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Modern Construction in Italy: the Institute of Mathematics in Bologna

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Abstract: During the second half of the twentieth century, the synthesis of the analytical and theoretical components of the design cultures with the practical and experimental aspects of the construction domain became central. In Italy, on the one hand, the use of reinforced concrete construction systems has continued to spread from the previous decades; on the other, spatial composition theory, strongly linked to the emerging social, political, and economic needs, imposed sharp breaks between the pre- and post-World War II design practice. Within this background, a tendency known as "architectural realism" was defined when mixed masonry-concrete building systems began to exhibit their own figurative and spatial qualities, also expressing the "craft-type" building sites of the time. A representative case study of this period of paradigm shift is the Institute of Mathematics of Bologna (1955–1965), designed by Giovanni Michelucci, one of the so-called "first generation" of Italian modern architecture masters. This paper aims to evaluate and contextualize the extensive technical repertoire of the building, critically analyzing the time's technological culture and the productive, economic, and social processes underpinning its ideation and realization. In the text, specific knowledge about the construction characteristics of the building elements is provided and associated with the spatial attributes of the architecture hosting them. In particular, a cross-analysis is carried out between information gathered by archival-historical research methods, digital surveys and information technologies. The result is the systematization of the knowledge about the building to inform its renovation and conservation processes.

Introduction

The merging of theoretical elements from the design culture domain with experimental practices of the construction field played a key influence on architecture during the second part of the twentieth century. On the one hand, in Italy, the usage of reinforced concrete construction methods, which had been steadily gaining endorsed in previous decades, continued to gain ground with consistency. On the other hand, spatial composition theory, strongly linked to the rising social, political, and economic concerns brought about by the exponential population expansion of the period, imposed stark divides between pre- and post-World War II design practice (Zevi 2004).

During this period of architectural paradigm shifts, the mixed masonry-concrete building system, established in Italy in the early twentieth century, began to demonstrate its own figurative and spatial autonomy in local contexts, defining a tendency known as "architectural realism" (Poretti 2008). While building structures remained reinforced concrete-based, building envelopes began to lighten in search of new aesthetical values and performance features. Such building type (confirmed as the prevalent manifestation of the "craft-type" construction sites of the period) established the foundation for the entire Italian reconstruction until the arrival of construction industrialization in the nation in the late 1960s.

Thus, if the technical procedures for constructing structures remained almost unchanged, the link between design and technique was altered during the century. In the 1920s and 1930s, reinforced concrete structures were hidden by the massiveness of the walls and the refined cladding. However, in the 1950s, there was a shift towards the direct prevalence of local materials over the figurativeness of the architectural image. A sharp disruption of construction methods arrived then in Italy only in the second half of the 1960s, when various prefabrication systems already in use in other countries (and in some cases already abandoned) began to be imported into Italian territory to catch up with the national technological lag.

Escaping from the historiographical discussion, the construction events and site histories of the twentieth century allow us to discover a way of building that spread with continuity and univocity in Italy, consisting of the integration between the masonry system and reinforced concrete elements. Knowledge of this particular construction system, which is extremely widespread throughout the country, plays a decisive role in renovating and conservating the nation's built heritage.

A significant episode of the transition phase of modern Italian construction in the late 1950s was the completion of the Institute of Mathematics in Bologna, designed by the architect Giovanni Michelucci. The relationship between the characteristics of architectural design and construction elements of this architecture emblematically describes the state of architectural research, practical implementation, and the material culture of the time, when the city was ready for exponential development in demographic and student populations (Gullì 2018). The building explicitly outlines the production, economic, and social processes underlying its conception and execution while embracing tectonics composed of particular elements of interest, characterized by

pursuing a relationship with new construction technologies, on the one hand, with tradition and locality, on the other.

Within this context, this study seeks to evaluate and contextualize the extensive repertory of technical solutions used to realize the building, critically analyzing the time's technological culture and the productive, economic, and social processes underpinning its ideation and realization. Specific knowledge regarding the construction and performance characteristics of the key building elements is provided and examined together with the design aspects.

To pursue such objectives, the research combines information gathered by extensive archival-historical research and structures it thanks to the use of information tools, such as digital survey and building information modelling, resulting in a digital system storing the technical knowledge about the building to inform its renovation and conservation processes.

1. Background

In the literature, the study of Modern architecture has traditionally been motivated by two factors. The first is to rescue from oblivion an entire generation of architects and works veiled by historical preconceptions, putting them in their proper historical context (Zevi 2004). The second relates to research on the material culture of twentieth-century construction, conducted to get in-depth knowledge of current building technical challenges and enable their conscious protection, conservation, and restoration (Iori 2014).

