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Energy Efficiency and Conservation of Late Twentieth-Century Architecture

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Marta Casanova, Federica Pompejano

ENERGY EFFICIENCY AND CONSERVATION OF LATE TWENTIETH-CENTURY ARCHITECTURE

Marta Casanova
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Note on translation and use of Artificial Intelligence

The essays and case studies in this volume were originally written in Italian. Artificial intelligence tools were used to assist in their translation into English and in the linguistic revision of the translated text. All translations were subsequently reviewed and edited by the corresponding author/s, with particular attention to scholarly terminology, conceptual accuracy, citations, and the preservation of the meaning and style of the Italian originals. The corresponding author/s exercised editorial control throughout the process and assume full responsibility for the final English text.



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CONTENTS

Preface	5
Wido Quist, Uta Pottgiesser	
The Importance of Conserving Contemporary Architecture and the Role of Energy Efficiency.	7
Maria Piccarreta, Cristian Filagrossi Ambrosino	
Acknowledgements	11
Introduction	13
ESSAYS	17
The Building Envelope in the Second Half of the Twentieth Century: Performance and Identity	18
Marta Casanova	
Built Heritage and the Energy Transition: European Policies, Conservation and Compatibility	26
Giovanna Franco, Stefano F. Musso	
Modern Heritage as a Resource beyond Energy Retrofit	36
Uta Pottgiesser, Wido Quist	
The Challenge of Change: Conserving Twentieth-Century Architectural Heritage	46
Federica Pompejano	
Restoration Techniques for Conserving Building Envelopes from the Second Half of the Twentieth Century	57
Daniela Pittaluga, Rita Vecchiattini	
Reading the Intervention: EeTAC's Criteria and Tools for the Ex Post Assessment	67
Marta Casanova, Federica Pompejano	
CASE STUDIES	71
Residential Architecture	75
Villa Rossi	76
Velasca Tower	82
Via Leopardi Building	88
Madonna Bianca Neighbourhood	94
Forte Quezzi INA-Casa Neighbourhood – Building A	100
Treno della Barca	106
Grattacielo a Porta San Pietro	112
Cité du Lignon	118
Kleiburg	124
Park Hill	130
Glass House	136

Office and Commercial Architecture	143
Grattacielo Pirelli	144
Fuel Service Station – Le Fucine	150
Ex Palazzo della Regione	156
RAI Headquarters	162
Haus Hardenberg	168
Healthcare and Social Care Architecture	175
Former Felix Platter Hospital	176
Burgerweeshuis	182
Industrial and Manufacturing Architecture	189
ICO Central Workshops	190
Cartiera Burgo	196
Educational and Research Architecture	203
Trifoglio – Politecnico di Milano	204
Salk Institute	210
Religious Architecture	217
Nostra Signora della Misericordia Church	218
Cultural and Recreational Architecture	225
Padiglione Agnelli	226
Padiglione Nervi	232
Teatro Nuovo	238
Alessandria Municipal Theatre	244
Padiglione Tavolara	250
Scharoun Theatre	256
Guggenheim Museum	262
Concluding Essay	269
Interventions on the Building Envelope of Architecture from the Second Half of the Twentieth Century: Experiences and Reflections from the EeTAC Research Project	270
Marta Casanova, Federica Pompejano	
Case Studies Bibliography	279
APPENDIX	299
Image Credits	300
Essay Authors' Biographies	303

PREFACE

It is the mission of DOCOMOMO International to exchange ideas relating to architectural conservation technology, to foster interest in modern heritage, and to elicit collective responsibility towards the modern inheritance.¹ This book contributes tremendously to this mission. Through extensive inventorying and analysis, many Italian and international case studies have been documented. The main message of this book is that, although not easy and not following a predefined scheme, it is very well possible to conserve and/or adaptively reuse post-World War II Modern buildings, while – amongst others – improving their energy efficiency.

In its Plan for Action, presented in 2021, DOCOMOMO International advocated open access publication beyond the *DOCOMOMO Journal*. Alongside the digitisation of old journals, newsletters, and *technology dossiers*, the DOCOMOMO Book Series was implemented to further elaborate on publishing Open Access. The DOCOMOMO Book Series provides an opportunity for National Working Parties, International Specialist Committees, research projects and initiatives of individual DOCOMOMO members to publish Open Access, digitally and via print-on-demand.²

We are very happy that Marta Casanova and Federica Pompejano trusted DOCOMOMO International to publish the outcomes of their research project *EeTAC – Energy Efficiency and Conservation of Contemporary Architecture: Preservation, Quality, and Innovation of the Building Envelope*, supported by *Sustainable Architectures for Contemporary Restoration*, a public call promoted by the Direzione Generale Creatività Contemporanea of the Italian Ministry of Culture.

We expect this book to spread quickly and find its way to students, professionals, and academics all around the world whilst serving as an inspiration for all of those taking care of the conservation and documentation of buildings, sites and neighbourhoods of the Modern Movement.

Wido Quist

Secretary General DOCOMOMO International

Uta Pottgiesser

Chair DOCOMOMO International

¹ See the website of DOCOMOMO International (<https://docomomo.com/organization/>)

² POTTGIESSER, U., QUIST, W. (2024). From Newsletter to Open Issue. *DOCOMOMO Journal*, 71, 2-3. <https://doi.org/10.52200/docomomo.71.01>

THE IMPORTANCE OF CONSERVING CONTEMPORARY ARCHITECTURE AND THE ROLE OF ENERGY EFFICIENCY

Maria Piccarreta, Cristian Filagrossi Ambrosino

What do we do when a contemporary building, perhaps built forty years ago, begins to 'age'? Do we consider it a historic building to be protected, or as any other building to be brought into line with current regulations, even at the cost of profoundly altering it?

It is this seemingly simple question, which in fact conceals an issue that is anything but straightforward, that the Direzione Generale Creatività Contemporanea of the Italian Ministry of Culture has been seeking to address in recent years through a range of initiatives: the *Censimento delle architetture italiane dal 1945 ad oggi* (Census of Italian Architecture from 1945 to the Present Day), the organisation of the conference *Restaurare il Presente* (Conserving the Present), and subsequently the public call *Architetture Sostenibili per il Restauro del Contemporaneo* (Sustainable Architectures for Contemporary Restoration), now in its second edition. And it is a question that, as time passes, will concern an ever-increasing number of buildings, cities, and people.

Why the Conservation of Contemporary Architecture Is a New Issue

To understand the significance of this question, it must be placed within a historical perspective. For centuries, the discipline of conservation has developed well-established theoretical and methodological tools for dealing with historic architecture. There are shared criteria for interventions on Renaissance façades, Baroque vaults or medieval urban contexts, supported by a solid tradition of scholarship.

By contrast, architecture dating from the second half of the 20th century remains largely unexplored territory from the point of view of conservation. Many of these works are now more than fifty years old and have reached a critical stage: they have often lost their original function or suffered from technological obsolescence as well as failing to meet current requirements for safety, comfort, and energy efficiency. They therefore stand at a dramatic crossroads: either undergoing ill-considered transformations or facing abandonment and demolition.

The point is that high-quality contemporary architecture is not simply architecture like any other. It is already heritage, even if we do not yet perceive it as such. It possesses historical and critical, material and identity-related values that deserve the same attention and rigour that we devote to an ancient monument.

The Public Call and the Funded Projects

The public call *Sustainable Architectures for Contemporary Restoration* responds to the need to fund research and dissemination, promoting the development of systematic and comprehensive knowledge. The programme is structured around several thematic strands of action:

Improving the energy efficiency of the building envelope

- *EeTAC – Efficienza energetica e Tutela dell'Architettura Contemporanea* (Energy Efficiency and Conservation of Contemporary Architecture), University of Genoa;
- *BIS – Belle, inclusive, sostenibili* (Beautiful, inclusive, sustainable), Department of History, Representation and Restoration of Architecture, Sapienza University of Rome.

Improving the energy efficiency of building systems

- *Heritage Recharged. Restauro ed efficienza energetica dell'architettura contemporanea* (Conservation and Energy Efficiency of Contemporary Architecture), Iuav University of Venice.

Adaptive reuse of contemporary architecture

- *Oltre il recupero. Riuso adattivo, circolare, energeticamente efficiente* (Beyond Restoration: Adaptive Reuse, Circularity, and Energy Efficiency), Department of Planning, Design and Technology of Architecture, Sapienza University of Rome;
- *L'Architettura che visse due volte. Conoscere per intervenire sul patrimonio contemporaneo* (Architecture That Lived Twice: Understanding Contemporary Heritage to Shape Its Future), University of Rome Tor Vergata.

These five projects follow diverse approaches and differ in methodology and scale, yet they all share the same underlying principle: before intervening, it is essential to acquire an in-depth understanding of the building – including its history, its materials, and how it may already have been altered – and to derive from this knowledge shared criteria rather than predetermined solutions.

The Critical Issue: Energy Efficiency and Conservation

Energy sustainability represents the area of greatest tension between conservation and transformation. While historic architecture can survive for centuries without performance-related interventions, a building from the second half of the 20th century without an adequate energy strategy risks being abandoned within a single generation. Energy performance thus becomes a determining factor in the very survival of the building.

This crucial issue is rooted in the very nature of modern design. As highlighted by critical historiography, beginning with the work of Reyner Banham, while historic architecture relied on passive solutions embedded in its form to provide environmental comfort, such as wall thickness, orientation and natural ventilation, architecture in the second half of the 20th century often delegated microclimatic comfort to building services. The advent of air conditioning, artificial lighting, and central heating made possible an architecture increasingly detached from climatic conditions, characterised by extensive glazed surfaces, lightweight envelopes and open-plan layouts, and based on the assumption of abundant, inexpensive energy.

Today, there is a considerable degree of methodological maturity both in the design of new nearly zero-energy buildings (nZEBs) and in the energy retrofit of protected historic buildings. What is still lacking, however, is an established methodology for the 'middle ground': improving the energy efficiency of architecturally significant contemporary buildings.

The practical risks lie at two opposite extremes:

1. **Overly invasive intervention:** the indiscriminate application of external thermal insulation systems, the replacement of windows and doors, and radical alterations to building services undertaken solely to improve energy ratings may ultimately erase the original fabric, façade design, and architectural syntax.
2. **An approach based on complete non-intervention:** the dogmatic rejection of any alteration, driven by a rigid interpretation of conservation principles, prevents buildings from meeting minimum statutory requirements and ultimately risks condemning them to disuse, the most silent form of abandonment.

Between these two extremes lies the true field of research, and this is precisely what the programme seeks to support: identifying, on a case-by-case basis, a balance between the requirements of conservation and those of reducing energy consumption. The aim is not to establish a single rule, but rather to develop replicable good practices, criteria, and operational tools that enable designers not to have to choose between conservation and sustainability, but to reconcile them.

Conclusions

Returning to the initial question, it is clear that the conservation of contemporary architecture is not a niche issue confined to specialists: it concerns the way in which our cities will continue to live and evolve over the coming decades. Every time we choose to retain and adapt, rather than demolish, a building from the second half of the 20th century that still has something to say, we are making a cultural choice before we are making a technical one. Within this framework, improving energy efficiency is not an external constraint to be endured. Instead, it can become an opportunity to rediscover these buildings, to study them in depth, and to give them a new lease of life that is both sustainable and faithful to their identity.

This is the deeper meaning of a programme such as *Architetture Sostenibili per il Restauro del Contemporaneo*: not simply to fund research, but to contribute, step by step, to building the culture we need in order to address a challenge that, whether we like it or not, is already upon us.

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This work was made possible by the commitment of the research team: Stefano Francesco Musso, Giovanna Franco, Daniela Pittaluga, Rita Vecchiattini, Simonetta Acacia and Elena Geria from the University of Genoa, and Wido Quist and Uta Pottgiesser from DOCOMOMO International. We thank them for their scholarly contributions, the discussions we shared, and their work throughout the project's different phases. We also thank the technical and administrative staff of the Department of Architecture and Design at the University of Genoa, who supported the administrative, financial, and organisational aspects of the project with care and dedication. Special thanks go to the DOCOMOMO International editorial team and, in particular, to Karen Knols, for supporting the preparation of the volume and overseeing its editorial production.

The case-study corpus could not have been assembled without the generosity of the designers and professionals who shared documents, drawings, data and images, and devoted their time to meetings and site visits, enabling us to gain a deeper understanding of the rationale, process and outcomes of the interventions. We thank ACPV Architects and Manuel Santacroce (RAI); Andrea Baudo (BRC Costruzioni); Andrea Bondonio and Isolarchitetti; Andrea Zamboni and ZAA – Zamboni Associati Architettura; Angel Ayón, Laura Boynton and WASA/Studio A; Antonio De Rossi, Carlo Deregibus and the Masterplan Team – Politecnico di Torino; Cameron Trowbridge and the Getty Conservation Institute; Christa Carr and The Glass House; Cristiana Chiorino and the Pier Luigi Nervi Foundation; Elena Frugoni and the Soprintendenza ABAP Torino; Elisa Pisano; Enrico Giacomelli and Stefano Fantucci; Federica Legnani; Francesco Conserva, Azzurra Stilo and Open Project; Gianluca Noto (Politecnico di Milano); Giulia Marino (EPFL-TSAM); Giulio Barazzetta and SBG Architetti; Giuseppe Ruscica and CREA.RE; Luca Biancucci, Franco Borsi and Martina Segreto (ACER Bologna); Marco Caprini (COPRAT); Matt McCallum, Lucy Taylor and Mikhail Riches; Müller Sigrist Architekten; Paolo Ravera, Mauro Caselli, Antonio Maria Zappa, Luisa Gilardenghi, Simone Abbado, RossiProdi Associati and Ai Studio / Ai Engineering; Paolo Sanjust; Piersimone Simonetti (Studio Cenami Simonetti Ticca); Pietro V. Ambrosini (Campomarzio) and Andrea Bombasaro; Wessel de Jonge and WDJArchitecten; Xander Vermeulen Windsant and XVW architectuur; Zito Artico Fracassi Architetti and Archest.

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INTRODUCTION

The European energy transition is driving a profound transformation of the existing building stock, including the architectural heritage of the second half of the twentieth century. Many buildings from this period are characterised by high energy consumption and by material decay or obsolescence that requires upgrading. At the same time, growing recognition of their cultural significance requires considering their materials and components not only in terms of the performance they provide, but also as evidence of a period of far-reaching transformation in architecture. This issue is particularly evident in the building envelope, which is the focus of a substantial proportion of measures aimed at reducing energy demand and in which essential constructional and formal characteristics are often concentrated. Apparently limited interventions may alter thicknesses, façade articulation and depth, or result in the loss of original components. Even where the overall architectural image is retained, changes may affect the material fabric, constructional details and environmental behaviour that contribute to the recognisability of the work. This condition gave rise to the questions that guided the research: how can the energy performance of building envelopes dating from the second half of the twentieth century be improved while limiting the effects on their material, technical and architectural values? According to which criteria can the comparative analysis of completed interventions assess compatibility and help inform future decisions? These questions do not presuppose a single solution; rather, they require understanding the characteristics that underpin each building's significance and the criteria through which the effects of transformation may be assessed.

The research project *EeTAC – Energy Efficiency and Conservation of Contemporary Architecture: Preservation, Quality, and Innovation of the Building Envelope* was developed by the University of Genoa in collaboration with DOCOMOMO International within the second edition of the public call *Sustainable Architectures for Contemporary Restoration*,¹ promoted by the Directorate-General for Contemporary Creativity of the Italian Ministry of Culture. The project treated completed interventions as a field of observation from which knowledge could inform future decisions. Rather than seeking exemplary solutions, the research privileged an analytical approach to reconstruct the initial conditions, objectives, and transformations associated with each intervention. For each building, the research integrated bibliographic, archival, and design sources with site surveys and exchanges with the stakeholders involved. The resulting data were structured within a relational database designed to support cross-sectional queries and comparisons across the corpus of completed interventions. The qualitative ex post assessment then linked the energy-efficiency intervention to the degree of conservation of the original material fabric, its impact on the building's formal and spatial configuration, the compatibility of new components, and the degree of reversibility of the transformations introduced.

Accordingly, this volume both presents the results of the project – providing a framework through which interventions on the envelopes of buildings from the second half

¹ The programme supports research aimed at reducing the environmental impact of high-quality contemporary architecture through energy retrofit, rehabilitation and reuse. EeTAC was selected under the action devoted to improving the energy efficiency of opaque and transparent building envelopes within the section *Improving the Energy Performance of Contemporary Architecture*.

of the twentieth century can be understood as choices affecting their architectural configuration and cultural significance – and brings together a series of essays in which different disciplinary perspectives are placed in dialogue. A few recurring issues run through these contributions, foremost among them the specific nature of the building envelope in the second half of the twentieth century and its role in the design of energy-efficiency interventions. Marta Casanova establishes the discussion's constructional basis, showing how the separation between load-bearing structure and enclosure, together with the use of industrialised components, gave rise to systems in which performance and architectural configuration depend on the relationships among their constituent parts. The modularity of panels, the design of joints, the depth of solar-shading devices, and the relationship between opaque and transparent surfaces contribute to both environmental performance and the definition of the façade. The envelope cannot therefore be regarded as a neutral surface to which corrective measures may simply be applied, since the modification of a single component may affect the performance of the system as a whole and alter its perceptual qualities. Daniela Pittaluga and Rita Vecchiattini bring this condition into the practical realm of architectural conservation, showing how the fragility of experimental materials, window systems, and connections requires investigations that identify construction techniques, patterns of deterioration, and possibilities for conservation. What emerges is a conception of the 'identity of the envelope' that cannot be reduced to the mere persistence of its image, but encompasses its material fabric, constructional details and the ways in which the envelope itself regulates the relationship between inside and outside.

It is precisely upon this dual technical and documentary character that the pressures generated by energy-transition policies are exerted. Giovanna Franco and Stefano F. Musso reconstruct the gradual convergence between energy-efficiency policies and the culture of conservation, highlighting the risk that energy upgrading may be reduced to replacing architectural elements and that performance objectives may take precedence over the overall quality of the intervention. Wido Quist and Uta Pottgiesser broaden the discussion by comparing different regulatory, cultural, and operational contexts. The history and experience of DOCOMOMO show how documentation and knowledge have, from the outset, served as essential instruments for the recognition and conservation of modern heritage. Strategies developed through international debate show that no single level of intervention is inherently correct. The issue lies instead in the capacity to relate the intensity of transformation to the building's significance, the condition of its material fabric, performance requirements, and the possibility of ensuring continuity of use. From this perspective, modern heritage is not an obstacle to the energy transition, but a resource whose continued use can be supported through informed reuse. Federica Pompejano brings these questions back to the theoretical foundations of the conservation of twentieth-century architecture, identifying the conscious management of change as a key principle for addressing interventions on a heritage born of experimentation but now subject to transformations that often begin before its cultural significance has been fully understood and collectively recognised. Defining cultural significance and identifying the attributes through which it is expressed makes it possible to move from a generic assertion of values to a deeper understanding of what is being preserved. Material fabric, form, construction technique, use, environmental behaviour and perceptual qualities may carry different degrees of significance and may also come into conflict. Design decisions must therefore make the hierarchy of priorities explicit, compare alternative

solutions and their consequences, and establish reasoned limits to transformation. Adaptation is not, therefore, opposed to conservation; rather, it becomes part of the conservation process insofar as its effects on cultural significance are made explicit, justified, and proportionate.

The cases discussed throughout the volume consequently reveal a range of approaches in which energy improvement may entail different degrees of material loss. This points to the need to move from pursuing maximum performance in absolute terms to identifying the greatest degree of improvement compatible with the recognised characteristics and values of the building. Knowledge thus emerges as a constitutive component of the design process. Reconstructing the original configuration, distinguishing what was actually built from what had been envisaged at the design stage, identifying subsequent transformations and conditions of use, and understanding the behaviour of materials and constructional junctions make it possible to recognise the attributes through which the values of the architectural work become legible. It is on this basis that alternative solutions can be compared and acceptable limits to transformation established. The volume does not propose a catalogue of conservation-oriented design solutions, since even the most significant experiences remain dependent on the specific conditions of the individual building and cannot be directly transferred to other cases. Nevertheless, the case studies presented in this volume provide the field within which these themes and problems can be examined in their concrete implications. The concluding essay by Marta Casanova and Federica Pompejano approaches *ex post* assessment as a critical instrument for reconstructing the rationale behind design decisions, distinguishing attributes that have been conserved from those that have been modified or lost, and relating an intervention's stated objectives to its actual effects on the building.

Finally, the corpus of thirty case studies makes it possible to identify several issues requiring further investigation. Among these is the need for more homogeneous data concerning pre-intervention conditions, the performance achieved, and the long-term behaviour of the solutions adopted. Future research could expand both the number and geographical distribution of cases considered, include lesser-known experiences or interventions characterised by problematic outcomes, and develop monitoring methods that assess, over the medium and long term, the effectiveness of design decisions and their implications for building conservation. A further area of research concerns developing tools that relate energy indicators to conservation assessments without translating cultural significance into a numerical score or treating it only after technical solutions have already been defined. Such an approach will need to address evolving climatic scenarios, patterns of use and expectations of comfort, while jointly considering winter and summer performance, durability, maintenance, and the impacts associated with the life cycle of materials. The aim of this volume, and more broadly of the EeTAC project, is therefore to provide a critical basis for these future developments, demonstrating that interventions aimed at improving the energy performance of the architectural heritage of the second half of the twentieth century cannot be reduced to applying predetermined models.

ESSAYS

THE BUILDING ENVELOPE IN THE SECOND HALF OF THE TWENTIETH CENTURY: PERFORMANCE AND IDENTITY

Marta Casanova

Building Envelope Configurations in the Second Half of the Twentieth Century

In the architecture of the second half of the twentieth century, the performance and identity of the building envelope are closely interconnected. The dimensions of curtain-wall modules, the arrangement of joints between prefabricated panels and the depth of solar-shading devices affect the thermal and daylight performance of the enclosure while also helping to define the proportions, depth, and perceptual quality of the façade. Assessing the modern building envelope requires that materials, constructional solutions, operation, and architectural configuration be considered together. Indeed, a transformation intended to improve performance may alter the relationships among the parts on which the building's character depends. From this perspective, the essay examines the principal building-envelope configurations of the second half of the twentieth century, with particular attention to the Italian experience, and discusses the implications of their constructional specificity for assessing vulnerabilities and defining interventions.

The relationship between performance and the architectural configuration of the envelope becomes particularly evident after the Second World War, when the building envelope emerged as one of the principal fields of architectural and constructional experimentation. The progressive separation of the load-bearing structure and the enclosure, which began in the late nineteenth and early twentieth centuries, profoundly changed the conception of the façade. No longer necessarily a homogeneous load-bearing wall, it could instead be configured as an assembly of distinct layers and components intended to provide protection from the weather and regulate indoor environmental conditions. The separation of structure and enclosure gave rise to a plurality of configurations that differed in their materials, production processes, and methods of assembly.

The variety of building envelopes developed during the second half of the twentieth century can be understood by considering two principal aspects: the relationship between enclosure and load-bearing structure, and the degree of industrialisation of the construction system. In framed buildings, the enclosure remains distinct from the structural frame. It may consist either of masonry infill or of lightweight systems assembled from components, such as curtain walls, window units, and multilayer panels. In prefabricated large-panel systems, by contrast, the relationship between structure and envelope takes different forms. The panels may contribute to the building's load-bearing capacity or serve as non-load-bearing infill or cladding elements. These different solutions coexisted and were combined throughout the second half of the twentieth century in response to production conditions, building uses, and design choices.

Among lightweight envelopes, the curtain wall is particularly significant because it combines the separation of structure and enclosure with new modes of production and installation. Its emergence was linked both to research within the European

Modern Movement, which pursued non-load-bearing, lightweight, and extensively glazed façades, and to the development of the United States construction industry. In the United States, these principles were translated into systems comprising mullions, transoms, glazing, and opaque panels, manufactured as factory-made components and installed predominantly through dry assembly processes. In the curtain wall, architectural conception and the industrial organisation of construction are closely interconnected (Poretti, 2009, pp. 39–40). The curtain wall demonstrates with particular clarity a characteristic common to assembled envelopes: the performance of the enclosure depends not only on the properties of the individual components, but also on the relationships established between them through joints and connections. The alteration or deterioration of one part may therefore affect adjacent elements and alter the functioning of the entire system. This functional interdependence links the architectural configuration of the façade to the way in which its parts are assembled.

In precast-concrete construction, the relationship between structure and envelope varies according to whether the panels perform a load-bearing, infill, or cladding function. The dimensions and weight of the elements affect production and the entire construction sequence, from transport to lifting and installation; the composition of the layers, connections, and surface treatments instead determines their technical performance and durability. The arrangement of the panels and the design of the joints define the modular articulation of the system and contribute to the architectural configuration of the façade.

The specialisation of components, reduction in thicknesses, and juxtaposition of materials with different characteristics introduce specific vulnerabilities. In lightweight envelopes, the ageing of gaskets and sealants, corrosion of profiles, deterioration of panels, and reduced efficiency of fixing systems may compromise the performance of the entire enclosure. In prefabricated concrete systems, the principal critical issues concern material deterioration, reinforcement corrosion, and connections and joints between elements (Franco, 2009, pp. 296–299). Assessment of these phenomena must consider the sometimes experimental character of the solutions adopted, the quality of construction, exposure conditions, and maintenance over time (de Jonge, 2017).

The Construction of the Modern Building Envelope in Italy

In post-war Italy, innovation in building envelopes developed within a construction sector where industrialisation remained uneven. A complete transformation of construction methods did not keep pace with the progressive spread of industrially manufactured products and components. Reinforced-concrete frames, frequently combined with composite clay-block and concrete floor slabs, continued to be built through processes involving extensive on-site work. The fragmentation of contractors, differences in the availability of production and lifting equipment, and the presence of specialist expertise created varied operating conditions. Competitions, patents, prototypes, and public programmes fostered experimentation without leading to the widespread adoption of uniform systems (Giannetti, 2015).

The reinforced-concrete frame often supported enclosures with different degrees of industrialisation, ranging from infill walls built using traditional techniques to prefabricated panels and lightweight façades. Both heavy-prefabrication processes based on panels, slabs, or three-dimensional elements, and lightweight open systems consisting of a discontinuous frame completed with infill panels, were tested in residential and school construction. The latter could use lightweight sandwich elements or heavy concrete panels (Franco, 2009, pp. 294–296). Industrial products and

Figure 1
Detail of the vault of
the Padiglione Agnelli
in Turin during
construction works.



on-site work could therefore coexist within the same building, producing solutions that cannot be classified as wholly standardised systems.

In the Madonna Bianca¹ Neighbourhood in Trento, the reinforced-concrete frame is combined with non-load-bearing prefabricated panels that define the enclosure and articulate the elevations. The configuration of the elevation is determined by the modular rhythm of the panels, whose arrangement does not necessarily coincide with the articulation of the structure behind them. The building's identity therefore derives from the seriality of the envelope rather than from the expression of the load-bearing frame. The case documents a form of industrialisation confined to the enclosure, in which the prefabricated component plays both a constructional and a figurative role.

Among the various configurations of the Italian building envelope, metal-and-glass façades reveal the relationship between industrial production and design development with particular clarity. Lightweight façades spread in Italy through the adaptation of industrialised systems to reinforced-concrete structures and to the construction sector's production conditions. Façade packages were entrusted to specialist firms, often originating in the metal-window industry, which combined catalogue profiles, glazing and opening mechanisms with bespoke pieces, patented devices and junctions developed during detailed design. The configuration of the wall resulted from collaboration between architects, technicians and contractors, and from their ability to adapt industrial products to the requirements of an individual building (Poretti, 2009, pp. 39–46).

In the early post-war period, the extension to the ICO Central Workshops,² built in Ivrea between 1947 and 1949 to a design by Luigi Figini and Gino Pollini, provides an early example of experimentation with the relationship between reinforced-concrete structure and glazed envelope. The long elevation on Via Jervis features double glazing with an accessible cavity, designed to illuminate the workspaces and help control indoor conditions. On the more exposed elevations, the reinforced-concrete

1 Madonna Bianca Neighbourhood, Trento. Architects: Marcello Armani, Luciano Perini, Efram Ferrari. Design: 1965–1967. Construction: 1968–1975. For a detailed analysis of the construction system, see the case study published in this volume.

2 ICO Central Workshops, Via Jervis 11, Ivrea. Architects: Luigi Figini, Gino Pollini, Annibale Focchi. Design: 1939. Construction: 1947–1949. For a detailed analysis of the construction system and the intervention on the building envelope, see the case study published in this volume.

floor slabs and vertical elements extend outwards to form a solar-shading system. The envelope responds to environmental and organisational requirements while contributing to the public representation of Olivetti's industrial modernity. Extending for more than 110 metres, the glazed elevation on Via Jervis has an explicitly expressive role (Bonifazio & Scrivano, 2001, pp. 48–59; Giacomelli, 2011, pp. 259–275).

In high-rise office buildings, the use of a lightweight façade raises questions about the relationship between the modular repetition of components, the reinforced-concrete structure, and the geometry of the volume. In the Grattacielo Pirelli, the glazed façade occupies the longitudinal elevations. It is bounded by opaque end elements that are part of the structural system and define the tower profile. The curtain-wall grid adapts to the gradual variation in the width of the elevations, making the tower's tapered geometry legible in the envelope (Cottone, 2009, pp. 20–27; Poretti, 2009, pp. 41–42).

In other office buildings, the dimensions and articulation of façade components derive primarily from the organisation of the interior spaces. In the building designed by Vico Magistretti on Corso Europa in Milan between 1955 and 1957, the dimensions of the window units are coordinated with the positions of movable partitions and furniture, allowing office sizes to vary without disrupting the correspondence with the façade. Serially produced elements and bespoke parts are integrated into a solution that connects envelope construction, spatial organisation and the composition of the elevation (Neri, 2014, pp. 50–57). A similar principle is found at the Confindustria Headquarters³ on Viale dell'Astronomia in the EUR district, where the curtain-wall grid is defined in relation to the movable partitions and internal elements (Capurso et al., 2009, pp. 170–177).

Envelope design also encompasses devices intended for environmental control. In the building constructed on Via Torino in Rome between 1955 and 1960 by Adalberto Libera, Luigi Calini and Eugenio Montuori, the glazed wall was developed together with a system of adjustable sliding louvres. The shading devices regulate solar radiation and define the depth and rhythm of the façade. The solar-control device is an integral part of the architectural configuration of the envelope (Iori, 2009, pp. 178–185).

The Italian experience encompasses different envelope configurations, united by the integration of industrial production and construction-site practices. In the various enclosure systems, constructional solutions are developed in relation to the structure and use of the building, but are also influenced by production conditions and decisions made during the detailed design phase. Even when they derive from serial production, envelope components acquire specific characteristics in relation to the interior spaces and façade configuration. Knowledge of the materials and assembly methods therefore makes it possible to assess how the alteration of one part affects the performance of the entire system and the building's architectural configuration.

Performance, vulnerability and compatibility of interventions

Assessment of the performance of building envelopes from the second half of the twentieth century must consider the technical knowledge, economic conditions, and comfort expectations prevailing at the time of design, as well as present-day requirements. Historical reconstruction forms part of the technical assessment because it clarifies the function assigned to the envelope, its intended relationship with building services, and the significance of constructional solutions within the building as

3 Confindustria Headquarters, Rome, designed by Vincenzo Monaco, Edoardo Monaco and Pier Luigi Spadolini from the late 1950s onwards.

a whole. Conservation design therefore requires historical and critical knowledge capable of recognising the relationships among function, construction, and spatiality within the architectural work (Reichlin, 2025, pp. 25–98). This approach avoids two equally reductive interpretations: judging these buildings solely by contemporary parameters, or assuming they were necessarily unconcerned with comfort and energy conservation. In many buildings, the regulation of environmental conditions also depended on the form and operation of the envelope. Orientation and the arrangement of openings, together with shading and ventilation devices, helped modulate exchanges between inside and outside. In other cases, the pursuit of transparency, lightness, and rapid assembly was not accompanied by comparable attention to thermal behaviour, which was increasingly entrusted to mechanical conditioning systems. Among the cases examined in this volume, the ICO Central Workshops and Villa Rossi exemplify the first approach, since the façade integrates devices for

Figure 2
Detail of the main
façade of the building
on Via Leopardi in
Milan.



regulating solar radiation, ventilation, and the relationship with the outside. By contrast, the Cité du Lignon and the Madonna Bianca Neighbourhood present hygrothermal problems attributable to the characteristics of the period's industrialised envelopes.

Victor Olgyay's studies brought the relationship among buildings, climate, and local conditions into a unified bioclimatic method (Olgyay, 1963). This systematisation developed themes already present in Modern Movement architecture through solutions integrated into the façade to promote daylight and natural ventilation or limit overheating. The Italian examples analysed by Mele and Franchini show how these devices combined environmental control with architectural expression (Mele & Franchini, 2021, pp. 488–493). The spread of these principles was uneven: buildings in which passive strategies and innovative technologies were consciously integrated existed alongside experimental constructions that revealed shortcomings in comfort and environmental performance at an early stage (Pottgiesser, 2021, p. 474). This variability has direct consequences for assessing interventions: when façade elements simultaneously perform environmental and figurative functions, their alteration may affect both performance and the elevation's identity.

The conditions against which performance is assessed have also changed over time. Patterns of use, expected indoor temperatures, and required air-change rates now differ from those assumed in the original design. A distinction must be drawn between intended operation, the behaviour of the building as constructed, and changes resulting from ageing. Construction-stage variations, replacements, alterations to building services, and maintenance may have substantially changed the initial performance. The progressive unavailability of industrial materials and products further complicates conservation of building envelopes. Replacement often requires components that differ in dimensions, performance and appearance, while the loss of construction techniques and skills makes it difficult to reproduce the original solutions (Godoli, 2025, pp. 263–278). The issue of authenticity extends beyond material fidelity alone. Where reproducing the original solutions is not technically feasible, it is necessary to determine which relationships between material, construction and configuration define the character of the envelope and should therefore be protected.

Energy upgrading cannot be reduced to the application of standard solutions, because interventions affecting the envelope, building services and ventilation have reciprocal effects and must be assessed at the scale of the building as a whole. Insulation may alter the hygrothermal regime of a wall or change the surfaces, joints and depth of the façade; replacing glazing entails changes in thickness, weight, transparency and reflectance (Buda et al., 2021). In treated solar-control glazing, colour and the way in which the surface transmits and reflects light contribute to the expression of the envelope as well as to its performance. A more efficient contemporary product may therefore alter the appearance of the façade and cannot be considered architecturally equivalent to the original (Marino, 2021, pp. 476–481).

Comparison of alternatives must integrate energy use, comfort, durability, technical feasibility and the retention of architectural character. The intervention at the Cité du Lignon demonstrates how a decision may emerge from balancing these criteria: surveys, testing, and simulations made it possible to relate the conservation of the original fabric, improved performance, and retention of the façade configuration (Graf & Marino, 2011, pp. 32–39). The objective is to identify an improvement compatible with the building's constructional concept and character, rather than to pursue the highest possible performance value in absolute terms.

Conclusions

The cases analysed reveal a constructional landscape more complex than the opposition between traditional techniques and industrial production would suggest. Masonry infill, lightweight façades, and prefabricated systems correspond to different relationships among structure, enclosure, and finish and may coexist within the same production context. In Italy, the uneven nature of industrialisation frequently led to components and processes being adapted to the structure, organisation of the construction site, and configuration of the individual building. Behind the apparent seriality of the envelope lie specific solutions and components that are not always interchangeable.

Performance and identity are inseparable dimensions of the building envelope. Profiles, glazing, panels, joints, opening elements, and shading devices contribute to its environmental behaviour and determine its proportions, depth, and perceptual qualities. Where deterioration, obsolescence or product unavailability necessitates replacement, authenticity concerns both the material fabric and the retention of the work's constructional concept (Godoli, 2025, pp. 263–278). The compatibility of an intervention depends on its ability to conserve the significant relationships among construction, operation, and architectural expression.

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BUILT HERITAGE AND THE ENERGY TRANSITION: EUROPEAN POLICIES, CONSERVATION AND COMPATIBILITY

Giovanna Franco, Stefano F. Musso

Introduction: Energy Efficiency in Cultural Heritage

A brief review of scientific initiatives and, in parallel, of the evolving regulatory framework for the energy upgrading of architectural heritage of cultural value reveals a gradual convergence between two fields that, at the beginning of the twenty-first century, appeared distant, if not opposed. This process is undoubtedly connected with the pervasive use of the term 'sustainability' and the practices associated with it across different fields of action, including the management of the built environment, not least in response to the new environmental and climate-related risks that characterise the present day.

During the severe period of crisis that marked – and continues to affect with growing intensity – the beginning of the new millennium, the policies of industrialised countries have regarded technological innovation as essential to economic prosperity and quality of life, even though the myth of infinite, incremental progress has long since faded. Innovation in environmental technologies has been invoked as a means of addressing the energy emergency afflicting the planet and jeopardising the ability of future generations to pursue more balanced and sustainable changes and transformations of the human-made environment, including through approaches different from those adopted by our own generation (Derrida, 2008). The environmental crisis has therefore called upon technology as a presumed means of salvation: a way to achieve high levels of energy efficiency, substantial reductions in consumption, major cuts in atmospheric pollutants, progressively improved indoor comfort, and optimised performance across the building stock as a whole, the transport system, and, more generally, the entire production sector.

Beyond the slogans and fashions that have permeated the construction sector for many years – including the overuse of the expression 'sustainable architecture', as though an 'unsustainable' counterpart could legitimately exist – several scenarios affecting the built environment are now well established and regulated, though not without evident shortcomings. In work on the existing building stock, the relationship between technological innovation and the pursuit of architectural and environmental quality remains largely confined to the straightforward application of products and technologies rather than genuine innovation. This creates an imbalance, if not a subordination, of design research to the technical – or technicist – dimension alone, without a corresponding cultural advance: namely, the capacity to assimilate and modify technology itself in pursuit of broader, longer-term objectives (Staudenmaier, 1988). The fundamental question is therefore a simple one: should we allow ourselves to be driven by change, or learn how to manage it?

For these reasons in particular, the cultural heritage sector – which engaged with environmental technologies more slowly than other fields – can now play a key role that extends beyond its own disciplinary remit, bringing debate and research onto a less reductive plane and fostering greater awareness of the implications of these issues for present and future living environments. Technological innovation in design,

whether applied to the existing building stock or to new architecture, on a large or small scale, cannot dispense with clear and explicit quality objectives. These objectives cannot be equated solely with efficiency, including energy efficiency, or with the effectiveness of the technical choices made. By moving beyond rigid disciplinary boundaries, cultural debate in the fields of conservation and the cultural and landscape heritage can inject new vitality into research and open up previously unexplored perspectives. It can help bring about a necessary reversal of objectives and frames of reference hitherto treated as exclusive, placing the protection of heritage alongside resource conservation at the forefront and promoting compatibility through the optimisation of the systems involved, rather than through the dominance – or maximisation – of one over another. Understood in its broadest sense, the culture of conservation brings into play a set of values that restores techniques to their proper role: means rather than the ultimate end of intervention on existing buildings.

The First International and National Tools for Education and Dissemination: Manuals and Guidelines

Numerous guidelines and manuals, published primarily in an international context from the first decade of the new millennium onwards, have provided methodological and operational reference points for a wide range of stakeholders and end users. They offer methodological and technical guidance intended to establish shared guiding principles and to explain how to implement them. The dissemination of knowledge and the education not only of professionals but also of homeowners and tenants have long been identified as priorities in the English-speaking world for achieving genuine cultural progress. To this end, brochures, technical guides and accessible manuals have been published that address recurring problems of damp, insulation, building-services upgrades and reduced thermal and electrical energy use in a pragmatic manner, supported by clear methodological principles and without neglecting the material conservation and active protection of the buildings concerned (Cornwall Council Historic Environment Service, n.d.; English Heritage, 2008, 2012; English Heritage & City of Westminster, 2013; Historic Scotland, 2008, 2013, 2014). By presenting completed projects through site photographs and readily understandable annual energy consumption data, these guides serve as effective vehicles for dissemination. Training and advisory work in the United Kingdom consequently involves the active participation of several institutions – including the Sustainable Traditional Buildings Alliance (STBA), Historic Scotland, English Heritage, Changeworks and the Society for the Protection of Ancient Buildings (SPAB) – which collaborate closely with one another.

UNESCO-listed heritage has long been the focus of specific research on energy conservation, efficiency and microgeneration. Within this field, Edinburgh has played a leading role, not only by disseminating technical knowledge but also by recognising the most noteworthy projects for the ‘sustainable’ alteration of Georgian houses (Changeworks & Edinburgh World Heritage, 2008, 2009). These experiences take into account the actions and effects of climate change on the historic built environment and the objectives of safeguarding and active protection. They shift attention from work on individual buildings to broader management issues, including the preparation of urban-scale risk maps. Such initiatives have also produced positive results in other UNESCO World Heritage cities, including Bath (Bath Preservation Trust, 2011), and have contributed to the wider dissemination of the outcomes achieved (Hartman et al., 2013).

In Italy, the former Ministry for Cultural Heritage and Activities – now the Ministry of Culture – worked at the local and national levels to promote research aimed at developing guidelines to ensure compatibility between energy-upgrading measures and the safeguarding of built heritage of cultural interest. Nevertheless, particularly in the national guidelines, a degree of separation remains between the different scientific fields involved: energy auditing, building services design and architectural conservation. These initiatives, together with the experience acquired by the Ministry itself – first in relation to the introduction of wind-energy installations in protected settings (Di Bene & Scazzosi, 2006), then concerning the energy efficiency of historic buildings (Ministero per i beni e le attività culturali, 2015), including through its regional directorates (Direzione Regionale per i Beni Culturali e Paesaggistici del Veneto, 2010; Franco, 2015) – provided an essential basis for establishing a genuine and effective dialogue with the local authorities responsible for protection.

