyester for the insulation; recycled wood to realize the outdoor furniture. The logic of recycling comes into play positively with respect to the rapidity of execution of works, based on the easy provision of the materials and on the reduction of the processing waste (with respect to this aspect, it is also envisaged to use construction technologies (reinforced concrete) dry. These aspects significantly affect the maintenance, in terms of ease and economic execution.



Fig. (4). Spaces for group learning.



Fig. (5). Internal view of the library.

2.3. Cost Assessment

As said, the design solutions proposed for the new school building "*Istituto Comprensivo of Montemiletto*" give specific attention to the issues of energy-environmental sustainability, life cycles and environmental comfort, and, at the same time, they have taken into account, during the design process, the cost sustainability.

In order to evaluate the total cost of the construction, a concise assessment of the individual construction costs is proposed, with specific reference to the current design choices. The evaluation of the construction cost is carried out using the parametric cost method, starting from the adopted design solutions, reported in the project graphs, on the basis of similar experiences already carried out on a homogeneous territory.

The unit price has also been estimated on the basis of statistical data obtained from costs of realizations relating to similar and comparable situations, with reference to the Price List of the OO.PP. of the Campania Region of 2016 [20]. In particular, similar parameters have been identified relating to the following categories of works:

- Prefabricated structural construction technologies;
- Closures, partitions, flexible arrangements;
- Coatings and floors with recycled and recyclable materials;
- Electrical and mechanical systems;
- Accessibility and security.

The total cost amount is estimated by identifying a unit construction price in euros, referring to the chosen parameter and multiplying it by the consistency of the work expressed as dimensions of the area in square meters. Small differences in the determination of unit costs are due to the different structural types, to the specific finishes, to the different typological and positional articulation of the spaces. These differences, as shown in the following tables, are obtained by defining, for each macro-category of functions, the unit costs of the different elements constituting the building organism. In particular, Table 1 shows for each level/part of the building the

parametric costs for each of the subcomponents of that level/part.

From Table 1 it is possible to evaluate the results obtained from the summary calculation of the costs for the different levels/parts of the building. Table 2, instead, summarizes the total cost for each level/part and the total expected cost for the whole building. It can be seen that there is coincidence between the project cost and the amount of the work estimated by the local authority validated by the Campania region in the amount of € 4.090.000,00. Furthermore, by dividing this amount by the projected walkable square meters, an average cost of € 1,300 / square meters has been obtained, which is very significant in line with the most innovative experiences in the sector.

2.4. Energy Efficiency Estimation

It is to note that all the previous discussions fall inside the more general topic of the mitigation of climate change, e.g. all the actions aimed at reducing the concentration of climate-altering gases in the atmosphere. From a long time sustainability is stressed inside the whole scientific and civic community. The concept of sustainability regards the capacity of a development process to sustain over time the reproduction of world capital made up of economic, human/ social and natural capital [21]. In 1987, the world Commission on Envir-

Table 1. Parametric costs for the different levels/parts of the building.

-	Parametric Costs (€/m ²)	-	Parametric Costs (€/m ²)
First Level-Entrance hall and laboratories	1130	Second Level-Flexible learning spaces and elementary school group learning spaces	1100
Structures	311	Structures	292
Vertical closures	226	Vertical closures	220
Horizontal closures	113	Horizontal closures	110
Internal partitions	57	Internal partitions	99
Floors and finishing works	124	Floors and finishing works	132
Mechanical plant	226	Mechanical plant	176
Electrical plant	73	Electrical plant	72
First Level-Dining hall (Kitchens and depositories)	870	Third Level-Flexible learning spaces and middle school group learning spaces	1100
Structures	46	Structures	292
Vertical closures	174	Vertical closures	220
Horizontal closures	87	Horizontal closures	110
Internal partitions	61	Internal partitions	99
Floors and finishing works	96	Floors and finishing works	132
Mechanical plant	165	Mechanical plant	176
Electrical plant	57	Electrical plant	72
First Level-Flexible learning spaces and nursery school group learning spaces	1125	Auditorium / Library (only low level)	1130
Structures	298	Structures	283
Vertical closures	225	Vertical closures	113
Horizontal closures	113	Horizontal closures	85
Internal partitions	79	Internal partitions	0
Floors and finishing works	124	Floors and finishing works	136
Mechanical plant	214	Mechanical plant	322
Electrical plant	73	Electrical plant	192

Table 2. The parametric costs, the expected workable areas and the total cost for each level/part and the total expected cost for the whole building.

	Parametric Costs (€/m ²)	Expected Workable Areas (m ²)	Design Costs (€)
-			
First Level-Entrance hall and laboratories	1130	610	€ 689300
First Level-Dining hall (Kitchens and depositories)	870	185	€ 160950
First Level-Flexible learning spaces and nursery school group learning spaces	1125	650	€ 731250
Second Level-Flexible learning spaces and elementary school group learning spaces	1100	800	€ 880000
Third Level-Flexible learning spaces and middle school group learning spaces	1100	650	€ 715000
Auditorium / Library (only low level)	1130	250	€ 282500
Ground level. Parking spaces	400	1000	€ 400000
Platform roofs and terraces.	60	1600	€ 96000
Open external spaces	45	3000	€ 135000
Total			€ 4090000

onment and Development outlined that “Humanity has the ability to make development sustainable, to ensure that it meets the needs of the present generation without compromising the ability of future generations to meet their own needs” [22].