The Italian architectural heritage of the last century was distinguished by high formal originality and significant technical experimentation (Poretti 2007). During the first phase of Modern Italian construction, the School of Applications made substantial scientific and theoretical advances by investigating the inapplicability of the elastic theory to anisotropic materials, conducting in-depth research on plastic behavior, and comprehending cracking and breaking phenomena. Meanwhile, the reinforced concrete construction technique was widely and rapidly expanding, with the particularity that Italian reinforced concrete frames were first masonry-mixed structures (Del Piano 1937). Then, from the 1920s to the 1940s, there was a period of enormous technological research and testing of reinforced concrete methods on public works construction sites.

In terms of building envelopes, the new construction approach did not immediately result in the rejection of old features associated with wall construction from a figurative standpoint. However, the incorporation of structural frames into buildings began to alter the design of masonry systems, resulting in a significant revision. During the autarchy, important public works were required to reflect autarchic ideology through stone facings that concealed structural mechanisms. On the contrary, after World War II, mixed masonry architecture began to exhibit its figurative and spatial autonomy—as seen in the Institute of Mathematics façade—forming a trend historians typically label as architectural realism (Poretti 2008).

Because Modern buildings are prevalent throughout the peninsula, a multidisciplinary understanding of them is essential for preserving Italian history. Modern buildings have recently been under the Italian Code of Cultural Heritage and Landscape protection rules. Therefore, these buildings have been recognized for their symbolic, historical, and architectural importance. Nonetheless, they are often influenced by features genetically inherent to their construction type that make them incompatible with the environmental, economic, and functional needs currently required for their use and management, usually related to major owners and public administrations. For this reason, conservation processes are not straightforward, considering that these structures were constructed before the 1970s without a comprehensive regulatory framework governing energy behavior and seismic structural safety.

These aspects extend, more generally, to the whole Modern built heritage of Europe. Across the continent, the period following World War II was characterized, for the first time, by the urgent need to rebuild damaged cities after the war and, subsequently, to accommodate the exponential demographic growth that took place within them. As a result, as of today, a large part of the European built heritage consists of buildings constructed in the period. In Italy, for example, about 31% of existing residential buildings (ISTAT 2011) and 18% of public buildings were built between 1946 and 1970 (Ministero dell'Economia e delle Finanze (MEF) 2015). This issue poses a significant problem to the preservation of the built environment, especially when considering the need to adapt these structures to comply with current structural safety and fire safety regulations or to improve their energy performance towards reducing consumption and environmental impacts. To enable aware protection processes to preserve these buildings' cultural and social values (while allowing their efficient daily use), acquiring and structuring technical knowledge about them is fundamental.

2. Case study

2.1. Overview

Within this background, a paradigmatic case study was identified. The Institute of Mathematics of Bologna, designed by Giovanni Michelucci, is a valuable example of Modern architecture built in the 1950s (Inglese 2008). Like the other Bolognese works of the architect, the Institute went almost unnoticed by architectural and construction criticism despite presenting spatial, technological, and construction innovations (Inglese and Ferrari 2010).

The building, whose main façade is depicted in Fig. 1, is located near the historic medieval walls surrounding Bologna's old town. It is made up of two blocks. Block A is 24 meters high and has ten staggered stories with an average floor space of 490 square meters. It has professor and researcher offices, small classrooms, a library, and a book warehouse. Block B is a 36-meter-high tower with eight stories and an average floor area of 365 square meters. It houses several big step-shaped classrooms as well as some offices. The building has a total area of 900 square meters. The portico, which echoes Bologna's medieval architecture, is the most distinguishing architectural element of the main façade.

After the original construction, some maintenance was carried out after the building was completed. An outdoor staircase was added for fire safety in the 1980s, and the asbestos roof of Block B was replaced with fiber-cement sheets owing to deterioration.

Because the Institute was created before the first Italian rules on structural seismic design and building energy

efficiency, it now has certain serious structural and energy performance difficulties. The building structure is made of reinforced concrete pillars and beams, with hollow brick and roof slabs of reinforced concrete with an air chamber. It has some critical features common to Modern Italian constructions, such as monodirectional frame structural layout, smooth reinforcing steel bars, low shear resistance in correspondence of beam-pillar nodes, high deformability of floor slabs, and variable concrete compressive strength. Moreover, the building envelope is characterized by a high thermal transmittance and, thus, low energy performance for heating. The facades are made up of two layers of solid bricks separated by a variable-thickness air chamber and finished with mortar and 2-cm-thick brick slats. Almost all the windows date back to the building's original construction and have anodized aluminum frames and single-glass. The roofing envelopes are reinforced concrete slabs coated (after construction) with polystyrene, bitumen, and tiles in Block A and fiber-cement sheets in Block B.