Above all, the European standard EN 16883:2017, *Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings* (CEN, 2017), has stimulated scientific research and debate. This is evident in the biennial EEHB – Energy Efficiency of Historic Buildings conferences from 2014 to the present (Lopez et al., 2014; De Bouw et al., 2016; Broström et al., 2018; Kilian et al., 2023; EEHB, 2024). The standard has also supported and guided professional practice. For the first time, the subject is addressed clearly and without a dichotomous approach: autonomous fields of expertise are integrated, and historical and evidential significance is included within the hierarchy of values alongside efficiency and technical effectiveness. The guidelines are intended for property owners, authorities and professionals involved in conserving and upgrading historic buildings, including relatively recent structures with reinforced-concrete frames and various forms of infill. These buildings often have poorer energy performance than older structures constructed using traditional masonry techniques, whose mass and associated thermal inertia reduce heat loss. The guidelines seek to facilitate the sustainable management of buildings by integrating measures to improve energy performance and reduce greenhouse-gas emissions with the conservation of their character and values. They also offer recommendations for sustainably improving the energy performance of buildings of historical, architectural or cultural value while respecting their heritage significance. In particular, they set out a systematic approach for identifying the optimum combination of passive and active solutions across highly diverse cases, while recognising that not every historic building requires an improvement in energy performance. They therefore propose an operational procedure for selecting energy-performance measures based on the study, analysis and detailed documentation of the building concerned, including its historical and cultural value, and on an assessment of the impact of those measures on the conservation of its character-defining elements.

The European Directives on the Energy Performance of Buildings and Energy Efficiency, and National Minimum Requirements

The 2015 Paris Agreement on climate change, which resulted from the twenty-first Conference of the Parties to the United Nations Framework Convention on Climate Change (COP21), is widely regarded as a major turning point, not least because of its regulatory consequences.

The ambitious targets for reducing greenhouse-gas emissions – initially for the period from 1990 to 2030, with reductions in energy use estimated at up to 40%, and subsequently extending to 2050 – together with the progressive increase in the share



Figure 1
The Trifoglio building at the Politecnico di Milano. The rooftop photovoltaic system was installed on a blue base whose outline echoes the building's plan, visually integrating the installation with the architecture (Photovoltaic System Installation Project for 12 Buildings on the Città Studi Campus, Department of Energy, 2023–2024).

of energy supplied from renewable sources led the European Parliament to adopt a series of directives beginning in 2010 (European Union, 2010, 2012, 2018). These measures include successive iterations of the *Energy Performance of Buildings Directives*, rendered in Italian as ‘Direttive sul rendimento energetico degli edifici’ (EPBD I, II and III). They seek to promote the energy renovation and decarbonisation of the new and existing building stock, which accounts for approximately 36% of atmospheric CO₂ emissions, in order to meet the environmental objectives set for 2050. Buildings of historical, cultural and architectural value were nonetheless excluded. The directives primarily concern new construction and what are termed ‘major renovations’ of the more recent building stock. They make the energy efficiency of new buildings unavoidable, to be achieved through both ‘passive’ measures applied to the external walls, ground floors and roofs – collectively and legally defined as the building envelope – and ‘active’ measures concerning building services, their architectural integration and the possibility or requirement to incorporate systems powered by renewable energy into new buildings.

These directives were transposed by all Member States of the European Union (EU), including Italy. Italian legislation began to align with the requirements of the EPBD through Legislative Decree No. 192 of 19 August 2005, amended by Law No. 90 of 3 August 2013, and subsequently through the Ministerial Decree of 26 June 2015. The latter establishes thermal-transmittance (U-value) limits for opaque and glazed building elements across Italy’s climate zones – the so-called ‘minimum requirements’ – and was updated by Legislative Decree No. 48 of 10 June 2020 (Italy, 2005, 2013, 2015, 2020). The Ministerial Decree is particularly significant because it sets out procedures for calculating the energy performance of buildings and establishes minimum energy-performance requirements for buildings and their individual components, including opaque and glazed elements. It also defines the criteria for designing nearly zero-energy buildings (nZEB), meaning ‘buildings with a very high energy performance’. These criteria have applied to new buildings and major renovations since 1 January 2019 for public buildings and since 1 January 2021 for all others.

The very low energy demand of nearly zero-energy buildings should be met to a significant extent by energy from renewable sources, including energy generated on

site or 'nearby'. The Ministry for Ecological Transition has nevertheless reported that nZEBs still account for only 0.03% of the existing building stock. In particular, fewer than 10% of nZEBs are renovated existing buildings, and these are mainly small detached or semi-detached houses and schools. This figure highlights the considerable work still required to achieve net-zero energy targets for Italy's existing building stock. Moreover, the fact that around 30% of the national building stock was constructed before 1945 means that most of these buildings are regarded as historic (Troi & Bastian, 2015), adding a further layer of complexity to efforts to improve their energy performance. The challenge is more demanding still in the case of buildings subject to statutory protection.

The New European Directive 2024/1275 (EPBD IV)

Although European regulations and their national transposition up to 2018 did not directly apply to architectural heritage of cultural value, numerous new problems have since emerged, along with their consequences. Objectives relating to energy efficiency, resource conservation, and the construction of nearly zero-emission buildings often fall outside the responsible management of the architectural heritage we have inherited. In this context, reliance on building-services technology has frequently reduced scientific debate and operational approaches to the mere measurement of fuel savings, preliminary energy audits, and the modelling of energy behaviour before and after intervention under 'ideal' conditions, often detached from the actual effects of ageing and physical deterioration that inevitably affect existing buildings.

By its nature, regulation standardises calculation methods and proposes compliant solutions; it cannot encompass the uniqueness of every individual case and therefore fails to consider technical innovation as a form and vehicle of design creativity. Yet for at least the past twenty years, much has been written about the failure of the idea of architectural and constructional quality, based on the indiscriminate application of 'compliant' solutions to radically different situations and contexts. The pursuit of quality that is not merely formal or procedural opens new avenues of research, including the integration of building-services systems and components, particularly in solar and photovoltaic technologies. This may involve products with lower visual impact, such as glass-glass or thin-film modules, as well as photovoltaic films and coatings.

Addressing these subjects in education responds to the need to equip new generations of architects and technicians with a comprehensive outlook that makes them responsible for conserving buildings, the environment, ecosystems and cultural identities. These constitute a powerful 'root of development itself, understood not simply in terms of economic growth, but also as a means to achieve a more satisfactory intellectual, emotional, moral and spiritual existence' (UNESCO, 2001). The transformation of the environment in which we live and, at the same time, the conservation of identity and cultural heritage are fundamental components of our relationship with the legacy of the recent and distant past. They presuppose the responsibility that, as heirs, we must assume towards future generations as well as towards those who preceded us.

All of this is even more pertinent in relation to the latest revision, EPBD IV, which introduces major changes to interventions on the existing building stock.

Directive 2024/1275, published in the *Official Journal of the European Union* on 8 May 2024 and also known as EPBD IV, following EPBD I, II and III, sets out strategies to improve the energy performance of buildings and to contribute to the climate objectives of the European Green Deal. It partially shifts the perspective and

approach adopted towards cultural heritage, whether or not it is subject to statutory protection. The new directive updates its predecessor to pursue more ambitious climate objectives and provides for progressively stricter requirements to increase the energy efficiency of buildings – the aforementioned ‘minimum requirements’ – promote the use of renewable energy, and reduce carbon and greenhouse gas emissions. Its principal innovation in relation to the building stock is the requirement for every Member State to prepare a National Building Renovation Plan covering residential and non-residential buildings in both public and private ownership, to achieve a highly energy-efficient and decarbonised building stock by 2050.

Italy, like other countries, must therefore move beyond the emergency logic first generated by the pandemic and subsequently by the current political situation. It must adopt a long-term perspective, with the ambition of pursuing the cultural change required to accelerate the ecological transition and fulfil its commitments to the international community.

The national situation is particularly challenging. Perhaps for this reason, Parliament has not yet transposed the European directive. Italy is subject to two infringement procedures initiated by the Commission, and no National Building Renovation Plan has yet been prepared. Italy’s building stock is old: a very substantial proportion of residential buildings was constructed before the energy-conservation legislation of the 1970s and 1980s. At the same time, it is highly heterogeneous, not only in date but also in settlement patterns, encompassing urban, peri-urban, rural and dispersed contexts. Much of the building stock is subject to statutory constraints of varying levels and types – historical and artistic, environmental, landscape and architectural – which limit the applicability of certain standard solutions that have come to be regarded as technically ‘compliant’ in new construction, not always successfully. One example is the indiscriminate use of external insulation on opaque envelope elements, often employing synthetic materials. The new directive allows protected properties to be exempted from its requirements, but to a lesser extent than before. For the first time, historic and valuable buildings are also included within the scope of the obligations, bringing risks, limitations, and opportunities. Highly fragmented ownership presents an additional obstacle to planning, decision-making, and administrative procedures. Finally, and no less importantly, energy poverty must be addressed, and the ecological transition must be accompanied by appropriate social measures, so that lower-income households are not excluded from energy-upgrading work and its associated benefits.

A constructive approach to transposing the EPBD in Italy requires long-term planning that is integrated with local planning and with European and national financial programming. It also requires the capacity to set priorities along a reasonable and sustainable trajectory towards 2030, 2040 and 2050. In essence, an integrated approach is needed, based on shared principles for the active protection of built heritage of cultural value – including buildings not directly protected by law – and on recognition of the considerable differences that characterise it.

Energy Generation from Renewable Energy Sources (RES): Architectural and Landscape Compatibility

A final issue concerns the installation of systems powered by renewable energy sources in existing buildings and settings – especially, though not exclusively, those of historic construction – for direct use or to feed electricity into the grid; the direct use of thermal energy is now mandatory in new construction. The amendments to Legislative Decree 190/2024, the Consolidated Renewable Energy Act, made by

Decree-Law 175/2025 and Legislative Decree 178/2025 (Italy, 2024, 2025a, 2025b) redefine authorisation regimes and the areas considered suitable for installing such systems. They create new operational possibilities for historic and more recent buildings of cultural interest. These changes are supplemented by Legislative Decree 200/2025, which provides for accelerated administrative procedures connected with the energy transition (Trovò, 2026a, 2026b). Among the most significant innovations is the inclusion, among the areas considered suitable for renewable-energy installations, of roofs in historic centres – even where they are protected under Legislative Decree 42/2004 – provided that their historical and architectural value is conserved and the visual impact on the setting is not altered. These provisions naturally arise from the cultural, technical and legislative process outlined briefly in the preceding sections. They nevertheless shift attention from the individual building towards an urban and territorial systems perspective.

The possible integration of solar-powered technological systems into rural landscapes, and the poorly defined boundary between modification and alteration – the former considered acceptable and the latter to be avoided – constitute a complex and multifaceted issue.

The most evident concerns associated with these technologies relate to the different forms of impact they exert on the landscape and the environment, which may be summarised as follows:

- visual intrusion and disturbance caused by the colour, form and reflective surfaces of collectors, which generally contrast with the morphology, materials and colours of the existing built fabric;
- modification of soil structure, fine-grained territorial patterns and existing vegetation, among other features;
- replacement of existing materials and loss of the material characteristics of traditional architecture;
- alteration of the ‘social perception’ of places.

The following are therefore recognised as factors capable of producing adverse effects:

- impacts on the physical fabric of the built heritage, landscape, environment and ecosystem, associated with an increasing degree of transformation and expressed through the concepts of integrity, modification and – negatively – alteration;
- impacts on the psychological and perceptual sphere, in which the concepts of integration and mimesis predominate. These concern the observer’s capacity, based on culturally recognised values, to accept the application of a new technology to traditional buildings or, conversely, to reject an alteration perceived as incompatible or a transformation considered unacceptable (Franco, 2015; De Medici, 2021).

Once the principle of protection is, as hoped, shared within the governance of change, assessments of compatibility can draw on experience gained nationally and internationally. Such assessments are based on the reciprocal relationship between factors associated with the physical characteristics of the territory, buildings, and technical systems, and the perceptual impacts of new installations. Possible criteria for compatibility with architectural and landscape protection depend on locational factors – including local character and land use, views, the constructional and morphological characteristics of the built fabric, and the actual state of conservation of buildings – as well as on quantitative factors. The latter vary according to whether

systems are isolated or repeatable and aggregated, and concern their surface area and relationship to the roof covering, or their height and width in ground-mounted solutions. Qualitative factors are equally important and include the morphology, colour, and texture of the system; its inclination and anchoring method; the manner in which units are grouped – including proportions and alignments; and the possibility of mitigating visual impact. All these aspects also interact with scale, with implications for the so-called cumulative effect at both the individual-building and landscape levels.

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MODERN HERITAGE AS A RESOURCE BEYOND ENERGY RETROFIT

Uta Pottgiesser, Wido Quist

DOCOMOMO International – the International Working Party for Documentation and Conservation of Buildings, Sites and Neighbourhoods of the Modern Movement – was established in 1988, formally consolidated as an organisation in Eindhoven in 1990 and defined its principal objectives in the so-called *Eindhoven Statement*. It emerged at a critical moment when 20th-century architecture was still relatively young and therefore not widely regarded as ‘heritage’, which in most countries followed the 50- or 100-year rule of age. At the same time, the early buildings of the Modern Movement were increasingly threatened by demolition, disfigurement, technological obsolescence and changes of use. DOCOMOMO International sought to challenge this situation by arguing that modern architecture constituted an important part of cultural heritage that required systematic documentation, research, conservation and public recognition. The research – by DOCOMOMO founders Hubert-Jan

Figure 1
Zonnestraal before
and after the
intervention;
photographs from
1986 (top) and 2007
(bottom).



Henket and Wessel de Jonge – into the possibilities of preservation of the abandoned Zonnestraal Sanatorium in the Netherlands served as a prominent example.¹

In 1990, representatives of 14 different countries gathered to follow a common goal to contribute to the fundamental characteristic of DOCOMOMO: the deliberate connection between documentation and conservation. The systematic recording of Modern Movement buildings through registers, drawings, photographs, archives and other forms of documentation was intended not only to develop knowledge about the Modern Movement but also to establish methods for the appropriate conservation of its buildings. Documentation was consequently not merely an archival activity but an instrument of heritage protection.

During the 1990s, documentation fished to create an inventory became one of DOCOMOMO's central practical activities. The objective was to identify significant examples of Modern Movement architecture and create a systematic knowledge base that could support research and conservation. Consequently, DOCOMOMO established its first International Specialist Committee on Registers (ISC/R) at the 1992 International DOCOMOMO Conference in Dessau (Germany) to develop the collective international register. Only two years later in 1994 the second International Specialist Committee on Technology (ISC/T) was founded in which specialists could exchange experience concerning the repair, maintenance and conservation of modern materials and technologies to foster the development and dissemination of appropriate conservation methods, documented in several ISC Preservation Technology Dossiers.²

In this way DOCOMOMO was helping to redefine the boundaries of architectural heritage. Instead of concentrating primarily on monuments from earlier historical periods, it demonstrated that 20th-century buildings, including ordinary housing, industrial buildings, schools, offices and infrastructure, could possess heritage value and deserve to be recognised through listing locally, nationally and internationally. ISC Registers' advisory report on *The Modern Movement and the World Heritage List* (DOCOMOMO ISC/Registers, 1997) demonstrates its underrepresentation and underlines DOCOMOMO's recognised advisory role.

With its work in the first decade DOCOMOMO transformed documentation into a conservation strategy by constructing the intellectual, documentary and professional infrastructure through which 20th-century architecture could be read and recognised as heritage. Its founding premise was that buildings, sites and neighbourhoods of the Modern Movement could only be effectively conserved when their cultural, architectural, technological and historical values were first understood and made visible. DOCOMOMO therefore contributed to a fundamental shift in the heritage discourse: the architecture of the Modern Movement was increasingly perceived as cultural heritage requiring active processes of identification, interpretation, conservation and continued use.

Already in the 1990s DOCOMOMO extended its scope beyond buildings, expressed in establishing a further International Specialist Committee Urbanism and Landscape (ISC/U+L) in 1996. After 2000, the ISC on Education and Theory (ISC/E+T), later renamed Education and Training, was established, followed in 2016 by the ISC on Interior Design (ISC/ID). The ISCs contributed to international exchange and collaboration beyond and next to the biennial International DOCOMOMO Conferences (IDC's). Through its international and interdisciplinary network of

1 Knoll Modernism Prize (<https://www.wmf.org/knoll-modernism-prize>).

2 The ISC/T Dossiers are available via the website of DOCOMOMO International (<https://docomomo.com/dossiers-isc-t-2/>).

architects, historians, conservation specialists and researchers across all continents, DOCOMOMO's most important conceptual contribution was to understand the Modern Movement as an international cultural phenomenon rather than a collection of nationally isolated architectural achievements.

In 2014 DOCOMOMO added 'adaptive reuse' to its principal objectives and further committed to sustainability and the UN's Sustainable Development Goals (SDGs), manifested in the *Eindhoven-Seoul Statement* (DOCOMOMO International, 2014). In 2022 the Council Meeting in Valencia (Spain) approved a further addition to DOCOMOMO's principles with the *DOCOMOMO Manifesto on Education* (DOCOMOMO International, 2022). Overall a good theoretical basis was created to improve and accelerate the conservation practice by different approaches such as restoration, rehabilitation, reconstruction or renewal, in particular when adaptive reuse comes into play.

From Documentation to Conservation

Since its establishment DOCOMOMO has grown from 14 to 85 national working parties from all five continents. In parallel, the scope of DOCOMOMO's work extended beyond the interwar period (1918–1939) to the post-war period (1945–1975). Through local initiatives, its international conferences and through the *DOCOMOMO Journal* also 'other modernism', 'multiple modernism', 'dissonant modernism' and 'imperfect modernism', were brought to the attention of a global audience, colouring the documentation and conservation of buildings, sites and neighbourhoods of the Modern Movement beyond the Eurocentric and North American perspective. This had several implications for the body of research and documentation, and for conservation challenges.

The conservation of 20th-century architecture increasingly confronts a fundamental tension between the preservation of architectural heritage and the need to meet contemporary or even future standards of environmental performance, safety, and usability. Buildings of the Modern Movement were frequently conceived through principles of technological innovation, lightweight construction, transparency and extensive glazing (Prudon, 2008). Yet the material and technological systems that enabled these architectural qualities are often associated with significant energy losses, material deterioration, corrosion, deferred maintenance and functional obsolescence. Glazed façades and lightweight steel- or aluminium-framed enclosures present complex conservation challenges because their architectural significance is often closely related to their material and technological characteristics. The conservation of such buildings consequently raises a fundamental question: how can their significance be sustained while their environmental and technical performance is adapted to contemporary requirements? It also raises a fundamental theoretical question concerning authenticity: must architectural authenticity reside in the survival of original material, or can it also reside in the continued legibility of architectural or even conceptual principles? The examples studied in this book and documented in earlier book publications suggest the latter possibility. High-performance glazing, enlarged vision areas, solar-control devices and façade redesign may alter material reality while attempting to preserve or reinterpret significant architectural characteristics. Such an approach moves conservation away from the concept of the building as a fixed historical object and towards an understanding of heritage as a continuously reconstructed relationship between material evidence, cultural meaning and contemporary use.



Figure 2
Recent book publications on preservation and rehabilitation of 20th century architecture, edited in collaboration with DOCOMOMO International (2022, 2019, 2026).



The appropriate strategy depends on factors such as the building's cultural significance, physical condition, energy performance, safety and potential future use. Underlying these approaches is the broader philosophy of transformation rather than demolition – principles associated with Anne Lacaton, Jean-Philippe Vassal and Frédéric Druot: 'never demolish, subtract or replace, but always add, transform and reuse.' (Spoormans et al., 2018). These principles position existing buildings as resources and emphasise enhancement, extension, transformation and continued use. Reuse establishes a form of continuity between conservation and sustainability. Rather than treating existing buildings as obsolete objects to be replaced by technically optimised new construction, it recognises their accumulated material, spatial, cultural and urban value. Transformation consequently becomes a means of preserving embodied architectural resources while enabling new forms of occupation.

Also, DOCOMOMO examines how buildings of the Modern Movement can be conserved and adapted without reducing conservation to the simple preservation of existing fabric. Instead, it proposes a differentiated understanding of levels of intervention and a search for the 'tolerance for change' in which restoration, rehabilitation, replacement, reframing and reglazing can contribute to the continued life of buildings, both ordinary and of cultural significance (Van den Heuvel et al., 2008; Kuipers & Quist, 2013).

The first comprehensive overview of good practices was presented in *Modern Heritage: Reuse, Renovation, Restoration*, a publication accompanying the first DOCOMOMO Rehabilitation Award (DRAW), edited by former DOCOMOMO International Chair Ana Tostões (2022). The book presents 24 international projects

clustered in 12 different categories to illustrate the broadness of preservation philosophy and conservation strategies.

Intervention Categories for the Building Envelope

Regarding the building envelope, authenticity and energy efficiency, DOCOMOMO has contributed to several publications to develop an intervention taxonomy for the building envelope conservation. Angel Ayón and Uta Pottgiesser co-authored *Reglazing Modernism: Intervention Strategies for 20th-Century Icons* (2019), and both edited *Preserving Modernism: Post-War Curtain Wall Renewal* (2026). Within this context, several categories of intervention are distinguished:

- Restoration represents the most conservative approach and seeks to retain and repair existing building components wherever possible. Different forms of restoration may involve repairing the original frame while retaining single-pane glass, introducing laminated glass, or applying surface-mounted films. Such interventions prioritise material continuity and the retention of architectural characteristics. However, the environmental performance of the existing envelope may establish limits to what can reasonably be achieved through minimal intervention. This creates the need for performance-oriented conservation, in which the technical upgrading of the building becomes part of the conservation strategy itself.
- Rehabilitation is a more substantial alternative when deterioration or performance requirements exceed the possibilities of minimal intervention. It is characterised as partial replacement where significant material loss has occurred in metal frames or glazing, where in-kind replacement is unfeasible, ineffective or inappropriate, or where upgrading is required to meet contemporary environmental or structural performance requirements and to support continuing or new programmes. Rehabilitation is reconciling conservation with upgrading.
- Overcladding is particularly significant in US/American context because it permits the introduction of a new façade layer without necessarily eliminating the entire existing construction. The publication identifies interventions ranging from complete façade redesign to localised aesthetic modifications, including glass cladding of metal spandrels, metal cladding of mullions and spandrels, and modifications to accommodate mechanical equipment.
- Replacement represents a further stage of intervention. This may include high-performance glazing, enlargement of vision glass, replication of the historic appearance through new façade systems where heritage designation requires it, new exterior solar-control devices and façade redesign. Replacement is therefore not presented as a single technical solution but as a range of possibilities for reconciling improved performance with architectural continuity.

All intervention categories demonstrate how environmental and technical requirements can become agents of architectural transformation.

Reglazing Modernism (2019) focused on steel-framed glazed buildings from the 1920s–1960s. Challenges include, for example, high energy losses, daylight requirements, corrosion, deferred maintenance and changing programmes. Restoration seeks to retain as much of the original fabric as possible. Examples include repairing existing frames while maintaining single-pane glass or combining repaired frames with laminated glass or surface-mounted films. The cases of the Hallidie Building, Villa Tugendhat, Fallingwater, the Glass House, the Farnsworth House and the TWA Flight Center illustrate the possibilities of this approach. These interventions can introduce improved glazing while retaining significant original elements.

Preserving Modernism (2026) focuses on aluminium-frame glazed buildings from the 1950s–1980s. Such buildings – mainly high-rises – present different conservation conditions: they tend to be larger and taller, may have limited formal heritage recognition (yet), and frequently exhibit significant energy losses, deterioration and functional obsolescence. The intervention categories identified include rehabilitation, overcladding, and replacement. Challenges include, for example, high energy losses, daylight requirements, corrosion, deferred maintenance and changing programmes. Case studies such as Bizkaia Tower in Bilbao (Spain), the former Royale Belge building in Brussels (Belgium), Goldman Sachs and 180 Water Street in New York City (USA) demonstrate how façades can be upgraded through new skins, improved glazing, localised interventions or complete replacement. These projects show that adaptation can involve both technical improvements and changes to a building’s architectural expression.

Conservation Strategies beyond Energy Efficiency

The shift from preservation to performance-oriented conservation indicates that improving environmental performance does not necessarily require the wholesale replacement of an existing building envelope. This distinction is important because the environmental performance of a heritage building is not reducible to the performance of individual components. The building operates as an interconnected system involving façade, structure, daylight, use and environmental conditions. Consequently, sustainable conservation requires an assessment of how interventions affect the complete building rather than simply maximising the technical performance of individual elements. We suggest that energy efficiency should be understood as a means of enabling continued occupation, rather than as an isolated technical objective. The purpose of upgrading is ultimately to allow significant buildings to remain functional and adaptable under contemporary and potentially future conditions.

Reuse as an environmental and cultural strategy

Within the context of this contribution, this principle has both cultural and environmental implications. Reuse avoids treating existing buildings as disposable objects and instead recognises their potential for adaptation. The existing structure and envelope become resources from which new forms of performance and use can be developed. This approach also changes the meaning of sustainability in architectural conservation. Sustainability is not presented solely as a matter of reducing operational energy consumption. It is connected to the long-term viability of existing buildings sites and neighbourhoods and to the capacity to adapt them to changing requirements. The preservation of architectural heritage and the reduction of environmental impact can therefore become mutually reinforcing when adaptation enables buildings to remain occupied and useful.

Conservation, performance and the environmental dimension of architectural heritage

We suggest that energy efficiency should become an integral consideration within the assessment of 20th-century architectural heritage. Case studies demonstrate a range of possible responses and strategies. These strategies imply that there is no single sustainable conservation solution that is always the preferred option. The appropriate intervention depends on the significance of the building, the condition of its materials, its existing performance, its future programme and the extent to which architectural characteristics can accommodate technical change. Here lies an important role for all stakeholders involved to join forces.

Figure 3
Large steel- and aluminium-framed glazed enclosures characterise many 20th-century buildings from the interwar and post-war periods; photographs from 2014 (top) and 2026 (bottom).



Conservation, performance and the problem of obsolescence

The conservation of modern architecture presents a particular set of difficulties because its architectural significance is frequently embedded in constructional and technological characteristics. A conservation strategy must consequently determine which characteristics of a building are essential to its significance and which can be modified in response to environmental or functional demands. The issue is not simply whether original fabric is retained, but how its retention can be reconciled with the building's continued performance and use. This suggests not only thinking in terms of constraints but focusing primarily on opportunities.

Reglazing as a strategy of sustainable adaptation

The relationship between conservation and energy efficiency is particularly evident in the treatment of glazing. This formulation is important because it situates environmental upgrading within the logic of conservation itself. Improved glazing is not understood simply as an independent energy intervention but as a means of enabling the continued use of a significant building. The environmental performance of the envelope thus becomes directly related to the long-term viability of the heritage asset. This approach suggests a conception of sustainability based on adaptation rather than technological replacement alone. The objective is not necessarily to reproduce the original technical condition, nor to maximise performance irrespective of heritage value, but to identify an appropriate relationship between existing fabric and new technical requirements.

Energy efficiency and the continued life of heritage

energy efficiency consequently assumes a dual role. On the one hand, it is a performance requirement associated with contemporary environmental expectations. On the other hand, it becomes a condition of continued architectural use. The two dimensions cannot easily be separated: inadequate environmental performance can contribute to functional obsolescence, while appropriate upgrading can support continued occupation and thereby contribute to the preservation of heritage.

Conclusion: Towards a Sustainable Model of Conservation

The case studies presented in this book suggest that sustainable conservation cannot be reduced to a hierarchy in which the least intervention is automatically regarded as the most appropriate. Minimal intervention may be desirable where existing fabric remains viable, but more extensive intervention may be justified where material deterioration or inadequate performance threatens the building's continued use. The concepts of compatibility (to what extent the intervention harms the existing fabric) and retreatability (to what extent an intervention could be repeated in the future) seem to be useful in contributing to the discussion on appropriate interventions.

This leads to a more differentiated understanding of conservation in which intervention intensity is related to both heritage significance and performance requirements. Restoration, rehabilitation, overcladding and replacement are not necessarily competing doctrines; they constitute potential responses to different material and environmental conditions. One could even argue that often 'more extensive interventions' can also be regarded as 'minimal interventions', because doing less would not have sustained the continued use of the building: doing as little as possible but as much as needed.

The environmental dimension therefore expands the conventional understanding of architectural heritage. The value of a building lies not exclusively in the survival of its original form but also in its capacity to remain meaningful and usable under changing conditions. At the same time, the pursuit of energy efficiency cannot automatically justify the removal of significant historic fabric. Sustainable conservation requires a negotiated balance between retention, performance and transformation.

The recurring case studies collectively demonstrate that reconciling conservation values with contemporary energy-efficiency standards is achievable across a range of intervention intensities, reinforcing DOCOMOMO's broader advocacy position: that Modern Movement heritage constitutes a documentable and manageable resource rather than an obstacle to sustainable adaptation. This perspective gives particular importance to (adaptive) reuse. The continued use of existing buildings can be understood as both a cultural and environmental objective: it sustains architectural heritage while creating the conditions for further adaptation. DOCOMOMO International's commitment to the documentation and conservation of the Modern Movement, together with its emphasis on responsibility towards this recent architectural inheritance, provides the broader institutional context for this position.

This perspective supports shifting from preservation as stasis towards conservation as managed continuity. The objective is neither to freeze all 20th-century buildings in their original state nor to subject them indiscriminately to contemporary performance standards. Rather, it is to establish forms of intervention that allow architectural significance and environmental performance to coexist, calling upon all stakeholders, instead of questioning the viability of preservation, to join forces to make it happen. This understanding is consistent with DOCOMOMO International's commitment to

documenting and conserving the buildings, sites and neighbourhoods of the Modern Movement while fostering responsibility towards this recent architectural inheritance. We ultimately suggest that the future of 20th-century architectural heritage depends upon developing conservation practices capable of negotiating technological change rather than resisting it. Preserving, reglazing and reframing can thus be understood as complementary instruments in the broader project of sustainable architectural continuity.

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THE CHALLENGE OF CHANGE: CONSERVING TWENTIETH-CENTURY ARCHITECTURAL HERITAGE

Federica Pompejano

Introduction

The architectural legacy of the twentieth century, and particularly that of its second half, constitutes a fertile field of reflection for the theory and practice of architectural conservation and restoration. Born of the twentieth-century culture of change, grounded in technical progress, continuous experimentation with construction techniques, and the search for new high-performance building materials, later twentieth-century architecture made transformation an intrinsic condition of the architectural work itself.

The protection and conservation of twentieth-century architecture confront a question that is only apparently paradoxical: how to preserve artefacts conceived to express progress, technological innovation, and the continual transformation of ways in which architectural space is inhabited, experienced, and lived. The twentieth century produced new building types, infrastructures, residential settlements and new landscapes through the use of industrialised construction processes and experimental materials, frequently characterised by a pronounced capacity for adaptation and transformation. For this reason, international debate has identified the very 'management of change' as one of the pivotal interpretative keys to the relationship between modern and contemporary architecture and conservation practices (Canziani, 2008, p. 7; Casciato, 2008, p. XIII). Moreover, the protection process is complicated by the peculiar temporal proximity that separates the construction of many buildings from their recognition as cultural heritage. This is especially true of architectural works from the second half of the twentieth century, which become the object of conservation, restoration or energy-efficiency interventions while still in use and, at times, before their historical and evidential values are fully acknowledged and shared by professionals and the wider public (Macdonald, 2013, p. 4). This condition, compounded by frequent problems of material and functional obsolescence, has often delayed the process of values recognition and heritagisation, exposing many examples to the risks of incongruous interventions, abandonment or even demolition (ICOMOS ISC20C, 2017, pp. 2–4; Macdonald, 2013, pp. 4–5). Within this framework, the conservation of later twentieth-century architecture demands an approach capable of reconciling the safeguarding of a plurality of heritage values with the dynamic and transformative nature that characterises this legacy. From this perspective, conservation may be understood as a dynamic process of conscious and informed change management, grounded in the recognition of the attributes and values that sustain the cultural significance of the building and in the preliminary assessment of the effects of diverse design alternatives, as well as in the definition of reasoned limits placed upon possible modifications. From this standpoint, change may itself become an instrument serving conservation purposes, provided that it is grounded in a thorough knowledge of the architectural and technological characteristics of the architectural work and is proportionate to the values recognised and verified over time.

Moving from this theoretical nexus between continuity and change towards the tools through which change can be oriented and managed within conservation and restoration projects, this chapter considers as its underlying thesis the conservation



Figure 1
Former headquarters of
the Emilia-Romagna
Regional Government
in Bologna, side
elevation.

of later twentieth-century architecture inherently as a dynamic process of change management. The issue is rendered urgent today because of the compelling energy transition, which systematically extends energy-efficiency interventions to the recent historic built environment, confronting architectural conservation and restoration with choices that bear upon the material fabric, the architectural form and volume, and the attributes that convey the cultural significance of the building (Casanova & Pompejano, 2026).

Conserving a Heritage Born of Change

The founding of DOCOMOMO in 1988 and, from the 1990s onwards, the consolidation of specialist networks and institutional programmes at national and international scale contributed to establishing and better defining the conservation and protection of modern architecture from the twentieth century as a distinct field of theoretical and applied study and research, within architectural restoration worldwide.

This was also supported by numerous awareness-raising initiatives, specialist training programmes, and cooperation promoted internationally and locally. Among these are the *Conserving Modern Architecture Initiative* (2011) and the *Keeping It Modern* programme (2014), launched by the Getty Conservation Institute in Los Angeles, United States; the latter, in particular, was aimed at developing conservation plans for twentieth-century architecture (Macdonald et al., 2018, pp. 62–75).

Later twentieth-century architecture presents technical-constructural and morphological characteristics that make its conservation particularly delicate, such as lightweight technologies, industrialised components, curtain walls, the integration of building structure and envelope, material experimentation, and climatic-comfort devices calibrated to particular conditions of use. Moreover, in many cases, the building envelope constitutes the main device through which the architectural work's formal expression and perceptual atmosphere are defined, as well as a witness to the innovative, at times pioneering, character of the constructive production logic of the period.

In this field, Italian debate developed a clear-cut theoretical position. Conserving the modern from the twentieth century entails the recognition of its technical and design specificities and its material dimension as an integral part of its evidential and cultural values, including experimental solutions and their inevitable limitations (Musso, 2015, pp. 12–38; Reichlin, 2011, pp. 11–29). Criticising the illusion of the practice of *ripristino*, i.e. stylistic reinstatement, through a supposed 'mechanical restitution' afforded by the chronological proximity that separates us from the twentieth-century architectural works, Carbonara (2018, pp. 13–17) reaffirms the central role of historical-critical judgement and of the act of recognition of the architectural work as an 'object of culture', which must guide the manner in which conservation and restoration interventions are conceived and implemented. From a methodological standpoint, therefore, even intervention on the most recent historic built environment cannot apply predefined solutions; it must continue to pose questions of theoretical, methodological, and technical nature, analysing the building as a complex system in its technical, material, performance, and semantic dimensions (Ambrogio, 2021, pp. 23–27). Thus, the principles of architectural conservation and restoration remain fundamental; what changes is the complexity of the cognitive process of the building, bound up with new and frequently experimental materials, with their durability, and with the need to replace components that are no longer available or, in any case, difficult to reproduce without a consequent loss of authenticity. This condition gives rise to a complex tension between the retention of original fabric, the continuity of the architectural image conveyed, for instance, by the building envelope and its form, the improvement or maintenance of functional performance, and the safeguarding of the original design concept.

A further difficulty concerns the recognition of heritage values of this legacy and, consequently, its protection, which in Italy takes on particular characteristics. For twentieth-century architecture, the *Codice dei beni culturali e del paesaggio*, i.e. the Code of Cultural Heritage and Landscape, does not establish a 'special protection', and the temporal threshold, combined with the distinction between public and private ownership, generates significant asymmetries in the possibility of activating protection procedures and, therefore, of managing the modifications consequent to possible processes of change (Di Francesco, 2018, pp. 19–23). Reconstructing the trajectory from Law No. 1089 of 1939 to the 2004 Code, Vittorini observes that statutory heritage designation often remains little more than a formal acknowledgement and proves insufficiently effective for the protection of twentieth-century architecture, especially in the absence of interaction between heritage authorities and designers

during the design and construction phases. Moreover, the temporal threshold for publicly owned properties has been raised from fifty to seventy years in order to reduce the burden on the State, thereby withdrawing a portion of twentieth-century buildings from protection (Vittorini, 2025, pp. 433–450).

In this context, understanding the notion of conservation as a process may offer a way of addressing these tensions. The Burra Charter defines ‘cultural significance’ as comprising aesthetic, historic, scientific, social, and spiritual values, and proposes an operative sequence that proceeds from the understanding of the place to the definition of conservation policies and strategies and, subsequently, to management. Furthermore, the principle of minimum intervention as the foundation of the architectural conservation and restoration project requires that use and intervention be compatible with cultural significance, and that every decision be supported by adequate knowledge (Australia ICOMOS, 2013, pp. 1–5). Intervention on twentieth-century architecture demands, therefore, adequate knowledge and specific technical and design instruments as well as legal and procedural awareness together with the capacity to articulate and argue for the design choices made (Casanova & Pompejano, 2026).

Continuity and Change: Attributes, Values, and Significance

Considering the propensity for modification as an intrinsic characteristic of the twentieth century’s architectural legacy, the conservation process and the architectural restoration project should be conceived as the governance and critical management of continuity within the process of change. Thus, attention shifts from the specific building, considered as a self-sufficient repository of heritage values, to its cultural significance and to the attributes through which the latter is relationally manifested, perceived and transmitted over time (Avrami et al., 2000). In this sense, cultural significance is the outcome of historically situated recognition and attributions, formulated by different subjects, and may encompass historical, aesthetic, technological, economic, social, environmental and use-related dimensions, hence configuring itself as a plural and dynamic concept, susceptible to evolution and change. It follows that both protection and conservation must contend with evidential values that may even be mutually conflicting, and with a plurality of stakeholders, integrating specialist knowledge with meaning acknowledged by communities (Avrami et al., 2000, pp. 7–10). Thus, the understanding of later twentieth-century architecture’s cultural significance constitutes the precondition of every decision-making process with conservative aims, orienting both its objectives and its operational limits (Bond & Worthing, 2016, pp. 57–66).

Nevertheless, the plurality of subjects and of recognised values requires a passage from the ‘why’ to the ‘what’: which material and immaterial attributes render the plurality of heritage values recognisable? The attributes that convey evidential values and contribute to cultural significance may be material/tangible, such as structure, building components, surfaces, details, compositional articulation, and furnishings, but also spatial, landscape-related, and immaterial/intangible, such as use, collective practices, symbolic associations, and collective social memory. Addressing the difficult question of the relative objectivity of judgement, Grignolo proposes the notion of *Gattung*, i.e. ‘genre’, as an operational tool that, by referring to function and to the cultural, social, and figurative character of a ‘family of buildings’, offers reasonably sharable criteria for identifying what is common and, thus, acting as a safeguard against the arbitrariness of judgement (Grignolo, 2025). Very often, indeed, cultural significance assessments do not identify with sufficient precision which elements are effectively the bearers of the heritage values, nor the degree to which they can be

Figure 2
View of the
construction site for the
new Civic Library
within the pavilions of
Torino Esposizioni.



modified without compromising the asset's integrity. Havinga, Colenbrander and Schellen (2020, pp. 282–293) propose to correlate relative cultural significance, attributes, and sensitivity or propensity to change, so as to render more transparent the assessment of impacts on twentieth-century architecture, particularly where interventions of sustainable refurbishment such as, for example, energy-efficiency interventions, are required. This threefold correlation could constitute a testing ground for addressing the tension between material and technological permanence and overall architectural formal image, since authenticity and integrity, in the heritage of the later twentieth century, frequently depend on the relationships between form, fabric, construction technique, use condition, and context. Focusing on the building envelope, for instance, a window may be significant for its visible profile, its opening system, its material, its mode of assembly, its performative behaviour and its relationship with the façade. Similarly, an exposed concrete surface may embody values traceable to its chromatic appearance, to the imprints left by the formwork, to the grading of the aggregates and to the traces of workmanship that form an integral part of its material and technical testimony, over and above the aesthetics of the image.

Moreover, the conflict between, for example, the enhancement of performance in energy terms and the conservation of the architectural character reactualises, in theoretical terms, the tension between the different systems of values recognised over time in architecture from the second half of the twentieth century: on the one hand, use value and novelty or present-day value; on the other, historical value and art value, according to a reading rooted in the Rieglian tradition. Recognising this plurality prevents the reduction of the intervention to a merely technical problem and obliges the architect to make explicit which material and immaterial attributes bear the values that characterise cultural significance, and what margin of transformation they can tolerate. Therefore, the acceptability of modifications depends on case-by-case judgements, grounded in a thorough and prior understanding of the cultural significance and integrity of the building within a broader strategic vision of change management (ICOMOS ISC20C, 2017, pp. 7–8). The *ex post* assessment of the case studies selected by the research project *EeTAC – Energy Efficiency and Conservation of Contemporary Architecture: Preservation, Quality, and Innovation of*

the Building Envelope examines, in qualitative terms, the impact of energy-efficiency interventions on the building envelope upon the conservation of the characteristics and elements of the building, verifying the extent of the transformations introduced and their degree of reversibility. The analysis also concerns the modifications to the formal and spatial arrangement, both external and internal, the permanence of the original characteristics of the constructional elements, and the coherence of the technical solutions adopted in relation to the existing materials and construction techniques, thereby demonstrating a possible application of this approach.

In the case of the ICO Central Workshops in Ivrea, built by Gino Pollini and Luigi Figini in collaboration with Annibale Fiocchi between 1947 and 1949, the double-skin glazed façade cannot be interpreted as a simple cladding system, since it is the device through which natural lighting, climate control, structure, and corporate image are integrated. The refurbishment designed by GStudio in collaboration with Dante O. Benini & Partners Architects and Diaspro S.r.l. between 2004 and 2006 restored the outer envelope and concentrated the new performance requirements in a reconstructed inner skin, accepting a selective loss of original material in order to maintain transparency, perceptual depth, and the overall functioning of the building system. The intervention demonstrated that critical-conservative judgement must identify the priority attributes and assess their sensitivity to modification. On this basis the conservation and restoration project incorporates the energy-efficiency intervention and defines the change that is compatible with maintaining the relationships between the attributes.