In general, the mitigation actions aim to reduce emission sources (the causes of climate change) and increase the storage of carbonic anhydride (CO₂) produced through the use of carbon sinks (natural or artificial systems that absorb and retain CO₂, removing it from the atmosphere). The mitigation actions aim to slow down climate change by reducing or eliminating the anthropogenic factors (emissions) that cause it. Energy efficiency measures and the application of renewable energy sources are examples of mitigation measures. It is to note that also the legislative innovations at European, national and regional level have given a good impulse towards distributed generation and energy saving. In this context, the schools have a big impact on the energy consumption in public buildings (in Italy more than 62,000 schools, of which about 45,000 are public). For this reason, in this field, it is possible to implement large reductions in consumption and emissions. The overall energy consumption of public buildings is very high, especially schools in Italy, consuming about 1 million of equivalent oil tons (TEPs) per year, of which 70% for heating and 30% for electricity. It has been estimated a possible reduction of energy consumption in Italian schools close to 20% of total energy consumption through low-cost interventions. Currently, numerous indications have been proposed to measure the impact of construction works [23, 24]. The first order of indications comes from the environmental reward criteria (*e.g.* recycled content, local availability) contained in the multi-criteria scoring tools for the environmental certification of buildings (*e.g.* LEED-Leadership in Energy and Environmental Design), born on the voluntary basis. The second order of indications comes from the environmental assessment of the life cycle LCA (Life Cycle Assessment), which makes it possible to understand whether a technical-constructive or material choice allows reducing environmental impacts, having as a horizon the life cycle of a product. The LCA is born within the policies, strategies and environmental regulations. The Life Cycle Assessment is a process that allows to quantify and evaluate the environmental damage related to the entire life cycle (from cradle to gate) of a product and is internationally

recognized in the ISO 14040 series [25]. One of the most important parameters for the correct evaluation of the LCA results in the emission of CO₂ as the only parameter identifying the climate change estimated as global warming. The rigorous life cycle assessment is out of the objectives of this paper, but, however, an estimation of the CO₂ emission per year is provided. The final CO₂ emission per year is 16.3 kWh/m², as shown in Fig. (6). This value allows reaching the highest class in the buildings energy performance.

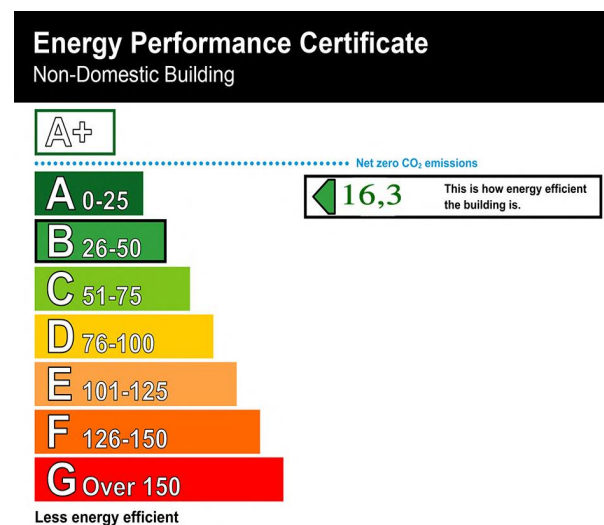


Fig. (6). Energy performance certificate for the building under consideration in this study.

CONCLUSION

This paper presents an innovative design for a school building, awarded in the concourse “Scuole innovative”, published by the Italian Ministry of Education, University and Research. The new school building is located in an urban area of Montemiletto (Avellino, Italy). The Comprehensive Institute that includes a kindergarten, a primary school and a secondary school, is proposed as a Civic Center, an “urban place”, characterized by new spaces of relationship and aggregation. The main idea of the project design is the creation of an innovative school with respect to the architectural, structural

and plant system aspects and to the energetic efficiency and characterized by the presence of new environments of learning and openness to the territory. The project proposals can be summarized in the different points: a) unit of the morphological-settlement solution and the articulation of the Civic Center, to be identified as new reference point in the city; b) adherence of the characters of the school to the landscape and visual connection with the castle; c) urban and architectural roles of the system of the paths and connections, which surround and enter in the intervention area; d) extension and permeation between the natural and artificial environments, assigning to the roof the task of increasing open spaces; e) accentuation of the public and multi-functional character of the different spaces, so that the school can be a place for meeting and comparison, in which it is possible to test new ways of teaching; f) use of different types of green open spaces as gardens, flowerbeds, educational vegetable gardens that change with the seasons, sporting fields, cycle-for-gate routes among the green. This paper focuses mainly on the aspects related to energy and environmental sustainability and life cycle cost with reference to the case study design. The goal is to reduce the impact on the ecosystem, trying to make the school building organic to the existing environment. The containment of energy consumption for the air conditioning of the rooms is done through the isolation of the massive walls of the façade, covered with local stone (Irpinia breccia) and polycarbonate. Water-saving is obtained by reusing rainwater for the irrigation of vegetable gardens, vegetation and sanitary use. The use of recycled materials and components is proposed: the Irpinia breccia covering the façade and, with different grain sizes, the external roofing and flooring; the polycarbonate; the polyester insulation; the outdoor furniture in recycled wood. In addition, dry reinforced concrete construction technologies are chosen. Definitely, the main concept is to have “a school in the park”.

CONSENT FOR PUBLICATION

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author (A.M.), on request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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