Figure 1. The Institute of Mathematics today (© C.Costantino, 2022).

2.2. The designer

Born in 1891, in the same years as Gropius, Mies, and Le Corbusier, the author of the building design, the architect Giovanni Michelucci, is part of the so-called "first generation" of Italian Modern architecture masters. The complexity of his thinking and the vastness of his works cannot be easily summarized, as they have traversed various styles, spanning different historical and social periods (Conforti, Dulio, and Marandola 2006).

A constant that can be easily traced throughout Michelucci's work is his attention to structural, technological, and innovative themes, which he gradually developed over time and solidified through his post-war relationships with the Faculty of Engineering in Bologna. During this period, the architect experimented with a unique approach to construction technology and addressed the theme of technology from various aspects: spatial, structural, figurative, and also related to artificial lighting (Inglese 2008). This vision of technology demonstrated how Michelucci, who served as a professor at the University of Bologna from 1947 and later became the Director of the former Institute of Architecture and Urban Planning, was particularly open to other disciplines from building sciences.

To understand the author's contribution within the context of construction history, it is essential to comprehensively analyze his entire work, focusing on the evolution of its architectural designs over time.

Among the various projects the architect dedicated himself to, one of the standout symbols of his early works is the Santa Maria Novella Station in Florence, designed in the 1930s. With its innovative façade facing the square, resembling a stone wall, and its large glazed windows, the station engages in a dialogue with the nearby Church of Santa Maria Novella, contrasting the church's verticality with its own horizontality. During the same period, Michelucci also worked on the designs for the Institutes of Mineralogy, Geology, and Paleontology and the Institute of General Physiology, Psychology, and Anthropology at the University of Rome from 1932 to 1935. On this occasion, he collaborated with many influential architects, including under the direction of Marcello Piacentini, who likely influenced him during that time. The project's solidity, representative of many works from the fascist period, contrasts with the more slender architecture Michelucci pursued in the post-war period. However, it is perhaps due to this experience that Michelucci later received commissions to design additional university buildings starting in the 1950s. In addition to the Institute of Mathematics and Geology (1955–1965), he was tasked with the renovation project for Palazzo Giolo-Golfarelli and the new headquarters of the Faculty of Letters and Philosophy in Bologna (1959–1965), as well as the project for the Institutes of Chemistry in Florence (1963).

In this second period, the architecture of realism, a trend that dominated the Italian scene during the reconstruction years, was characterized by the visible integration of structural systems into architectural surfaces. The use of mixed reinforced concrete and masonry structures began to be prominently featured, expressing, on the one hand, a reference to a well-established craft-based construction technique and, on the other, introducing elements of innovation. If Michelucci's university works emphasized these aspects, aligning with the local context while embracing experimentation, the architect's experimental approach to construction technology was perhaps most distinctly showcased in his most renowned work, the Church of the Autostrada del Sole in Campi Bisenzio. In the church, the author successfully brought to life open spaces through avant-garde structures, challenging both in terms of calculation and construction. This building can be seen as a culmination of the architect's Bolognese period, where the integration of scientific and technological elements, derived from the field of engineering, with the structural, architectural, and natural components was masterfully achieved (Scotto 2012).

Michelucci's focus on structural and innovative themes has thus solidified and matured over time, thanks to collaborations with the engineering faculty. The period of the 1950s–1960s was the phase during which the architect experimented with new projects, such as the Church of Larderello, the Cassa di Risparmio, the building on Via Guicciardini in Florence, the Osteria del Gambero Rosso in Collodi, and also in Institute of Mathematics in Bologna. In these projects, the interests of the experimentation towards spaces open to the city and the study of construction and technology converged. These aspects, which allow the author's work to be attributed not only to architectural history but also to construction history, were complemented by the architect's pursuit of a new expression of tradition and locality in the post-war period.

How Michelucci's works of that era document, one of the fundamental points that emerged during this period was the relationship with the city, both on a historical and cultural level, thanks to rigorous research on characteristic historical building elements and adapting them appropriately.

2.3. The design

Following the approval of Law No. 1085 on July 31, 1956, the Consortium for University Buildings of the University of Bologna assigned the architect Michelucci, in collaboration with engineers Lugli, Guidotti, and Cinti Luciani and the De Faveri Sadi company, to design the Institute of Mathematics. Subsequently, architect Michelucci was also commissioned to design the Institute of Geology on the same urban site (see Fig. 2). These two projects were undertaken when the city experienced significant population growth. It is worth noting that the new urban plan, approved in 1958, envisaged an increase in population from 400,000 to one million (Cervellati 1977).