Orienting Change: Material Fabric, Reuse, and Sustainability

Today, the energy transition represents one of the most incisive conditions posed by the challenge of change to the imperatives of conservation of twentieth-century architecture. The decarbonisation strategies promoted by the Green Deal and transposed into Directive (EU) 2024/1275 on the energy performance of buildings (EPBD) affect a recent heritage that is often devoid of formal protection but that, in some cases, is recognised as part of European cultural heritage for its historical, technical and constructional value. The conditions, instruments, and responsibilities of conservative interventions are today redefined by the requirements of energy adaptation, which can no longer be interpreted as a simple technical and regulatory update. The risk is that the pursuit of performance requirements may produce physical and perceptual modifications that are not adequately assessed in relation to the characteristics of the building. Moreover, this critical issue sits within a regulatory framework that has historically addressed buildings of cultural interest through regimes of exception and derogation, with outcomes in practice that are not always consistent (Mazzarella, 2015, pp. 23–31). In this scenario, the building envelope constitutes the most critical architectural component, since in modern architecture it frequently coincides with the formal, technical and perceptual identity of the building. Indeed, many of the most representative edifices of twentieth-century architecture entrust their expressive character to the envelope and to the use of experimental materials that are often difficult to reproduce.

Applications of external insulation, the wholesale replacement of lightweight façades or the superimposition of new technological skins may substantially alter the architectural image, the proportions, and the constructional logic, with effects that are difficult to reverse (Casanova & Pompejano, 2026). The question presents an analogous complexity in historic reinforced-concrete buildings, a material emblematic of the twentieth century, whose character is closely bound to processes of workmanship

and to the effects produced by ageing, but which is, at the same time, vulnerable to specific phenomena of decay (Macdonald & Arato Gonçalves, 2020). In buildings with exposed concrete, structure, surface and architectural language tend to coincide; consequently, an energy-efficiency intervention that is technically effective but based on an inadequate knowledge of these aspects may compromise the colour, the texture, the formwork imprints and the overall perception of the work. In this field, research further confirms that chromatic correspondence does not depend exclusively on the cement employed, but also on the sand, the aggregates, the techniques of placement and subsequent atmospheric exposure (Currie & Bronski, 2018, pp. 891–905).

For this reason, material fabric conservation and the restoration intervention that entails energy-efficiency improvement are inseparable from constructional analysis and require procedures grounded in multidisciplinary expertise, the preliminary assessment of cultural significance, investigation of physical conditions, the definition of explicit criteria, testing and mock-ups, control of execution, maintenance and monitoring (Macdonald & Arato Gonçalves, 2020, pp. 14–24). These aspects assume particular importance in architectural examples in which material fabric, technique, and language prove strongly intertwined, as, for example, in the New Brutalism or in the work of Carlo Scarpa. From this perspective, for a significant part of the twentieth-century heritage, the notion of ‘material authenticity’ must be considered with particular caution, since the integral conservation of the original fabric often proves difficult to pursue (Godoli, 2025).

Interventions on the building envelope cannot, therefore, be assessed solely in terms of performance enhancement, and the prevailing attention to quantitative indicators and carbon-payback scenarios is not sufficient to orient the design of buildings endowed with cultural significance. Assessment instruments capable of systematically integrating conservative and performative outcomes and evaluating the impact on the attributes that convey the manifold heritage values remain, in fact, still poorly structured, relating the criteria of effectiveness elaborated in the field of reuse to possible indicators of the conservation of the built fabric (Arfa et al., 2022; Gonçalves et al., 2022, pp. 1047–1062). Current systems of assessment and/or certification, conceived in large measure for new buildings, frequently treat the cultural dimension in a partial manner, whereas effective sustainability requires the conjugation of environmental, economic, and social indicators with the maintenance of heritage values, the criteria of compatibility and durability, maintenance and monitoring, embodied energy and life-cycle management (Gonçalves et al., 2022, pp. 1047–1050, 1058–1061). Hence, a methodological void takes shape, particularly evident in the case of the building envelope of later twentieth-century architecture, which is at once a technical device and an expressive component, yet is still frequently treated by energy-retrofit practice as a ‘neutral performative surface’ (Casanova & Pompejano, 2026).

Reuse introduces a further problem, bound to the function of the building organism. The maintenance of continuity of use may favour the care of the building, economic sustainability and the transmission of cultural significance over time. Nevertheless, when reuse proves incompatible with the architectural characteristics of the building, the outcome of the refurbishment operations may compromise those very characteristics. The design must, therefore, verify the capacity of the new programme to respect spatiality, structure, circulation, light, relationships with the site, and distributive hierarchies. The identification of heritage values and attributes that convey cultural significance does not, then, constitute an external constraint applied after the fact, but a ‘design basis’ through which to assess which modifications may add a new ‘layer’

without effacing the elements that render the architectural work recognisable and relevant (Kuipers & de Jonge, 2025, pp. 65–98).

The project for the new Civic Library in the pavilions of Torino Esposizioni, located in Turin, exemplifies the scale and the ambivalence of such an operation. The hypogeal courtyard made it possible to insert storage and workshops without adding external volumes and while preserving the perception of the vast interior space and of the vault designed by Pier Luigi Nervi. At the same time, new windows, insulating layers, consolidation systems and a geothermal plant introduced permanent transformations. The strategy adopted by the designers, thus, privileges the continuity of the spatial layout and of the synthesis between structure and architectural form over the integral conservation of the components, on the basis of a precise conservation plan and of integrated multidisciplinary investigations. The case clarifies how the principle of minimum intervention may be referred to the attributes identified as significant and to the objectives of compatible use, so as to manage change while maintaining the continuity of the very attributes that convey the building's cultural significance.

The central question in conservation processes and architectural restoration and reuse projects that entail energy-efficiency improvements to later twentieth-century architecture concerns the construction of a judgement capable of comparing scenarios, impacts and benefits, distinguishing the attributes that must endure from those that may be modified. In this perspective, conservation, sustainability, and reuse constitute interdependent dimensions of an architectural project that must render cultural continuity, environmental responsibility, and functional updating mutually compatible.

Governing Change: Principles and Instruments

The principal doctrinal and normative references converge on the centrality of a design grounded in knowledge and understood as a methodological condition that accompanies the intervention in order to orient decisions, responsibilities, and management over time. The ICOMOS ISC20C document *Approaches to the Conservation of Twentieth-Century Cultural Heritage*, known as the Madrid–New Delhi Document, underlines how the conservation of twentieth-century heritage requires the prior understanding of the cultural significance and integrity of the architectural work, together with the definition of vulnerabilities, limits of transformation, and acceptable modifications within a framework of change management conceived as a long-term process (ICOMOS ISC20C, 2017, pp. 7–8). Consistently, the standard UNI EN 16883:2017, *Conservation of cultural heritage – Guidelines for improving the energy performance of historic buildings*, structures an iterative and interdisciplinary decision-making process, grounded in the thorough investigation of the building, in the explicit statement of objectives, and in the weighing of options in relation to cultural significance, configuring the knowledge base as a prerequisite of the intervention (Ente Italiano di Normazione, 2017, pp. 10–13).

Nevertheless, the tools available today present significant practical limitations. UNI EN 16883, while offering a logically clear structure, has at times been judged too generic, lacking in examples and burdensome at the procedural level (Leijonhufvud et al., 2021, p. 11). Moreover, no single instrument covers in full all the phases suggested by the standard, making necessary a modular approach grounded in the combined use of complementary methods (Buda et al., 2022, p. 35). Nor can the assessment of cultural significance be treated as a single, unequivocal datum, since methods and specialist expertise are required to make tolerance of change explicit and to assess the degree of impact of interventions in an integrated manner (Eriksson & Broström, 2021, pp. 1–3).

A further critical point concerns the scarcity of comparative *ex post* assessments. The heterogeneity of documentation, the absence of subsequent monitoring, and the difficulty of rendering different interventions comparable often prevent an understanding, in the medium and long term, of the actual effectiveness of the choices made by architects and of their impact on the heritage values of the asset (Casanova & Pompejano, 2026). This deficiency weakens the possibility of constructing a cumulative body of knowledge, capable of orienting future decisions by integrating the critical analysis of observed outcomes with general principles.

In this perspective, thorough and prior knowledge, compatibility, minimum intervention, legibility, documentation, and reversibility or 'potential reversibility' may be assumed as principles to be weighed critically, since they may enter into mutual tension. For example, reversibility may prove incompatible with durability; a replacement, even a partial one, may render the new indistinguishable from the original; the integral conservation of the material fabric may preclude performance indispensable to the continuity of use. A scientifically grounded design decision must therefore make such conflicts explicit, document the alternatives considered and justify the hierarchy adopted, limiting as far as possible the irreversibility of the modifications (Macdonald & Arato Gonçalves, 2020).

Therefore, the conservation process should be articulated into recurrent and interdependent steps: the construction of the knowledge base; the identification and hierarchisation of heritage values and attributes conveying cultural significance; the comparative assessment of scenarios and impacts; and the programming of maintenance and monitoring. Within this trajectory, the restoration and reuse project constitutes a fundamental phase, in which hypotheses are progressively verified and outcomes monitored over time. The Conservation Management Plan constitutes, for instance, one of the possible instruments for translating this approach into the long-term management of the architectural work. Applied to later twentieth-century architecture and, more generally, to the whole of twentieth-century architecture, it would make it possible to connect historical research, survey, diagnosis, the recognition of attributes and values, vulnerabilities, intervention priorities, use, maintenance and monitoring. In fact, the Conservation Management Plan aims to construct an updatable frame of reference, capable of orienting future decisions in coherence with the recognised cultural significance. Its usefulness appears particularly evident in extensive, fragile, and continuously used complexes, in which statutory protection alone is not sufficient to coordinate functional adaptations, available resources, and management responsibilities (Borgarino & Del Curto, 2023, pp. 3–15).

Conclusions

The challenge posed by twentieth-century architectural heritage consists in keeping operative, legible, and recognisable the relationships that ground its cultural significance. Temporal proximity, technical experimentation, functional obsolescence, and the current demands of energy-efficiency improvement often render adaptations, additions, and replacements necessary. Nevertheless, such interventions cannot justify reducing conservation to the mere reproduction of the architectural image. For later twentieth-century architecture, and for its envelope in particular, the risk of altering material fabric, detail, compositional hierarchies, perception, and recognisability remains high, since energy adaptation frequently entails physical and performative modifications destined to produce effects that are difficult to reverse.

Energy-efficiency improvement, today an urgent condition of intervention on the existing built environment, cannot, however, be assumed as a self-sufficient parameter of

the architectural restoration and reuse project, since the conservation process requires a critical balancing between performance urgencies and conservative demands. The international references insist on the centrality of an appropriate knowledge base, minimum intervention, and the management of change; Italian debate reaffirms the role of historical-critical judgement and of material fabric as documentary testimony; and the design must translate such principles into verifiable, reasoned, and proportionate choices. In this perspective, heritage values and attributes prove essential for distinguishing what must endure, what may be modified and what may be reinterpreted, assessing jointly material fabric, form, use, performance, and immaterial aspects such as architectural atmosphere perception and collective memory.

The central question consists in constructing tools capable of methodically reconciling conservation and change. *Ex post* assessments should, therefore, make possible the critical comparison of interventions, making explicit the criteria of judgement and the indicators that allow an analysis of impact that is as objective as possible, in order to improve the quality of future design decisions. In this way, the argumentative dimension of the restoration and reuse project, which should also encompass energy-efficiency interventions, gains, within the process of *ex post* evaluation, a broader scope, in which performative and conservative demands become components of the same design responsibility. When modifications are reasoned, documented, and verified over time against the recognised heritage values and attributes, change may be integrated into the conservation process without reducing it to a simple performance upgrade.

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RESTORATION TECHNIQUES FOR CONSERVING BUILDING ENVELOPES FROM THE SECOND HALF OF THE TWENTIETH CENTURY

Daniela Pittaluga, Rita Vecchiattini

Introduction¹

Conserving cultural heritage is an apparently shared principle and an almost self-evident premise from which to begin any consideration of the built heritage. Its practical application, however, is far from straightforward. The history and theory of conservation have extensively debated which assets can and should be conserved, questioning the criteria by which a work's value may be recognised and the appropriate forms of protection determined. While different theoretical positions have progressively challenged the idea that the value of an artefact can be established solely based on its belonging to a particular historical period, the history of conservation itself demonstrates that temporal proximity often hinders recognition of a work's cultural value. Recognising the value of a work of architecture is necessarily a complex and layered process, irrespective of the period to which it belongs. Historical distance may foster the development of a shared awareness. In contrast, temporal proximity tends to make the qualities of exceptional significance, authenticity or meaning that may justify conservation less immediately perceptible. Architecture that still belongs to the realm of everyday life, and often continues to serve the functions for which it was designed, may be more difficult to recognise as cultural evidence. The process of attributing value cannot therefore be separated from that of knowledge and material conservation: for an asset to be recognised, studied and subsequently protected, it must first survive. This observation leads to a first central question: is twentieth-century architecture, and particularly that of the second half of the century, now fully recognised as cultural heritage? The question is especially relevant in light of the progressive extension of the concept of heritage to the architecture of the recent past. If temporal proximity is itself a potential obstacle to recognising value, a further problem lies in the still partial knowledge of many works dating from the second half of the twentieth century.² Limited knowledge of their design, constructional and material characteristics may lead to reduced awareness of their cultural significance and, consequently, greater vulnerability to alteration, replacement or demolition. Knowledge also becomes particularly important when physical intervention on a building becomes necessary (Pittaluga, 2021). A lack of information about construction systems, materials, execution techniques and design intentions may make it more difficult to define intervention strategies consistent with the character of the work. Knowledge is therefore not only a prerequisite for recognising value, but also an indispensable condition for properly guiding subsequent conservation decisions. These considerations raise a second question, closely connected to the first: can architecture from the second half of the twentieth century be conserved? This question concerns not only the theoretical possibility of recognising such works as heritage, but also the practical feasibility of conserving them. Twentieth-century architecture

1 Although the research was conducted jointly, the sections 'Introduction' and 'Integrated Approach' were written by D. Pittaluga, while 'Conservation of the Building Envelope and the Energy Transition: The State of the Art in Italy', 'Historic Windows and Curtain Walls' and 'Conclusions' were written by R. Vecchiattini.

2 Pittaluga, 2021, 2023; Pittaluga & Quirós Castillo, 2024, 2025.

exhibits specific vulnerabilities, sometimes particularly pronounced compared with buildings from earlier periods³. The use of innovative materials, experimental construction systems, industrialised components, and technologies whose long-term durability is difficult to assess has produced buildings in which deterioration and obsolescence may take distinctive forms. Added to this is the need to address performance and functional requirements that have changed profoundly since the buildings were constructed.

This research is situated precisely within the tension between conserving architectural character and adapting buildings to contemporary needs. In particular, it examines intervention strategies for the external envelopes of architecture from the second half of the twentieth century, to identify restoration and conservation approaches capable of combining the protection of a building's architectural and material values with the achievement of appropriate levels of energy efficiency, in response to both present and future needs. In this context, the envelope plays a particularly significant role. In architecture from the second half of the twentieth century, it is not merely a technical component of the building; it may be one of the elements that most strongly defines the work's identity through its image, the relationship between inside and outside, the composition of surfaces, and the expression of materials and construction systems. An intervention aimed exclusively at improving energy performance, unless carefully calibrated to the building's specific characteristics, may therefore significantly alter its architectural character and, in some cases, compromise its integrity and legibility⁴. The need to intervene on the envelope thus raises the problem of balancing apparently conflicting requirements: on the one hand, conserving the elements that define the work's cultural and architectural value; on the other, adapting its performance to changed patterns of use, current energy requirements and the progressive decarbonisation of the construction sector. The issue cannot be resolved through the indiscriminate application of standard technical solutions, but requires a case-specific assessment of the building's characteristics, materials, construction techniques and the values to be preserved. From this perspective, understanding how to intervene in the envelope, identifying the essential elements to conserve, and determining which transformations may be permitted without compromising the architectural identity are fundamental to defining intervention strategies that are genuinely compatible with the heritage character of these buildings. The research therefore contributes to the broader debate on the relationship between conservation, transformation and performance upgrading in architecture from the second half of the twentieth century. It asks whether energy upgrading can be pursued not as an alternative to conservation, but as part of a broader strategy for protecting and transmitting to the future a heritage that remains largely to be understood, recognised and interpreted (Fig. 1).

Conservation of the Building Envelope and the Energy Transition: Selected International Examples

The international panorama reveals a variety of situations, partly dependent on the legislative and regulatory context and on how strictly the ultimate objective of achieving high levels of energy efficiency is pursued, but even more strongly influenced by awareness of the value of the work concerned. In some cases, this awareness may justify accepting lower performance levels to ensure greater conservation (Pittaluga, 2023; Pittaluga & Quirós Castillo, 2024, 2025).

³ An emblematic example is Wright's Fallingwater (Jerome et al., 2006), which has already undergone numerous conservation interventions; unfortunately, it is far from the only case.

⁴ Pittaluga, 2023.

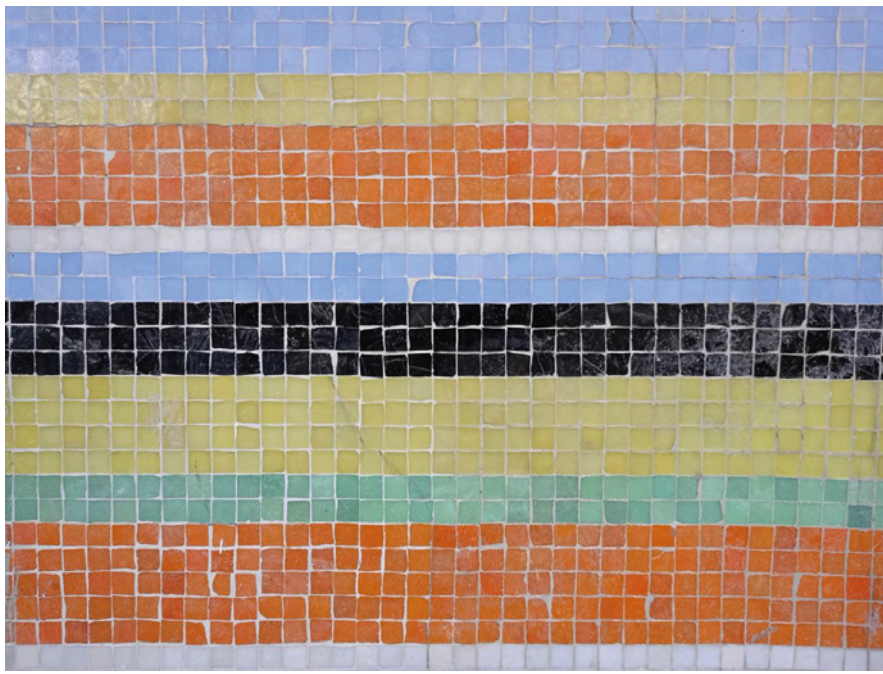


Figure 1
Glass Mosaic,
Istanbul: post-war
modernist façade.
Energy retrofitting also
poses challenges for
so-called glass
façades composed of
thousands of small
glass tiles.

A range of solutions is adopted in energy-upgrading projects. The most common are:

1. replacement of original glazing with higher-performance insulating glazing
2. work on gaskets and seals
3. insulation applied internally
4. combined interventions on several fronts, through which multiple measures jointly improve energy performance
5. energy upgrading through the technological improvement of existing components
6. a secondary façade creating a buffer space

Alongside these strategies, which vary in their attention to conserving the existing fabric, the complete replacement of windows or parts of the envelope unfortunately remains common. It is sometimes possible to retain the geometry, modular articulation and dimensions of the original components while introducing contemporary materials and technologies. Although this solution may significantly improve energy performance, it inevitably entails at least a partial loss of historic fabric. It may alter the building's architectural image to a greater or lesser extent.

Alongside targeted measures, some international cases demonstrate more comprehensive strategies that pursue improved energy performance through an integrated, multidisciplinary approach. In these interventions, conservation is not a constraint to be addressed separately from energy upgrading, but one of the criteria guiding design decisions.

Integrated Approach

Among the examples examined, the Cité du Lignon in Geneva is particularly significant for its comprehensive approach to the energy upgrading of a modern complex of considerable architectural and urban value. Built in the post-war period, it is distinguished by its scale and by a construction system based on industrialised techniques and prefabricated components. These characteristics, together with recognition of its cultural value, make the relationship between conserving its architectural and material identity and meeting increasing energy-performance requirements particularly complex. The Lignon case shows that the energy upgrading of modern architecture

of cultural value cannot be addressed through standard solutions, but requires an integrated approach in which architectural, constructional, energy, economic and regulatory aspects are considered together. The objective is therefore not merely to reduce energy consumption, but to improve performance while preserving, as far as possible, the material, constructional and formal character of the work. The Conservation Plan approved in 2009 provided a fundamental instrument for coordinating conservation and upgrading objectives. The intervention is based on a graduated and selective strategy in which the intensity of transformation is proportionate to the value of the elements in question. Conservation of the external envelope, enhanced insulation from the interior, targeted replacement of glazing, and improved airtightness are complementary measures that can increase performance while limiting their impact on the existing fabric. The most significant aspect of the Lignon experience lies not in adopting a single technological solution but in defining a multidisciplinary decision-making process. Assessing the different alternatives makes it possible to consider energy effectiveness, conservation of material fabric, costs, technical feasibility and architectural coherence simultaneously. The case thus demonstrates how the energy upgrading of modern heritage can be pursued through building-specific strategies, without relying on maximum achievable performance as the sole assessment criterion. The Cité du Lignon consequently provides an important reference for interventions on the architectural heritage of the second half of the twentieth century. It shows that improved energy performance need not necessarily entail the loss of material authenticity and architectural identity, provided that performance requirements are assessed within a broader conservation project. From this perspective, regulations and energy requirements can be interpreted using conservation, design, and assessment tools that recognise the asset's specific characteristics and calibrate the intensity of intervention. The Swiss experience therefore demonstrates the possibility of balancing energy performance and conservation through specific technical solutions, preliminary testing, multidisciplinary assessments and integrated authorisation procedures. Rather than pursuing an absolute level of performance, it highlights the need to identify, for each building, the maximum improvement compatible with conserving its material, architectural and cultural values.

'Minimal Improvement': Improving Energy Efficiency without Compromising Conservation

In some cases, particularly outside Italy, solutions have been adopted that pursue energy improvements⁵ while accepting performance levels below those required by current regulations when this enables the conservation of more of the asset's material

5 In their article 'La contaminazione dei saperi nella conservazione di involucri e chiusure vetrate del moderno', published in *TECHNE*, Sara Di Resta and Jacopo Gaspari provide an in-depth discussion of the dialectic between 'upgrading' and 'improvement' in relation to the energy performance of glazed Modern Movement buildings. They highlight various solutions, tested primarily outside Italy, with differing and in some cases highly significant outcomes.

fabric. Examples include Chipperfield's intervention on the Neue Nationalgalerie in Berlin and the work carried out on the Pavillon Le Corbusier in Zurich⁶.

Conservation of the Building Envelope and the Energy Transition: The State of the Art in Italy

Buildings constructed in Italy during the second half of the twentieth century are a major focus of recent energy-upgrading policies. After the Second World War, the availability of new materials – precast reinforced concrete, anodised aluminium and galvanised steel, among others – together with new opportunities to create large glazed surfaces encouraged the spread of construction systems characterised by lightness, modularity and rapid execution. Industrialised construction processes and the progressive separation of structure from perimeter enclosure – the latter conceived as a technologically complex component – led to the concept of the building envelope, which emerged in the architectural debate of the 1960s and 1970s (Banham, 1984). Buildings constructed during these decades, which represent a significant proportion of the national stock, reflect the profound technological transformation that occurred between post-war reconstruction and the subsequent, often indiscriminate, urban expansion. They differ substantially from earlier buildings with load-bearing masonry, or reinforced-concrete frames with structurally engaged infill and timber windows, and often employ deliberately experimental, untested technical solutions that may prove deficient or fragile over time (Vittorini, 2021).

In residential complexes designed by architects such as Mario Ridolfi, Ludovico Quaroni and Michele Valori under the INA-Casa programme (1949–1963) – one of the most important experiences in post-war Italian housing – traditional construction techniques coexist with early industrialised experiments that anticipate the transformations of subsequent decades. From an energy perspective, these buildings generally have uninsulated brick walls, timber or steel windows with single glazing, and widespread discontinuities in the envelope. The situation differs in the

6 At the Neue Nationalgalerie in Berlin, Mies used glass only 12 mm thick in panes measuring 5.40 x 3.43 m, a choice intended to achieve the greatest possible transparency. Only a few of these cast-glass panes remained at the time of David Chipperfield's most recent restoration (2012–2021). All the others had broken because of façade movement and had been replaced with subdivided glazing; production had ceased in 1972 because of the high cost of manufacturing panes of this size. Chipperfield opted for the greatest possible degree of conservation. After careful assessment, he rejected insulating glazing, which would have made it impossible to retain the existing vertical mullion frames, in favour of laminated safety glass twice as thick as the original panes. A 3 mm interlayer bonds the two sheets of glass. To counteract the condensation that formed on the single glazing at low external temperatures and had severely corroded some frames, an air curtain was introduced on the inner face of the new façade, supplied through ventilation slots. For conservation reasons, a greater reduction in UV transmission was not pursued, since a UV coating within the glazing cavity would have produced a blue-violet reflection. The desire to preserve light that was as natural and transparent as possible prevailed over energy efficiency (Canziani & Di Resta, 2020; Pittaluga, 2023). In this case, conservation of the original design concerns the material of the historic glazing only in part; the final decision was also strongly influenced by the quality of natural light within the interiors and therefore, in a sense, by their internal atmosphere. The intervention mitigates the façade's critical shortcomings, but makes no attempt to achieve complete thermal insulation. This is consistent with the decision not to seek full compliance with contemporary standards, but to achieve greater material conservation. The pursuit of solutions that perform somewhat less well in thermal and acoustic terms but conserve more of the architecture also guided the intervention on the Pavillon Le Corbusier in Zurich. To maximise conservation of its glazed surfaces, the exhibition programme was adapted to the seasons, ensuring suitable indoor comfort for people and works of art without invasive insulation measures (<https://ilgiornaledellarchitettura.com/2019/06/11/il-padiglione-le-corbusier-a-zurigo-unoperazione-da-gioiellieri/>).

major developments of the 1960s and 1970s, such as the Vele housing complex at Scampia in Naples (1962–1975), designed by Francesco Di Salvo, and Corviale in Rome (1972–1982), designed by Mario Fiorentino. In both cases, reinforced concrete is the dominant material and the envelope has a serial configuration characterised by prefabricated panels, continuous balconies and extensive window areas. Heat loss and obsolete building services affect both complexes, where energy problems intersect with structural and social issues. A third category comprises buildings based on the curtain-wall model, which had been widely tested internationally and was introduced in Italy slightly earlier than the examples just mentioned. It found its fullest expression in office buildings constructed during the economic boom. Numerous buildings in Milan designed by BBPR, Gio Ponti, Luigi Moretti and Vico Magistretti document the use, first of lightweight steel-and-glass façades and later of aluminium-and-glass systems, in which the separation of the load-bearing structure and the envelope represents a principal technological innovation. In these cases, summer overheating, winter heat loss and structural thermal bridges between metal and reinforced concrete are the main energy-related problems to be addressed.

The performance obsolescence of these building envelopes is now one of the principal critical issues affecting the built heritage of the second half of the twentieth century. From an energy perspective, uninsulated walls, structural thermal bridges, the low thermal resistance of infill panels, high air permeability in windows and doors, and high U-values in glazed elements cause substantial winter heat loss and significant summer overheating. Energy losses are generally incompatible with the objectives established by European decarbonisation policy, which constrains and guides the national transition⁷. Moreover, the progressive deterioration of gaskets, joints and sealing systems leads to water and air infiltration, compromising both material durability and indoor comfort.

The response to these problems cannot be limited to the mere technological replacement of building components, even if this may appear consistent with the fragmented nature of the constructed artefact. It must be emphasised that an increasing proportion of the architecture of the second half of the twentieth century is now recognised by communities as being of cultural interest. This calls for new reflection by designers responsible for energy-upgrading projects and, when interventions are undertaken, for the application of conservation principles.

In recent years, the concept of energy upgrading has progressively evolved from an exclusively performance-based logic towards a relational or integrated approach that also considers the environmental, economic and cultural aspects of intervention. This is especially important for heritage of cultural interest: the parts of a building cannot be assessed solely in performance terms, but must also be considered as material evidence of the construction culture of their time. This requirement is particularly strongly felt in Italy, where the principles of minimum intervention and recognisability have been defined on the basis of authenticity and material integrity. Recent efforts have therefore sought to integrate energy improvement within a conservation project that safeguards the work's cultural and material values, avoiding transformations that compromise its historical and architectural identity.

Design strategies include high-performance, thin materials such as aerogel, vacuum insulation panels (VIPs) and mineral insulating plasters, which increase thermal resistance while limiting changes to the architectural image. Internal insulation, provided

⁷ Directive (EU) 2024/1275 on the energy performance of buildings promotes the progressive reduction of energy consumption across the existing building stock, while recognising the need for specific solutions for buildings of historical and architectural interest.

that it is preceded by careful hygrothermal assessments to prevent interstitial condensation, offers a valid means of conserving external finishes. The correction of thermal bridges through targeted work on constructional junctions and connections between structural elements and infill, combined with high-efficiency building services and mechanical ventilation with heat recovery, can achieve significant reductions in energy consumption without compromising the legibility of the historic envelope.

Energy upgrading should form an integral part of the conservation project rather than, as unfortunately still happens in many cases, being treated as an autonomous operation. Growing concern for environmental sustainability has long demonstrated that conservation can be a privileged means of extending building life cycles, limiting the consumption of new resources and reducing the carbon emissions associated with demolition and reconstruction. Although this principle is now fairly widely accepted for the conservation of historic reinforced-concrete structures, exposed-concrete panels and ceramic cladding, it is less readily accepted for renders and windows, even though their replacement often entails the loss of the work's expressive qualities.

Historic Windows and Curtain Walls

One of the most complex issues concerns the energy upgrading of metal windows and curtain walls. Few interventions achieve more or less complete conservation of the original windows. Examples include the construction of a new internal glazed façade during the 2004–2006 refurbishment of the ICO Central Workshops in Ivrea (1939–1949), and the replacement of glazing alone in the 2002–2005 intervention on the Grattacielo Pirelli (1952–1961) in Milan (Graf & Albani, 2011). Complete window replacement remains one of the most widespread practices, but entails the loss of components specifically designed by the work's authors and, in some cases, substantially alters the façade design. In buildings designed by Franco Albini, Ignazio Gardella or Luigi Moretti, for example, windows are decisive design elements in defining architectural identity. Indiscriminate replacement of their profiles with standard products therefore risks irreversibly altering the relationship between solid and void, the proportions of the elevations and the perceptual quality of the envelope. An emblematic case is that of the windows at the Museo Civico di Architettura e Scultura Ligure in Genoa, designed by Franco Albini and completed after his death (1977). The full-height, all-glass façade windows in burnished aluminium, designed in continuity with Albini's concept, were an integral and essential part not only of the external image but also of the museum's interior space. In 2018, an exceptionally severe storm, in terms of both intensity and wind speed, caused the partial collapse of one of the façade windows. Despite attempts by the parties involved in the project – the Municipality, the heritage authority and the University – to conserve the original windows, the complexity of the regulatory framework and, above all, the need to assume responsibility for their safety ultimately led to complete replacement. As owner of the museum, the Municipality was unable to obtain guarantees from contractors invited to tender if only the glazing were replaced and minimal works undertaken, such as enlarging the glazing bead or stiffening the transom. It should be emphasised that regulations and the many recommendations, most of which are non-binding, concern new windows and therefore do not provide for total or partial conservation, leaving clients responsible for safety (Vecchiattini, 2026).

Figure 2
Velasca Tower in Milan following the energy retrofit carried out by the Hines Group and designed by Asti Architetti, completed in 2025.



Conclusions

For the heritage of the second half of the twentieth century, the objective should not be to meet the standards required for new construction, but to achieve the maximum improvement compatible with conserving the work's material and formal values. Although this principle is now one of the most important and widely shared methodological references at the theoretical level in seismic safety, it has yet to become established in the field of energy upgrading, particularly in construction practice. The recent refurbishment of the Velasca Tower in Milan (BBPR, 1955–1957) is one of the few Italian projects to have followed this approach. It prioritised conservation of the architectural image through careful diagnosis, the technological upgrading of building services and components, and the conservation of finishes (Lollini et al., 2016), demonstrating how improvements in building-services and energy performance can be integrated while respecting the work's historical values (Fig. 2). Projects combining improved energy performance with high levels of material conservation have also become increasingly evident in international practice in recent years.

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READING THE INTERVENTION: EeTAC'S CRITERIA AND TOOLS FOR THE EX POST ASSESSMENT

Marta Casanova, Federica Pompejano

Building a Common Knowledge Base

The EeTAC research adopts the analysis of selected case studies as a means of investigating the relationship between the improvement of energy performance and the conservation of the building envelopes from the second half of the twentieth century. The corpus comprises thirty buildings, twenty Italian and ten international, differing in chronology, location, intended use, constructional configuration and forms of recognition and protection. The selection is not intended to provide an exhaustive repertoire, nor to identify a sequence of exemplary interventions; rather, it brings together experiences that are sufficiently documented to allow the observation of different technical solutions, decision-making processes, and outcomes. On the methodological level, the construction of the corpus draws on previous experiences of surveying and documenting the architectural works built in the second half of the twentieth century, in which the systematic collection of data was combined with the critical selection of buildings and the preparation of different consultation tools (Franco & Musso, 2016). EeTAC develops this approach, shifting the focus from the identification and survey of buildings to the analysis and qualitative *ex post* assessment of energy-efficiency interventions.

The case studies concern interventions that have been completed or are at an implementation stage sufficient to allow the studying of the design choices as well as the analysis of the transformations introduced. The research therefore assumes a predominantly *ex post* perspective, based on the comparison between the building's original configuration, the state of conservation prior to the energy-efficiency intervention, the stated objectives, and the solutions adopted and implemented. Where available, performance data, site records and post-intervention monitoring also make it possible to assess the results achieved. The analysis reconstructs the process through which conservation, performance, functional, and economic requirements were translated into specific intervention choices.

The *ex post* assessment is based on homogeneous fields of analysis, compiled through bibliographic and archival sources, graphic documents, technical reports, photographs, site inspections, and the testimonies of the parties involved. The application of the same reading criteria makes it possible to relate the case studies to one another without neglecting their specificities.

In the volume, the descriptive texts of the case studies are grouped according to intended use, so as to bring together buildings subject to at least partly analogous functional requirements. This is, however, only one of the possible ways of reading the corpus: the case studies may also be related to one another by considering the type of envelope, the techniques employed in energy retrofitting, the extent of the transformations or the relationship between conservation and performance improvement.

The results of the case-study analysis are presented through the descriptive texts and the analytical forms available on the project website. In the volume, the descriptive texts offer a critical synthesis of the information needed to understand the buildings and the

interventions, structured so as to facilitate a sequential and comparative reading. On the EeTAC project website, by contrast, a more extended version is published in analytical forms accompanied by the sources and documentary apparatus and organised so as to allow further in-depth study and cross-sectional consultation of the corpus.

From the Original Configuration to the Modifications

The analysis of the intervention considers the original configuration of the envelope as its first term of comparison. The historical-critical and material knowledge of the building in its original configuration guides the design and makes it possible to recognise the attributes or characteristics on which the architect may intervene (Reichlin, 2011, pp. 11–29). The recognition of the cultural significance of the architectural work and the assessment of its integrity and its vulnerabilities constitute the prerequisite for defining the conservation process within which the energy-efficiency intervention should be situated (ICOMOS ISC20C, 2017).

The *ex post* assessment considers the relationship between structure and enclosure, the composition of the opaque and transparent parts, the materials, the construction techniques, the processes of production, assembly and installation of the components, as well as the opening and shading systems that regulate natural lighting, ventilation and solar gains. These elements are examined for the functions they perform and for the role they play in defining the proportions, depth and configuration of the façade. The analysis thus presents the envelope as a construction system and as a fundamental attribute of the building's architectural configuration. Drawings and design reports, historical photographs, archival documents and contemporary publications convey the design intentions, but do not always correspond to what was built. The survey and *in situ* inspections of the building, complemented by the documentation of the construction phases, make it possible to verify these sources and to recognise the differences between design and realisation, as well as any subsequent transformations. The comparison between the design documentation, the existing building, and the subsequent transformations makes it possible to define the original configuration of the envelope through an iterative and interdisciplinary cognitive process, in accordance with the provisions of UNI EN 16883:2017 (UNI, 2017).

Before examining the most recent intervention, the *ex post* assessment also considers the state of conservation of the building prior to the energy-efficiency intervention. Phenomena of decay, functional obsolescence, maintenance interventions, changes to the internal layout and previous adaptations may have transformed both the behaviour of the envelope and its configuration. Distinguishing the original characteristics from the conditions that have developed over time is necessary in order to understand the problems to which the energy-efficiency project sought to respond, and so as not to attribute, to the initial construction, shortcomings produced by subsequent alterations or replacements.

Each case study is therefore assessed by considering the stated objectives, the design process and the solutions adopted, and may respond simultaneously to problems of conservation, structural safety, regulatory and building-services adaptation, accessibility or change of use, within the limits set by the available resources. Understanding the weight assigned to each requirement makes it possible to recognise the reasons for the solutions adopted and the role played by the improvement of the envelope within the overall intervention.

The extent and type of intervention on the envelope are also examined, distinguishing between conservation, adaptation of the existing elements, modification, selective replacement and extensive renewal. The modifications are studied through the

same references used to describe the configuration prior to the energy-efficiency intervention. This approach makes the conserved, removed, replaced or added parts recognisable and facilitates the corroboration of how materials, thicknesses, openings and environmental-control devices have changed. The interfaces between new components and conserved parts are examined because they affect the technical behaviour of the envelope and its architectural configuration.

The comparison between the condition prior to the energy-efficiency intervention and the transformations carried out constitutes the documentary basis for the subsequent evaluation of the outcomes.

Criteria for the Evaluation of Outcomes

The evaluation relates the stated objectives to the transformations carried out and the results obtained, considering the performance effects and the impact on the attributes that characterise the building. This approach is reflected in UNI EN 16883:2017, which requires the various intervention options to be examined in relation to the cultural significance of the building and to the expected risks and benefits (UNI, 2017). In order to translate these principles into operational criteria, instruments are needed that take into account the characteristics of the buildings and the degree of completeness and reliability of the available documentation (Buda et al., 2022, pp. 34–52; Casanova & Pompejano, 2026, pp. 597–607).

The *ex post* evaluation proposed by EeTAC does not assign an overall score to the intervention, nor does it rank the case studies in an order of merit. The qualitative assessment is articulated into five domains: knowledge framework, method and traceability; technical adequacy and compatibility of the solutions; reversibility; impact on the architectural volumes and spatial arrangement; and conservation of the original architectural elements.

The first domain assesses the completeness and pertinence of the knowledge framework and its effective use in the design decisions. Surveys, diagnostic investigations, historical-archival analyses, and energy and hygrothermal assessments are examined in relation to their capacity to document the constructional characteristics, the vulnerabilities and the cultural values of the building. The documentation of the alternatives considered, decisions taken during the design and changes made on site also makes it possible to understand the reasons behind the choices and the traceability of the process.

The second domain considers the technical adequacy and compatibility of the solutions adopted. The materials and components introduced are examined in relation to the physical, constructional and hygrothermal characteristics of the envelope, to the effects on the conserved parts and the behaviour of the interfaces between the original systems and the new elements. The evaluation also considers minimum intervention and potential reversibility as criteria for limiting the undesired effects of the modifications resulting from the energy-efficiency intervention (UNI, 2017; ICOMOS ISC20C, 2017).

The degree of reversibility is evaluated by considering the possibility of removing, replacing or modifying what has been added without causing further losses. In twentieth-century envelopes, which are often made up of interdependent components, complete reversibility is difficult to achieve. Therefore, the evaluation considers the invasiveness of the intervention, the extent of the demolitions and replacements, the conservation of the existing fabric and the possibility of carrying out subsequent maintenance operations.

A technically adequate and compatible energy-efficiency intervention may, nonetheless, affect the formal and spatial arrangement of the building. In this case, the *ex post* evaluation considers the effects of the transformations on exteriors and interiors, volumes, proportions, subdivisions, materials, finishes, colours and perceptual qualities. Variations in thickness, setbacks and modifications to profiles, reveals, window and door frames or claddings are examined in relation to the legibility of the architectural whole. The relationship between the new additions and the existing parts is also assessed, considering their distinguishability and their impact on the understanding of the building.