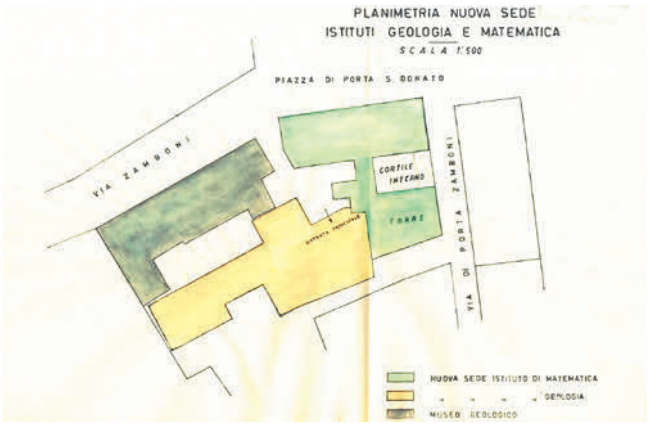

Figure 2. The floor plan of the new headquarters for the Institutes of Geology and Mathematics, 1958 (Archivio Storico dell'Università di Bologna).

The project for the new building involved the demolition and subsequent reconstruction of an entire block consisting of old and deteriorated residences in the current Piazza di Porta San Donato. The scale of the project and the context, integral parts of an urban fabric characterized by significant historical buildings, require the design to be approached not only from a construction point of view but from the entire block. The project embraces the irregular perimeter of the urban block, creating two distinct architectural elements: a vertical one, resembling a "tower" for the spacious double-height auditoriums with large glass facades on the north side, and a horizontal one that defines the perimeter of the square, intended for offices and smaller classrooms.

From the initial sketches, both the modern lines and references to the building heritage of Bologna were evident. Notably, the traditional construction characteristics were reinterpreted in a contemporary manner through technological innovations and the pursuit of material expressiveness: the lower part of the main façade, shown in Fig. 3, was excavated to create a double-height entrance, clearly inspired by the construction tradition of Bolognese medieval wooden porticos. Other distinctive elements are the references to the tower, the forked pillars of the portico, the outer surface of the stone basement and the red brick elevations that refer to the Bolognese cultural identity (Gresleri 2001); even the overall volume harked back to the ancient building practices of Bologna, where towers were attached to block-shaped structures. Perhaps for this reason, Michelucci designed a flat roof reminiscent of the old towers. Another element that refers to the medieval city is the roof overhang, which was employed in the past to expand upper-level residences without reducing the streets' width (Inglese and Ferrari 2010).

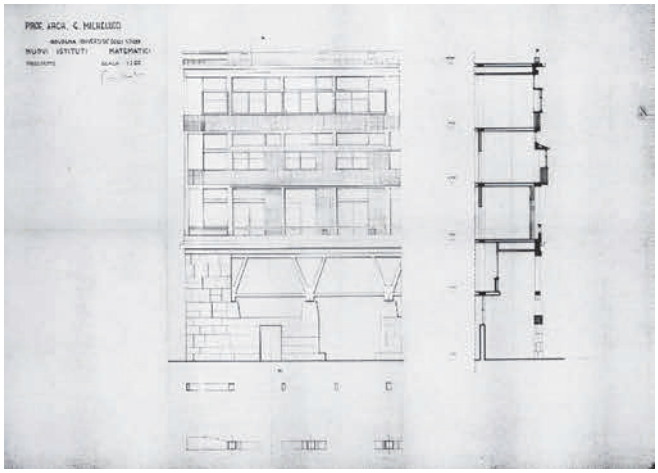

Figure 3. Elevation and section for the design of the porticoes on the main facade (Archivio Storico dell'Università di Bologna).

3. Methods and tools

3.1. Archival research

To understand the construction peculiarities of the entire building, a cross-analysis was carried out between many archival sources (historical photographs, preliminary and executive drawings, reports, and structural calculations), geometric data (acquired from a digital survey and the technical drawings provided by the administrators) and inspections. In particular, the archival research has been conducted in several public archives including the Archive of the Emilia Romagna Region, the Archive of the Genio Civile Office of Bologna, the Historical Archive of Bologna's Municipality, the Historical Archive of the University of Bologna, the Historical Archive of the Chamber of Commerce of Bologna, the archive of the Technical Office of the University of Bologna, and the archive of the Department of Architecture of the University of Bologna.

3.2. Digital survey

Moreover, an accurate survey of the Institute of Mathematics' exteriors has been carried out with terrestrial photogrammetry techniques. The survey campaign took one working day, in which 253 photos were taken to reconstruct the exterior surface of the main elevation and interior parts of the entrance portico and 119 to map the overall volume and lateral facades. From an operational point of view, several trajectory types were required due to obstacles between the structure and its surrounding context, for example, trees, electric cables, walkways, and especially the interference caused by traffic on the main front.

After the data collection campaign, the photos were used a) to visually analyze the façade construction elements and b) to create a photogrammetric point cloud using Agisoft Metashape software. Despite the complexity and occlusions of the surveyed space, it was possible to achieve an accurate survey highlighting some inaccuracies compared to the technical drawings acquired through manual methods. The point cloud was used to extract the orthophotos (Fig. 4), which made it possible to understand the building's dimensional aspects by making direct measurements.

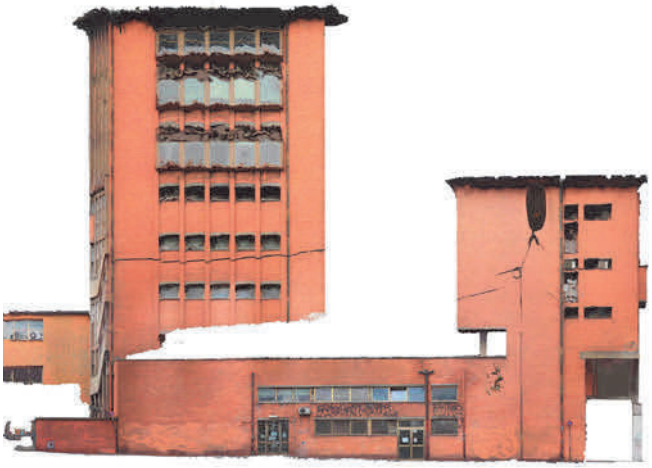

Figure 4. Orthophoto of the front and side elevation of the Institute of Mathematics (© C. Costantino, 2021).

3.3. Heritage Building Information Modeling

Finally, based on the acquired geometric and construction information, the construction's building information model (BIM) was created using Autodesk Revit. This process involved utilizing previously developed BIM libraries for the construction elements of the building, which required specialized modeling techniques. Its primary purpose was to serve as a heritage digital repository, documenting technical knowledge about the construction elements and their components, to integrate and structure information obtained from surveys, inspections, and archival research.

In particular, the BIM model comprized two different models (Fig. 5). The first one integrated the geometric data of the building's envelope with information related to the functions performed within the building, its envelope's construction characteristics, and the materials' thermal properties. Its semantic structure included walls, windows, doors, roofs, slabs and spatial elements. Particular attention was given to the development of windows and envelope components from the perspective of their use in an energy modeling environment. As a parallel outcome, thanks to this embedded knowledge, this BIM model was further utilized for research to support the preliminary design of energy retrofit interventions in the case study, with a particular focus on the envelope system (Massafra, Predari, and Gulli 2022). The second model pertained to the geometries of the structural components, enriched with valuable information for the structural assessment of the building, such as material strength and the number of reinforcing bars. This information was obtained from project drawings through a reverse engineering approach. It included column, beam, stair, and structural slab elements.