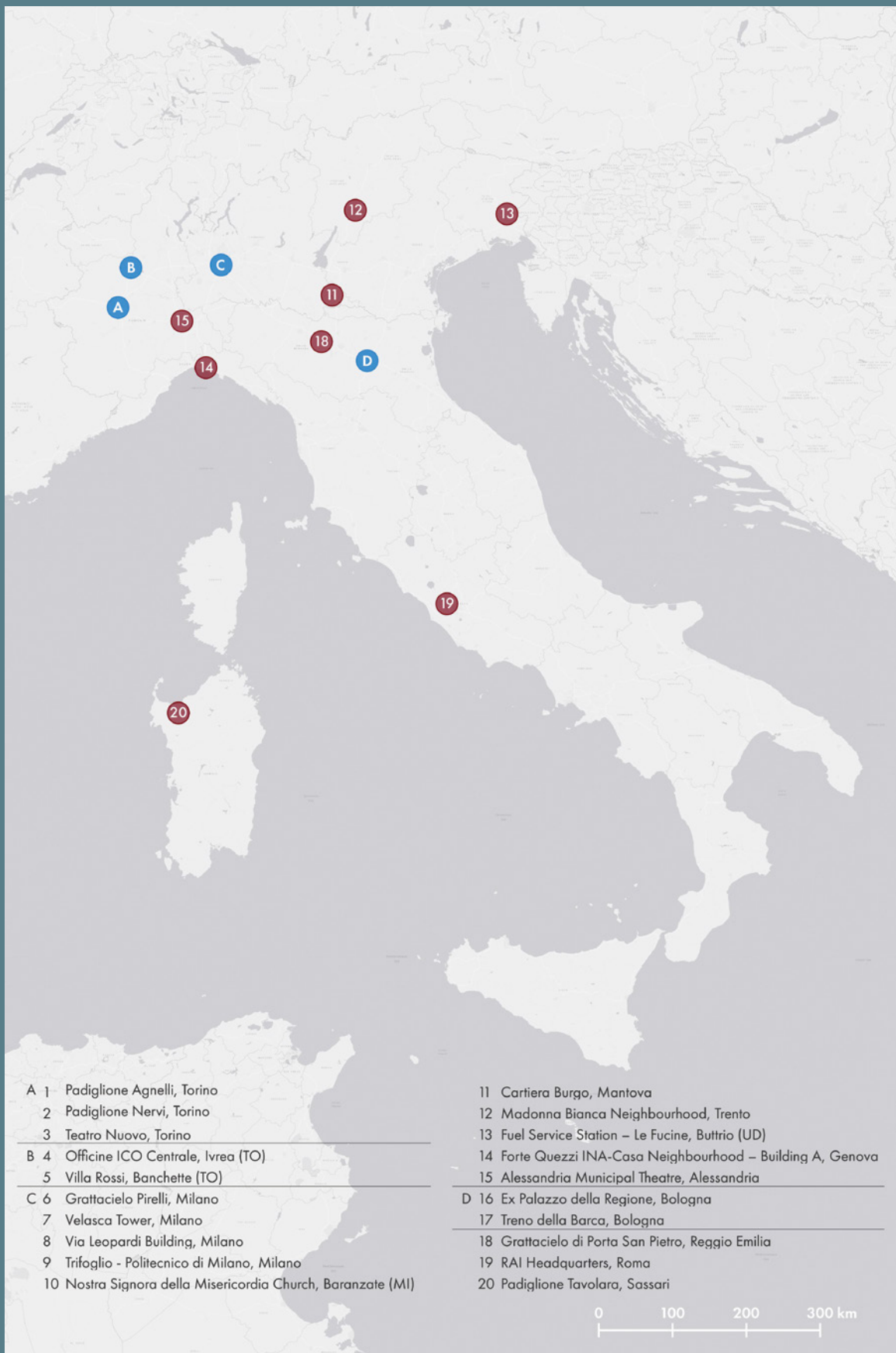
The evaluation of the effects on the formal and spatial arrangement is accompanied by that of the degree of conservation of the original architectural elements. The retention of the original constructional elements and materials, selective replacement confined to the compromised parts, and the conservation of the existing additions recognised as significant are distinguished from extensive renewal or from the reproduction of forms by means of different materials and techniques. The assessment considers the state of conservation, the possibility of keeping the existing elements in use, the performance requirements and the role played by the conserved parts in the configuration and functioning of the envelope.

The five qualitative domains are complemented by the available data on the energy performance effectiveness of the intervention. Where documented, the consumption values, before and after the works implementation, and any energy-environmental certifications are reported in the evaluation. The energy data are kept distinct from the qualitative assessment and are related to the extent and impact of the modifications introduced. The joint assessment of the energy data and the five qualitative domains clarifies the priorities, results and critical aspects of each intervention and the relationship established between performance improvement and the conservation of the building's characteristics. The *ex post* assessment and the analysis thus offer terms of comparison and opportunities for critical reflection among different experiences, rather than solutions to be replicated.

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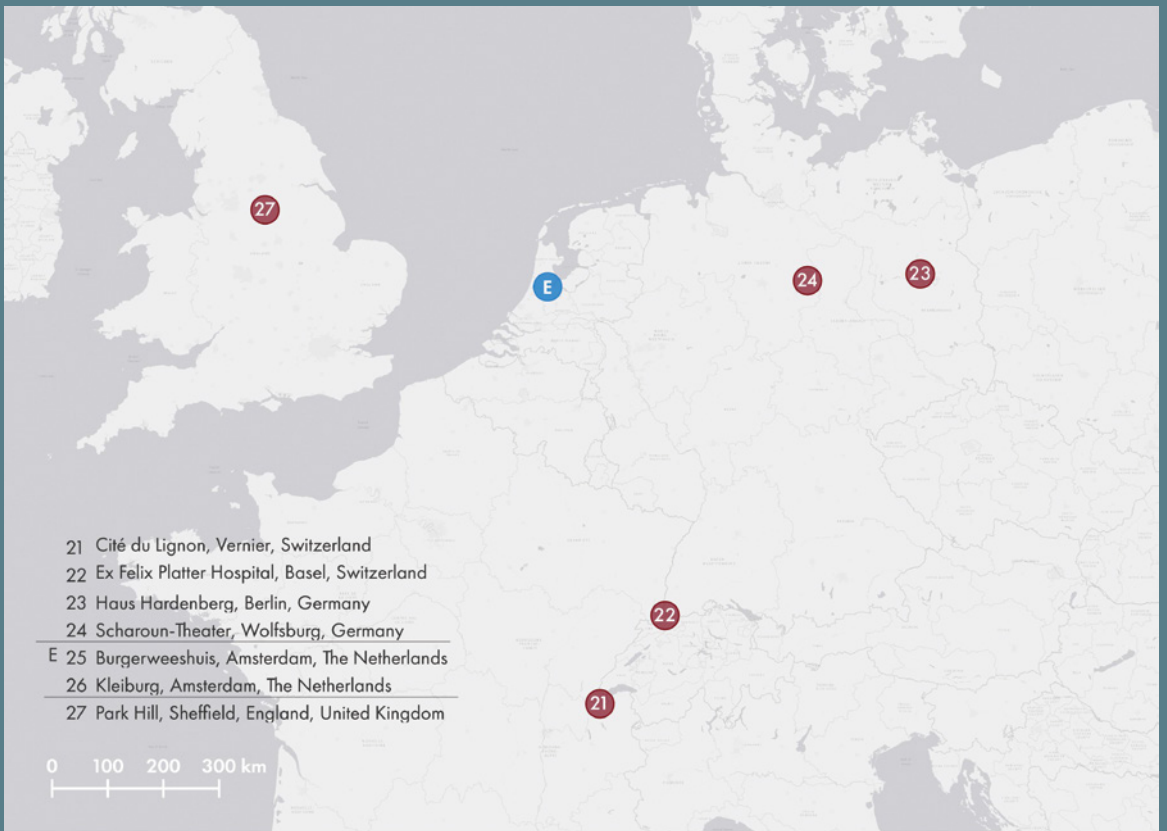
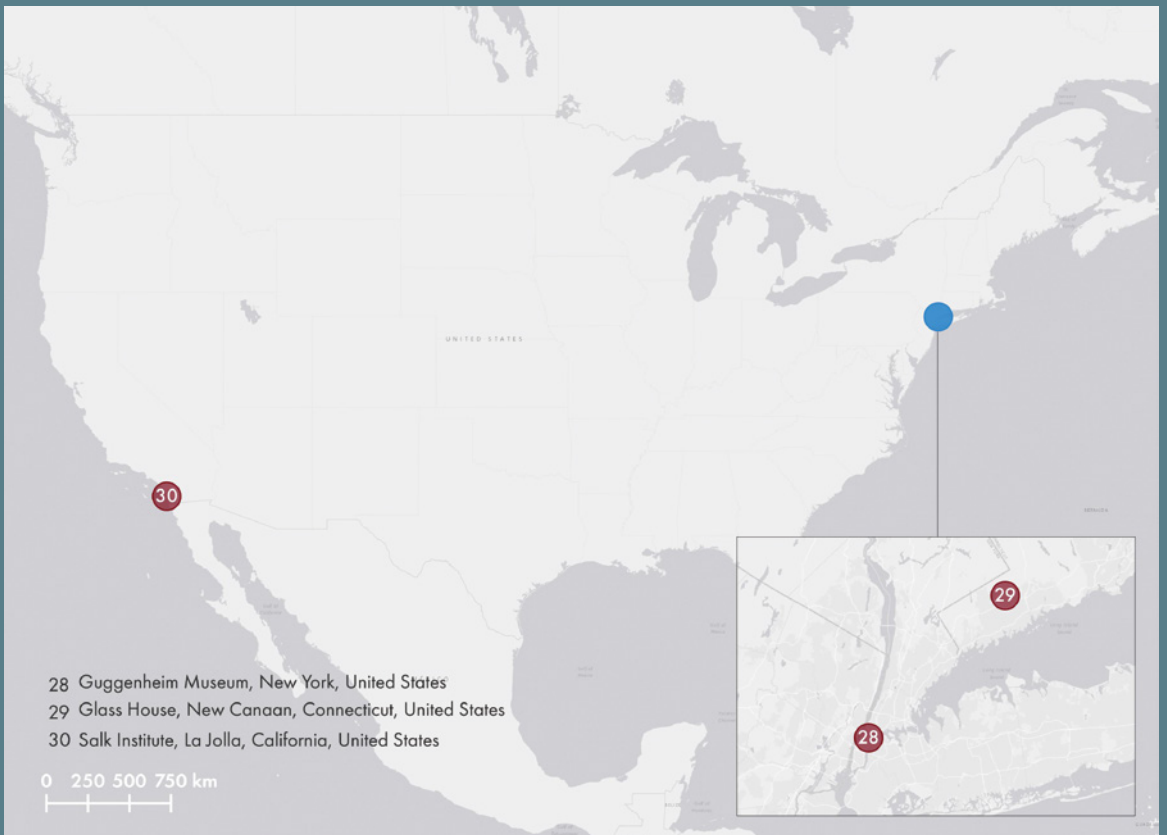
CASE STUDIES



- A 1 Padiglione Agnelli, Torino
2 Padiglione Nervi, Torino
3 Teatro Nuovo, Torino
-
- B 4 Officine ICO Centrale, Ivrea (TO)
5 Villa Rossi, Banchette (TO)
-
- C 6 Grattacielo Pirelli, Milano
7 Velasca Tower, Milano
8 Via Leopardi Building, Milano
9 Trifoglio - Politecnico di Milano, Milano
10 Nostra Signora della Misericordia Church, Baranzate (MI)

- 11 Cartiera Burgo, Mantova
12 Madonna Bianca Neighbourhood, Trento
13 Fuel Service Station - Le Fucine, Buttrio (UD)
14 Forte Quezzi INA-Casa Neighbourhood - Building A, Genova
15 Alessandria Municipal Theatre, Alessandria
-
- D 16 Ex Palazzo della Regione, Bologna
17 Treno della Barca, Bologna
-
- 18 Grattacielo di Porta San Pietro, Reggio Emilia
19 RAI Headquarters, Roma
20 Padiglione Tavorala, Sassari

0 100 200 300 km





RESIDENTIAL ARCHITECTURE

VILLA ROSSI

Italy, Piedmont, Banchette (TO)

1959 - 1961

Emilio Aventino Tarpino

ORIGINAL DESIGN

Villa Rossi, commissioned by Mr and Mrs Rossi and designed in 1959 by the Olivetti Employee Housing Advisory Office (UCCD), directed by Emilio Aventino Tarpino, formed part of the company-sponsored residential programme in Ivrea. Completed in 1961, it was one of four villas built that year for Olivetti executives and represents the most mature expression of the new architectural language developed by the UCCD. It marks a transition from the late rationalism of the 1950s towards a composition based on compact volumes, flat roofs, deep loggias, and a richer articulation of materials and colour.

The building stands on a gently sloping site of more than 2,000 m² along Via Castellamonte, opposite the Olivetti Office Building. The topography determines the arrangement of the volumes and the relationship between the house and garden. The cruciform plan results from the orthogonal interlocking of two L-shaped wings and rigorously develops a biaxial scheme previously explored by the UCCD.

The organisation is centripetal, with rooms distributed around a central node and the living room projecting along the shorter axis. Located at the intersection of the arms, the fireplace gives sculptural emphasis to the central node and rises prominently above the roof.

The villa is arranged on two levels connected by an internal staircase. The lower floor, partially below ground and limited to the downhill section, contains a playroom, garage, workshop, laundry, bathroom, boiler room and cellar, where the foundation rock is left exposed. The upper floor contains living accommodation, with the daytime areas to the south and west and the bedrooms to the north and east. The living room opens southwards and extends into a covered cantilevered loggia, while the kitchen, service rooms and staff bedroom form an independent unit. The main entrance on the north elevation is approached by a short ramp sheltered by the pronounced roof overhang.

The structural system consists of reinforced-concrete columns and walls, with composite reinforced-concrete and hollow-clay-block floor slabs. The masonry infill walls incorporate a cavity and are finished with ceramic stoneware, timber strips, and stone. A base of squared grey stone blocks mediates between the building and the ground and continues into the

Figure 1

View from Via Jervis
(now Via
Castellamonte),
autumn 1961.





Figure 2
Side façade before
restoration.

retaining walls and garden parapets. The upper-floor volumes are defined by surfaces clad in small stoneware tiles of different formats and shades, from tobacco brown to ivory white with grey and green nuances, laid in varying orientations to emphasise the parts of the composition.

On the south and west elevations, the loggias and balconies are screened by four brise-soleil made of perforated pearlescent-white glazed terracotta elements, mounted floor to ceiling on metal frames.

The timber window systems, conceived either as transparent walls at the back of the loggias or as continuous vertical slots, use the Wagner system: two hinged frames with 3 mm single glazing and an air cavity, combined with roller shutters.

The flat roof, partly flush with the walls and partly projecting, consists of two hollow-clay-block and concrete slabs separated by a 7 cm ventilated horizontal cavity, with mineral-wool insulation and small ventilation stacks on the extrados. A silver-coloured metal profile conceals the edge and emphasises its slenderness. Along Via Castellamonte, the reinforced-concrete boundary wall, approximately 65 m long, is decorated with a bas-relief inspired by the spiral of the Olivetti logo designed by Marcello Nizzoli in 1954.

As a whole, Villa Rossi translates the UCCD principles of simplification and serial design into a high-quality residence in which layout, structure, materials and relationship with the landscape are integrated into a unified composition.

Previous interventions

No interventions were documented; before restoration, the building was abandoned.

Pre-intervention general conservation conditions

The building was abandoned, with obsolete building services and poor energy performance. The ceramic cladding and brise-soleil were deteriorating, roof ventilation was ineffective, and the

building had single glazing, thermal bridges and asbestos-containing linoleum in the living room. The original roof-ventilation system was also performing poorly.

Specific environmental or climatic pressures

Hygrothermal problems and summer and winter comfort issues associated with thermal bridges, window spandrels, single glazing and ineffective ventilation of the flat roof.

Figure 3
Villa Rossi after
completion of the
restoration.



NEW INTERVENTION

2020 - 2022

GStudio (Enrico Giacomelli, Cristina De Paoli), Stefano Fantucci (energy analysis), FAPA Engineering (building services design), Gianfranco Angera (structural design and safety)

The restoration and energy-upgrade project, carried out by GStudio between 2020 and 2022, recovered Villa Rossi after a period of abandonment and inadequate maintenance. It adopted an integrated approach combining material conservation, functional upgrading, and energy efficiency to make the building habitable without altering its formal, spatial, and material character.

Conservation work focused on the façades, which had deteriorated because of invasive vegetation, lack of maintenance, and decay of timber and metal components. The works included deep cleaning, anti-vegetation treatments, localised consolidation, targeted repairs and like-for-like replacement of components beyond recovery. The ceramic cladding and brise-soleil were restored, with missing pieces replaced using original spares or elements compatible in material, colour and texture. Metal components required the repair or replacement of deteriorated parts, redesigned fixings and strengthening; the windows, doors and timber panels were restored.

The energy upgrade concentrated on the building envelope, with strategies to reduce winter energy demand and control summer overheating. The solutions were developed using thermographic surveys and measurements of thermal transmittance before and after the works. The perimeter walls, comprising two masonry leaves with a cavity approximately 10 cm wide, were insulated by injecting recycled granulated cork, avoiding external insulation and preserving the stoneware and clinker cladding. Thermal bridges were corrected internally using rigid cork panels, a vapour barrier, and gypsum board; window spandrels and radiator niches were treated with aerogel blankets and an aluminium radiant barrier.

The original Douglas-fir windows using the Wagner system were restored and upgraded with pyrolytic low-emissivity glazing. The flat roof was upgraded without any perceptible change to its profile. The build-up was insulated and protected with a high-reflectance cool-roof finish; phase-change material (PCM) panels inserted within a ventilated suspended ceiling increased thermal inertia and time lag. The original natural ventilation of the roof cavity was reactivated using stacks of adequate height to increase the stack effect and cool the roof.

The original high-temperature gravity-fed heating system was replaced with a heat pump. At the lower level, the exposed pipework was retained, and the restored radiators were reused.



Figure 4
Side façade after
restoration.

Layout changes were limited to enlarging the bathrooms and combining the kitchen with the former staff bedroom, preserving the domestic organisation of the 1950s. Non-original or inefficient finishes were replaced through an analogous design approach, introducing flooring and panelling consistent with Tarpino's architectural language.

Knowledge of the building and continuity between conservation and innovation were central to the design process. Measured surveys, exploratory investigations, redrawing, historical and archival research, and diagnostic studies reconstructed the design phases, identified material characteristics and established which elements should be conserved, restored, integrated or upgraded. Archival documentation and thermographic and performance testing informed carefully calibrated interventions. The project enhanced principles already present in the original work – orientation, loggias, brise-soleil, roof ventilation and overhangs – adapting them to contemporary requirements.

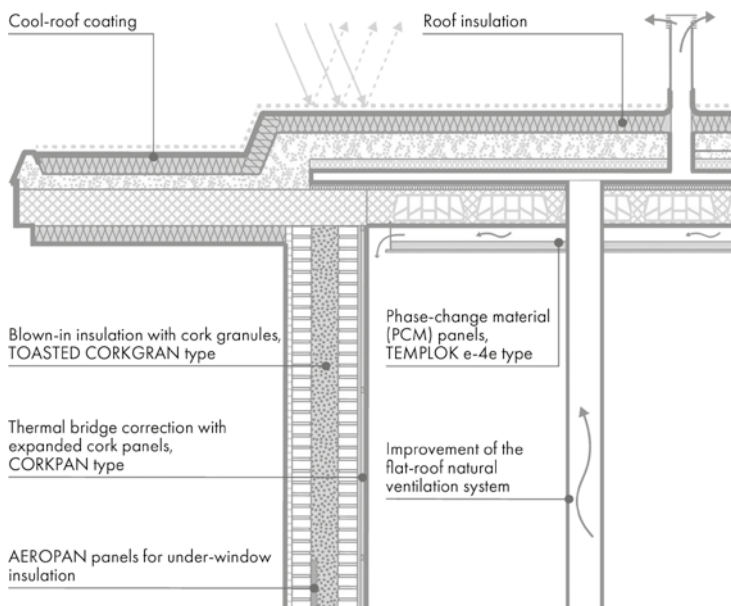


Figure 5
Section showing the
new insulation
components and the
natural ventilation
system.

Objective of the envelope intervention

The explicit objective was to improve the building's thermal behaviour without disrupting the original design concept, either in terms of building services or internal layout.

Extent of the envelope intervention

The intervention focused mainly on the upper-floor envelope, including opaque walls, window systems, the roof, and junctions with the basement level.

Solutions adopted for the envelope

The intervention included injecting cork granules into the vertical cavities, insulating horizontal surfaces with rigid insulation panels (Stiferite), inserting phase-change material (PCM) panels in the suspended ceiling, and insulating the window spandrels with aluminium-faced aerogel. Roof ventilation was improved with new stacks, while a cool-roof coating was applied to the extrasdos. Low-emissivity glazing with a screwed double-frame system and insulation of the roller-shutter boxes completed the envelope upgrade.

Other interventions

Restoration of the external cladding and brise-soleil; minor alterations to internal partitions; partial replacement of internal flooring and wall finishes; restoration of internal doors and windows; replacement of the heat generator.

Pre-intervention consumption

589.92 kWh/m² year (energy class G)

Post-intervention consumption

161 kWh/m² year (energy class B)

Certifications / Awards

2023–2024 9th Domus Restoration and Preservation – Fassa Bortolo International Prize (Built Projects – Honourable Mention).

Knowledge framework, methodology and traceability

Knowledge is treated as an operational prerequisite: surveys, material and condition assessments, diagnostic investigations and archival research

inform the design. Knowledge is not merely a descriptive background, but an operative criterion for defining values, vulnerabilities, and acceptable limits of transformation.

Technical adequacy and compatibility of the adopted solutions

The solutions are specific and calibrated to the original construction system. Avoiding external insulation, injecting cork into the cavities, using cork panels at thermal bridges, aerogel at window spandrels, and PCM and roof ventilation all exploit the existing structure. Restoring the Wagner window systems and inserting low-emissivity glazing preserve the original device while limiting hygrothermal and visual interference.

Degree of reversibility

The intervention limits demolition and replacement, favouring internal and localised additions. Nevertheless, cavity injection, insulation layers, the cool-roof finish, protective treatments and service runs introduce changes that are only partly reversible or difficult to inspect.

Impact on the formal and spatial configuration

The volumes, proportions, subdivisions, cladding, and perceptual qualities of the elevations are substantially conserved. The intervention operates within cavities, on internal surfaces, at window spandrels and on the roof, avoiding new external skins. Performance upgrades are positioned so that they remain visually subordinate and do not compromise the legibility of the building.

Degree of conservation of original architectural elements

The intervention conserves the ceramic cladding, brise-soleil, configuration of the elevations and timber window systems, limiting replacement to components with critical performance deficiencies. Replacements are localised and justified by deterioration, safety requirements, including the presence of asbestos, or irreparability, thereby preserving material and perceptual authenticity. The new materials are compatible and have limited visual impact.



Figure 6
Internal insulation using cork panels.

Figure 7
Installation of phase-change material (PCM) panels in the suspended ceiling.

VELASCA TOWER

Italy, Lombardy, Milan

ORIGINAL DESIGN

1950 - 1958

Studio BBPR (Lodovico Barbiano di Belgiojoso, Enrico Peressutti, Ernesto Nathan Rogers), Arturo Danusso (structural engineering)

Designed by Studio BBPR in the heart of Milan, The Velasca Tower reinterprets the high-rise building type through a highly distinctive form in which functional requirements, structural logic and a dialogue with the historic setting combine to define a unified whole. Approximately 106 m high, the tower comprises 27 storeys above ground and two basement levels housing parking and plant rooms. It stands about 500 m from Milan Cathedral, in an area severely damaged by the 1943 bombing raids. Its configuration seeks continuity with the historic character of central Milan without resorting to imitation.

The floors are organised by use: retail spaces occupy the ground and first floors; offices extend from the second to the seventeenth floor; the eighteenth accommodates plant and service spaces; and flats occupy floors nineteen to twenty-six. The attic contains further plant rooms and lift machinery. The transition from the office section to the residential floors is marked by the widening of the plan, supported by a complex system of ties and struts that gives the building its distinctive profile. The larger floor area of the upper levels meets the need for apartments with greater depth and more articulated layouts than the office spaces below.

The tower stands on a raft foundation. Its reinforced-concrete load-bearing structure consists of a central bracing core containing the stairs and lifts, together with sixteen perimeter columns at approximately 8 m centres. A steel solution was initially considered but rejected because its cost was estimated to be around 25% higher. From the third floor upwards, the tapered columns have a variable T-shaped section, with the outer rib left exposed. Concentrating circulation and services within the core frees the perimeter and allows the floors to adopt different layouts suited to offices and flats.

The floor slabs are of hollow-clay-block-and-concrete construction, with joists spaced at approximately 80 cm. The slabs at floors fifteen and eighteen have specific structural roles, acting respectively as a strut and a tie at the base of the external diagonal members supporting the upper volume. Columns, spandrel beams, ties, struts and the soffits of the cantilevered

Figure 1
The Velasca Tower in
the late 1950s.





Figure 2
The residential block
on floors 19–26,
nearing completion.

areas are coated with layers of mortar and cement render containing chips of Verona marble, integrally coloured, rough-floated and only lightly smoothed at the surface. On inclined and projecting elements, the render is secured to the structure by stainless-steel mesh.

The façade is articulated by prefabricated reinforced-concrete pilasters anchored to the structure. These serve a decorative function while also reducing the unsupported span of the infill panels. Pilasters, sills and reveals are made from white-cement mortar with Red Verona marble aggregate. The monolithic reinforced panels, ribbed on the back, measure approximately 40 × 220 cm and are about 4 cm thick; their smooth outer surface consists of red and yellow clinker elements bound with fine Verona marble chips. Moving inwards, the wall build-up comprises a 5 cm cavity, a self-supporting polystyrene board extending across the structural elements, a second air cavity and an internal leaf of hollow clay blocks, finished with plaster and a gypsum skim coat.

The pilasters establish an ordering grid within which windows and loggias are positioned freely in response to the internal layouts. The residential section has timber window frames, while the office section has anodised-aluminium vertical sliding windows; both are fitted with external roller shutters. The upper volume is completed by a recessed crown and a pitched roof clad in copper, above which the plant enclosures rise. At first-floor level, a projecting forebuilding accommodates the entrance lobby and mediates between the tower and the square in front.

Previous interventions

Since its construction, the tower had not undergone any comprehensive repair or refurbishment. Façade works are, however, documented in 1978–1979 and 1995. Undertaken in response to the deterioration of the exposed structural elements, they included localised crack sealing and patch repairs to the render.

Pre-intervention general conservation conditions

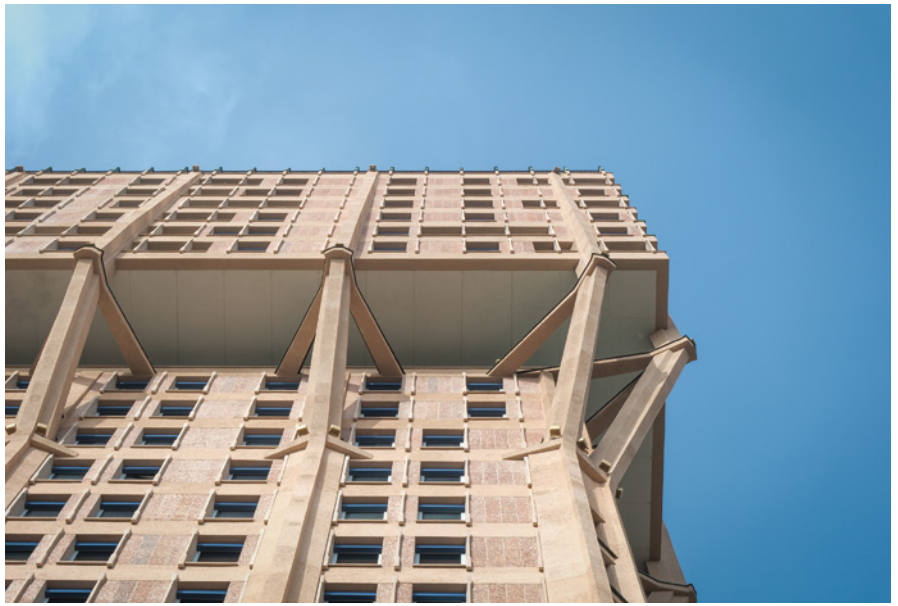
The external surfaces exhibited deterioration caused by atmospheric pollution and exposure to weathering. The reinforced-concrete structural

elements showed carbonation, cracking, concrete-cover spalling and reinforcement corrosion. Widespread detachment also affected the mortar and render layers coating the structure.

Specific environmental or climatic pressures

The tower is exposed to an urban environment containing carbon dioxide, which causes concrete carbonation and the resulting loss of protection to the reinforcement. This is compounded by moisture and precipitation. The protective render nevertheless limited the penetration of CO₂ and water.

Figure 3
View from below of
the floor-plan
expansion at the
nineteenth floor.



NEW INTERVENTION

2019 - 2025

Asti Architetti (architectural design), CEAS (structural engineering and façade design), ESA Engineering (building services design, acoustics and energy performance)

The restoration and refurbishment of the Velasca Tower, designed between 2019 and 2023 and carried out from 2023 to 2025, encompassed the façades, structure, windows, interiors, building services and the square at the base of the tower. The project sought to preserve the building's historic identity while upgrading its functional and energy performance and building services, and redefining its relationship with the urban setting.

As the building is statutorily protected, the design process was developed in consultation with the heritage authority, reconciling conservation requirements with the target of LEED Gold certification. The study of historical documentation was accompanied by analyses of the materials and their condition. Particular attention was paid to the coating of the structural elements: characterisation of the original render informed the formulation of a dedicated binder, which was subjected to accelerated ageing tests.

The deteriorated render, including that applied to the structural elements, was removed following the analyses needed to define the new mortar. Developed in collaboration with Mapei, the Velasca binder is based on white cement and polymers and is mixed with selected aggregates to reproduce the colour, texture and response to light of the original coating while ensuring water resistance and durability. The render consists of 30% binder and 70% Red Verona, Coral Red, Ebony Black and Botticino White aggregates, with particle sizes ranging from 0 to 6 mm.

The prefabricated façade elements were restored through the reconstruction of deteriorated portions, cleaning, chromatic integration and the application of a protective water-repellent treatment. The structural elements underwent reinforcement repair and reinstatement of the concrete cover, including the installation of non-magnetic welded stainless-steel mesh. Strengthening was carried out with carbon-fibre-reinforced composite materials, avoiding external post-tensioning cables that would have altered the silhouette of the characteristic ties and struts.

In the retail areas and on floors up to the nineteenth, the windows were replaced with new triple-glazed aluminium units. Designed to replicate the appearance of the previous windows, they incorporate the roller-shutter boxes without altering the image of the envelope. Concealed opening lights and slender profiles embedded in the wall leave only 73 mm



Figure 4
The tower viewed from
the terraces of Milan
Cathedral.

of frame visible. At the request of the heritage authorities, two original window frames on the fifteenth floor were retained for their documentary value; only the glazing was replaced for safety reasons. The original iron balustrades were retained and supplemented with extra-clear glass elements to meet safety requirements while preserving the legibility of their original configuration. The performance of the opaque envelope was improved internally through an insulated glass-wool lining finished with plasterboard, avoiding perceptible changes to the elevations.

The interiors were reorganised into different functional areas, and the eighteenth floor was converted to restaurant use. A drylining system with glass-wool panels and plasterboard finish was adopted for the partitions to improve thermal and acoustic performance. Building services were upgraded and integrated into the interiors, minimising their visibility wherever possible.

Finally, the square at the base of the tower was pedestrianised and redesigned as a public space, strengthening the relationship between the building and the city and restoring the base's role as an urban interface.



Figure 5
Corner of the tower at
the office levels.

Objective of the envelope intervention

The primary objective of the intervention was to preserve the building's historic identity while meeting contemporary requirements for functional and energy efficiency.

Extent of the envelope intervention

The intervention encompassed the entire building envelope, addressing both the exterior – rendered surfaces and windows – and the interior, through insulation.

Solutions adopted for the envelope

On the exterior, the precast elements were cleaned, repaired and protected. Deteriorated render was removed, the reinforcement was treated, the concrete cover reinstated, and the structures strengthened with carbon fibre. Window frames up to the nineteenth floor were replaced with aluminium frames and triple glazing, except for two original frames retained on the fifteenth floor, whose glazing alone was replaced for safety reasons. The original iron balustrades were supplemented with extra-clear glass. The opaque walls were insulated internally with glass wool and plasterboard.

Other interventions

The project included a comprehensive upgrade of the mechanical systems for ventilation, heating and cooling. Coordinated with the reorganisation of the functional areas, the services were integrated into the interiors to minimise their visibility. Strengthening works were also carried out on the internal structure. The square at the base of the tower was completely redesigned and pedestrianised, reinstating its role as an urban public space and strengthening the relationship between the building and the city.

Certifications / Awards

LEED Gold certification; WiredScore Gold certification; 2023 THE PLAN Real Estate Award (Investment and Asset Management / Completed – Honourable Mention); 2026 Premio Architettura e Urbanistica Urbanfile (Riquilificazione edifici esistenti).

Knowledge framework, methodology and traceability

The project is grounded in the study of historical and construction documentation, condition surveys and investigations into the concrete, reinforcement, render and prefabricated elements. Analysis of the original render guided the formulation of a dedicated mortar, subjected to acceler-

ated ageing tests. Consultation with the heritage authority and material testing made it possible to define and document the adopted solutions.

Technical adequacy and compatibility of the adopted solutions

The repair of the concrete structure and reinforcement, localised strengthening with composite materials and restoration of the prefabricated elements were tailored to the specific deterioration conditions. The new mortar reproduces the colour and surface characteristics of the existing render, while internal insulation and new windows improve the envelope's performance without substantially altering the configuration of the elevations.

Degree of reversibility

Carbon-fibre strengthening, replacement of the render and installation of the internal insulated lining introduce materials and layers permanently connected to the structure and perimeter walls. The replacement of most of the window frames up to the nineteenth floor also entailed the loss of the previous components. Some dry-assembled internal elements can be removed, but the overall reversibility of the envelope intervention remains limited.

Impact on the formal and spatial configuration

The intervention retains the tower's silhouette, the rhythm of the exposed structural elements, the grid of prefabricated pilasters and the façades' chromatic articulation. The new windows reproduce the design of the previous units and have a narrow visible profile, while carbon-fibre strengthening avoids introducing external elements alien to the original configuration. The changes to the envelope therefore have a limited effect on the overall perception of the building.

Degree of conservation of original architectural elements

The intervention retains the concrete structure and prefabricated elements, which were repaired, locally reinstated, cleaned and given surface protection. The configuration and compositional character of the façades remain recognisable. The preservation of original elements is nevertheless partial: deteriorated render was removed and replaced with a new render, while the window systems on the non-residential floors were replaced with components reproducing their design and proportions.



Figure 6
The projecting volume at first-floor level.

Figure 7
An aluminium-framed window at the office levels, the panel with coloured clinker elements, and the small prefabricated columns.

VIA LEOPARDI BUILDING

Italy, Lombardy, Milan

1958 - 1961

Vico Magistretti, Guido Veneziani

ORIGINAL DESIGN

The residential and office building on Via Leopardi, designed by Vico Magistretti and Guido Veneziani between 1958 and 1961 for the insurance company Assicurazioni l'Abeille, was conceived as a mixed-use complex within a Milan neighbourhood characterised by nineteenth- and early twentieth-century buildings. The design responds to this setting through an articulated composition in which materials, projections, and volumetric variations differentiate the functions without compromising the unity of the whole.

The building has a T-shaped plan. One wing extends along Via Leopardi, while the other runs transversely from a central position and contains the entrance, set back from the street behind a small forecourt; two landscaped internal courtyards open to either side. On the street elevation, two low projecting volumes define the base and frame the entrance. Supported by paired columns, they create covered spaces. Above, the residential volume is set back from the street line and articulated by terraces and projecting elements.

The building comprises eight storeys above ground, a semi-basement and a basement housing garage, plant rooms and storage rooms. The first three floors originally accommodated the insurance company's offices, while the upper levels contained upper-middle-class flats. The internal layout reflects this functional division: the lower levels are predominantly arranged as offices within linear wings, while on the upper floors the flats occupy the side wings and are served by the central block containing stairs, lifts and goods lifts.

The different uses are expressed through distinct material and compositional treatments. The office levels, clad in white marble slabs, feature full-height aluminium-framed windows set between dark metal panels. The base is articulated by continuous vertical elements and opaque areas of varying height, also determined by the built-in furniture behind them. The residential levels have exposed-brick infill laid in horizontal courses, with large single-glazed timber-framed windows; their defining feature is a series of deep terraces with continuous brick parapets. The elevations facing the internal courtyards have a higher ratio of solid to

Figure 1

View over the courtyard, showing the interplay of volumes.





Figure 2
Street-facing elevation,
with the levels
intended for offices.

void and are animated by the cylindrical stair and lift shafts and by semicircular balconies, producing greater plastic articulation than the street elevation. The extensive use of corner windows introduces a distinctly modern note within the surrounding context.

The load-bearing structure is a reinforced-concrete frame, with *in situ* reinforced-clay floor slabs and reinforced-concrete balconies. The foundations consist of inverted reinforced concrete beams. The roof is partly flat and accessible as a terrace and partly pitched, with copper-sheet cladding. At the residential levels, the infill consists of 12 cm solid facing brickwork, while the stair blocks are enclosed by exposed reinforced-concrete walls. On the office floors, the façade comprises aluminium mullions and transoms, with sliding opening lights and fixed glazing alternating with opaque panels. The latter are externally clad in granite, insulated with glass wool and dimensionally coordinated with the internal filing cabinets. The black anodised mullions are fixed to a secondary frame of press-braked steel. The office levels have aluminium windows, and the residential levels have timber windows, all originally single-glazed. Solar-control devices include sliding timber shutters, roller shutters, and internal Venetian blinds. The combination of marble, granite, metal, brick, timber, and copper makes the distinction between the office base and residential levels legible while maintaining the unity of the composition.

Previous interventions

Over time, the building had been converted almost entirely to office use. External air-conditioning units had been installed on the façades and terraces, while the courtyards had been inappropriately used as parking areas.

Pre-intervention general conservation conditions

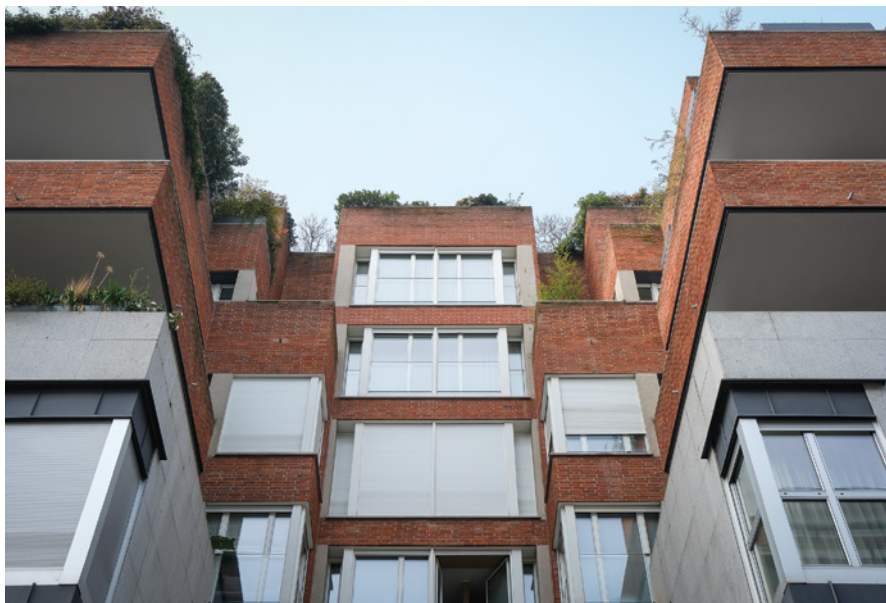
The building was in a fair state of conservation, apart from several critical areas and inappropriate alterations. These included neglected roof gardens, external air-conditioning units installed

on the façades and roof terraces, and the use of the internal courtyards as parking areas. The aluminium window systems were in very poor condition.

Specific environmental or climatic pressures

Its location in central Milan exposes the building to summer heatwaves, intensified by the urban heat-island effect, while the extensive single glazing increased both overheating and heat loss.

Figure 3
View of the façade,
showing the setback of
the transverse wing.



NEW INTERVENTION

2013 - 2018
BMS Progetti

The intervention, carried out between 2015 and 2018, transformed the building into an almost entirely high-end residential complex while retaining the legibility of its original architectural and morphological character. The project benefited from historical and architectural advice provided by the Fondazione Studio Museo Vico Magistretti, which reviewed the decisions concerning the exterior and the building's most significant elements. Its advice was especially important in defining the new window systems, designed to reproduce the appearance of the originals while delivering thermal and acoustic performance in line with contemporary standards.

The new use required a radical reorganisation of the layouts, resulting in 75 flats of different sizes and types, including simplex and duplex units. To meet parking demand, two additional basement levels were constructed, while the existing basement was demolished and rebuilt. The work followed a top-down construction sequence, using micropiles and perimeter retaining walls to support the building during excavation and to create garages, car and motorcycle parking, storage rooms and service spaces. Shared amenities were also introduced at semi-basement level, including a meeting room, gym, concierge desk, laundry and refuse room.

The circulation system was updated by relocating the lifts from the external metal-clad cylindrical volumes to a more central position. Although no longer functional, the cylinders were emptied and retained to safeguard the original design of the courtyard elevations. Cars were removed from the courtyards, which were reinstated as green spaces; the entrance passage was enclosed with glazing, and the lobby reconfigured following the relocation of the vehicular ramp to the garage. Glass terrace partitions were used to minimise visual impact. The most visible alteration was the lightweight upward extension of the central volume, which accommodates a panoramic flat with large terraces.

Improving the energy performance of the envelope was one of the principal objectives. The intention to preserve the building's appearance led to the decision to work exclusively from the interior, without altering the volumes, materials or finishes of the façades. All spaces were insulated using dry-lined walls with thermal and acoustic insulation, limiting the build-up thickness and supporting the reversibility of the intervention. The partitions between



Figure 4
Window frames on
the levels originally
intended for offices.

flats were also thermally insulated with rock-wool panels within the cavity and acoustically insulated with panels of mineralised spruce wood wool bound with Portland cement.

The windows were replaced with new units matching the proportions and design of the originals while providing upgraded performance. Careful design of the junctions and subframes improved the continuity of the insulation while preserving the appearance of the elevations and the relationship between transparent and opaque surfaces.

The building-services strategy uses a centralised, all-electric system. Winter heating and summer cooling are provided by heat pumps connected to 27 geothermal boreholes, each 135 m deep, and underfloor or ceiling radiant panels, supplemented by fan-coil units for dehumidification. Domestic hot water is also produced by heat pumps. The system operates through closed-loop ground-source heat exchange and uses no fossil fuels. The integration of conservation, adaptive reuse, internal insulation and building-services upgrades enabled every unit to achieve energy performance class A.

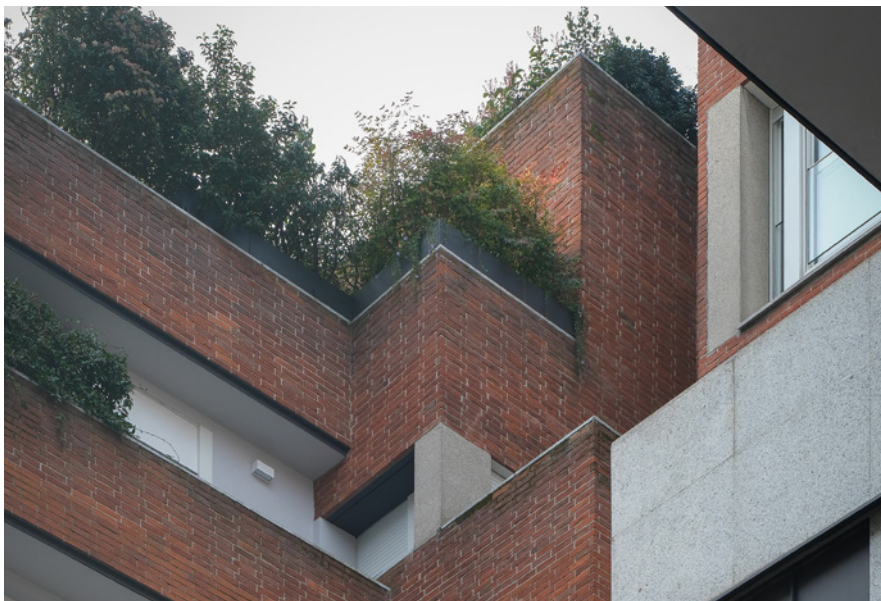


Figure 5
Detail of the main
façade.

Objective of the envelope intervention

The guiding principles of the intervention were compatibility – understood as a balance between retained spaces and materials and new elements – energy improvement, fire safety and accessibility. The alterations were designed to have minimal impact on the existing fabric through the use of dry construction systems.

Extent of the envelope intervention

The intervention encompassed the entire building envelope, including both opaque and transparent components.

Solutions adopted for the envelope

The envelope was upgraded from the interior to avoid altering the building's appearance. The infill walls were structurally strengthened with fibre-reinforced render, and a dry-installed plasterboard lining insulated with 25 cm of open-cell rock wool was added. Thermal bridges were treated with 5 cm aerogel panels. The original windows were replaced with new timber-and-aluminium or PVC units reproducing their design and fitted with triple glazing to provide high thermal performance.

Other interventions

Two additional basement levels were constructed to meet the parking demand generated by predominantly residential use. The access and circulation systems were completely redesigned, including the relocation of the vehicular access ramp. The courtyards were returned to gardens, and the roof gardens converted into green terraces. A centralised, all-electric system was installed, with dry-laid radiant panels and fan-coil units for dehumidification.

Post-intervention consumption

27.90 kWh/m² year

Certifications / Awards

Energy performance class A (APE, 2017).

Knowledge framework, methodology and traceability

The intervention is grounded in a comprehensive knowledge framework that considers the building's historical and architectural value, its condition, and its original typological, material and spatial characteristics. The involvement of the Fondazione Magistretti reinforces the methodological coherence of the process. The design decisions seek to preserve the building's overall image and perception through documented solutions justified in relation to conservation and performance-improvement objectives.

Technical adequacy and compatibility of the adopted solutions

The intervention demonstrates a high degree of technical appropriateness because its energy-upgrade solutions are compatible with the conservation of the elevations and the envelope's principal material characteristics. Internal insulation avoids altering the brick façade, whereas the new windows improve performance while retaining the design, proportions, and rhythm of the original elements. High-efficiency building services, integrated without significantly interfering with the architectural image, reinforce the coherence between energy objectives and conservation requirements.

Degree of reversibility

The intervention is partially reversible. In theory, the dry-lined internal walls used for insulation offer greater scope for alteration than solutions applied directly to the façades. However, the replacement of the windows, the reconfiguration of the internal layouts, and the work to the basement spaces introduce changes that are difficult to reverse. The intervention therefore achieves an intermediate degree of reversibility, with some locally reversible solutions.

Impact on the formal and spatial configuration

The impact of the envelope upgrades on the building's externally perceptible formal character is limited: the articulation of the elevations, brick facing, courtyard system, cylindrical volumes and relationship with the context remain legible. The assessment becomes intermediate when the intervention is considered as a whole, since the upward extension, new basement levels and integration of building services introduce more substantial changes, particularly to the material fabric and internal spatial organisation.

Degree of conservation of original architectural elements

The conservation of original architectural elements is explicitly selective. The intervention retains the legibility of the elevations' compositional character, brick facing, garden courtyards and cylindrical lift volumes, while replacing the deteriorated original windows, which no longer met performance requirements, with new elements of similar design and contemporary technology. The result balances preservation of the architectural image with targeted replacements justified by energy and functional requirements.



Figure 6
Circular balconies and the metal-clad cylindrical volume.

MADONNA BIANCA NEIGHBOURHOOD

Italy, Trentino-Alto Adige, Trento

1965 - 1975

Marcello Armani, Luciano Perini, Efrem Ferrari

ORIGINAL DESIGN

The Madonna Bianca Neighbourhood is located south of Trento, on level ground at the foot of the hillside. Developed between 1968 and 1975 on the initiative of ITEA, formerly IACP, it was designed by Marcello Armani and Luciano Perini, with Efrem Ferrari, as part of the city's residential expansion policies.

The estate comprises eight fourteen-storey towers, each containing 52 flats, positioned around the perimeter of the site and interspersed with five two-storey linear terraced blocks, each containing 19 dwellings. This arrangement leaves a large central green space, where facilities including schools, a church, a social and shopping centre, and a swimming pool were subsequently built. Pedestrian and vehicular routes are clearly separated. Vehicular traffic is largely confined to the perimeter, while many facilities can be reached only on foot.

Characterised by a low residential density, the scheme was forward-looking, although contemporary critics were somewhat sceptical of its lack of dialogue with the context. It embodies Modernist ideals of large-scale planning, housing set within landscaped grounds, and integrated community facilities. Extensive use of prefabrication enabled rapid construction; the buildings are characterised by exposed concrete throughout and the strong horizontality of continuous balconies. Standardised components and modular repetition contribute to the unity of the ensemble.

The towers have rectangular plans, with entrances aligned along the east–west axis. All flats have dual aspects, with bedrooms facing east and living areas west, ensuring good cross-ventilation. The elevations are differentiated: the short north and south façades have openings grouped into a single vertical strip, flanked by opaque surfaces with a rough finish; on the east façade, smooth-finished opaque horizontal bands alternate with glazed bands, while the west façade is articulated by a sequence of recessed balconies. This differentiation responds to orientation and internal use while maintaining the material uniformity of the complex.

The buildings have reinforced-concrete frame structures, with beams and columns, and 24 cm-thick composite clay-block and concrete floor slabs. The flat roofs use the same

Figure 1

General view of the Madonna Bianca Neighbourhood.





Figure 2
West façade of one of the towers, dominated by the horizontal emphasis of the continuous balcony.

construction and are accessible as terraces. The infill walls comprise two concrete panels, 20 cm thick internally and 8 cm externally, separated by an 11 cm cavity, giving an overall thickness of approximately 40 cm. The original envelope has no insulation; the cavity provides the only break between the two concrete leaves.

The large prefabricated external panels are left exposed, with smooth or rough exposed-aggregate finishes selected in relation to the composition of the elevations. The thinner spandrel panels beneath the windows are approximately 10 cm thick and comprise two 3 cm concrete panels separated by a 2 cm cavity. The windows have anodised aluminium frames and single glazing, with plastic roller shutters. Centralised boilers serving the flats are located on the roofs of the towers.

Between 1975 and 1979, the estate was extended with the adjoining Villazzano Tre complex, comprising a further six towers flanked by low-rise buildings. Together, the two estates form a unified ensemble of fourteen towers, recognisable in Trento's urban landscape through the relationship between housing, green space, and community facilities.

Previous interventions

In the late 1980s, opaque dividing screens were installed between the balconies of Tower 1 to provide greater privacy and improve structural and fire safety; in 1996, glazed dividers were installed in all the other towers. In the early 1990s, strengthening work was undertaken by constructing a plinth around the base of the walls and ground-floor columns affected by carbonation. Over the years, some roller shutters and windows have also been replaced.

Pre-intervention general conservation conditions

The buildings were in fair condition. The main issues were structural, with deterioration at several junctions and components (portico columns, fixings

to the prefabricated reinforced-concrete façade panels, and prefabricated balcony elements), and energy-related (a complete absence of insulation; only an 11 cm cavity separated the two concrete leaves of the 40 cm-thick infill walls).

Specific environmental or climatic pressures

Trento's climate, characterised by harsh winters and summer heatwaves, exposes the towers to marked temperature fluctuations and high levels of solar radiation, with consequences for comfort within the dwellings.

Figure 3

View of the towers
after the intervention,
with solar shading
inspired by a work by
the artist Senesi.



NEW INTERVENTION

2018 - 2023

Campomarzio & Andrea Bombasaro

The refurbishment of the Madonna Bianca towers began with a careful assessment of whether it would be more appropriate to demolish and rebuild the complex or to retain and upgrade it. Recognition of its historical, architectural, and material significance led to the choice of conservation-led refurbishment. This decision developed through a progressive process of research and reappraisal, a key milestone being the 2017 exhibition and catalogue *Almanacco 70*, curated for MART by Campomarzio, Margherita de Pilati, and Gabriele Lorenzoni. The project therefore aimed to improve energy performance and seismic safety without altering the towers' architectural identity or their role in the urban landscape.

Supported by Italy's Superbonus 110% and Sismabonus 110% incentives, the intervention was implemented in three phases. The first project, concerning Towers 6, 7, and 8, which were predominantly privately owned, resulted from a competition won in 2018 by Campomarzio with architect Andrea Bombasaro and was completed in 2023. The second phase concerned Towers 9 and 10 and was completed in December 2024; the third involved Towers 11, 12, and 14 and was completed at the end of 2025. The buildings remained occupied throughout the works, encouraging the use of lightweight, prefabricated systems that could be installed rapidly.

Structurally, the concrete infill panels were strengthened with an approximately 6 cm layer of glass-fibre reinforcement, while the reinforced-concrete stair and lift cores were strengthened for seismic resistance using thin FRP systems. The envelope was insulated with a dry external system comprising large prefabricated sandwich panels, sized and proportioned in relation to the original panels. Their 8 cm PIR insulation core provides high performance with limited weight and thickness. Off-site preassembly reduced on-site operations and accelerated installation.

The finishes reinterpret the original distinction between smooth and rough surfaces through smooth grey cementitious finishes and dark-grey stoneware with an exposed-aggregate effect. On the east façade, the opaque areas between the windows were clad in insulated sandwich panels with a white metal finish. On the west façade, the prefabricated balcony parapets were retained and repaired using passivating treatments and restorative skim coats. The balcony slabs were also insulated both above and below, together with the side walls; rainwater drainage and tiled flooring were reinstated.



Figure 4
Detail of the prefabricated sandwich panels forming the external insulation system.

The recessed balconies were fitted with acrylic-fabric solar screens in colours inspired by Luigi Senesi's 1977 work *Progettazione cromopaesaggistica*. The palette differentiates the individual dwellings and gives each tower a predominant hue. The roller-shutter boxes were replaced and insulated; in ITEA-owned flats, white PVC windows with low-emissivity double glazing were installed, with a design similar to the original.

At ground level, the soffit of the first-floor slab was insulated with 16 cm of glass wool; the stairwells and load-bearing walls were treated following installation of the seismic reinforcement mesh. The entrances were redesigned to improve accessibility. The roof was insulated above the slab with 18 cm of XPS, waterproofed, and finished with raised paving and a photovoltaic array with modules laid flat.

Finally, the building services were rationalised by installing new vertical risers in the central part of the stairwells and relocating the gas pipes to the façades, where they are screened by light-grey expanded metal. The heating and domestic hot-water systems were also renewed, with condensing boilers, thermostatic valves, and systems for control and individual metering of energy use.

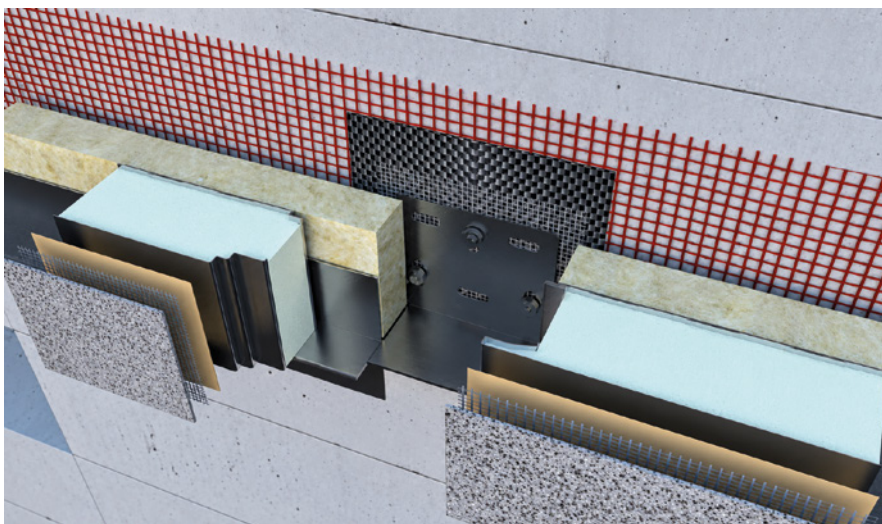


Figure 5
Insulated façade system with seismic reinforcement.

Objective of the envelope intervention

The project had three principal objectives: upgrading the energy performance of the building envelope, replacing the heat generators, and improving accessibility.

Extent of the envelope intervention

The intervention covered the entire building envelope, including replacement windows in the publicly owned flats and the installation of solar shading.

Solutions adopted for the envelope

External thermal insulation was applied to all vertical and horizontal envelope surfaces, with the most appropriate build-up selected for each element in relation to the available space, the need to preserve daylight, and the treatment of thermal bridges. The façades were clad with prefabricated sandwich panels incorporating a PIR insulation core, sized to match the original modules and differentiated by finish. The balcony slabs and side walls, roller-shutter boxes, first-floor slab, and roof were also insulated, the latter with XPS.

Other interventions

Seismic upgrading included strengthening the infill panels and the stair and lift cores with thin reinforcement systems. The building services were rationalised through new vertical risers in the stairwells, renewal of the heating and domestic hot-water networks, and relocation of the gas pipes to the façades, screened by expanded metal. A photovoltaic system was installed on the roof. At ground level, the entrances were upgraded to improve accessibility and remove architectural barriers.

Pre-intervention consumption

187.42 kWh/m² year

Post-intervention consumption

42.77 kWh/m² year

Certifications / Awards

Energy performance class A2 (Tower 8 – APE, 2022); 2025 Euregio Award for Building Culture.

Knowledge framework, methodology and traceability

The intervention design is based on a robust body of knowledge. The decision to retain and upgrade the existing complex stems from a progressive recognition of the estate's urban and architectural significance, supported by the *Almanacco 70* exhibition and catalogue, ITEA archives, surveys, before-and-after photographs, and façade details. The objectives of conservation-led refurbishment are clearly stated.

Technical adequacy and compatibility of the adopted solutions

The prefabricated external insulation system, developed and patented specifically for the Madonna Bianca towers, uses sandwich panels with a PIR insulation core and finishes calibrated to the character of the elevations. The system addresses energy, formal, structural, and construction requirements in an integrated manner: it allows the lateral prefabricated panels to be strengthened externally without disrupting the use of the occupied flats. The transformative nature of the intervention is balanced by a technically targeted solution compatible with the original architectural image.

Degree of reversibility

The use of a dry external insulation system and off-site prefabricated components indicates efficient constructability and greater potential for dismantling than conventional wet systems. Reversibility is nevertheless only partial: the intervention includes seismic reinforcement, continuous insulation, new finishes, windows, shading, waterproofing, and building-services works that make lasting changes to the envelope and reduce the legibility of the original fabric.

Impact on the formal and spatial configuration

The impact on the formal and spatial configuration is limited. The towers have a predominantly landscape value, associated with their recognisable silhouettes, the serial articulation of their elevations, and their landmark role within the estate; from this perspective, the intervention introduces no significant alterations. Their profiles, horizontal rhythm, principal subdivisions, and volumetric relationship with the context are retained. The new finishes and shading alter the close-range perception of the surfaces but do not substantially affect the overall image of the work.

Degree of conservation of original architectural elements

The conservation of original elements is partial but significant. The layout, volume, pattern of subdivisions, position of window openings, and compositional logic of the elevations are retained. Although concealed by the new envelope system, the prefabricated façade panels remain *in situ* and are integrated into the structural reinforcement. The windows have been replaced, however, and the external finishes are no longer directly legible. These replacements are justified by deterioration, safety, and performance requirements, but they reduce the direct material legibility of the 1970s envelope.



Figure 6
West façade of one of the towers after the intervention.

FORTE QUEZZI INA-CASA NEIGHBOURHOOD – BUILDING A

Italy, Liguria, Genoa

1956 - 1968

Luigi Carlo Daneri, Eugenio Fuselli

ORIGINAL DESIGN

Building A of the Forte Quezzi INA-Casa Neighbourhood, known as the Biscione ('great snake') because of its sinuous course along the contours, was designed from 1956 onwards and completed in 1968 as part of the second seven-year INA-Casa programme. Coordinated by Luigi Carlo Daneri with Eugenio Fuselli, the complex arose from the decision to concentrate a large number of dwellings in five linear blocks positioned at different levels along a small, south-facing amphitheatre-shaped valley. The curvilinear form was not a purely expressive choice; it resulted from adapting to the steep terrain, preserving views towards the city and the sea, and limiting the building footprint. Located at the highest level, Building A defines the upper edge of the estate and is its most recognisable element in the Genoese landscape.

The building extends for approximately 540 m, rises to eight storeys above ground, and comprises 32 stairwells and 384 flats. The residential volume is organised as two superimposed three-storey blocks, separated by a continuous covered loggia conceived as a space for circulation, walking, and social interaction. This intermediate open level interrupts the building mass and introduces an internal street connecting the different parts of the building. It recalls the concept of the *unité d'habitation*, reinterpreted in relation to Ligurian topography and the exceptional scale of the development. Arranged in repeated modules, the flats predominantly face the valley, benefiting from the southern exposure and panoramic views. A single pair of lifts, centrally positioned and reached through a tunnel from street level, serves the entire building via the intermediate loggia.

Garages for residents are located on the lower semi-basement level. Above them runs a continuous portico providing access to the vertical circulation and to spaces originally intended for shops and services. The base absorbs the difference in level between the road and the residential block, organising superimposed levels in which vehicular movement, pedestrian routes, communal spaces, and housing are integrated into a single structure.

Figure 1
The west end and
loggia of Building A.





Figure 2
View from the loggia
of Building A, looking
west.

This arrangement gives the building an urban dimension, only partly realised because the planned facilities were not built or were completed only in part.

The principal elevation is defined by a succession of recessed balconies separated by walls and organised on a 4×2.9 m module. The repeated grid follows the building's curvature and unifies the elevation through an alternation of solids and voids. The deep loggias mediate between the interiors and the landscape, while the blind end walls interrupt the horizontal pattern and reveal the depth of the building. Over time, the regularity of the grid has been altered by awnings, screens, and partial enclosures introduced by residents.

The construction consists of exposed reinforced-concrete frames, with the same material used for the floor structures. The structural grid follows the modular arrangement of the flats and loggias and is expressed on the façade through the regular sequence of columns, beams, and walls. The balcony slabs are constructed in composite clay-block and concrete, while the load-bearing walls on the lower level and the loggia parapets are reinforced concrete. The hollow-brick cavity infill walls are set slightly behind the structural elements, emphasising the legibility of the frame and the depth of the loggias. Prefabricated components were also used in the structures and in the finishes of the façades and balconies, consistent with the serial nature of the module and the building's exceptional dimensions. The original windows had timber frames; the flat roof is not accessible.

Previous interventions

In the 1990s, façade maintenance was carried out, including work on the structural elements. Their appearance was altered only minimally through the use of a colour similar to exposed concrete, while ostensibly protecting the material from weathering. Work was also undertaken on the soffits and roof.

Pre-intervention general conservation conditions

The reinforced-concrete structural elements and balcony soffits were in poor condition owing to corrosion of the reinforcement; large areas of render on the infill walls were also detaching.

Specific environmental or climatic pressures

Its south-facing hillside location exposes the building to intense summer solar radiation, wind, and driving rain, with consequences for residents' comfort.

Figure 3
General view upon
completion of the
intervention.



NEW INTERVENTION

2020 - 2024
Maurizio Michellini

The intervention on Building A of the Forte Quezzi INA-Casa estate was developed within the framework of Italy's Superbonus and Sismabonus incentives, which shaped its objectives, programme, and technical choices from the outset. Design work began in 2020 and concerned the entire building, comprising 384 flats and 32 stairwells. Construction started in July 2021 and was completed at the end of 2024. The operation, with a total value of approximately €50 million, was fully funded through the two incentive schemes, with no direct cost to the owners.

The design process focused on meeting the energy and structural requirements of the incentive mechanisms, while also addressing the landscape designation and the need to preserve at least some of the building's formal characteristics. Dialogue with the heritage authority resulted in several specific requirements. On the end walls, the grid that characterised the original surface was surveyed and reproduced by incising the finish of the new external insulation. On the uphill elevation, however, the cladding to the infill walls and structural elements was allowed to lie in the same plane, relinquishing the slight original recess that had made the relationship between frame and enclosure legible.

The energy upgrade involved most of the opaque envelope. External thermal insulation was applied to the uphill elevation and both end walls; the roof was insulated above the slab, and all floors over open spaces were insulated at soffit level. The system comprises 12 cm expanded-polyurethane panels, finished on the vertical surfaces and soffits with reinforced base coat and acrylic-siloxane render. Ten-centimetre panels were applied over the structural frames on the uphill elevation to align the new façade plane. The inaccessible flat roof was then protected with new waterproofing layers.

The structural works repaired the reinforced-concrete elements affected by deterioration and spalling of the concrete cover. After treatment of the reinforcement, the surfaces were rebuilt with thixotropic mortars and finished with a reinforced base coat incorporating basalt-fibre mesh, resulting in the loss of the original exposed-concrete finish. The floor structures were strengthened with a composite topping slab connected to the existing structure by reinforcing-bar dowels and welded mesh. The works particularly involved the slabs at the pilotis level and the communal loggia.



Figure 4
Detailed view of the uphill elevation after the intervention.

Photovoltaic panels serving the communal areas of each of the 32 stairwells were installed on the uphill side of the roof. Additional modules for private use were subsequently added on the downhill side. As individually commissioned ancillary works, the external windows and entrance doors of 73 properties were also replaced in 2025 with PVC windows incorporating double-chamber profiles, insulated roller-shutter boxes, and EI 60 doors. The intervention therefore combined improvements to the envelope's energy performance, repair and strengthening of the structures, and renewable-energy generation, while altering aspects of the elevations' original material configuration and depth.



Figure 5
Detail of the junction between the insulation beneath the floor slab and the existing window frame at the pilotis level.

Objective of the envelope intervention

As an intervention funded through the Superbonus and Sismabonus schemes, its primary objectives were to improve the building by two energy classes and enhance its seismic performance.

Extent of the envelope intervention

The intervention involved the whole of Building A and all envelope surfaces, except for the walls of the street-facing elevation opening onto private balconies.

Solutions adopted for the envelope

External thermal insulation was installed on vertical surfaces and on soffits above open spaces, using expanded polyurethane (12 cm; 10 cm over structural frames). On the roof, the insulation was installed above the slab and waterproofed.

Other interventions

The reinforced-concrete structural elements were strengthened with thixotropic mortars and basalt-fibre mesh; a composite topping slab was installed over the floor structures at the pilotis and loggia levels; photovoltaic panels were installed on the roof to serve the communal areas of each stairwell.

Certifications / Awards

Energy performance classes B/C (depending on the unit – APE, 2026).

Knowledge framework, methodology and traceability

The project is supported by a robust and well-structured body of knowledge, based on consultation of bibliographical and archival sources, surveys, and diagnosis of deterioration affecting the concrete and render. The available documentation does not fully explain the relationship between historical and material knowledge, conservation objectives, and energy-related choices.

Technical adequacy and compatibility of the adopted solutions

The intervention addresses significant technical issues associated with deterioration of the reinforced concrete, detachment of finishes, the absence of insulation, and obsolescence of envelope components. The decision to work predominantly from the exterior is also understandable given that residents remained in their flats,

which severely limited the possibility of internal work. External insulation, insulation of the roof and soffits, repair of the reinforced concrete, new windows, and photovoltaic panels therefore contribute to the overall improvement in performance.

Degree of reversibility

The degree of reversibility is limited. The intervention retains the primary structure and some original fabric beneath the new layers, but introduces work that is strongly bonded or integrated with the substrate, including external insulation, reinforced base coats, waterproofing, concrete repairs, basalt-fibre mesh, and the composite topping slab. These solutions meet performance and repair requirements but would be difficult to remove in future without loss of or damage to the original surfaces and finishes, reducing the inspectability and material recoverability of the envelope.

Impact on the formal and spatial configuration

The impact on the formal and spatial configuration is limited at the urban scale: the sinuous outline, the development's large scale, its relationship with the road, and the sequence of balconies on the principal elevation remain recognisable. The characteristic grid of the end walls has also been reproduced. At close range, however, the intervention alters perception of the envelope: the insulation increases its thickness, weakens the distinction between structure and infill, and replaces the sculptural and material reading of exposed concrete with a predominantly chromatic and surface treatment.

Degree of conservation of original architectural elements

The conservation of original elements is selective. The primary structure, circulation layout, loggias, and overall articulation of the elevations are retained, but many envelope components are concealed or reinterpreted by the new performance layers. Exposed concrete, infill walls, and soffits lose their direct legibility, while the grid of the end walls is reproduced rather than conserved. Replacement of the windows and roller-shutter boxes responds to energy and functional requirements but introduces components different from the originals.



Figure 6
View from the colonnade at the pilotis level.

Figure 7
Detail of the end elevation after the intervention.

TRENO DELLA BARCA

Italy, Emilia-Romagna, Bologna

ORIGINAL DESIGN

1957 - 1962

Giuseppe Vaccaro, Umberto Chiarini, Luigi De Filla, Alberto Legnani, Alfredo Leorati et al.

The Barca social housing building lies south-west of Bologna, at a bend in the River Reno. It was developed by the Bologna IACP, INA-Casa, UNRRA-Casas, and INCIS. Design began in 1957 under the second seven-year INA-Casa programme and covered an area of approximately 30.8 hectares within one of the principal expansion zones identified by the master plan, which envisaged accommodation for around 40,000 residents and a substantial provision of services, only some of which were built. The estate was conceived as an urban district with a degree of autonomy, integrated into the city's road network and separated from the Reno by a broad strip allocated to a public park and sports facilities. Its layout capitalised on the landscape qualities of a site open towards the hill and Sanctuary of San Luca, the historic city, the river, and the foothills of the Apennines.

The urban plan is organised around a gently curving spine road approximately 600 m long, bordered to the west by the building known as Il Treno, a porticoed residential and commercial block that forms the estate's principal visual and functional structure. The long portico offers a modern interpretation of the continuity of covered spaces characteristic of Bologna, while the main public facilities were planned on the opposite side of the road around interconnected pedestrian squares. Giuseppe Vaccaro coordinated the development and also designed several building types based on combinations of a two-storey H-shaped module raised on pilotis, with a central staircase serving four flats per floor. Different arrangements of this module generated neighbourhood units organised around pedestrian spaces, wash houses, drying areas, playgrounds, and small allotments, embodying a concept that integrated housing, services, and communal life.

In Il Treno, the modules are joined end to end to form small raised courtyards and gardens, allowing views and routes through the complex. At ground level, the structure is set back from the façade line to create the portico, which is lined by shops and provides access to stairwells enclosed by glazed walls. The portico therefore performs a dual distributive and urban role, serving as a continuous sheltered route and a place of interaction between commercial activities and the street. The residential volume above is capped by a deeply

Figure 1
General view of
Il Treno, in the
still-under-construction
Barca neighbourhood.





Figure 2
View of the
construction site.

projecting roof, while the long elevations are characterised by a regular sequence of openings and full-height sliding timber shutters.

The entire complex is based on a high degree of standardisation, adopted to contain costs and simplify construction. The load-bearing structure comprises reinforced-concrete frames set out on a 4.90×4.90 m grid; beams, columns, and floor slabs are dimensioned and repeated according to the same grid, which governs the organisation of the flats, stairwells, and commercial modules. Along the portico, the structure remains exposed, with recessed columns and beams supporting the volume above. The 28–30 cm perimeter infill walls are built of solid brick as cavity walls, with an outer brick leaf, an inner leaf, and an intervening cavity. The original windows have galvanised sheet-steel frames and are screened by sliding timber shutters, whose guide system is incorporated into the beam band. The 30 cm floor slabs are of composite clay-block and concrete construction. The roof, also of composite clay-block and concrete and 25 cm thick, consists of shallow-pitched planes clad in galvanised sheet metal. The estate was served by a central heating plant designed by Vaccaro and Amaturo and located to the east.

Previous interventions

The ground-floor gardens were converted to parking. Shortly before the present intervention, an energy-upgrade project was carried out in several ground-floor commercial units. The shop-front windows and the ribbon glazing above were replaced with new PVC frames and insulating glass in place of the original iron frames and single glazing. The roller-shutter box was also insulated internally and some of its components replaced.

Pre-intervention general conservation conditions

The estate as a whole was in a critical condition owing to the obsolescence of its buildings and its physical separation from the city. The predominantly publicly owned buildings were in poor repair, particularly their façades. The windows had inadequate weathertightness and the heating systems were malfunctioning. From a social perspective, numerous regeneration programmes had been implemented over the previous twenty years.

Specific environmental or climatic pressures

Bologna's climate, characterised by hot, humid summers and frequent heatwaves, exposes the building to the risk of summer overheating, with consequences for comfort within the dwellings.

Figure 3
End elevation and
concave façade of
Il Treno after the
intervention.



NEW INTERVENTION

2021 - ongoing

Alessandro Psimitis, Fabio Molinari, Gabriele Roberto

The energy upgrade of Il Treno della Barca was initiated in 2021 by the condominium association, comprising private owners and ACER Bologna, with funding from the 110% Superbonus scheme. The project concerned only the two residential floors and comprised a coordinated series of works to the opaque envelope, without altering the circulation layout, uses, or central heating system connected to the estate's district-heating network. The intervention therefore focused on reducing heat loss through the opaque elements.

The development of the technical solutions took account of the building's recognised historical and documentary value under municipal planning provisions and the resulting requirement for review by the Commission for Architectural and Landscape Quality. The Commission required original photographs and drawings to be studied in order to reconstruct the complex's compositional, constructional, and colour scheme and to identify the representative features of Giuseppe Vaccaro's work. These included the continuity of the portico, structural modularity, the rhythm of the elevations, and the relationship between openings, projections, and sliding shutters. Since 2021, Il Treno della Barca has also formed part of the serial UNESCO World Heritage property The Porticoes of Bologna, as a modern interpretation of the Bolognese portico. Approved by the Commission in June 2022, the project was presented to the 2023 UNESCO World Heritage Centre – ICOMOS advisory mission, which made no specific recommendations.

The roof was upgraded by renewing the covering and installing profiled-sheet-metal sandwich panels incorporating a 12 cm polyurethane layer above the existing structure. The solution reproduces the form and general appearance of the previous roof while increasing thermal resistance without intervention to the soffit of the slabs. The floors above the portico were instead insulated at soffit level with 10 cm polyurethane panels finished with render. The new continuous layer improves the floor's thermal performance but changes the perception of surfaces originally characterised by the legibility of the reinforced-concrete frame.

The vertical envelope was treated selectively. The end walls and elevations facing the internal courtyards received a 12 cm expanded-polystyrene external thermal insulation system, detailed around openings and projecting elements. The long curved east- and west-facing elevations were excluded to preserve their original character, defined by the sequence of openings, the depth of the projections, and the system of sliding timber shutters. The strategy



Figure 4
The portico with commercial premises after the intervention.

concentrated alterations on surfaces less directly visible from the street, limiting changes to the principal elevations.

The initial design envisaged retaining the exposed reinforced-concrete frame on the end walls and the soffit of the portico. The application of insulation and new finishes, however, made it impossible to preserve its material expression; the structural rhythm was therefore reintroduced through colour differentiation on the rendered surface. The intervention thus retains a graphic reading of the original grid, while replacing the physical presence of exposed concrete with a surface representation. Overall, the project adopts a differentiated transformation strategy, combining insulation of less prominent areas with conservation of the most character-defining elevations in an attempt to reconcile improved energy performance with the building's architectural legibility.



Figure 5
Detailed view after the intervention.

Objective of the envelope intervention

The intervention's primary objective was to improve the building's energy performance.

Extent of the envelope intervention

The intervention was limited to the residential floors and involved the roofs, end walls, courtyard elevations, and the soffit above the portico.

Solutions adopted for the envelope

The roof was renewed by installing profiled-sheet-metal sandwich panels incorporating 12 cm of polyurethane above the existing structure, reproducing the form of the previous covering. The end walls and internal courtyard elevations were selectively insulated with a 12 cm expanded-polystyrene external thermal insulation system, while the principal curved elevations were preserved. The soffits of the floors above the portico were insulated with 10 cm polyurethane panels finished with render. The structural grid was reinterpreted through colour differentiation on the insulated surfaces.

Other interventions

No other work was undertaken, as the intervention concerned only the energy upgrading of the envelope.

Knowledge framework, methodology and traceability

The project is based on an adequate body of knowledge that considers the building's recognition as a work of historical and documentary interest, its original compositional characteristics, graphic and photographic documentation, and a preliminary energy assessment. The traceability of the process is strengthened by the Commission for Architectural and Landscape Quality's review of the intervention, although the available documentation does not allow the depth of the material and hygrothermal investigations or the post-intervention outcomes to be fully verified.

Technical adequacy and compatibility of the adopted solutions

The adopted technical solutions improve the performance of the envelope while limiting interference with the principal elevations: insulation is applied to the roof, end walls, courtyards, and portico soffit, while the reinforced-concrete frames are evoked through colour differentiation. Compatibility is generally adequate in formal and performance terms; however, discontinuities between insulated and uninsulated surfaces may create critical junctions, with potential thermal bridging and uneven hygrothermal behaviour across the envelope.

Degree of reversibility

The intervention does not involve extensive demolition, but its reversibility is limited. The application of external insulation systems, reinforced base coats, mechanical fixings, and adhesives to the walls, portico soffit, and roof introduces bonded layers and fixing systems that would be difficult to remove without altering the substrates.

Impact on the formal and spatial configuration

The intervention does not alter the spatial arrangement or overall perception of the volume: its outline, curving form, continuous portico, horizontal articulation, and the role of the sliding shutters on the principal elevations remain recognisable. Its impact is nevertheless perceptible on the end walls, in the courtyards, and beneath the portico, where external insulation, base coats, and increased thicknesses weaken the sculptural and material reading of the exposed reinforced concrete, partly replacing it with a colour-based reinterpretation of the original design.

Degree of conservation of original architectural elements

The intervention retains the complex's overall identity, settlement logic, continuous portico, and principal elevations. Some original surfaces are concealed by insulation, so the reinforced-concrete system remains legible in part through a colour-based reinterpretation.



Figure 6
The convex façade with its distinctive sliding shutters.

GRATTACIELO A PORTA SAN PIETRO

Italy, Emilia-Romagna, Reggio Emilia

1950 - 1953

Cooperativa Architetti e Ingegneri di Reggio Emilia

ORIGINAL DESIGN

The Porta San Pietro skyscraper occupies a strategic location in Reggio Emilia between the historic centre and the ring-road avenues, on the site of one of the former customs houses, at a key urban crossing and gateway to the centre. Commissioned in the early 1950s, the Cooperativa Architetti e Ingegneri prepared an unrealised master plan for the entire area that also envisaged a second tall building replacing the other customs house. Completed in 1953, the tower became a symbol of post-war reconstruction and the city's modernisation along the route to the railway station.

The building rises thirteen storeys above ground over a basement and has a Y-shaped plan adapted to the street alignments, increasing the number of outlooks and providing varied orientations. The composition has a clear tripartite organisation of base, residential body, and crown. At ground level, a through-portico supported by tall circular columns gives access to the entrance hall, commercial premises, and café. The recessed, fully glazed first floor contains offices and reinforces the visual separation between the base and the tower. The opaque ground-floor surfaces are clad in travertine slabs, while a band of turquoise glazed ceramic marks the floor line; the columns are faced with matt green mosaic tiles.

The residential floors, originally clad in pale-grey glass mosaic, contain three flats of different sizes, one offset from the other two in response to the geometry of the plan. All units have generous loggias. Set back from the volume below, the penthouse contains a single dwelling surrounded by perimeter terraces and sheltered by a cantilevered canopy that defines the crown of the tower. Intended for the emerging entrepreneurial middle class, the flats incorporated modern features including underfloor heating and internal refuse chutes. In some cases, the architects also designed the interiors, with terrazzo floors and sliding timber-and-glass partitions.

The load-bearing structure consists of reinforced-concrete frames. The 30 cm composite clay-block and concrete floor slabs comprise 20 cm of structural depth and are built with lattice-girder joists with clay soffit units and hollow clay blocks; the unusually deep finishing build-up accommodates the underfloor heating system. The flat roof uses the same

Figure 1
General view in the
1960s.





Figure 2
View of the skyscraper
from the west.

construction. The infill walls consist of two 10 cm brick leaves separated by an uninsulated and unventilated cavity varying from 5 to 10 cm.

On the upper floors, the external surfaces are clad in glass mosaic tiles, except for the rendered spandrel panels, which are recessed from the adjacent surfaces. At ground and mezzanine levels, beneath the portico and alongside the extensive glazing, the opaque areas are faced with travertine and turquoise glazed ceramic. The loggia and balcony parapets consist of corrugated precast-concrete panels; on the west and north elevations, some loggias are screened by corrugated clay elements. The original timber windows combine pivoting and sliding movements and provide a compression seal around the perimeter. In the loggias, they are paired with sliding shutters, while the windows have roller shutters housed in uninsulated boxes. Heating has been centralised since construction, connected to the municipal district-heating network and distributed through an underfloor radiant system; domestic hot water is provided by individual electric storage heaters.

Previous interventions

The original mosaic-tile cladding was replaced in the 1980s; traces of the initial finish survive within the loggias. Most of the original windows were also replaced over time. In 2011–2012, ZAA–Zamboni Associati Architettura carried out work on the ground- and mezzanine-level façades.

Pre-intervention general conservation conditions

Before the intervention, the building suffered from substantial heat loss, localised detachment of mosaic tiles, and deterioration of façade details, particularly the parapets. The existing building services were also affected by obsolescence and inefficiency.

Specific environmental or climatic pressures

As the building is more than 35 m high, several design decisions, particularly those concerning envelope materials, had to comply with the fire-safety requirements for residential buildings established by Ministerial Decree 25/01/2019.

Figure 3
South-east façade with
the mosaic cladding
removed during the
initial stages of
intervention.



NEW INTERVENTION

2020 - 2024

ZAA – Zamboni Associati Architettura (Andrea Zamboni – architect, Maurizio Zamboni – engineer)

The refurbishment of the Porta San Pietro skyscraper was developed from an in-depth understanding of the building, the changes made over time, and its principal conservation, structural, and energy-related issues. Awareness of the specific concerns involved in conserving modern architecture guided the search for a balance between seismic improvement, enhanced envelope performance, and retention of the tower's architectural image. Although the outcome is not wholly conservative in material terms, it seeks to preserve the overall legibility of the building through solutions compatible with its visual character.

Carried out between 2022 and 2024 using the Sismabonus and Superbonus incentives and involving a general contractor, the works encompassed the entire envelope of the residential floors, with a total heat-loss area of approximately 6,875 m². The ground and mezzanine floors, characterised by extensive glazing and high-quality stone and ceramic cladding, were excluded.

Structurally, local strengthening was undertaken to prevent out-of-plane failure of the infill walls and improve the behaviour of the perimeter beams and balcony slabs. This work required removal of the mosaic-tile cladding, which had already been replaced in the 1980s. Energy performance was improved by installing external rock-wool insulation, insulating the roof, replacing the windows with new high-performance units, and adding solar shading. The new sliding shutters reinterpret a strongly character-defining original feature while updating its operation and performance. The external surfaces were reclad in glass mosaic matching the original colour found within the loggias. Photovoltaic panels serving the communal areas were installed on the roof.

New internal risers were installed in the stairwell to optimise distribution from the central heating system, while the gas connections to the individual units were adapted on the west elevation. The intervention did not otherwise include the existing heating system or domestic hot-water production. The two lifts were replaced and a stairlift installed, improving accessibility within the communal stairwell without altering the original circulation layout.

Installation of the external insulation required particular attention to the most delicate architectural junctions, especially at the masonry reveals of the loggias and the balcony slabs. Higher-performance insulation was used locally to limit thicknesses; the design and position of the parapets were consequently revised to conceal the increased depth of the slab edges



Figure 4
Detail of the loggia
with a microperforated
sheet-metal balustrade
and sliding shutters
with adjustable
louvres.

and maintain the original perception of the loggias. The adopted solutions introduce perceptible changes at the scale of detail and replace some existing materials, but they retain the legibility of the elevation composition, the relationship between solids and voids, and the principal elements defining the tower's architectural identity.

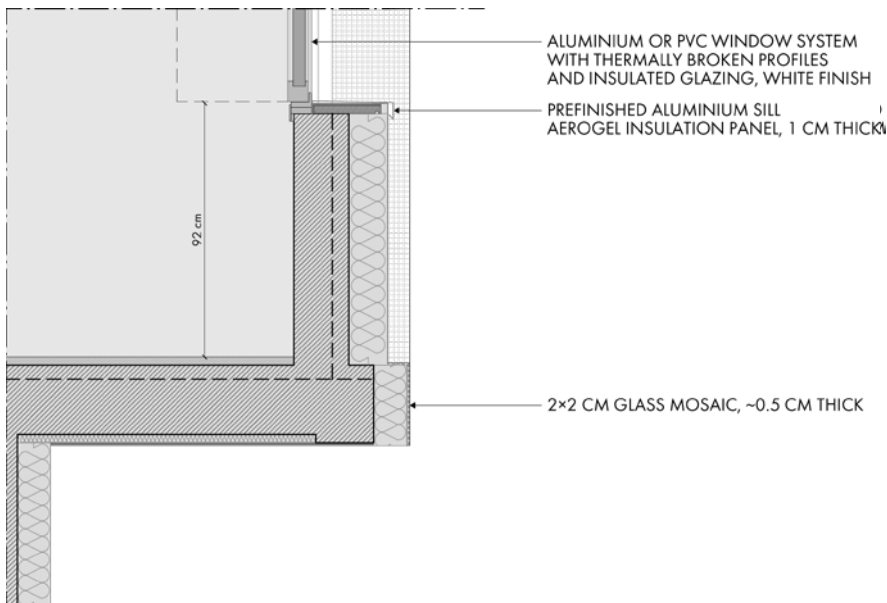


Figure 5
Construction detail of
the panel beneath the
window.