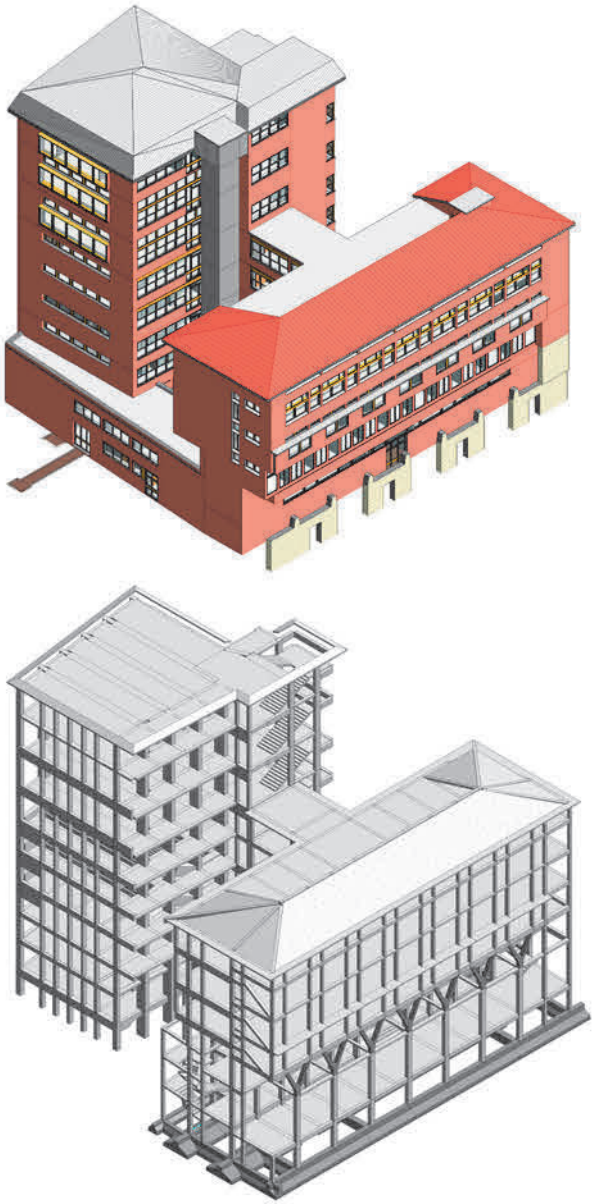

Figure 5. Federated BIM models of the Institute of Mathematics. On the top, architectural model (© V. Passerini, 2021). On the bottom, structural model (© A. Massafra, 2021).

4. Construction

The construction of the building began in June 1962 and was completed in July 1965. The contract for masonry works was awarded to the De Faveri Sadi Company of Bologna. The construction supervision was entrusted to Engineer Ruggero Cinti Luciani, assisted by Ennio Beltrami, who handled the accounting. Engineer Leonardo Lugli and Engineer Giancarlo Guidotti made structural calculation and design. The final floor plans used for the construction show a significantly modified internal layout. In fact, Michelucci had originally planned for multiple common spaces with specific functions, such as the lounge for students with a bar and for distribution purposes, like the spacious atriums corresponding to the stairwells.

As mentioned, the construction of the building was based on the integration of practices that had become established in the post-World War II Italian construction sites (those of the so-called "mixed construction") with more innovative technological solutions for the period. These solutions were oriented towards seeking a new spatiality and expressiveness

in architecture, a circumstance that emerged precisely in the architectural thinking of that period, and meeting the typical functional requirements of University buildings, such as the need for ample spaces to be allocated for classrooms.

4.1. Building structure

The structure of the building was founded on reinforced concrete grade beam foundations, whose concrete was made with cement of maximum strength of 500 kg/cm^2, with a width ranging from 1.10 to 3.10 meters, height from 1.20 to 1.60 meters, laying 4.40 meters under the ground (Fig. 6). Below the foundation beams, there was planned to be piling, as documented in the executive project documents for Block B. These piles had a maximum load capacity of 50 tons (diameter 54 cm) and 35 tons (diameter 42 cm), with a length of 12 meters in order to reach a gravel layer beneath less favorable clayey soil layers. The inverted beams support reinforced concrete walls up to the basement level, and from there, they connect to the elevation pillars.

The vertical structures were of the reinforced concrete frame type, also made of concrete based on cement of maximum strength of 500 kg/cm^2 and reinforced with homogeneous steel (Fig. 7). From a structural perspective, the grid of pillars has remained almost unchanged with respect to the early design. However, as a result of static calculations, pillars' cross-sections have seen a significant increase.

Prominent structural elements include the portico on the main façade. The integration between the portico's structural system and the transparent envelope elements is noteworthy. The forked structure of the pillars, which in the design was entirely independent of the vertical posts that divide the intermediate glass band, in the construction, continued to the upper level, framing the aluminum window openings. Another interesting element that constitutes the structural system of the double-height lecture halls is the suspended slab, situated in correspondence with the professor's chair. This slab is entirely cantilevered and is supported by reinforced concrete tie rods anchored in the beams on the floor above. The use of tie rods is also employed in Block A to support the overhang of the northeast corner, which has been hollowed out and lacks an underlying pillar (Fig. 8).

The staircases and elevator shafts are also made of reinforced concrete. The floor slabs are of a mixed type, combining reinforced concrete and bricks, designed to support a load of 400–500 kg/m^2. On the other hand, the roof consists of a hollow-core slab designed to support a load of 250 kg/m^2 (Fig. 9). It is waterproofed, technically insulated with glass wool, and finished with cement and granulated marble tiles. Mixing asbestos fibers with concrete was a technique widely used in the 1960s and 1970s. However, it was abandoned in the 1980s due to its harmful health consequences. The roof covering already exhibited durability and reliability issues as early as 1978, leading to its replacement.

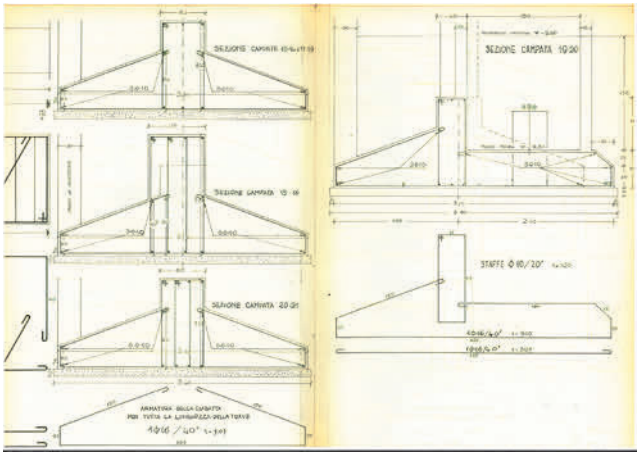

Figure 6. Design of the reinforcement bars for the foundation beams of Block A. Calculations by Engineer Carlo Fava. Archivio della Regione Emilia Romagna (Faldone 4066, 1962–1969).