Objective of the envelope intervention

Using the Superbonus and Sismabonus incentives, the intervention aimed to improve the energy performance of the envelope by two energy classes and enhance the building's seismic behaviour.

Extent of the envelope intervention

The intervention involved the entire envelope of the residential floors, excluding the basement, ground, and mezzanine levels.

Solutions adopted for the envelope

The vertical surfaces received a 14 cm external thermal insulation system of lamellar rock wool; 14 cm graphite EPS panels were used at penthouse level. The penthouse roof was insulated above the slab with 12 cm rigid polyisocyanurate foam (PIR) panels incorporating an expandable-graphite fire-retardant treatment (Stiferite Fire B). Ground-floor slabs exposed to external spaces were insulated at soffit level with 14 cm of rock wool, while the soffits of the floors above the portico were clad. The work also included new external glass-mosaic cladding, replacement windows, and new sliding shutters with adjustable louvres.

Other interventions

The lifts were replaced and a stairlift installed to remove existing access barriers. Photovoltaic panels were installed on the roof to supply electricity to the communal areas. The entrance doors to the individual dwellings were replaced so that they would provide REI-rated fire compartmentation from the stairwell.

Pre-intervention consumption

244.12 kWh/m² year

Post-intervention consumption

124.59 kWh/m² year

Certifications / Awards

Energy performance class E (APE, 2023).

Knowledge framework, methodology and traceability

The intervention is founded on a well-structured body of knowledge, integrating a historical and critical reading of the building and its urban role with analysis of previous alterations and the project's technical documentation. The objectives of the energy and seismic improvements explicitly seek to avoid altering the image of the tower and provide a coherent basis for the design decisions.

Technical adequacy and compatibility of the adopted solutions

The adopted solutions are largely tailored to the specific building and combine envelope upgrading with protection of the tower's architectural image. The rock-wool insulation, mosaic finish matching the original colour, roof insulation, windows, and solar shading improve energy performance without disrupting the overall legibility of the elevations. The assessments document a significant improvement in performance, despite the introduction of non-original materials and construction details.

Degree of reversibility

The intervention has limited reversibility because the new envelope build-ups and the replacement of façade cladding and components are integrated with the substrate and difficult to dismantle. Retention of the tower's visual character therefore does not correspond to a high degree of material recoverability of the previous configuration.

Impact on the formal and spatial configuration

The impact on the formal and spatial arrangement is limited in the overall perception of the tower but becomes more evident at the scale of detail. The outline, tripartite composition, recessed penthouse, rhythm of the loggias, and colour of the cladding remain recognisable. The redesign of the parapets helps control the visual effect of the increased thickness introduced by the insulation. The new insulation build-ups and replacement of windows and shading devices nevertheless give the elevations a different material and constructional definition, most perceptible in the depth of the openings and the façade profiles.

Degree of conservation of original architectural elements

Conservation of the original architectural elements is partial but remains legible. The load-bearing structure, outline, volumetric composition, rhythm of the loggias, recessed penthouse, and relationship with the base are retained. Envelope elements are conserved selectively: some surfaces are incorporated within the new build-ups, while the windows, shading devices, and parapets are replaced with components consistent in design and compositional role. Retention of the building's architectural identity therefore does not amount to complete material conservation.



Figure 6
The skyscraper after completion of the intervention.

CITÉ DU LIGNON

Switzerland, Geneva, Vernier

ORIGINAL DESIGN

1962 - 1971

Addor & Julliard (Georges Addor, Jacques Bolliger, Dominique Julliard), Louis Payot

The Cité du Lignon is one of the most significant achievements of European post-war urbanism. Conceived in the 1960s as a self-sufficient satellite city in response to Geneva's rapid population growth, it combines exceptional residential density with extensive parkland and a comprehensive system of community facilities. The complex consists of a continuous linear building more than one kilometre long, following the topography through a broken alignment and rising between eleven and fifteen storeys, together with two detached towers of twenty-six and thirty storeys. The site plan avoids direct confrontation between building fronts, giving the flats in the original master plan, housing, two churches, a primary school, a shopping centre, and a public square were embedded within a broad green framework, with an approximate ratio of one square metre of floor area to one square metre of land. The scheme recalls biological models and contemporary research on the idea of 'habitat', yet translates those references into an urban form of marked territorial and architectural autonomy. Its architectural quality derives from the close integration of urban figure, structure, and industrialised envelope. The load-bearing system introduced tunnel-form construction in Switzerland at an unprecedented scale: transverse reinforced-concrete shear walls and solid floor slabs approximately 14–16 cm thick were cast simultaneously in reusable steel forms on a regular 3.90-metre module. Shallow foundations, composed of footings and grade beams, bear on stable glacial moraine; reinforced-concrete walls retain the garages and basement levels, while prefabricated stair flights are incorporated into the vertical circulation cores. Modular repetition accelerated construction, ensured structural consistency, and coordinated building services, including electrical conduits embedded directly in the concrete pours. This massive concrete framework is paired with approximately 125,000 square metres of prefabricated curtain wall. Full-height panels measuring 2.80 × 2.40 metres or 2.80 × 1.80 metres combine an internal pinewood frame, which supports the glazing and contributes to thermal control, with an external aluminium skin that provides weather protection and visual continuity. Transparent sections alternate with opaque tempered-glass infill panels, originally backed by mineral insulation, in a rhythmic sequence that modulates light, shadow, and reflection across the elevations. The loggias apply the same principle through layered panels of aluminium sheet, rigid insulation, and gypsum board. Non-load-bearing interior partitions consist of prefabricated gypsum blocks or gypsum board on timber framing; slabs

Figure 1
Aerial view of the
complex under
construction, 1969.





Figure 2
View of the park with
children playing,
historical photograph.

above common exterior walkways are insulated with wood-wool panels. Flat roofs employ multilayer bituminous waterproofing, insulation, and protective gravel ballast, with acrylic dome skylights positioned above service shafts and roof-access stairs. The original heating system is centralised, with district heating supplying hydronic radiators beneath the curtain wall spandrels. North-south orientation, dual-aspect flats, cross-ventilation, and abundant daylight integrate passive strategies into the project's overall environmental logic. The Cité du Lignon therefore demonstrates that industrial standardisation can generate not only construction efficiency but also spatial quality, architectural identity, and continuity between domestic life and nature. Its extraordinary size does not result in a monolithic image: the broken alignment, changes in height, and patterned curtain wall give plasticity and visual variation to the immense volume. Protected by Geneva's 2009 Plan de Site, the complex remains a fundamental reference for collective housing and for the conservation of modern architectural heritage in Europe.

Previous interventions

Prior to the 2009 heritage listing, the complex suffered from fragmented maintenance. Many individual owners and management entities performed unauthorised updates to the building envelope. The most significant issue was the piecemeal replacement of the original pine and aluminium window frames with low-quality white PVC units. These interventions altered the visual unity of the kilometre-long façade and disregarded the technical specificities of the original box-type curtain wall system, highlighting the urgent need for a unified conservation and energy strategy for the whole site.

Pre-intervention general conservation conditions

By 2008, the building envelope showed signs of significant technical obsolescence and material fatigue. The original curtain wall suffered from poor air and water tightness due to the failure of initial caulking and the absence of modern pres-

sure joints. Thermal performance was highly inadequate, leading to excessive energy consumption that failed to meet the new Swiss SIA 380/1 standards. Despite these issues, the primary concrete structure remained sound, and the architectural coherence was still legible, albeit threatened by unauthorised PVC modifications and material decay.

Specific environmental or climatic pressures

The complex faced intense pressure to adapt to Swiss energy laws requiring a drastic reduction in heating needs. The massive surface area of the glass envelope made it highly vulnerable to thermal loss in winter and solar gain in summer, necessitating a specialised intervention that balanced heritage preservation with high environmental metrics.

Figure 3
Aerial view of the
complex, 2012.



NEW INTERVENTION

2008 - ongoing

EPFL-TSAM (Franz Graf, Giulia Marino – scientific research, diagnostics and conservation guidelines),
Jaccoud & Spicher Architectes Associés (architectural design, executive design and site management)

The intervention on the Cité du Lignon, coordinated by EPFL's TSAM laboratory, is a pioneering example of 'silent restoration', reconciling the preservation of a high-density modern housing complex with contemporary energy-reduction requirements. The design process began in 2008 as a multidisciplinary research programme grounded in detailed building analysis and experimental verification. Historical studies, surveys ranging from 1:50 to 1:5, and documentation of unauthorised alterations identified materials, components, construction variants, and weaknesses in the envelope. An energy assessment developed with the EnerCad model and measured against SIA 380/1 standards quantified heat loss, thermal bridges, inadequate air and water tightness, and deterioration of the original insulation. The decision-making phase used a multicriteria matrix to compare four scenarios – Options A, B, C, and D – according to heritage value, technical feasibility, cost, and potential energy savings. A decisive step was the construction of full-scale prototypes directly on Building 49, which tested installation methods, construction schedules, performance, and compatibility with continued occupancy. The results supported Option C, a conservation-based refurbishment of the envelope designed to reduce energy consumption by approximately 70% without altering the complex's exterior appearance. The prototype campaign also converted technical uncertainty into shared evidence, allowing conservation goals, budgets, and site constraints to be evaluated together. The intervention preserves the original curtain-wall skin, retaining the aluminium profiles and exterior glazing layers in order to safeguard the visual continuity of the façade, which extends for more than one kilometre. The inner layers are upgraded through new timber elements added to the existing frames, aligned with the historic profiles and imperceptible from the exterior. Original single glazing is replaced with high-performance 4/20/4 mm insulating glass units, with a U-value of no more than 1.1 W/m²K, a tempered outer pane, and an ACS spacer. In the opaque panels, the original mineral insulation is replaced with more efficient materials, including rigid polyurethane foam, substantially increasing thermal resistance. New EPDM gaskets and supplementary seals improve air and water tightness; functional components such as the manual cranks for the Venetian blinds are retained or reproduced from original models, preserving both user experience and material integrity. Rather than applying wholesale replacement with standardised products, the project develops custom solutions compatible with the building's



Figure 4
View of the square
between the towers,
2012.

construction logic. A cost-benefit analysis allows owners and management bodies to select intervention levels consistent with their financial resources, supported by streamlined administrative procedures and energy incentives. The operation, covering over 100,000 square metres of façade and involving about ten thousand residents, requires rigorous logistical planning, phased by sector to limit noise, dust, access times, and interference with daily life. The research compiled the technical solutions and operating rules in a 'répertoire ad operandum' attached to the heritage designation. This manual establishes unambiguous criteria for future work, preventing fragmented ownership from generating inconsistent maintenance or progressive alterations to the envelope. The case demonstrates that conserving late twentieth-century heritage can be based on diagnosis, testing, and incremental implementation, transforming legal protection into an active management tool.

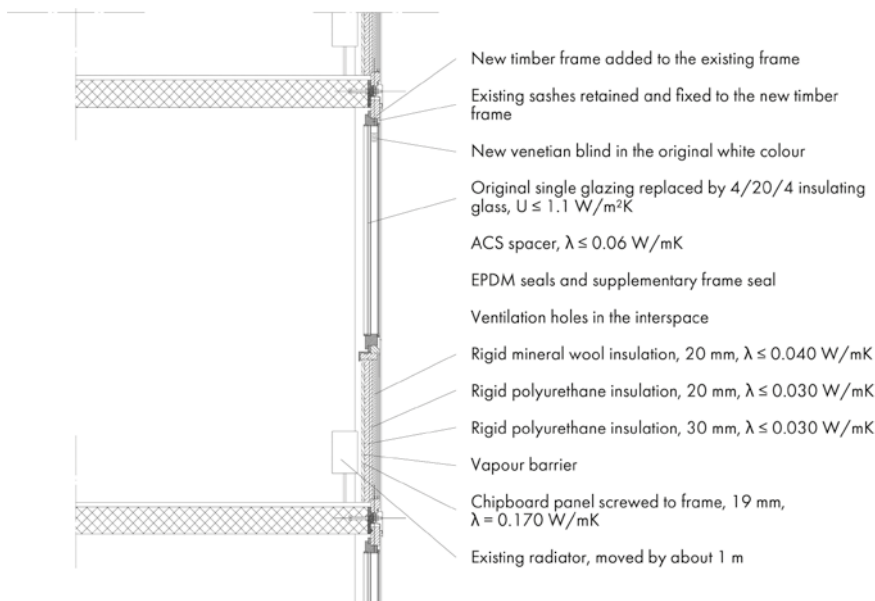


Figure 5
Detailed section
through the façade of
the typical floors.

Objective of the envelope intervention

The primary goal is to achieve a 70% energy reduction while scrupulously preserving the original material identity and visual appearance of the 125,000 m² curtain wall, in compliance with SIA 380/1.

Extent of the envelope intervention

Full-scale restoration of over 100,000 sqm of building envelope, including linear blocks, towers, walkways, and ground-floor halls, conducted while the complex remained fully inhabited by residents.

Solutions adopted for the envelope

Option C (Refurbishment) was adopted: the original aluminium skin and outer frames were conserved and cleaned. A new internal timber frame was added to host high-performance 4/20/4 insulating glass ($U \leq 1.1 \text{ W/m}^2\text{K}$). Opaque units were upgraded with 20–30 mm polyurethane rigid foam. New EPDM seals and ACS spacers improved airtightness. These bespoke solutions are invisible from the exterior, maintaining the historical 'silent' aesthetic. By avoiding standard products, the project respects the 1963 industrial logic while meeting modern Swiss energy laws and heritage conservation standards for the whole site.

Other interventions

Stairwells and halls were refurbished, restoring Trani stone surfaces and original 1963 colour schemes. Modern lighting and fire-rated EI 60 doors were installed. Entrance halls were thermally isolated to become 'cold zones', reducing the building's heated volume. Internal hydronic radiators were shifted inward by 100 mm to accommodate the new window frames. Technical risers for ventilation and electricity were modernised. All interventions were codified in the 'répertoire ad operandum' to guide future owner maintenance.

Pre-intervention consumption

~ 132 kWh/m² year

Post-intervention consumption

~ 40 kWh/m² year

Certifications / Awards

Minergie standard (target).

Knowledge framework, methodology and traceability

The project developed through a multidisciplinary process based on historical research, envelope surveys, material diagnostics, and energy simulations. Four scenarios were compared according to conservation, technical, and economic criteria and verified through full-scale prototypes. The

approved solutions were compiled in an operational manual attached to the heritage protection plan, ensuring traceability and consistency in subsequent interventions.

Technical adequacy and compatibility of the adopted solutions

The adopted solution preserves the external aluminium skin and intervenes primarily on the interior through new timber frames, insulating glazing, seals, and insulation of the opaque panels. The components were custom-developed and verified through simulations and full-scale prototypes under real conditions, avoiding incompatible standard window systems. The intervention improves airtightness and thermal performance without altering the visual continuity of the façades.

Degree of reversibility

The intervention limits alterations to the inner layers of the modules while preserving the external aluminium skin. New frames, seals, and selected components are installed using replaceable systems, facilitating maintenance and future upgrades. Reversibility is nevertheless incomplete, since the original glazing, insulation within the opaque panels, roof waterproofing, and some skylights are replaced, resulting in permanent changes to the envelope build-up.

Impact on the formal and spatial configuration

The interventions are substantially imperceptible from the exterior and preserve façade continuity, the modular rhythm of the panels, the alternation of transparent and opaque elements, and the slender articulation of the aluminium profiles. Alterations are concentrated within the inner layers of the envelope and do not affect the volumetric or spatial configuration of the complex. The adoption of coordinated solutions also allows the progressive recovery of façade coherence, previously compromised by isolated replacements with PVC windows.

Degree of conservation of original architectural elements

The project preserves the external aluminium surfaces, existing frames, and recoverable sashes, maintaining the modular system and the original façade configuration. Replacements primarily concern glazing, seals, internal insulation, and components that are deteriorated or technically inadequate; new elements are integrated on the interior and do not alter the external skin. Conservation therefore prevails for the elements that define the architectural identity of the envelope.



Figure 6
View of the façade of the main block, 2012.

KLEIBURG

The Netherlands, North Holland, Amsterdam

1965 - 1971

Fop Ottenhof, Siegfried Nassuth (urban masterplan)

ORIGINAL DESIGN

The Kleiburg residential complex, designed by architect Fop Ottenhof and completed in 1971, is one of the most imposing and radical examples in Amsterdam's Bijlmermeer district, developed by Siegfried Nassuth. Integrated into an ambitious master plan inspired by the modernist principles of the Athens Charter and research conducted within CIAM, the building embodies the ideal of the 'vertical garden city'. Kleiburg was conceived as a megastructure: a linear block following a honeycomb-like zigzag pattern and extending for 400 m. The building comprises eleven storeys, consisting of a ground-floor plinth and ten residential levels. The block is integrated into an extensive park system organised according to a hexagonal grid and articulated by ponds and pedestrian paths that complete the modernist urban landscape.

The original organisation was based on the strict functional separation of circulation flows. Elevated pedestrian 'streets in the sky' on the first floor were connected to multi-storey car parks, keeping cars separate from the park level. This configuration relegated the ground floor to a predominantly service-oriented zone fragmented by numerous pedestrian underpasses. The plinth was also occupied almost entirely by 500 individual storage rooms, one for each dwelling. The result was a 'dead zone' at the base of the complex, lacking social vitality and visually impermeable to its surroundings. The 500 dwellings were divided into four principal types, ranging from two to five rooms, and organised as through-plan units. Each unit extended across the full 10.40 m depth of the slab. This arrangement provided natural cross-ventilation and maximised daylight from both the access-gallery and balcony sides.

In architectural terms, Kleiburg displayed a distinctly Brutalist character, defined by its massive exposed structural frame and gallery parapets made of precast concrete panels with an exposed-aggregate finish. The load-bearing structure consists of a framework of precast reinforced-concrete panels and transverse load-bearing walls arranged according to a constant modular grid. The structural depth of 10.40 m corresponds to that of the dwellings, establishing a direct relationship between spatial organisation and constructional logic. The PAL-type foundations use reinforced-concrete piles driven into the stabilised sand

Figure 1
Historical photograph
of the building from
the south-west.





Figure 2
Aerial view of the
complex from the
north-east, 1973.

layer characteristic of Amsterdam's polder landscape. The floor structures consist of reinforced-concrete slabs with a standard thickness of approximately 14 cm. The original envelope comprised external walls made of precast concrete panels with an exposed-aggregate finish, reinforcing the building's distinctive Brutalist materiality. The vertically proportioned external windows were fitted with high-quality solid-timber frames, originally painted white. The flat roof consisted of a structural slab, an 8 cm layer of hollow-core insulation panels and a bituminous waterproofing membrane.

External partitions, such as the dividers between balconies, consisted of galvanised steel frames with wired-glass infill panels. The heating systems were centralised and connected to the municipal district-heating network; heating and domestic hot water were distributed through vertical risers located within fixed service cores. The electrical system followed the same centralised vertical distribution through the service shafts.

Previous interventions

During the 1980s, three external lift towers were added to the façade to address the insufficiency of the original internal systems, disrupting the building's horizontal linearity. In the 1990s, the urban restructuring of Bijlmermeer led to the removal of elevated roads, rendering the first-floor 'interior street' connecting to car parks obsolete. Many surrounding blocks were demolished, leaving Kleiburg isolated from the original urban fabric. These changes contributed to the building's severe technical decline and high vacancy rates before the start of the 2011 works.

Pre-intervention general conservation conditions

Before the 2011 renovation, the building was in a state of severe dilapidation and abandonment, having remained vacant for several years following an official evacuation. It had been officially

slated for demolition, with the necessary permits already granted. Kleiburg stood as the 'last man standing' of an urban system that had been largely dismantled through the removal of elevated walkways and the destruction of adjacent honeycomb blocks. Its concrete surfaces were degraded by layers of peeling paint, and its ground floor was a dark, unhealthy, and impenetrable 'dead zone'.

Specific environmental or climatic pressures

The building is located in a polder area at an elevation of 2.70 metres below sea level (NAP). This geophysical location required deep pile foundations to reach the load-bearing sand layer and exposed the megastructure to constant climatic stress and strong wind currents typical of open polders, impacting the envelope's long-term maintenance.

Figure 3
View of the building
from the metro.



NEW INTERVENTION

2011 - 2016

NL Architects & XVW architectuur

The DeFlat intervention (2011–2016) transformed Kleiburg from a dilapidated structure on the brink of demolition into a vibrant residential community through a strategy of ‘sublimation’ rather than radical alteration. Led by NL Architects and XVW architectuur, the project introduced a revolutionary *klusflat*, or do-it-yourself, business model, which fundamentally shifted the responsibility of internal fit-outs to the future owners. The architects focused their efforts on renovating the collective elements – the main structure, lifts, galleries, and central installations – while delivering the 500 flats as empty, unfinished shells. This approach minimised initial investment and allowed for unprecedented typological flexibility, as owners could purchase multiple modules and combine them horizontally or vertically, breaking the rigid standardisation of the 1970s. A primary architectural objective was the ‘activation’ of the ground-floor plinth. The dark, impenetrable ‘dead zone’ of the original storage units was dismantled; the 500 individual lockers were relocated to the upper residential floors, sacrificing one flat per building arm at each level. This move liberated the entire 400-metre-long base, which was reprogrammed with live-work units, commercial spaces, and social facilities. The original pedestrian underpasses, previously small and low, were regrouped into fewer, larger, and more scenic openings that established a generous connection between the building and the surrounding park. The Brutalist aesthetic of the façade was restored through a meticulous process of sandblasting. Over the decades, the concrete had been obscured by layers of flaking paint; stripping these layers revealed the high-quality precast aggregate texture, which the architects treated with the same dignity as natural stone. The original solid hardwood window frames were preserved, repainted, and upgraded with high-performance double glazing. On the gallery side, opaque panels were replaced with double glass to liven the façade and turn it into a personal carrier of identity. To maintain architectural unity while allowing for individual expression, the architects provided residents with a ‘Lego set’ of standardised façade modules. These options included sliding doors, double doors, or recessed entries, creating a varied but harmonious ‘interface’ along the galleries. The 1980s external lift towers, which had disruptive verticality, were removed, and new lift systems were integrated back into the original structural cores. By retaining the massive concrete frame and its embodied carbon, the project stands as a landmark of sustainable reuse. The intervention successfully reconciled the building’s heroic scale with contemporary needs for domestic variety, earning the 2017 EU Mies van der Rohe Award. The design process



Figure 4
View of the building
from the north-east.

was characterised by a pragmatic and intimate ‘knowledge-in-action’ approach. Lacking a formal heritage listing at the project’s start, the team conducted a detailed survey of the Intervam prefabrication system to assess the feasibility of structural modifications. Technical diagnostics focused on identifying the distribution of rebar within load-bearing panels to facilitate horizontal and vertical unit connections. A significant constraint was discovered regarding the original PAL pile foundations, which were unevenly distributed; this led to a decision-making scenario where new ground-floor columns were aligned strictly with existing piles rather than following a regular grid. The energy diagnosis prioritised lowering consumption through shell improvements, specifically replacing original single-pane gallery panels with high-performance double glazing. Decisions were guided by a ‘Beauty in the Beast’ philosophy, revealing the original aggregate through sandblasting. Considered as a whole, the process documents a decision-making path grounded in knowledge of the building, according to compatible and controllable criteria.

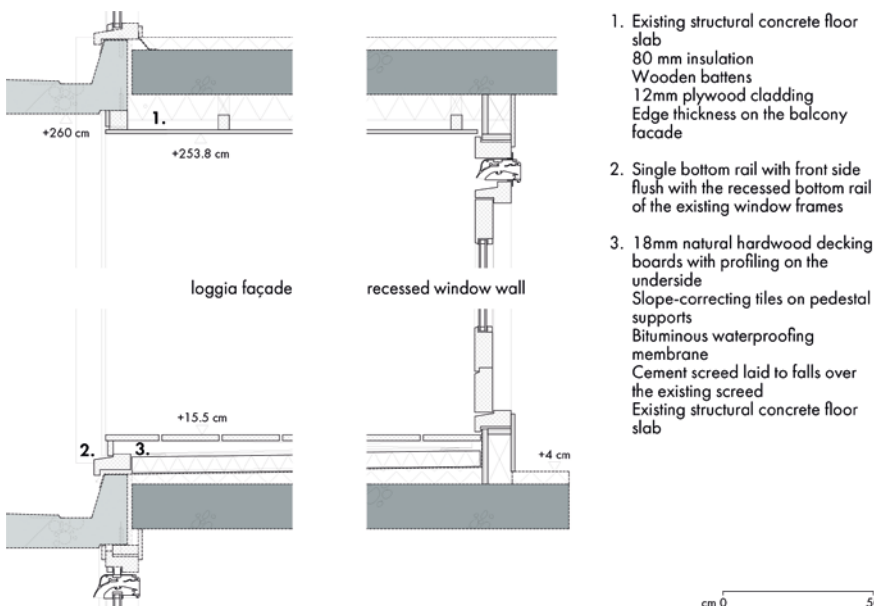


Figure 5
Detailed sections of
the loggia façade and
recessed window
system.

Objective of the envelope intervention

Sublimating the Brutalist frame via sandblasting, enhancing thermal performance through glazing upgrades, and fostering individual identity through a modular 'Lego set' façade project.

Extent of the envelope intervention

Comprehensive overhaul of the entire 400-metre façade: a fully glazed ground-floor plinth, double-glazed modular window replacements on all upper galleries/balconies and sandblasted original concrete.

Solutions adopted for the envelope

The architects employed sandblasting to strip decades of paint from the precast concrete panels, revealing the original aggregate. Opaque gallery façade panels were replaced with high-performance double glazing to enhance thermal comfort and visual transparency. A standardised 'Lego set' of window modules was developed for residents, including sliding and double-folding doors. The original solid hardwood frames were meticulously stripped and repainted. Large glazed fronts were installed at the ground level to enclose new live-work units and social spaces within the activated plinth.

Other interventions

The ground floor now accommodates shops, offices, and glazed flats opening onto the park. Three external 1980s lift towers were removed to restore the building's horizontal continuity, with new lifts integrated into existing cores. Structural 'break-throughs' were made in load-bearing cross-walls to allow for the combination of modules. Pedestrian underpasses were regrouped into larger openings. New continuous wooden handrails were added to galleries, and centralised vertical technical risers for heating and electricity were renewed.

Certifications / Awards

2017 Dutch Design Awards (Habitat, Future Award); 2017 European Union Prize for Contemporary Architecture – Mies van der Rohe Award.

Knowledge framework, methodology and traceability

The project is based on a survey of the prefabricated construction system, structural verification, and an assessment of the condition of the building envelope and services. Investigations into reinforcement layouts and foundations informed the openings introduced in load-bearing walls and the transformation of the ground floor. The design choices are justified in relation to the technical

and economic feasibility of the intervention, while the identification and prioritisation of architectural values emerge primarily through the adopted solutions.

Technical adequacy and compatibility of the adopted solutions

The solutions are calibrated to the prefabricated construction system and the architectural character of the building. Sandblasting removed deteriorated paint layers and re-exposed the finish of the concrete elements, while the existing timber frames were restored and repainted. Replacing the opaque gallery panels with insulating glazing improves both thermal performance and envelope transparency. The new ground-floor openings are integrated within the existing structural grid.

Degree of reversibility

Reversibility is limited by the extensive sandblasting of the concrete surfaces, the replacement of the gallery panels, and the introduction of new glazed enclosures at ground-floor level. The removal of the lift towers added in the 1980s and the openings made in the load-bearing walls constitute permanent transformations. The flexibility of the flats and the replaceability of window modules facilitate future adaptation, but do not offset the extent of the modifications introduced.

Impact on the formal and spatial configuration

The linear configuration of the structure, the continuity of the galleries, and the rhythm of the prefabricated elements remain recognisable. Removing the lift towers added at a later stage restores the horizontal character of the elevations. The impact remains perceptible, however, in the replacement of opaque panels with glazed surfaces, the variety of the new window units, and the transformation of the ground floor, which is made more open through new entrances, workspaces, and two-level dwellings.

Degree of conservation of original architectural elements

The intervention preserves the prefabricated concrete structure, galleries, parapets, and recoverable timber frames, maintaining the overall configuration of the large residential building. Conservation of the envelope is nevertheless selective: the opaque gallery panels are replaced with glazing, the ground floor is extensively reconfigured, and non-load-bearing internal partitions are removed. Conservation therefore primarily concerns the structure and overall configuration rather than individual components.



Figure 6
View of the 'reactivated' podium, with new openings and ground-floor spaces.

Figure 7
View of the access gallery and the new windows of the residential units.

PARK HILL

United Kingdom, England, Sheffield

ORIGINAL DESIGN

1955 - 1961

Jack Lynn & Ivor Smith (lead architects), Frederick Nicklin (collaborator), J.L. Womersley (city architect and coordinator)

Park Hill stands as one of the most iconic and ambitious examples of post-war Brutalist mass housing in the United Kingdom. Commissioned by Sheffield City Council and designed between 1955 and 1957 by architects Jack Lynn and Ivor Smith, with Frederick Nicklin, under the coordination of City Architect J.L. Womersley, the complex was completed in 1961. The project was conceived as a radical solution to the city's urgent need for high-density social housing following the clearance of mid-century slums. Philosophically, it was heavily influenced by the Smithsons' 'streets-in-the-sky' concept and Le Corbusier's Unité d'Habitation, aiming to translate traditional ground-level neighbourliness into a vertical urban format. The most distinctive architectural feature of the estate is its immense scale and serpent-like plan, consisting of five interlocking blocks that follow the steep natural topography of the site. To manage this slope, the architects maintained a continuous, horizontal roof-line across the entire complex. Consequently, the building's height scales from four storeys at its southern end to thirteen storeys at the northern end overlooking the city centre and railway station. This design choice ensures that open spaces between the blocks become progressively larger as the height increases, maximising the entry of sunlight, fresh air, and panoramic views for the residents. The façade is defined by an exposed reinforced-concrete structural grid, or 'H-frame', which remains the building's primary visual signature. Within this structural framework, the elevations are articulated by non-structural brick infill panels. These panels were originally produced in four specific shades – purple, terracotta, light red, and cream – arranged to reflect the internal layout of the dwelling modules and provide a sense of warmth and variation across the vast surface. Access to the flats is provided via wide cantilevered concrete galleries, located every three levels and known as the 'streets in the sky'. These three-metre-wide walkways were designed to accommodate milk floats and facilitate spontaneous social interaction, serving as communal front yards. The technological system of the Park Hill development was centred around its robust, cast-in-place reinforced-concrete H-frame structure. This exposed frame functioned as the primary load-bearing skeleton, providing the modular grid that allowed for diverse unit configurations while

Figure 1
Aerial view of the
complex, 1960.





Figure 2
View of the
characteristic 'streets in
the sky', 1961.

defining the building's aesthetic. Foundations were engineered to accommodate heavy loads on the hilly site, including significant geotechnical consolidation of old mine workings beneath specific blocks through grout injections. The façade utilised non-structural, solid brickwork infill panels meticulously selected in a tonal palette of four shades to provide visual texture and signify internal layout boundaries. The roofing system comprised flat reinforced-concrete slabs integrated into the primary frame, maintaining a consistent horizontal line; these areas hosted thirty-eight penthouse units and extensive public garden terraces finished with paved zones, planting soil, and children's play equipment like sand pits. Window systems originally consisted of white-painted wood frames, often full-height, set within the deep reveals created by the concrete grid to provide natural shading. Internally, partitions were constructed using a combination of masonry and concrete blocks to satisfy acoustic and fire safety requirements of the era. A pioneering feature was the Garchey refuse system, a water-borne waste management technology integrated into kitchen sinks.

Previous interventions

Following a period of severe decline, the first major intervention occurred in 1990 with the demolition of Block B at Hyde Park. The remaining blocks were refurbished in 1991 to serve as the athletes' village for the World Student Games event. The comprehensive, multi-phase regeneration led by Urban Splash began in 2007. Phase 1 (2007–2016), designed by Hawkins/Brown and Studio Egret West, involved stripping the structure to its H-frame and replacing original brickwork with vibrant, multi-coloured anodised aluminium panels to fundamentally rebrand the estate's identity for the new private market.

Pre-intervention general conservation conditions

By the late 1990s, Park Hill was in a state of advanced physical and social decay. Decades of underinvestment had transformed the once-celebrated

estate into a 'sink estate' associated with crime and vandalism. The concrete H-frame suffered from significant carbonation and structural leaks, while the original timber windows were thermally inefficient and rotted. The brickwork was heavily soiled by industrial pollution, and the communal galleries were perceived as unsafe. Many residential units and commercial spaces were boarded up, leaving the structure largely derelict prior to its 1998 listing.

Specific environmental or climatic pressures

The site's steep topography and history of mining required complex geotechnical engineering and mine consolidation. The estate was located on the leeward side of the Don Valley industrial zone to reduce smoke exposure; nevertheless, the exposed concrete megastructure faced severe climatic pressures caused by thermal bridging and moisture.

Figure 3
View of the complex
from the city.



NEW INTERVENTION

2015 - 2022

Mikhail Riches (lead architect), Austin-Smith:Lord (landscape design), Civic Engineers (structural design)

Park Hill Phase 2 represents the second chapter of the monumental regeneration of Europe's largest listed structure, a Grade II* Brutalist icon. Following the initial Phase 1 (2007–2016), which stripped the blocks to their concrete H-frame and replaced original brickwork with vibrant aluminium panels, this second phase led by Mikhail Riches (2018–2022) adopts a meticulous 'light-touch' philosophy. While Phase 1 was a radical rebranding to change public perception, Phase 2 acts as 'cultural archaeology', seeking to faithfully restore the building's material integrity. The intervention encompasses the central section of the serpent-like plan, providing 195 residential units for private sale and rent, alongside 2,500 m² of commercial space. The project successfully reconciles the building's historical status with modern living standards. A key architectural move is the retention and cleaning of the original 1950s bricks, whose shades of purple, terracotta, and cream are once again visible. This approach differs from Phase 3, Béton House, converted into student accommodation, while anticipating the conservation-led strategy now continued in Phase 4. In Phase 2, the architects reconfigured the internal layouts by eliminating problematic bedsits to unlock flexible knock-through flat types. All units now benefit from open-plan living areas oriented to maximise panoramic views over Sheffield, preserving the dual-aspect logic that ensures natural cross-ventilation. The 'streets in the sky' are revitalised; unlike the narrowed galleries of Phase 1, Phase 2 maintains the original 3.05 m width to foster neighbourliness. Security and identity are enhanced through small glazed panels next to front doors and patterned doormats that extend into the public walkway. The ground floor is transformed from a series of blind technical rooms into a vibrant urban interface, hosting a new double-height glazed lobby and commercial units like restaurants and bars that face the city centre. This active frontage replaces the previous 'no-go area' stigma with a welcoming quarter. The steep topography is managed through new courtyard landscaping by Austin-Smith:Lord, providing wildflower planting and pedestrian paths. Technically, the challenge of the uninsulated concrete frame – a massive cold bridge – was met with high-performance internal insulation. This allowed the exposed concrete to remain visible externally, satisfying conservation requirements while enabling a transition to a fully electric energy system. By focusing on fabric efficiency and nuanced colour accents on balcony reveals, Phase 2 demonstrates how Brutalist mass housing can be humanised without erasing its heroic past. It defines a mid-century modern quarter for Sheffield. This phase proves that the original vision was not



Figure 4
View of the residential
façade through the
landscaped grounds.

a failure of architecture, but one of maintenance, now rectified for a new generation. The design process began in 2015 with a competition by Urban Splash, in which architects were invited to live in the derelict blocks for two weeks to experience the site. This immersive historical and physical analysis helped the team uncover traces of past inhabitation, such as balcony colours and patterned linoleum, which informed the 'light-touch' strategy. The knowledge framework was supported by surveys of the concrete frame and original brickwork. Energy diagnosis used advanced thermal modelling by Greengauge to identify the most thermally leaky elements, especially balcony reveals. This was combined with hygro-thermal risk analysis of the external walls to optimise internal insulation placement while mitigating moisture risk. Decision-making shifted from the radical replacement adopted in Phase 1 towards a retentionist model, favouring the cleaning of the original masonry rather than overcladding it. As a whole, the project confirms a synthesis of material continuity and functional transformation, making the principal design choices traceable and preserving significant architectural features.

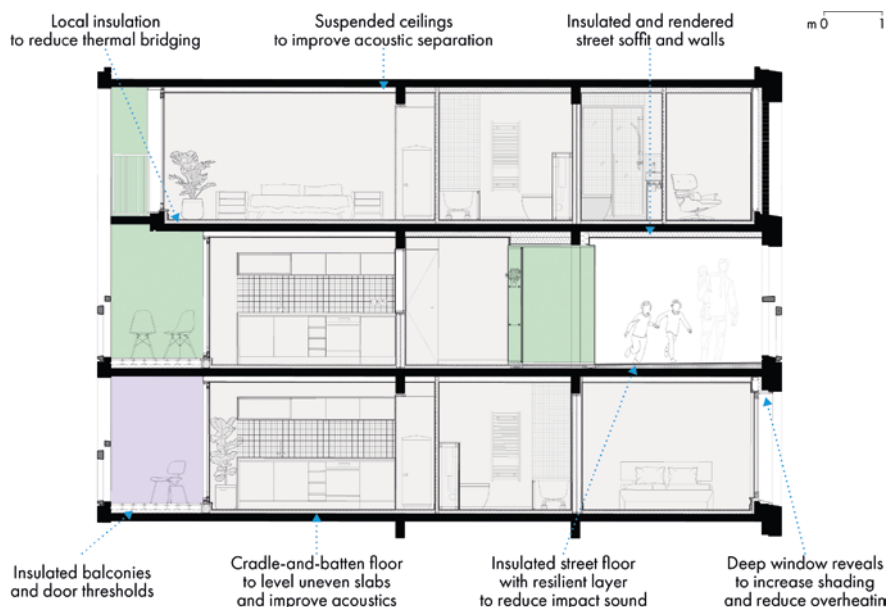


Figure 5
Cross-section showing
the thermal and
acoustic improvements.

Objective of the envelope intervention

Upgrade the thermal and acoustic performance to modern standards while faithfully restoring the Grade II* listed fabric, preserving original bricks and the exposed H-frame without external cladding.

Extent of the envelope intervention

Full internal thermal insulation of all residential units, cleaning of all masonry façades, and replacement of window systems across the central serpent-like section (Levels 05 to 13) of the complex.

Solutions adopted for the envelope

Internal insulation applied to all surfaces to mitigate massive cold bridging from the exposed concrete H-frame, restricted by low 2,515 mm ceiling heights. Original brickwork cleaned and retained. High-performance minimalist dark metal window frames replaced original timber. Coloured insulated render panels applied to balcony reveals and soffits to address thermal leakage identified via imaging. Tapered insulation on balconies and roofs for drainage. High-performance internal insulation retrofitted to ground slabs and 'street' soffits to ensure thermal comfort. Airtightness was also prioritised.

Other interventions

Thirty-seven flat types are reconfigured into 195 units, merging bedsits into open-plan layouts. District heating is replaced by a fully electric, grid-powered system. Acoustic upgrades include suspended ceilings and cradle-and-batten flooring to level uneven slabs. Residential sprinklers are installed. A double-height glazed entrance lobby and 2,500 m² of commercial space activate the lower floors. The 'streets in the sky' regain their original width, with patterned thresholds and glazed side panels beside unit doors to enhance security and identity.

Pre-intervention operational carbon

151 kgCO₂/m² year

Post-intervention operational carbon

20 kgCO₂/m² year

Certifications / Awards

2022 RTPI Awards for Planning Excellence (Excellence in Planning for Heritage and Culture – Commended); 2022 RTPI Yorkshire Awards for Planning Excellence (Best Project – Highly Commended); 2023 AJ Retrofit Awards (Housing, Listed Building £5 million and over, Retrofit of the Year); 2023 Housing Design Awards (Overall

Winner); 2024 RIBA National Award; 2024 RIBA Reinvention Award (Shortlist); 2024 RIBA Stirling Prize (Shortlist); 2024 RIBA Yorkshire Award.

Knowledge framework, methodology and traceability

The project is grounded in direct observation of the building, analysis of previous transformations and comparison with Phase 1. Surveys of the concrete frame and masonry were integrated with energy modelling, thermographic investigations and hygrothermal risk assessments. Comparison of design options informed a strategy to retain existing components compatible with functional and energy-performance upgrades.

Technical adequacy and compatibility of the adopted solutions

The solutions address thermal bridging while retaining and cleaning the brick masonry. Insulation is mainly internal, with local applications at balcony reveals and gallery soffits. Energy modelling and hygrothermal assessments informed the new assemblies, taking account of the limited interior height.

Degree of reversibility

Reversibility is limited by extensive interior insulation, insulating treatment of balcony reveals and gallery soffits, and upgrades to roofs and floor assemblies. Existing timber windows are replaced with metal units, while transformation of the base introduces new openings and glazed enclosures. Retaining the concrete frame and masonry reduces demolition, but the new assemblies cannot be removed without affecting the substrates.

Impact on the formal and spatial configuration

The concrete frame, brickwork, building form and original gallery width remain recognisable. New dark window frames, coloured balcony reveals and balustrades alter the façades, while glazed entrances and new ground-floor uses change the building's relationship with public space.

Degree of conservation of original architectural elements

The intervention retains and repairs the concrete frame, preserves the brick masonry and many partition walls between dwelling units, and maintains the galleries' configuration and width. Envelope conservation is selective: timber windows are replaced, balcony reveals and gallery soffits are clad, and balustrades renewed. Principal structural and compositional elements remain legible, while several façade components are replaced or modified.



Figure 6
View of the inner façade facing the communal garden.