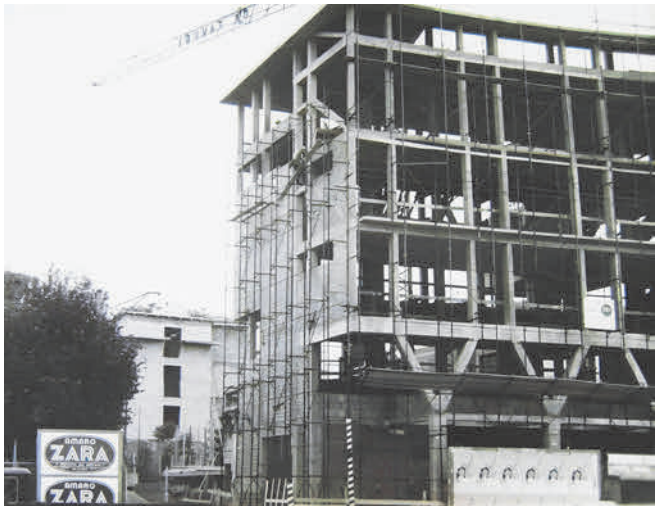

Figure 7. Elevation structure under construction. Main façade on Piazza di Porta San Donato. (Archivio Storico della Camera di Commercio di Bologna, scaffale 5C).

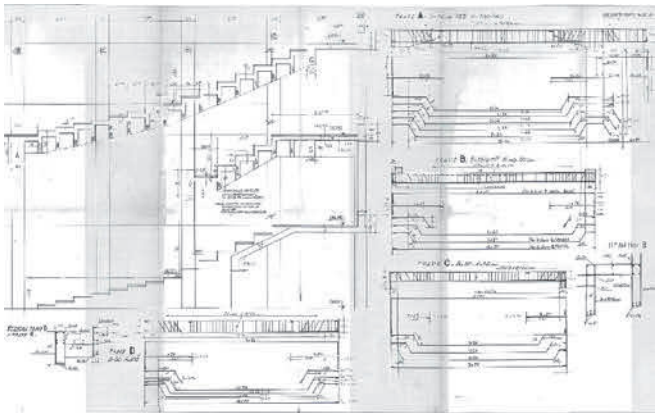

Figure 8. List of reinforcement bars for the floor beams of the stepped lecture halls. (Ufficio Tecnico dell'Università di Bologna).

Figure 9. Roof slab of Block A under construction. (Archivio Storico della Camera di Commercio di Bologna, scaffale 5C).

4.2. Building envelope

Regarding the outer walls, all the solutions are directed, on one hand, towards the figurative expression of the materiality of the facades, recalling the typical local materials (Gresleri 2001), and on the other hand, toward achieving good energy performance of the components, to be considered within the building standards of that time, which were quite different from the current ones. The basement walls are insulated placing an air gap between the two brick masonry layers. The upper floors present cavity walls, composed of two walls of hollow clay bricks separated by a 10 cm thick air gap, laid floor by floor and bonded with cement mortar. The facades are planned to be clad with stone up to the first floor and with specially sandblasted handcrafted bricks for the remaining height. Also in this case, there is a clear reference to the medieval towers of the city where the basement is realized using selenite stone blocks and masonry bricks for the upper levels.

Windows are primarily composed of single-glazed aluminum frames made of a tubular extruded section in aluminum alloy. These were manufactured by the company "l'Invulnerabile", a pioneering Bolognese construction company specializing in the production of security roller shutters and windows with metal frames. During this period, manufacturers specializing in window components and curtain wall systems play a crucial role. These companies, as l'Invulnerabile and Curtisa among the Bolognese ones, are responsible for solving the whole technical and construction issues, collaborating closely with architects to create customized tailor-made solutions for each project. This approach fosters strong and enduring relationships between designers and these companies (Romanelli and Scapaccino 1979). In particular, Curtisa has become one of the best Italian companies for metal-frame windows in a market where wood still prevailed, also working at an international level. The versatility and excellent quality of their products were indeed highly regarded. As a result, they collaborated on projects with prominent Italian engineers and architects, including Giuseppe Vaccaro, Giovanni Guerrini, Marcello Piacentini, Gio Ponti, Pier Luigi Nervi, Giovanni Michelucci, in both private and public construction works (Curtisa 1955). Their production of tailor-made windows was assembled by their own skilled artisans, particularly for clients seeking exclusive yet reliable elements.