GLASS HOUSE

United States, Connecticut, New Canaan

1945 - 1949

Philip Johnson, Richard Kelly (lighting design), James Fanning (landscape design)

ORIGINAL DESIGN

Completed in 1949, the Glass House represents a pivotal monument of the Modern Movement and the International Style in the United States. Designed by Philip Johnson as a personal weekend retreat, the structure is situated on a 19-hectare estate in New Canaan, Connecticut, overlooking a steep bluff and a small pond. Architecturally, the house is a simple rectangular prism, measuring 17.07 m in length, 9.75 m in width, and 3.20 m in height. Its defining characteristic is the vertical enclosure, which consists almost entirely of floor-to-ceiling plate-glass sheets. These massive transparent panels are secured within a minimalist black-painted steel frame. The glass is held in place by steel stops and angle brackets, emphasising the industrial, mass-produced nature of the materials. The plan is entirely open, with the exception of an off-centre cylindrical mass constructed of red brick. This cylinder serves as the primary service core, containing a fireplace on the living area side and a bathroom within its interior. It is the only architectural element that punctures the flat roofline, acting as a vertical anchor for the horizontal composition. The floor is constructed of glazed brick laid in a precise herringbone pattern. Johnson's decision to suppress the structural expression at the corners creates a 'closed box' effect that distinguishes it from Mies van der Rohe's Farnsworth House, which served as a primary inspiration. The house is part of a larger garden estate that Johnson developed over five decades, which he described as the 'diary of an eccentric architect'. The property eventually grew to include fourteen structures, including the opaque Brick Guest House (1949), which serves as a formal foil to the transparency of the Glass House. Other significant additions include the circular swimming pool (1955), the Lake Pavilion (1962), the earth-bermed Painting Gallery (1965), and the angular Sculpture Gallery (1970). The Glass House serves not only as a residence but also as a platform for the display of art and furniture, featuring iconic pieces by Mies van der Rohe. The relationship between the interior and the meticulously manicured landscape is seamless; from within, the surrounding scenery functions as an ever-changing wallpaper, blurring the distinction between domestic space and nature. The technological system of the Glass House is defined by its minimalist steel-and-glass envelope. The primary structure utilises eight wide-flange black-painted steel columns made of stock H-beams at the

Figure 1
View of the south
façade, historical
photograph.





Figure 2
View of the main (east)
façade, historical
photograph.

corners and intermediate points, supporting a flat roof composed of concealed H-beams and exposed steel channels. The exterior walls are composed of single-glazed plate-glass panels 3.18 m high, with the largest reaching widths of up to 5.38 m. These panels are fixed into the steel frame using angle brackets and steel stops, originally sealed with traditional putty and later updated with modern silicone sealants. The thermal performance is managed through a radiant heating system consisting of 25.4 mm wrought iron pipes embedded within a concrete setting bed beneath the floor. The 3.18 m high enclosure is approximately 90% glass, presenting unique challenges for thermal stress and structural movement. From a structural standpoint, the central brick cylinder is built of solid masonry and functions as the primary structural and mechanical core, providing the necessary rigidity for the overall lightweight steel assembly. The roof structure includes a three-coat plaster ceiling applied to a metal lath system, which is fastened to the overhead roof timbers. Over time, these fasteners required modernisation to support the ceiling's weight.

Previous interventions

Since the site was placed under the care of the National Trust for Historic Preservation in 2005, maintenance has focused on preserving the original appearance. Historically, broken glass panels were replaced under Johnson's supervision with 9.5 mm float glass. Recent interventions include the replacement of five glass panes with 9.5 mm tempered glass to meet modern safety codes. The steel frame is repainted every five years, and sealants are replaced as needed. In 1953 and 1985, the adjacent Brick House underwent interior remodelling of its vaulted ceiling and bathroom facility.

Pre-intervention general conservation conditions

By 2015, the 167-square-metre plaster ceiling showed significant sagging due to inadequate fasteners and poor construction of the origi-

nal support system. Decoupling from the roof timbers compromised half of the ceiling and prevented two of the four glass doors from opening. Furthermore, the original top coat of plaster was found to contain asbestos. Regarding the envelope, two massive glass panels cracked in 2019 due to thermal stress caused by temperature differentials and the lack of flexibility in the original steel frame, posing safety risks and impacting aesthetics.

Specific environmental or climatic pressures

The building faces significant environmental pressures due to its 90% glass envelope. The large panes are susceptible to thermal stress caused by extreme temperature differentials in the Connecticut climate. Additionally, the lack of movement in the rigid steel frame and local wildlife collisions have historically led to recurring glass failure.

Figure 3
Exterior view of the
Glass House from the
south-east.



NEW INTERVENTION

2015 - 2020

National Trust for Historic Preservation (Ashley R. Wilson – lead architect), EverGreene Architectural Arts (finishes and plaster restoration), Silman Structural Engineers (structural analysis and ceiling support design), Wiss, Janney, Elstner Associates, Inc. (glazing engineering and technical design)

The recent intervention at the Glass House was carried out in several phases to restore structural integrity, improve visitor safety, and remediate hazardous materials while strictly respecting the original design. The first phase involved the complete replacement of the building's 167.2 m² interior ceiling. A 2015 structural study had identified significant sagging and separation from the roof timbers, which prevented two of the four main glass doors from opening. Work began in December 2017 and included the controlled removal and remediation of the original system, which consisted of three coats of asbestos-containing plaster. The ceiling was then reconstructed by applying a new three-coat plaster system over metal lath supported by enhanced fasteners designed to carry the weight of the finish. In addition to removing a safety hazard, the operation restored the building's functionality.

The second phase focused on the house's defining feature: its glass envelope. In 2019, the National Trust replaced two panes measuring 5.38 × 2.39 m that had cracked under thermal stress. The panels, which belonged to an earlier generation of replacements and consisted of 9.5 mm annealed glass, were replaced with 14.3 mm laminated safety glass incorporating a polyvinyl butyral (PVB) interlayer. Working with the manufacturer Agnora, the team designed the new units to meet ANSI standards and withstand extreme wind loads without exceeding the load-bearing capacity of the original steel supporting rails.

To prevent corrosion of the metal elements and moisture-induced clouding of the glass, the design team introduced weep holes into the glass pockets and used new-generation glazing tapes and silicone sealants. The steel stops were removed, while the frames were meticulously cleaned, prepared, and repainted to achieve a uniform finish. Installation required a crane to lift the large panes over the house, highlighting the logistical complexity of working on a historic site.

Led by Ashley R. Wilson with support from consultants including EverGreene and Silman, the project followed a rigorous conservation methodology. The knowledge framework combined Philip Johnson's original 1948 drawings, records of the early replacements, on-site inspections, and structural analyses by Silman. The investigations identified both the loss of connection between the ceiling fasteners and roof structure and the concentrations of thermal stress responsible for the failure of the 9.5 mm glass. Evaluation of the available options



Figure 4
Partial installation of
the metal support and
suspended-ceiling
mesh, 2017.

favoured 14.3 mm laminated glass over a standard replacement, balancing compliance with ANSI safety standards against the structural limits of the historic steel rails. The team sought a pragmatic solution that could also inform work on comparable modern buildings.

Energy performance remained secondary to safety; nevertheless, silicone sealants and modern glazing tapes improved protection from the elements compared with the original putty. The work was scheduled between December and March to minimise disruption to public tours and programmes. By integrating safety glass and more reliable fasteners into the existing structure, the intervention addressed severe material failures and long-term deterioration, making the Glass House safer and more durable without altering its appearance, which remains visually indistinguishable from Johnson's 1949 design intent.

The adopted strategy coordinates diagnosis, design, and construction through testing, verification, and tailored solutions, thereby limiting unnecessary replacement.



Figure 5
Installation of external
protective measures
over the cracked
glazing, 2019.

Objective of the envelope intervention

Restore structural safety and door functionality by replacing the sagging ceiling and cracked glass panels while meticulously maintaining the original 1949 aesthetic and the industrial profile.

Extent of the envelope intervention

Complete replacement of the 167.2 m² interior ceiling system and the localised replacement of two massive 5.38 × 2.39 m exterior glass panes on the building's transparent building envelope.

Solutions adopted for the envelope

Replaced 9.5 mm glass with 14.3 mm laminated safety glass and PVB interlayer. Installed modern silicone sealants and high-performance glazing tape. Added internal moisture weeps to steel frame pockets to prevent rust and glass clouding. Corrected the ceiling attachment system to restore the operation of the doors. Cleaned and repainted the entire 1949 steel framework with a uniform industrial black finish to ensure long-term durability and aesthetic consistency across the structure, providing a technologically superior solution to the performance issues inherent in the original mid-century design.

Other interventions

Comprehensive asbestos remediation within the original three-coat plaster ceiling. In the broader estate, regular maintenance includes cleaning protocols, path timber repairs, and periodic painting of all structures. The adjacent Brick House underwent vaulting repairs (1953) and bathroom remodelling (1985). Efforts continue to focus on maintaining landscape integrity, including pond and fountain restoration. The 2015–2020 project specifically aimed to restore the functionality of the intended 'room in nature' experience by solving the structural failure of the ceiling system.

Knowledge framework, methodology and traceability

The project was preceded by a study of the original documentation and of the replacement interventions carried out over time, supplemented by inspections and structural assessments. The investigations identified the causes of the ceiling failure and the conditions that had led to the cracking of some glass panes. The selection of the new components was assessed against safety requirements and the load-bearing capacity of the existing metal profiles.

Technical adequacy and compatibility of the adopted solutions

The solutions address the identified critical issues while limiting replacement to the compromised components. The two cracked panes were replaced with laminated safety glass compatible with the existing metal profiles; new sealants, glazing tapes, and drainage systems improve protection against water infiltration. The new ceiling anchoring system ensures its stability and allows the glazed doors to be fully reopened.

Degree of reversibility

The replacement of the two glass panes and the use of sealants and glazing tapes allow future interventions on individual components without altering the metal frame. Reversibility is more limited in the case of the ceiling, which was completely removed following asbestos abatement and reconstructed with a new support system and a three-coat plaster finish. The intervention therefore combines replaceable operations with permanent transformations of some pre-existing elements.

Impact on the formal and spatial configuration

The intervention preserves the transparency of the envelope, the design of the metal structure, and the continuity of the visual relationship between interior and landscape. Replacement is limited to only two large glass panes, while the metal profiles are retained, cleaned, and repainted. The new ceiling also reproduces the appearance of the previous one. The introduced modifications are therefore minimally perceptible and do not alter the building's spatial configuration.

Degree of conservation of original architectural elements

The intervention preserves the metal structure and nearly all of the glazed surfaces, limiting replacement to two cracked panes. The profiles and glazing stops were removed where necessary, cleaned, protected, and reinstalled. The most significant loss concerns the original ceiling, which was completely removed because of the presence of asbestos and the failure of its anchoring system, and subsequently reconstructed to reproduce its original finish. Overall, the conservation of existing elements predominates.



Figure 6
Interior view of the living area.

Figure 7
View of the bedroom area from outside.

OFFICE AND COMMERCIAL
ARCHITECTURE

GRATTACIELO PIRELLI

Italy, Lombardy, Milan

ORIGINAL DESIGN

1952 - 1961

Gio Ponti, Arturo Danusso, Pier Luigi Nervi, Studio Ponti Fornaroli Rosselli, Studio Valtolina Dell'Orto

Commissioned by Pirelli S.p.A. as its new office headquarters, the tower synthesises Gio Ponti's research into the 'finite form', architecture as crystal, and the nocturnal image of a self-illuminated building. Approximately 127 m high, the tower has a double-convex plan whose major axis is broadly aligned with the prevailing wind. Its lenticular form, tapering at the ends and towards the top, moves beyond the concept of the skyscraper as an undifferentiated rectangular prism and gives the building a unified, resolved character.

The internal plan is based on a 95 x 95 cm module that defines the grid of partitions and the rhythm of doors and furniture, allowing a flexible office layout. The two principal elevations are curtain walls with anodised-aluminium frames and Thermopane glazing, alternating with horizontal spandrel bands faced externally in glass to create a continuous, flush envelope. The façade module measures 2,850 x 3,700 mm, with 1,900 mm opening lights and 950 mm fixed lights.

The reinforced-concrete structural design by Pier Luigi Nervi and Arturo Danusso was conceived to provide large unobstructed spans. The load-bearing system comprises four triangular wall-columns near the lateral ends and two intermediate transverse portal walls, connected by beams and cross-members. The beams in the central bay are prestressed and approximately 75 cm deep, spanning 24 m; their width varies from 16 cm at midspan to 60 cm at the fixed ends. The progressive tapering of the structural elements contributes to the building's form and changes the façade bay widths from floor to floor. The service-core walls are located on the Via Filzi elevation.

Externally, the structural elements are clad in reflective 2 x 2 cm blue-grey ceramic mosaic tiles that interact with the glass and aluminium curtain walls. The Thermopane units comprise two 6 mm glass sheets, perimeter-sealed by a heat-welded metal joint, with a 12 mm dehydrated air cavity. The transparent areas alternate with opaque spandrel panels comprising an external glass sheet, anodised-aluminium and galvanised-steel trays, and glass-wool insulation. A key feature is the elastic joint anchoring the façade to the load-bearing structure. Extensively laboratory-tested, it accommodates structural deformation, thermal expansion

Figure 1
View of the Pirelli
Centre from Piazza
Duca d'Aosta, 1973.





Figure 2
The skyscraper under construction, detail of the façade.

and wind loads. Securit glass was also used, particularly in the entrance lobbies and internal balustrades.

At the top of the building, a double-height space forms a belvedere overlooking the city. Above it, the flat roof is perceived as an autonomous element suspended over the tower. The skyscraper rises from a podium occupying the entire site and containing parking, service spaces, the auditorium and other rooms. The adjacent low-rise volumes, including the present council chamber and auditorium, have a structure of intersecting portal frames finished internally and externally with textured render. In the auditorium, the structural grid is integrated with the ceiling: backlit transparent strips emphasise the path of the beams in contrast with the opaque suspended-ceiling panels.

The Grattacielo Pirelli also incorporated advanced building services, including a dual-duct induction air-conditioning system, electrical distribution beneath the floor and within special steel ducts, and numerous lifts concentrated in the central core to provide rapid vertical movement for staff.

Previous interventions

Over the years, the interiors underwent various maintenance works and alterations, particularly after acquisition by Regione Lombardia in 1978, under a project by architect B. Noorda. In 1998, two competitions were held for refurbishment of the 31st floor and the former auditorium, won respectively by RSG Architetti and Corvino+Multari. Following the 2002 aircraft accident, their appointments were extended to the restoration and functional recovery of the entire building.

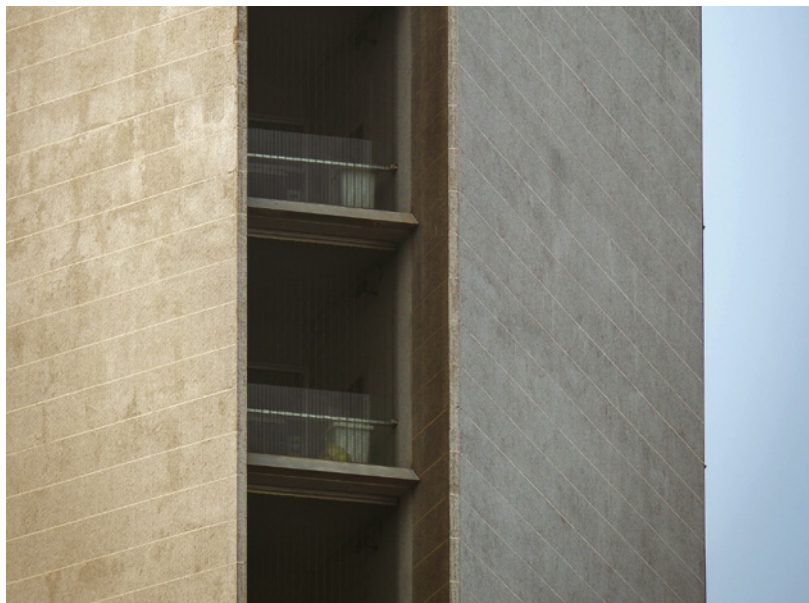
Pre-intervention general conservation conditions

The interiors had been altered and maintained over the years, whereas the external envelope had never been treated. Almost all the metal window frames were deteriorated and large areas of the mosaic cladding were detaching. The intervention followed the event of 18 April 2002, whose impact caused major damage both to the floors struck by the aircraft and to other levels, compromising the façades and load-bearing structures. The 26th-floor deck deflected downwards by approximately 25 cm, while the floor above was displaced upwards by around 6–7 cm.

Specific environmental or climatic pressures

At more than 125 m high, the Grattacielo Pirelli is subject to strong horizontal wind loads.

Figure 3
The side elevation clad
in grey-blue ceramic
mosaic tiles.



NEW INTERVENTION

2002 - 2005

RSG Architetti, Corvino+Multari (developed design), BMS Progetti (detailed design), Migliacci and Acito (structural design), Ariatta Ingegneria dei Sistemi (building services design), Crotti (curtain walls design)

Following the 2002 event, a technical and scientific committee was appointed to establish the intervention guidelines. The design was preceded by an investigation of the building based on archival and bibliographic sources. This directed the project towards a conservation approach that enhanced the quality of the original design and existing materials while safeguarding the Grattacielo Pirelli's artistic and cultural value. Diagnostic investigations were also carried out in the laboratory and on site to understand the causes of deterioration and the characteristics of the materials. This knowledge phase established the technological significance of the original façades and guided the project towards maximum conservation of their authentic components.

The restoration and functional recovery encompassed the façades and external cladding, horizontal structures, and internal and external flooring. It formed part of the emergency response following the accident of 18 April 2002, when a light aircraft struck the elevation facing Piazza Duca d'Aosta between the 25th and 27th floors, severely damaging the façades and several horizontal structural elements. The project was developed by the winners of an earlier competition for the auditorium and 31st floor, assisted by the technical and scientific committee. The committee defined the principal guidelines: an integrated approach, compliance with conservation and restoration requirements, and upgrading to meet safety, comfort and energy-efficiency standards.

Once the telescopic interlocking system of the mullions had been understood, the window frames were dismantled after cataloguing, allowing the profiles to be stripped, brushed, polished and re-anodised in the workshop. Marking the elements ensured that they were re-installed in their original positions and remained distinguishable from replacements. The seals were replaced with silicone-rubber gaskets to ensure water- and airtightness. The glass was replaced with insulating glazing comprising 5+0.38+5 mm laminated glass externally and 4+0.38+4 mm internally, separated by a 16 mm argon-filled cavity; the external pane has a low-emissivity coating. The opaque panels were dismantled and cleaned, while the insulation was replaced with bagged resin-bonded glass-wool panels incorporating a vapour barrier.



Figure 4
Detail of the curtain
wall.

The accident destroyed or compromised part of the curtain wall, so new aluminium-alloy frames were extruded using dies produced from the existing profiles. The missing section was reconstructed to restore the visual unity of the envelope, while the new components were identified by specific markings. The mosaic cladding was cleaned; detached areas were re-adhered by injecting epoxy resins, and losses were repaired with matching tiles manufactured for the project.

A further aspect was the repair of the damaged structures. To maximise material conservation, demolition of the damaged parts was rejected in favour of alternative strategies. The 26th-floor decks were realigned using hydraulic jacks to impose an upward displacement. The horizontal structures regained load-bearing capacity through external post-tensioned steel cables running alongside the joists and anchored at their ends. Beams and slab soffits were also strengthened by bonding fibre-reinforced composite laminates.

The building services were upgraded using groundwater for heat exchange, integrating improved performance with conservation of the building's architectural character.

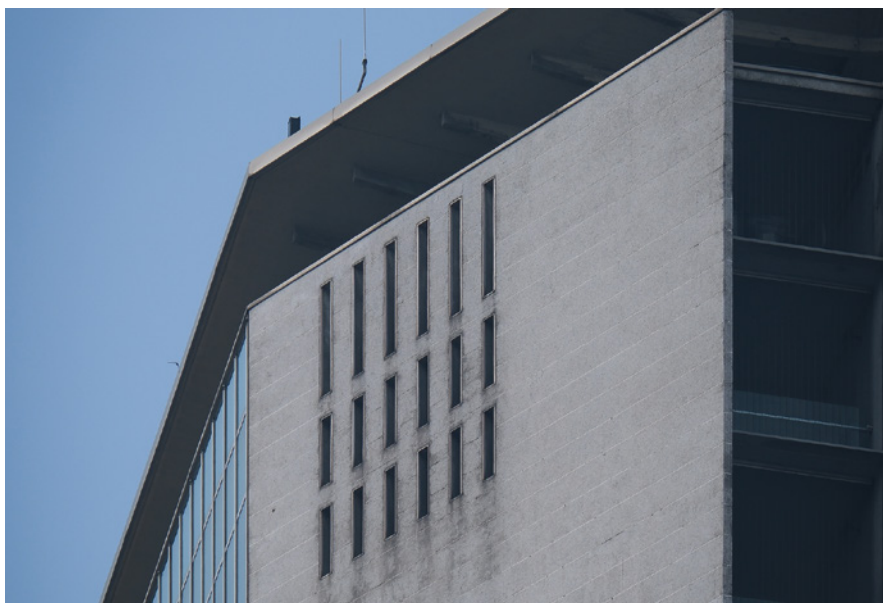


Figure 5
Close-up view of the
top and side elevation,
featuring narrow
vertical openings and
the flat roof suspended
above the tower.

Objective of the envelope intervention

The intervention aimed to improve the building's functionality, energy efficiency and safety by applying conservation principles to a modern work while safeguarding its authenticity and historical and architectural value.

Extent of the envelope intervention

The intervention encompassed all vertical surfaces, both glazed – approximately 10,800 m² – and opaque surfaces clad in mosaic tiles.

Solutions adopted for the envelope

Glazed surfaces: units that were lost or irreparably damaged were replaced with new aluminium frames extruded from dies based on the existing profiles. The original frames were dismantled, cleaned, realigned, re-anodised and reinstalled. All glazing was replaced with new laminated low-emissivity insulating glass units and silicone-rubber gaskets. Ceramic cladding: detached areas were re-adhered by injecting low-viscosity two-component epoxy resin; losses were repaired using matching mosaic tiles manufactured specifically for the intervention.

Other interventions

Structural works restored the damaged horizontal structures: beams were strengthened with post-tensioned cables, while beams and slab soffits received bonded carbon-fibre-reinforced polymer (CFRP) laminates. Building services: groundwater geothermal energy was used, and the existing floor-mounted fan-coil units were replaced with reversible water-source heat pumps. Flooring: porcelain stoneware tiles and studded rubber tiles with a cement-like finish were laid in the external plaza; internally, loose-laid rubber tiles were used in the auditorium and Carrara marble in the entrance hall, with rubber, linoleum and timber on the other floors.

Certifications / Awards

2006 Gold Medal for Italian Architecture (Special Prize for Restoration); 2007 European Aluminium in Renovation Award (Historical Buildings – Gold Medal).

Knowledge framework, methodology and traceability

The project is based on a broad multidisciplinary knowledge framework developed through archival research, surveys, condition assessment, material investigations and structural verification. A technical and scientific committee guided the conser-

vation decisions, and the process is documented through reports, drawings, mapping, samples and records of the dismantling, restoration and reinstallation of the façades.

Technical adequacy and compatibility of the adopted solutions

The solutions are specifically calibrated to the envelope construction system. The aluminium profiles were dismantled, catalogued, restored and reinstalled, limiting replacement to elements beyond recovery. Performance improvements rely on new insulating glazing, silicone gaskets and targeted additions. Thermal breaks were not introduced into the mullions, since this would have required replacement of the framing and altered the façade design.

Degree of reversibility

The intervention prioritises controlled dismantling, restoration and reinstallation of the original profiles, limiting replacements to elements beyond recovery. The new glazing, gaskets and some additions to the weathering system can be replaced without compromising the retained framing. Reversibility is not complete, however, because some components were permanently replaced and certain profiles modified to improve water and condensation drainage.

Impact on the formal and spatial configuration

The intervention fully preserves the legibility of the silhouette, vertical rhythm, continuity of the glazed façades, metal profiles and relationship between transparent surfaces and ceramic cladding. The new glazing and gaskets improve performance without significantly changing the subdivisions, thicknesses or colour scheme. Mosaic repairs and selective replacements are visually integrated and do not alter the building's overall image.

Degree of conservation of original architectural elements

The intervention conserves more than 90% of the aluminium façade profiles through dismantling, treatment and reinstallation, and retains the original construction system and details. Replacements primarily concern glazing, gaskets and components beyond recovery, while the ceramic cladding was restored and losses repaired. Conservation of the original architectural elements therefore prevails, combined with limited performance upgrades.



Figure 6
General view of the Grattacielo Pirelli.

FUEL SERVICE STATION – LE FUCINE

Italy, Friuli-Venezia Giulia, Buttrio

1961 - 1962

Marcello D'Olivo

ORIGINAL DESIGN

The Buttrio service station, built in 1961–62 to a design by Marcello D'Olivo, extends parallel to the regional road as a low, strongly horizontal structure. The elevation facing the carriageway is almost entirely open and was intended for refuelling operations, while the workshop, office, and other service rooms are located to the rear beneath the same roof. The layout is articulated by five pairs of circular columns, whose repetition gives order and rhythm to the composition. The large projecting canopy has an inflected profile, lowered at the centre and rising towards the edges. It is the building's most recognisable feature and acts as an urban marker along the road.

The structure, constructed entirely in reinforced concrete, defines the architecture, as in other projects developed by D'Olivo during the 1950s. It expresses his 'wholly distinctive way of understanding construction' (Luppi & Nicolosi, 2002, p. 45), particularly during the first phase of his career. The five pairs of columns support five upstand transverse beams, corresponding to ribs above the roof slab that resist the stresses generated by the approximately 11 m cantilever towards the road. At around 25 cm thick, the slab maintains a relatively slender profile in relation to its span and forms the characteristic 'pagoda' roof.

The two columns in each pair perform different structural functions. The inner column, with its mushroom capital, has a rigid connection to the beam, while the outer column acts as a simple support. This distinction is documented in the reinforcement drawings held by the D'Olivo Archive in Udine and published by Sergio Poretti, which show both the different configurations of the supports and the upstand beams, partly concealed by the roof's overall form. The visual continuity between the uprights and canopy therefore corresponds neither to genuine mushroom-slab behaviour nor to the use of the form-resistance of a curved surface; instead, it derives from a load-bearing system based on concealed linear elements.

For this reason, Poretti describes the relationship between form and structure in D'Olivo's work as 'ambiguous': the roof's continuous sculptural image arises from the superimposition of architectural configuration and structural behaviour, without the two fully coinciding. On the soffit, the slab retains the exposed imprint of the formwork as part of the building's material expression.

Figure 1

Project perspective.

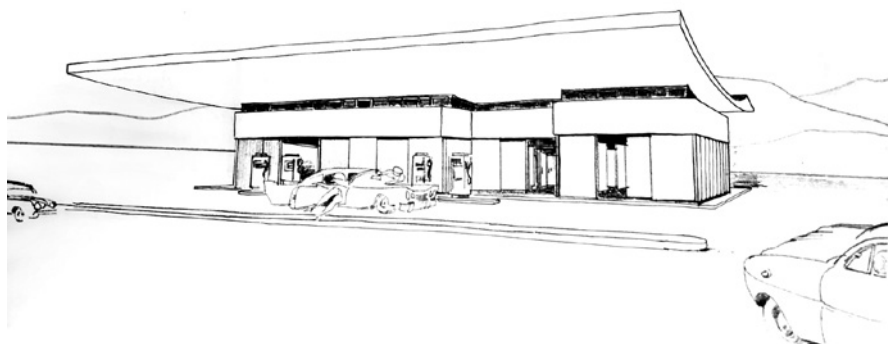




Figure 2
General view.

The rooms at the rear were enclosed by differentiated infill elements: fully glazed, fully opaque, or mixed, with an opaque lower portion and transparent upper section. The glass, generally patterned, provided diffuse daylight and partial screening of the interiors. The lightness of these enclosures heightened the contrast with the sculptural mass of the structure and the canopy's deep projection, reinforcing the perception of a recessed, visually permeable service volume beneath a unified roof.

Previous interventions

No significant interventions prior to the adaptive reuse are documented. After the service station closed, the building remained abandoned for many years.

Pre-intervention general conservation conditions

The pre-intervention condition reflected years of abandonment. The photographic documentation

attached to the DGCC census record indicates not so much severe deterioration as the inability of the original envelope to meet the requirements of the new use.

Specific environmental or climatic pressures

Conversion to a bar-bistro introduced more demanding requirements for hygrothermal comfort and solar control, particularly important given the extensive glazed surfaces.

Figure 3
General view after
completion of the
intervention.



NEW INTERVENTION

2020 - 2022

Zito Artico Fracassi Architetti (concept design), Archest, PSE S.r.l. (building services design)

After years of abandonment following the closure of the service station, Marcello D'Olivio's building underwent radical adaptive reuse and a change of use. It was converted into a bar-bistro with a kitchen, customer facilities, and plant rooms arranged around a large dining space visually open to the exterior. The project began by recognising the work's historical and architectural significance and analysing recurring features of D'Olivio's architectural language. In particular, the sequence of columns and the curved 'pagoda' roof were identified as the building's most representative elements. Their operation was investigated through archival documents, construction drawings, and reinforcement details, relating the structure's formal configuration, structural behaviour, and material characteristics.

On this basis, the project distinguished between the elements to be retained – particularly the columns, capitals, roof, and soffit bearing the imprint of the formwork – and those that could be transformed to accommodate the new use. The envelope enclosing the internal spaces was completely replaced, and the plan was reorganised with predominantly dry-assembled partitions. These were concentrated in the service areas, leaving the main room open and preserving the legibility of the original structural rhythm. Three sides were enclosed by a full-height curtain wall comprising aluminium mullions and transoms with low-emissivity double glazing; reducing the number of horizontal transoms enhanced the continuity of the transparent surfaces. External solar shading with adjustable vertical fins was introduced on the most exposed elevations. The south-facing rear elevation was instead enclosed by a dry-assembled opaque wall with a lightweight frame, rock-wool insulation, and external fibre-reinforced cement-board cladding.

The structural upgrade avoided steel bracing or ties that would have interfered with the legibility of the original structure. The columns were strengthened with reinforced-concrete jackets, formed by injecting cementitious grout into cylindrical steel formwork. The mushroom capitals were repaired by reconnecting the vertical shafts to the roof and locally adapting their geometry where they meet the new curtain wall.

To keep the formwork imprint on the soffit visible, the roof was insulated above the slab with EPS insulation, a vapour barrier, a lightweight-concrete falls layer, and two layers of high-albedo bituminous membrane. The valleys were also reshaped, new outlets installed, and the rainwater drainage system reinstated. The floor was rebuilt and insulated above a new



Figure 4
Night view after
completion of the
intervention.

ventilated crawl space, incorporating service routes and recessed fan-coil units. The intervention thus adapted the building to the functional, energy, building-services, and structural requirements of its new use, while retaining the roof and original supports as the principal focus of its architectural reading.

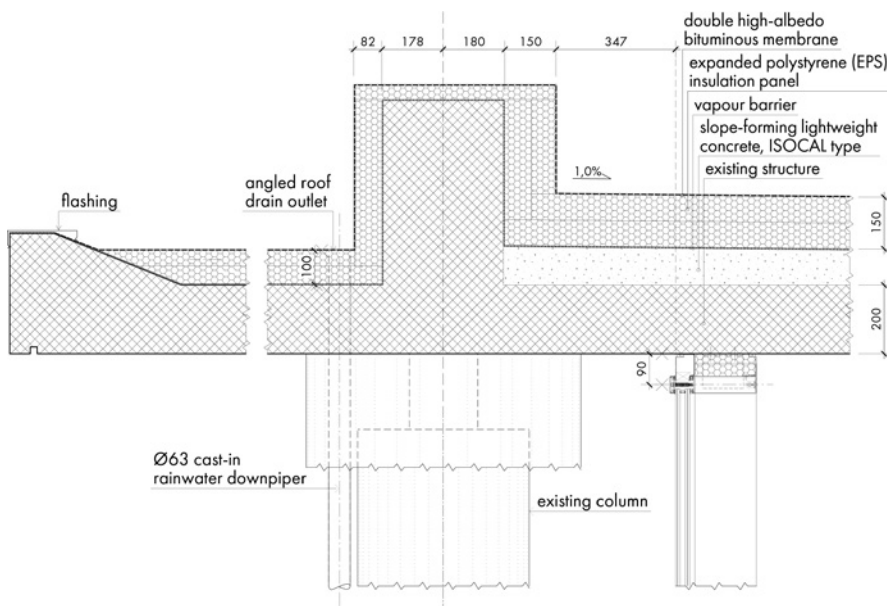


Figure 5
Typical façade section
at roof level.

Objective of the envelope intervention

The intervention sought to create a new envelope that was as transparent as possible, allowing the structure – the columns and curved canopy – to remain legible.

Extent of the envelope intervention

The intervention involved the entire envelope, which was replaced in full.

Solutions adopted for the envelope

New transparent vertical enclosures with aluminium profiles and laminated safety double glazing; an opaque wall only on the south elevation, required for functional reasons and constructed with plasterboard and rock-wool insulation panels (10 + 5 cm). The roof was insulated above the slab with 15 cm of XPS to leave the formwork imprint visible. The ground floor was insulated with a ventilated crawl space (approximately 50 cm), a 10 cm lightweight-concrete layer, and 10 cm of XPS.

Other interventions

Seismic safety work included reinforced cementitious jacketing of the columns. All building services were renewed and routed within the floor (8 cm screed) to avoid compromising the transparency of the envelope. Heat pumps provide domestic hot water and winter and summer space conditioning.

Post-intervention consumption

203.29 kWh/m² year

Knowledge framework, methodology and traceability

The project is based on a body of knowledge appropriate to the circumstances of the case. The building had already been altered over time and was poorly documented, but the designers undertook targeted archival and documentary research, supplemented by surveys, on-site observations, and a critical reconstruction of the changes. The column-and-pagoda-canopy system, documented through bibliographical sources, pre-intervention images, historical drawings, and construction details, is identified as the defining feature. The design adopts a multidisciplinary approach that is traceable across its architectural, structural, and building-services phases.

Technical adequacy and compatibility of the adopted solutions

The technical solutions are tailored to the objective of making the structure legible: large glazed surfaces, insulation above the roof slab, and services routed through the floor reduce visual interference.

Degree of reversibility

Although some solutions, such as the new glazed enclosures, are potentially reversible, the intervention includes works that cannot readily be removed without further alteration of the surviving fabric, notably the roof insulation and reinforcement of the columns with reinforced-concrete jackets. This assessment must nevertheless be viewed in context: the building had already been substantially compromised by earlier alterations, so the limited reversibility mainly concerns works required for reuse, safety, and improved performance.

Impact on the formal and spatial configuration

Perception of the formal configuration remains firmly anchored in the curved canopy and paired columns, which the project emphasises through transparency, visual continuity, and lighter enclosures. The new envelope, comprising predominantly glazed surfaces and an opaque south elevation, offers a contemporary reinterpretation of the original subdivisions and material character. The transformations are perceptible but remain subordinate to preserving the legibility of the principal structural gesture.

Degree of conservation of original architectural elements

The intervention retains and enhances the principal identity-defining elements – the columns, pagoda roof, and soffit bearing the imprint of the formwork – which are treated as recognisable repositories of the work's architectural value. Replacement of the building envelope must be understood in the context of a condition already compromised by earlier alterations, as well as technical obsolescence and the new use. Although replacement of the windows, infill walls, and finishes takes precedence over material conservation, the design choices seek to restore the legibility of the original structural and spatial system.



Figure 6
View of the construction site.



Figure 7
View of the construction site before the interior fit-out.

EX PALAZZO DELLA REGIONE

Italy, Emilia-Romagna, Bologna

ORIGINAL DESIGN

1968 - 1971

Leone Pancaldi

The former headquarters of the Emilia-Romagna Regional Government, designed by Leone Pancaldi in 1968, was built on a vacant site in the area of nineteenth- and twentieth-century expansion beyond the city walls, along the section of the ring road between Porta San Felice and Porta Lame. In a context characterised mainly by detached two- or three-storey buildings, the complex introduces a marked shift in scale, responding more directly to the breadth of the avenue and to the large residential blocks on the opposite side of the road.

Originally conceived as a high-end residential complex with sixteen flats per floor, the scheme was substantially modified during construction following the establishment of the Emilia-Romagna Regional Government in 1970. The new office use required a revision of the functional programme and, in 1971, the insertion of the Regional Council chamber on the ground floor.

The building comprises two principal wings set at right angles and linked by the stair and lift core to form a T-shaped plan. Their differing heights and the setbacks in the elevations introduce compositional variation within a strongly regular arrangement articulated by repeating ribbon windows. The complex rises between six and eight storeys above ground and is partly raised on pilotis, a solution that lightens the building mass and promotes continuity between open spaces at street level.

The constructional system reflects the Brutalist synthesis of structural rigour and sculptural exploration. The load-bearing structure is an *in situ* reinforced-concrete frame with columns of varying cross-section and beams partly contained within the depth of the floor slabs. The foundations comprise continuous inverted beams beneath the stair-core walls and isolated pad foundations beneath the columns. Designed for higher imposed loads, the first-floor slab is of composite clay-block and concrete construction with 21 cm hollow clay blocks; the intermediate floors use blocks 18 or 20 cm deep. BISAP precast units and CELERSAP joists are used in the council chamber.

The envelope alternates exposed white-concrete surfaces with horizontal ribbon windows. The original window frames were brown anodised aluminium, with matching PVC roller

Figure 1
Historical photograph
of the south and west
façades.





Figure 2
Detail of the east
façade, 1972.

shutters, and provided diffuse natural light to the interiors. The beam-and-column grid is expressed on the elevations, making the constructional logic legible, while exposed concrete defines the building's entire volume.

Particular attention is given to the upper terminations and accessible roofs, conceived as terraces equipped with concrete pergolas. The flat roof has a double-layer waterproofing system protected by raised paving; service volumes, lift overruns, and pergolas are treated sculpturally in exposed white concrete. Publicly accessible landscaped areas at the foot of the building help connect it with the surrounding streets.

The original heating system comprised an oil-fired plant, distribution networks of black Mannesmann steel pipework, and radiators. Rainwater and wastewater were discharged through vertical stacks extending to roof level.

The building is one of the most significant expressions of Pancaldi's exploration of the aesthetic potential of exposed reinforced concrete. Structure, envelope, and volumetric articulation combine to create an architecture in which constructional clarity becomes language; it was subsequently recognised as a work of modern architecture of documentary interest.

Previous interventions

In 1972, internal alterations were authorised for the canteen on the seventh floor and the bar on the eighth, followed by further variations until 1984. During the 1980s, the ground-floor rooms were extended northwards. When the Regional Government relocated in 1985, the change of use of the entire complex from residential to office accommodation was formally regularised. Before 2012, localised repairs were carried out to the exposed concrete and some obsolete building services were replaced to accommodate organisations including ARPA and the Civil Protection Department.

Pre-intervention general conservation conditions

Before 2012, the complex suffered from severe technological obsolescence. The exposed white

concrete, a defining feature of Pancaldi's work, had deteriorated, with surface spalling and areas of damaged render. The original metal windows showed galvanic corrosion and no longer met thermal-transmittance standards. The interiors, created through the conversion of the 1970s flats, had rigid layouts, worn resilient flooring, and out-dated mechanical systems, with external condensing units disfiguring the façades.

Specific environmental or climatic pressures

The ribbon-window elevations are exposed to intense solar radiation, resulting in summer overheating. The location along the ring-road avenues exposes the building to high levels of noise and air pollution, accelerating the chemical deterioration of the exposed concrete and corrosion of the metal window frames.

Figure 3
View from Giardino
Aldo Borgonzoni.



NEW INTERVENTION

2012 - 2019
Open Project

Coordinated by Open Project between 2012 and 2019, the programme of functional, architectural, and energy refurbishment sought to reconcile performance upgrades with the preservation of the Brutalist identity of Leone Pancaldi's former Regional Government headquarters. The building's classification as a work of modern architecture of documentary interest informed a design approach that respected its original subdivisions, geometries, and the sculptural qualities of its exposed white concrete.

The works involved the second floor of the west wing, the basement levels, the central entrance hall, the upper floors and, in 2019, the eighth floor of the north wing. The principal envelope intervention was the replacement of the original metal windows with new brown thermally broken aluminium units designed to match the 1968 scheme, including the vertical grooves in the mullions. The new glazing improved both energy and acoustic performance in relation to the ring road.

To avoid altering the elevations, the opaque walls were insulated internally using plaster-board linings with 120 mm mineral wool at the former roller-shutter boxes and 40 mm glass wool elsewhere, achieving U-values below 0.30 W/m²K. The exposed white concrete was restored by consolidating areas affected by carbonation and chemically cleaning the surfaces. Removal of the condensing units attached to the elevations reinstated the legibility of the original façades.

On the ground floor, the entrance hall was demolished and rebuilt with glazed steel framing and porcelain stoneware finishes. The internal reorganisation overcame the rigidity of the existing layout by removing partitions and creating flexible workspaces with dry-lined plasterboard systems, float glass partitions, and raised-access floors for building services. Finishes distinguish the different functions, with PVC flooring in the offices, parquet in executive areas, and modular sound-absorbing suspended ceilings.

The building-services upgrade included a building management system (BMS), a new heating and cooling plant with hydronic terminal units, and air-to-air heat pumps, bringing the complex to energy class E. Fire-safety upgrades comprised REI-rated compartmentation, fire doors, a dedicated electrical substation, and underground water tanks in the garden. The roof works included renewal of the waterproofing, new raised paving to the panoramic terraces, bird-deterrent systems, and permanent fall-protection lines.



Figure 4
Detailed view of the
south façade.

Open Project's multidisciplinary coordination included project management, construction supervision, and health and safety coordination. The approvals process was based on SCIA 5321/2013 and subsequent variations to adapt the layouts to the requirements of institutional occupiers, including ARPA and the Civil Protection Department, as well as private tenants. The Commission for Architectural and Landscape Quality (CQAP) reviewed every external alteration, from the replacement windows to the rooftop services, to safeguard the building's Brutalist character. The process also included fire-safety upgrades across more than 6,000 m², with technical derogations for the existing staircases, culminating in the issue of the fire-prevention certificate and partial occupancy approval. The intervention thus preserved the complex's documentary value while adapting it to contemporary standards.



Figure 5
View of the
ground-floor portico.

Objective of the envelope intervention

Energy and acoustic upgrading through new windows and the conservation of the exposed white concrete, while ensuring the continuity of the defining features of modern Brutalism.