An original document from the company, dated July 18 1964, archived in the Technical Office of the University of Bologna archive, provides a detailed description of the various typologies of custom-made windows that were product exclusively for the Institute of Mathematics (Fig. 10). This document outlines a total of 52 different types of windows. All of these were constructed with gold-coloured anodized aluminum frames, equipped with "Bostik" seals and everything necessary to ensure a perfect seal between the frames, the masonry walls, and the single-glass panes.

4.3. Finishings

The interior partition walls are made of turned or solid perforated brick, with a thickness of 8 cm, and cement mortar. All internal plastering is done in Roman stucco with pastel-colored paint applied in two coats. The floors are made of

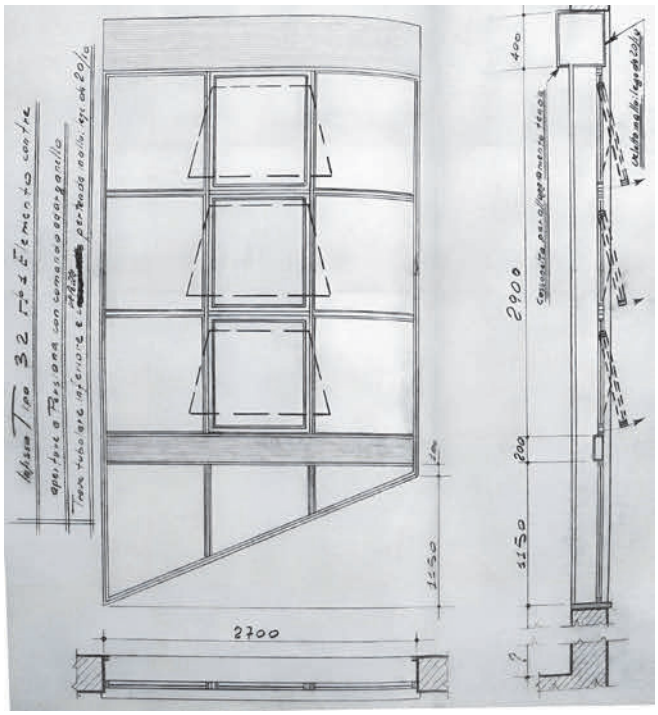

Figure 10. Window type number 32 from L'Invulnerabile, 1964. (Archive of the Technical Office of the University of Bologna).

Botticino marble, Trani, or Paonazetto for the ground floor atrium and stairs; Colombian stone in "opus incertum" pattern for the ground floor gallery; Venetian-style with medium-grain lead-polished marble inlaid with tarsia for the library, student lounge, mezzanine study rooms, and gallery; solid-color cement tiles for exercise rooms, drawing rooms, and hallways; rubber for the lecture halls; and grooved ceramic tiles for the restrooms.

Conclusion

The Institute of Mathematics in Bologna, conceived by architect Giovanni Michelucci in the 1950s, serves as a notable example of modern construction in Bologna and, more broadly, in Italy. It was constructed during a transitional period marked by the emergence of prefabrication systems (which only reached Italy in the late 1960s) and traditional production methods that emphasized the technique of mixed construction in masonry and reinforced concrete, which characterized the whole Italian reconstruction after the war.

The technical strategies employed in the design and construction of this building were intended to highlight the architectural forms, confirming, on one side, a well-established construction technique in the twentieth century in Italy, namely the integration of local brick walls with reinforced concrete frameworks. On the other side, they introduced innovations in construction practices through experimentation with specific structural components necessary to fulfill unique static and spatial demands. The integration of traditional structures with these elements, such as the main facade's portico, reinforced concrete tie rods in the classrooms, and large knee beams for stepped rooms, marks the building as a significant representation of its period, diverging from the pre-war masonry language prevalent at the local level and venturing into new technological,

constructional, and architectural explorations that shaped the so-called Italian architectural realism.

The critical analysis process, entirely non-invasive and non-destructive, relied on integrating detailed visual inspections on-site, examination of construction site records, analysis of the design's evolution, and historical-archival research. This approach effectively showcased the building's extensive construction repertoire with adequate detail, initially by segregating it into distinct segments and subsequently reassembling its overall framework by delineating the interconnections among various structural components. This knowledge process, together with the definition of the genetic vulnerabilities of the building and the underlying causes of its degradation phenomena, will constitute a step for its sustainable conservation, here intended as the transmission of its cultural, social, artistic and architectural values to future generations, in full respect of its dual figurative-formal and historical-material nature.

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