Extent of the envelope intervention

Complete replacement of the external windows, affecting approximately 19% of the total heat-loss area of the building complex, together with restoration of the exposed-concrete façades.

Solutions adopted for the envelope

New brown thermally broken aluminium windows were installed, with profiles and subdivisions matching Pancaldi's original design. The solar-control glazing has a U-value below $1.90 \text{ W/m}^2\text{K}$ and a g-value below 0.35. The work included the conservation of the exposed white concrete, consolidation of deteriorated areas, removal of the external air-conditioning units, and construction of insulated internal plasterboard linings, with 120 mm mineral wool at the former roller-shutter boxes and 40 mm glass wool in the remaining sections, reducing the U-value of the opaque walls to below $0.30 \text{ W/m}^2\text{K}$.

Other interventions

The offices were reconfigured using flexible and fitted partition systems; sanitary facilities were refurbished and sound-absorbing suspended ceilings installed. A BMS was introduced to monitor energy consumption and alarms. The heating and cooling plant was completely renewed, with fan-coil distribution. Lifts were brought into regulatory compliance, as were the REI-rated compartments in the stairwells and basement car parks at level -2. New specialist systems were installed, and underground firefighting water tanks were constructed to improve the safety of the entire complex.

Post-intervention consumption

182.48 kWh/m² year

Knowledge framework, methodology and traceability

The project is founded on a detailed understanding of the complex's architectural, technological, and material characteristics. It recognises the building's documentary value within the heritage of the second half of the twentieth century, its Brutalist origins, the expressive role of exposed concrete, and the compositional continuity of the ribbon windows. Consultation with the Commission for Architectural and Landscape Quality, the approvals process and the management of design variations make the design decisions traceable and

document an informed approach to safeguarding the building's defining characteristics.

Technical adequacy and compatibility of the adopted solutions

The adopted solutions are carefully calibrated to the building's architectural and technological character. The new brown thermally broken aluminium windows reproduce the profiles, subdivisions, and colour of the original 1968 design while incorporating solar-control glazing to improve thermal and acoustic performance. Conservation of the exposed white concrete and removal of incongruous external units reinforce the material and perceptual continuity of the façades. The intervention responds specifically to deterioration, corrosion, overheating, and acoustic pressures while maintaining a high degree of formal, functional, and technological compatibility.

Degree of reversibility

Reversibility is partial. The intervention retains the structure and exposed-concrete surfaces, but the complete replacement of the windows entails the loss of original components. Refurbishment of the roof, with new waterproofing and insulation layers, also introduces changes that are not fully reversible. Internally, dry construction systems facilitate disassembly, but demolition, removals, and building-services upgrades reduce the extent to which the work can be considered minimal intervention.

Impact on the formal and spatial configuration

The envelope upgrade has a limited impact on the building's external appearance. The most perceptible changes concern the different material quality of the new windows and the reconfiguration of the entrance hall and interiors, but they do not compromise the legibility of Pancaldi's volumetric and compositional design.

Degree of conservation of original architectural elements

The conservation of original characteristics is selective but critically informed. The principal features of the envelope are retained and restored, particularly the exposed concrete, the structural order of the façades, the pilotis, and the proportions of the openings. Although justified by corrosion, the need to improve thermal and acoustic performance, and regulatory requirements, the complete replacement of the original windows entails a significant material loss. Conservation of the building's image and compositional system therefore takes precedence over the full retention of its original constructional elements.



Figure 6
View of the south façade from Viale Silvani.

RAI HEADQUARTERS

Italy, Lazio, Rome

1961 - 1965

Francesco Berarducci, Alessandro Fioroni, Maria Teresa Parpagliolo (landscape design)

ORIGINAL DESIGN

The RAI Headquarters on Viale Mazzini stands in a residential district, and its design was subject to restrictions imposed by planning regulations. These precluded a tall building and led to a predominantly horizontal scheme. Berarducci deliberately departed from the architectural language of the surrounding context, proposing a modern building both in its massing and in its choice of materials. The result is a steel-and-glass building – the only example of its kind in his work – comprising eight storeys above ground and a basement partly used for parking. The presence of groundwater prevented deeper excavation and helped determine the building's overall configuration.

The ground floor occupies almost the entire block and accommodates public areas, reception and ceremonial spaces, the library and other shared facilities. At its centre is a garden courtyard, which becomes the compositional focus through the glazed walls overlooking it. The courtyard brings light and vegetation into the heart of the building and visually organises the common areas. Above the podium, the upper floors are arranged as four blocks conceived as functionally, spatially and structurally self-contained. Transparent bridges connect the volumes, maintaining continuity of circulation without compromising their autonomy or distinct identity.

The reinforced-concrete basement has a column structure and large-diameter piled foundations, and forms the base for the steel load-bearing frame of the floors above. At ground level, the columns have cruciform sections that taper towards the base, while standard sections are used on the upper floors. The structural grid varies by level: the spans at ground-floor and penthouse levels are wider than those on the intermediate floors. The upper storeys have a steel structure, with transverse tubular trusses concealed within the internal partitions. The vertical-circulation and service-duct cores are instead built in reinforced concrete and provide the rigid elements to which the steel frame is anchored; they concentrate the principal circulation and building-services functions.

The floor structures are made of profiled steel decking or composite clay-block and concrete slabs. The roof is composed of free-form pitches supported by steel lattice trusses and clad

Figure 1
The building's steel
structure under
construction.



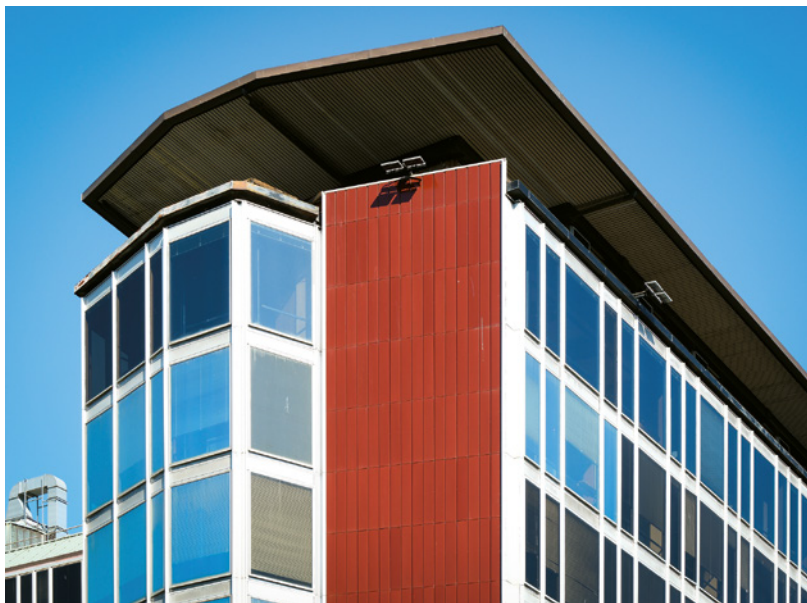


Figure 2
Detail of the cantilever
over Viale Mazzini.

in copper sheet. Its configuration crowns the different blocks and reinforces the building's volumetric articulation.

The interiors were designed for flexibility through the use of movable partitions, allowing the layout and size of the offices to be modified over time in response to RAI's changing needs. The only fixed elements are the vertical-circulation, service-duct and utility cores. The combination of steel structure, modular grid and movable partitions allows the spaces to be adapted without altering the permanent elements.

The vertical envelope is predominantly a curtain wall, with dark-bronze anodised aluminium frames and VIS glass. The rhythm of the elevations is defined by the vertical framing and by the alternation of two opening modules – with either vertical or horizontal hinges – and one double fixed module. The curtain wall follows a regular module coordinated with the structure and the subdivision of the interior spaces. The limited opaque areas are clad with panels or strips of dark-red enamelled steel sheet, contrasting with the glazed surfaces and anodised aluminium frames. The envelope thus expresses externally the principles of modularity and flexibility governing the building's structural and spatial organisation.

Previous interventions

Construction of three external fire-escape stairs housed in circular towers with conical roofs, known as the *matitoni* ('large pencils'), designed by Berarducci himself in 1985; refurbishment and upgrading of the canteen facilities (1980–1987).

Pre-intervention general conservation conditions

The building is in fair condition and has undergone alterations for functional reasons. During

construction, the load-bearing steel structure received a spray-applied fireproofing treatment containing asbestos.

Specific environmental or climatic pressures

The urban location is exposed to traffic noise and summer heatwaves; the extensive glazed envelope increases the risk of overheating and glare.

Figure 3
Overall project
rendering.



NEW INTERVENTION

2022 - ongoing

ACPV Architects (architectural design and coordination), Faces Engineering (façade design), DBA PRO (building services design), VDP (environmental and acoustic design)

The environmental remediation and comprehensive redevelopment of the RAI Headquarters on Viale Mazzini was preceded by an extensive investigation programme aimed at assessing the condition of the building and defining the design strategy. At the lower levels – the ground floor and basement – exploratory openings and cover meter surveys were carried out on the structural elements, extending to the areas affected by the principal alterations. The survey used 3D laser scanning, GNSS equipment and a total station, allowing the point clouds to be georeferenced. BIM modelling, developed in a cloud-worksharing environment, was used for interdisciplinary coordination and to manage the design, construction, handover, and operation and maintenance phases.

The project, currently underway, includes asbestos removal and the complete strip-out of architectural elements and building services, while retaining the original structural-steel frame. Its aim is to recover the characteristics and stylistic qualities of Francesco Berarducci's design – transparency, lightness and formal clarity – by removing elements added over time to meet changing operational requirements, including the circular fire-stair towers introduced by the architect himself in 1985.

The intervention pursues high standards of environmental sustainability through technologies designed to reduce primary energy consumption. It also seeks to maximise the reliability and automation of the building services, as well as their flexibility and modularity, allowing future spatial reconfiguration and facilitating maintenance. Newly introduced materials recall the aesthetics of the original building while giving priority to compliance with current regulations.

The removal of architectural elements and building services is accompanied by the conservation of the principal features of value. The rosewood panelling in the large Sala degli Arazzi will be retained; the marble floor around the inner courtyard will be protected and restored *in situ*; and Gino Marotta's suspended ceiling will be dismantled, restored and reinstated. The new glazed envelope will preserve the original rhythm based on the alternation of two opening modules and one double fixed module. The mullions will be aluminium and the glazing will be double or triple, depending on the required performance. Opaque areas will be rebuilt as a ventilated rainscreen façade using painted honeycomb composite panels with concealed mechanical fixings.



Figure 4
One of the fire-escape stair towers added in 1985, to be removed as part of the intervention.

Because the envelope is largely glazed, thermal insulation will be applied around the lift shafts, to the opaque façade walls, the soffit over the basement, the separating walls between heated and unheated basement areas, the roofs of the main building and lower blocks, and the soffits of the first-floor cantilevers. On the long south-facing elevations and the outermost south-west-facing façade towards Via Podgora, new horizontal brise-soleil – respectively 70 and 50 cm deep – will be installed at the floor-edge bands. They will consist of solid aluminium sheet on the upper face and expanded aluminium mesh below.

The roof has been redesigned to preserve its aesthetic character while integrating building services into technical spaces formed within it. The existing covering will be entirely replaced with new copper sheets joined with double standing seams. Photovoltaic panels will be installed on the flat uppermost areas. The intervention also includes seismic-improvement works to the structure.

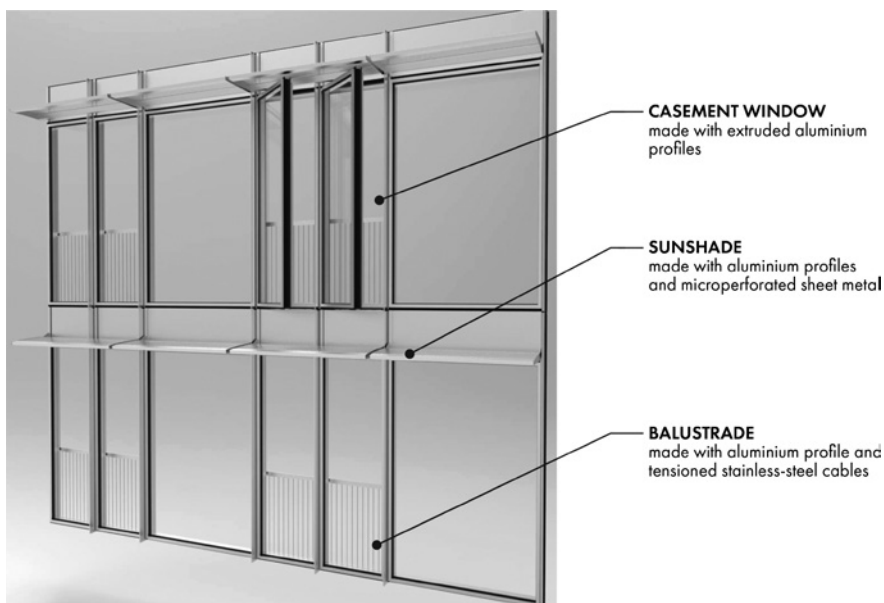


Figure 5
Diagram of the glazed façade with solar shading.

Objective of the envelope intervention

The primary objective is to remove the asbestos coating the steel structure and to provide a compliant external envelope, internal partitions and building services, with the aim of achieving nZEB status.

Extent of the envelope intervention

The intervention covers the entire building, since the structure will be completely stripped of all finishes and services.

Solutions adopted for the envelope

The new glazing will comprise both fixed and side-hung opening units with double- or triple-glazed units (DGU/TGU). Opaque surfaces will be constructed as a ventilated rainscreen façade, using painted honeycomb panels in the original colour but with different dimensions, combined with rock-wool and PIR insulation. The lift shafts and stair cores will be insulated with 4 cm of rock wool. XPS panels will insulate the basement at both floor level (8 cm) and soffit level (10 cm). In general, roofs will use EPS panels combined with rock wool, while the soffits of slabs exposed to the exterior will use rock-wool panels. Where necessary, thin polyurethane insulation panels will be used.

Other interventions

Structural works: jacketing of the reinforced-concrete shear walls in the stair and lift cores; tying together the building blocks by welding steel bracing to the floor beams; abrasive blasting, corrosion protection and strengthening of existing steel beams and columns by welding on steel plates. Installation of roof-mounted photovoltaic panels. Replacement of all building services.

Post-intervention consumption

84.87 kWh/m² year

Certifications / Awards

Energy performance class A2 (design target – APE, 2023); LEED certification (target); WELL certification (target).

Knowledge framework, methodology and traceability

The project is grounded in a wide-ranging and well-documented knowledge base: historical and archival sources, analysis of the building's compositional and technological characteristics, structural investigations, GNSS and laser-scanner surveys, and BIM-based design management. The design objectives are explicit: remediation, performance upgrading and functional redevelopment. The available documentation provides good traceability of the decisions and transformations.

Technical adequacy and compatibility of the adopted solutions

The envelope solutions are technically advanced and carefully calibrated to the performance objectives, including thermally broken curtain walls, high-performance glazing, hygrothermal, acoustic, structural and fire-safety assessments, solar shading and maintenance systems. Although the existing envelope cannot be retained, the new solution reprises the curtain wall's typological logic and the building's technological character. The intervention nevertheless remains highly invasive, involving extensive replacement of the façades.

Degree of reversibility

The intervention entails a high degree of transformation: strip-out, remediation, demolition of partitions and wholesale façade replacement result in extensive loss of original fabric. The new systems are partly demountable and maintainable, with some components designed as dry-assembled systems; overall reversibility remains limited.

Impact on the formal and spatial configuration

The intervention's impact on the formal and spatial configuration is limited but perceptible. The project removes elements considered incongruous and aims to recover the lightness, transparency, modularity and compositional clarity of the original curtain wall. However, the introduction of new profiles, high-performance glazing systems and solar shading, together with the reinterpretation of the roof and reorganisation of the interiors, significantly changes the perception of the building. Its principal compositional characteristics remain recognisable, although its material character and technical operation are clearly updated.

Degree of conservation of original architectural elements

Material conservation of the envelope is limited, since the glazed façades are replaced in their entirety and the roof is not retained in its original technical and constructional configuration, but redesigned to integrate new building services. The intervention chiefly preserves the building's structure, overall form, compositional rhythm and image, rather than its original architectural components. The replacements are justified by remediation, safety, technical obsolescence and energy-efficiency requirements, but result in a significant loss of original fabric.

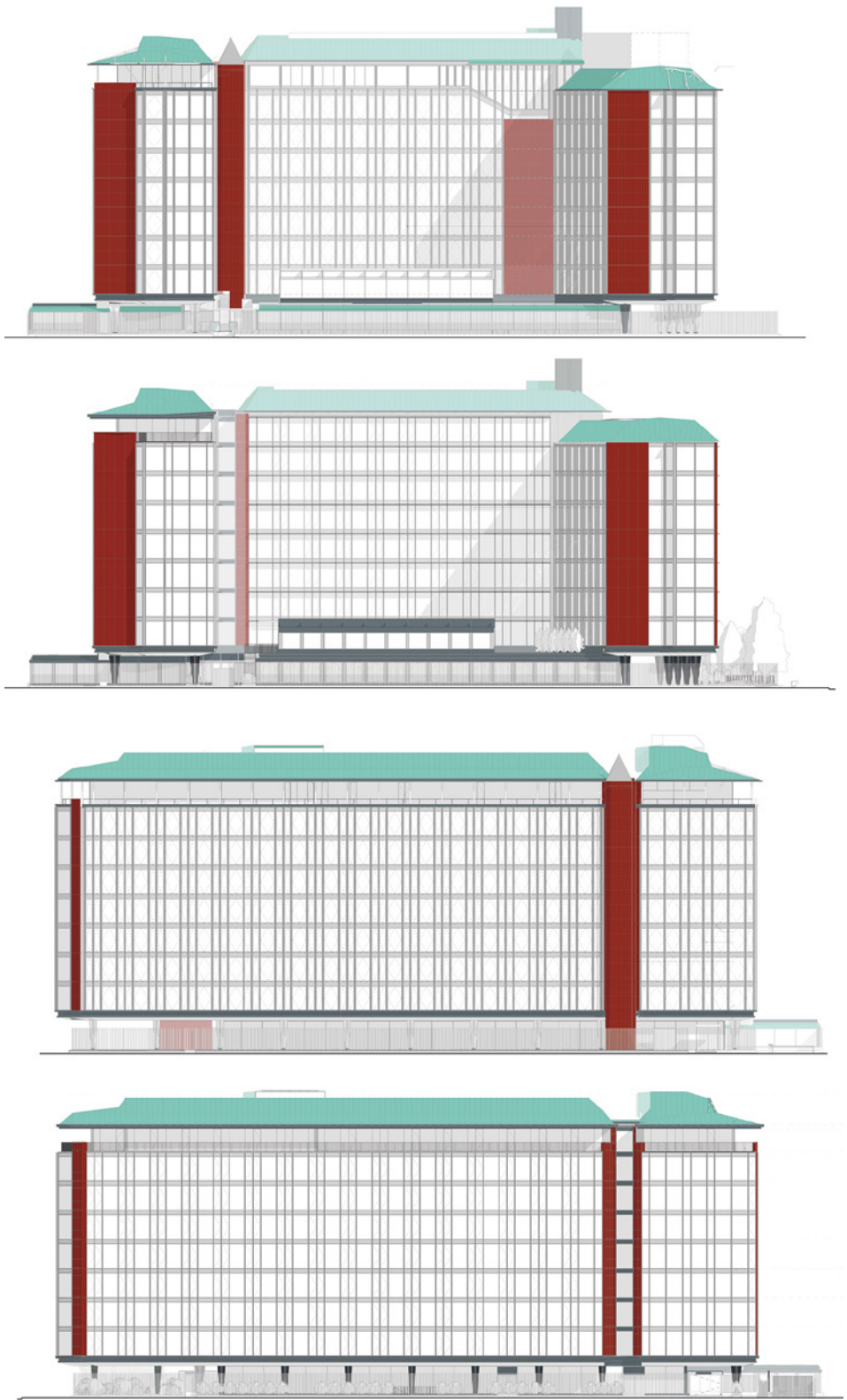


Figure 6
West elevation (existing and proposed); east elevation,
(existing and proposed).

HAUS HARDENBERG

Germany, Berlin, Berlin

ORIGINAL DESIGN

1953 - 1956

Paul Schwebes

Haus Hardenberg stands as a pre-eminent exemplar of post-war Modernism in West Berlin (Charlottenburg district). Designed by architect Paul Schwebes between 1953 and 1955 and completed in 1956, the building originally served as the headquarters for the Kiepert bookstore. The architectural composition is defined by a seven-storey reinforced-concrete skeleton that adapts to the complex urban morphology of its corner site at Hardenbergstraße and Knesebeckstraße. Schwebes employed a curved plan layout that creates a continuous, flowing façade plane stretching across three adjacent streets, a design choice that reflects the influence of Erich Mendelsohn's dynamic expressionism and emphasises a characteristic horizontality. The vertical organisation of the street-facing elevations follows a tripartite classical logic: a transparent ground-floor retail zone, five intermediate office storeys, and a setback penthouse level. The ground-floor retail shopfronts, which are slightly recessed from the main façade plane and sheltered by a continuous horizontal awning, have brass-coloured anodised aluminium frames. Above this base, the five office floors are enveloped in a rhythmic steel-frame curtain wall system. This system is delineated by prominent horizontal bands of white Detopakglas – an opaque glass with a coated surface – which clad the edges of the floor slabs. In contrast, black Detopakglas is strategically used for the spandrel panels, creating a striking monochromatic contrast that reinforces the building's linear character and sophisticated materiality. The seventh-floor penthouse is dramatically emphasised by a slender, large-scale cantilevered concrete eave, which appears to float above the roofline and serves as a signature element of 1950s Berlin architecture, especially at corner locations. While the street-facing façades prioritise transparency and urban prestige, the rear courtyard elevations adopt a purely functionalist aesthetic. These rear façades feature projecting semi-circular steel-framed glazed staircases with translucent and opaque glass, adding dynamism to the more industrial material palette. Internally, the building's structural logic – a reinforced-concrete frame with a 6.40-metre column grid – facilitates an exceptionally flexible open-plan layout. The primary façade components are 'Chicago Window'-type units, characterised by a large, central fixed vision panel flanked by two narrow, in-swing casements. These windows are constructed from slender, non-thermally broken steel mullions

Figure 1
South-east view from
Hardenbergstraße,
historic photograph.



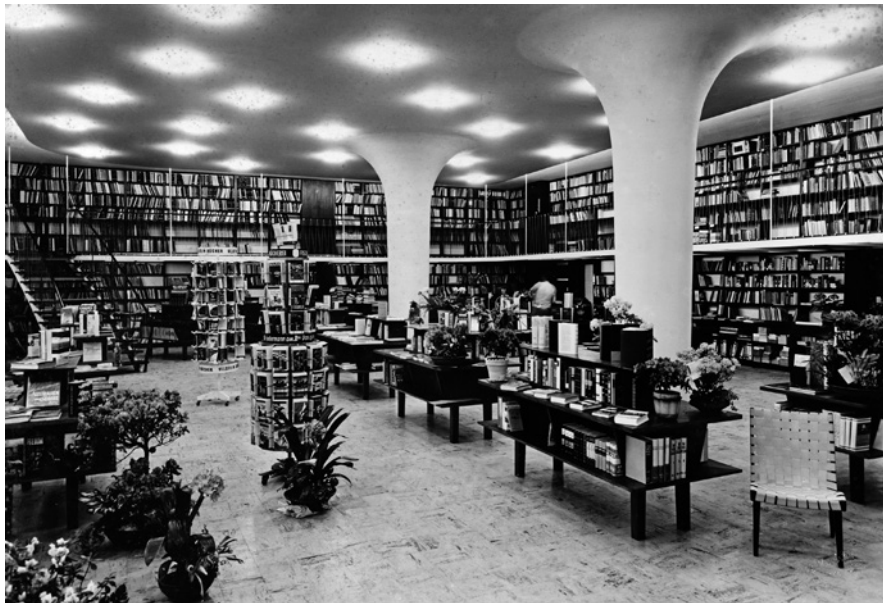


Figure 2
Interior view of the former Kiepert bookstore with mushroom-shaped reinforced-concrete columns, historic photograph.

and profiles, typically 49 mm wide and 75 mm deep. This arrangement was designed to maximise interior daylighting while facilitating natural ventilation through the operable side casements. The window configuration employs a double-casement system that creates a supplemental insulating air cavity when both sashes are closed, a significant thermal strategy in post-war design. Passive environmental control was originally managed through exterior white roller sunscreens intended to mitigate solar gain. The heating system utilised a low-temperature hydronic approach, with radiators positioned below the windows to counteract thermal loss and prevent condensation on the single-glazed steel frames. For vertical circulation, the building incorporates a sculptural spiral concrete staircase and original steel-framed glass skylights that provide natural illumination to the interior core.

Previous interventions

A significant interior adaptation was executed from 1973 to 1974 by architect Günther Wehde to modernise the retail and office environments for the Kiepert bookstore. In 2001, the original neon signs were removed from the ground-floor shop windows. A critical factor during this fifty-year period was the notable lack of systematic maintenance. Additionally, the staircase glazing suffered from previous inappropriate repair attempts.

Pre-intervention general conservation conditions

By 2003, the building exhibited severe material degradation due to five decades of deferred maintenance. The non-thermally broken steel profiles were substantially damaged by corrosion, and numerous glass panes were broken. The original

passive solar protection was non-functional, as the sunscreens were damaged, leading to intense summer overheating. Furthermore, the double-casement window assemblies suffered from air leaks and failed seals, compromising their thermal performance. The rear staircase glazing was also in poor condition following failed previous repairs.

Specific environmental or climatic pressures

Berlin's climate imposes significant seasonal stress. High solar exposure in summer, combined with a window-to-wall ratio exceeding 50%, led to intense interior overheating once the original sunscreens failed. Conversely, cold winters caused substantial thermal loss through the non-thermally broken single-glazed steel frames.

Figure 3
View of the block from
the north, 1955.



NEW INTERVENTION

2003 - 2004

Winkens Architekten (architectural design), Ingenieurbüro Welke + Schönepauck (tendering and site management)

The 2003–2004 rehabilitation of Haus Hardenberg, overseen by Winkens Architekten, is a pivotal example of how post-war modernist icons can be technologically revitalised while respecting the rigours of monument protection. This intervention was prompted by the building's transfer to Hühne Immobilien in 2002, at a time when the structure suffered from five decades of deferred maintenance, resulting in severe material degradation and a total failure to meet contemporary energy standards. The design strategy was built upon a 'dual-speed' approach: a highly conservative restoration for the street-facing elevations and a performance-oriented technological replacement for the functional courtyard façades. The street façades, celebrated for their elegant curved glass curtain wall and horizontal emphasis, required a craft-intensive process. Each steel window assembly was systematically dismantled to allow for the removal of rust and the application of new protective coatings before the original frames were reinstalled. A critical innovation within this conservation framework was the 'reglazing' strategy. While preserving the original 49 mm slender profiles, the architects replaced the inner panes of the double-casement system with 6mm Pilkington K Glass, a low-emissivity product that reflects heat back into the interior during winter, while managing solar gain in summer. This upgrade addressed the building's inherent thermal weakness – a window-to-wall ratio exceeding 50% – without sacrificing the transparency of the 1950s 'Chicago Window' typology.

Furthermore, the original white exterior blinds were replaced with new brass-coloured ones; this aesthetic enhancement, mirroring the anodised aluminium of the ground-floor shopfronts, improved visual comfort by reducing internal glare and sun reflection. Conversely, the rear courtyard façades and the secondary staircase glazing were completely replaced with modern, thermally broken aluminium frames and insulated glass units. This strategic substitution was essential to optimise the building energy balance and mitigate thermal losses at the rear, shielding the more delicate historic fabric on the street side from excessive performance pressures. The intervention also extended into the building's infrastructure, modernising the mechanical services to provide an integrated HVAC system (heating, ventilation, and air conditioning) suitable for retail and office requirements. At the pedestrian level, the ground-floor shopfronts were revitalised with advertising ribbons and upgraded aluminium profiles, while the secondary staircases were transformed into prestigious entrances with direct street



Figure 4
Restored concrete structure and new aluminium-framed glazed enclosure to a stairwell on the rear façade, 2019.

access. A key feature of the night-time urban presence was the installation of a new integrated lighting design that highlights the building's signature 'flying roof' cantilevered eave and the ground-floor canopy. The design process began with a comprehensive diagnostic analysis of the 1950s envelope, which confirmed that the original U-values were incompatible with modern energy regulations. Historical research and on-site surveys revealed significant structural damage to the steel profiles and failed window seals. The decision-making process, coordinated between the owner and heritage authorities, evaluated scenarios ranging from total façade substitution to pure conservation.

The team selected a hybrid strategy: a craft-led restoration of the prominent street-side steel frames combined with the high-performance substitution of functional rear elements. This process involved specialised training for the workforce to dismantle and re-adapt each assembly to meet contemporary protection standards. Energy modelling guided the selection of 6mm low-E Pilkington K Glass for the inner sashes to optimise the thermal balance while preserving the iconic thin profiles. The adopted strategy proposes a method capable of coordinating diagnosis, design, and construction, according to compatible and controllable criteria.

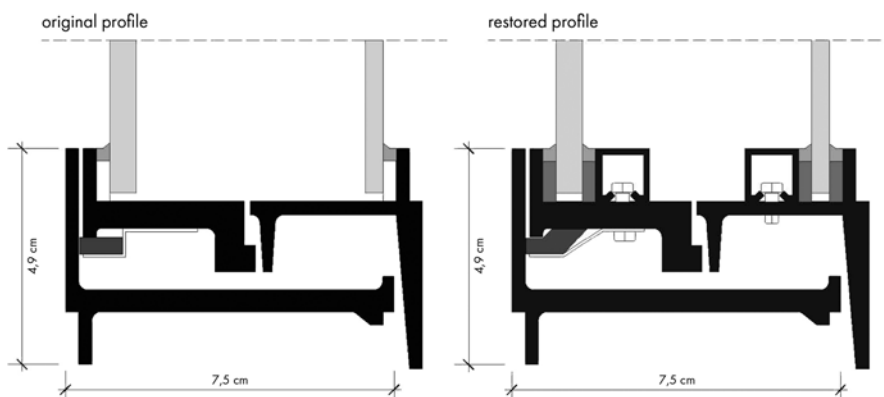


Figure 5
Detail of the window-frame profile before (left) and after (right) the intervention.

Objective of the envelope intervention

Restore original materiality and aesthetic spirit while achieving modern U-value requirements and mitigating summer overheating through targeted glazing and shading upgrades.

Extent of the envelope intervention

Full restoration of all street-facing curtain walls; complete replacement of courtyard façade elements and stair enclosures with modernised aluminium and insulated glass systems.

Solutions adopted for the envelope

Street façades: restoration of original steel frames with new low-E Pilkington K Glass panes in the inner sashes and replaced seals. Courtyard façades: new thermally broken aluminium frames and high-performance insulated glazing. Shading: new brass-coloured solar blinds to reduce glare and solar reflections. Shopfronts: upgraded brass-coloured anodised aluminium frames with a new advertising ribbon. Sealing: new glazing beads and concealed weatherstripping improve airtightness and thermal performance.

Other interventions

Modernisation of building services, including new centralised HVAC systems for shops and offices. Ground-floor retail units were renovated to accommodate new tenants such as the Lehmann bookstore. The two side staircases were upgraded to serve as primary entrances with direct street access. Night lighting: an integrated lighting design enhances the ground-floor canopy and the signature cantilevered roof eave. Interior adaptation: general refurbishment of office floor plates and updated modular distribution. The works retain the existing modular layout and flexible use of the office floors.

Certifications / Awards

2004 Bundespreis für Handwerk in der Denkmalpflege (Sonderpreis).

Knowledge framework, methodology and traceability

The project is grounded in historical and documentary research, surveys, and analyses of the state of conservation and the performance of the building envelope. Comparison among different intervention scenarios led to a differentiated strategy agreed upon with the heritage authorities: conservation and restoration of the principal street-facing façades, and selective replacement of the enclosure systems on the courtyard elevations. The dismantling, restoration, and reinstallation

of components are documented and entrusted to specialised craftsmen.

Technical adequacy and compatibility of the adopted solutions

The solutions are differentiated according to the architectural significance of the façades. On the principal street-facing elevations, the steel frames were dismantled, restored, and reinstalled, integrating new glazing, seals, and weatherproofing systems without altering the slender profile sections. On the less character-defining courtyard façades, the windows were replaced with contemporary thermally broken systems. The reinstatement of solar shading devices also contributes to controlling solar radiation.

Degree of reversibility

The dismantling, restoration, and reinstallation of the steel frames on the principal façades allow the original system to be retained and glazing, seals, and glazing beads to be replaced in the future. Overall reversibility is nevertheless partial, since the enclosure systems on the courtyard façades and secondary staircases are entirely replaced. The upgrading of retained components also involves localised modifications that do not allow a complete return to the previous configuration.

Impact on the formal and spatial configuration

The intervention preserves the curved configuration of the principal façades, the horizontal articulation of the glazed surfaces, the slenderness of the metal profiles, and the chromatic alternation of the opaque panels. New glazing and technical integrations are introduced without significantly altering the design of the street-facing elevations. The most perceptible transformations affect the courtyard façades, secondary entrances, and solar shading devices, with limited impact on the building's overall architectural image.

Degree of conservation of original architectural elements

On the principal façades, the steel frames, opaque panels, and window configuration that define the building's horizontal character are retained and restored. Glazing, seals, and metal components that can no longer be recovered are replaced for conservation and performance reasons. On the courtyard façades and secondary staircases, the enclosure systems are instead largely replaced with contemporary components. The conservation of original architectural elements is therefore substantial but selective.



Figure 6

Restored steel-framed window wall with brass-coloured mullions, opaque black-glass panels and white cladding to the slab edges, 2005.

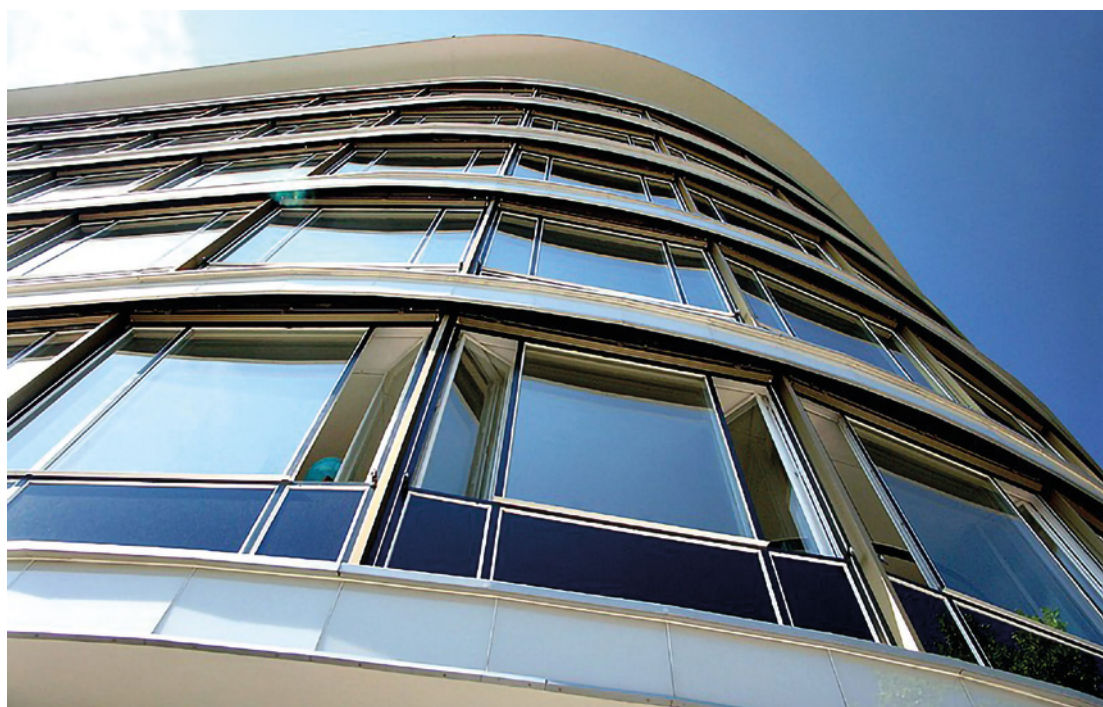


Figure 7

View from below of the restored window wall and roof overhang at the corner of the street-facing façades, 2005.



HEALTHCARE AND SOCIAL CARE ARCHITECTURE

FORMER FELIX PLATTER HOSPITAL

Switzerland, Basel-Stadt, Basel

1959 - 1967

Fritz Rickenbacher, Walter Baumann

ORIGINAL DESIGN

Built between 1963 and 1967 according to the designs of architects Fritz Rickenbacher and Walter Baumann, the Felix Platter Hospital stands as a landmark of Swiss post-war Modernism. Located in the Iselin district of Basel, this ten-storey high-rise slab measures about 105 metres in length and 20 metres in width, earning it the nickname 'the ship' due to its nautical silhouette and commanding presence within the low-rise suburban enclave.

The building is an outstanding architectural example of the peak of the 1960s economic boom, characterised by a rigorous structural logic and a tripartite façade system that reflects its internal hospital functions. The northern façade is defined by a rhythmic, floor-to-floor pre-fabricated concrete grid with wooden window infill panels, interrupted by a vertical aluminium-and-glass strip that functions like an avant-corps. Conversely, the southern longitudinal façade features a distinctive 'folded' or accordion-like metal-and-glass curtain wall. This crystalline structure was designed to optimise natural light for the patient wards while creating a vibrant, modern aesthetic. The patient rooms were oriented towards the southwest to maximise solar exposure. At the ground level, the building transitions into a comb-like floor plan consisting of several single-storey pavilions that protrude into the surrounding park. These wings were constructed with exposed red brick walls and topped with deep concrete eaves supported by exposed beams, creating a human-scaled interface between the massive monolithic block and the landscape. These pavilions originally housed the hospital's public and semi-public functions, such as the entrance hall, lecture hall, administration, and therapy rooms.

The internal layout was centred around wide corridors – up to 100 metres long – designed for medical efficiency and clinical flow, connected by three main vertical circulation cores. The top floor, or attic, originally accommodated a library, a sunbathing area with a terrace, and technical facilities, protected by louvred metal screens that maintained the building's stark silhouette. The building's structural system is a robust reinforced-concrete skeleton designed for high load capacities and long-term durability. This framework consists of a rigid grid of columns and beams supporting flat concrete slabs, providing the necessary flexibility for the large hospital wards. The 100-metre-long structure is divided by two expansion joints to

Figure 1
View of the north
façade, 1967.





Figure 2
View of the south
façade during
construction, 1966.

manage thermal movement. The envelope is differentiated into three primary technological systems. The northern façade utilises heavy, 3.5-tonne prefabricated concrete grid elements anchored back to the floor slabs. These elements act as a secondary aesthetic and protective layer, with wood-framed windows mounted on the interior. The southern façade is a more delicate aluminium-and-glass curtain wall, featuring a 'folded' accordion geometry. This construction originally used single-pane sliding windows and insulated composite spandrel panels in a distinct green hue. The ground floor pavilions utilise a load-bearing brick masonry system combined with exposed concrete beams and deep eaves for solar protection. Vertical circulation was handled by three central concrete cores containing passenger and bed lifts.

The technical infrastructure was concentrated in the basement and attic floor, with mechanical systems distributed via vertical spines within the cores. Internal partitions were primarily non-load-bearing masonry and lightweight panels, allowing for a clear ceiling height of 3.10 metres, which facilitated the subsequent adaptive reuse. Flooring materials varied by function: artificial stone was used in high-traffic foyers and stairs, while parquet was preferred for dining halls and linoleum for medical wards.

Previous interventions

Since its 1967 opening, the building had undergone targeted updates to maintain clinical standards. In 1985, a nursing school extension was added. Significant renovations to the surgical and clinical areas occurred in 1989. In 1990, annexes for orthopaedics and administration were built. Between 1998 and 1999, Bürgin Nissen Wentzlaff performed a major interior ward update. In 2010, the concrete façade underwent professional cleaning and minor repairs.

Pre-intervention general conservation conditions

Prior to the 2018 conversion, the building was in fair physical condition, maintaining its original modernist character. The façades remained largely unchanged, though some concrete members and metal fittings had been repainted. Glazed encl-

tures on the upper floors showed signs of weathering, and ground-floor shopfronts had been altered or moved outward over the years. Structurally, the reinforced-concrete frame was sound, but it suffered from severe functional obsolescence, poor fire safety, and insufficient energy efficiency, which initially led the government to favour complete demolition.

Specific environmental or climatic pressures

The building faced pressures to comply with the MuKE energy standards and modern seismic safety regulations. The large, uninsulated glass surfaces created high thermal loads in summer and heat loss in winter. Noise from Burgfelderstrasse was an environmental factor, originally mitigated by moving deliveries to the underground basement level.

Figure 3
View of the south
façade from the city.



NEW INTERVENTION

2018 - 2022

Müller Sigrist & Rapp Architekten

The transformation of the Felix Platter Hospital into a residential complex is a pioneering example of adaptive reuse that prioritises modernist heritage while fostering social sustainability. The project converted the massive clinical structure into a vibrant ‘vertical village’ containing 134 cooperative flats, ranging from student studios and family duplexes to a 12-unit senior co-living community.

The design strategy, developed by the consortium of Müller Sigrist and Rapp, focuses on minimal structural intervention to maintain the building’s iconic silhouette. A central innovation is the *rue intérieure* (‘internal street’), a winding public path that repurposes the former wide hospital corridors. This path connects the units vertically and culminates in a communal roof terrace and social space, fostering interaction among residents. To address thermal inefficiencies without altering the historic aesthetic, a new secondary triple-glazed wood-aluminium skin was installed behind the original ‘folded’ south façade. This created an unheated interstitial space that functions as a climate buffer, providing residents with year-round winter gardens and private balconies.

On the northern façade, the historic concrete grid was cleaned and preserved, with 160 mm of internal mineral wool insulation added and new triple-glazed wooden windows installed to match the originals. The north aluminium strip façade was replaced in kind with a high-performance replica. The ground floor pavilions were revitalised to include a neighbourhood café, a supermarket, a fitness centre, and a day-care facility, ensuring the building remains a social anchor for the new Westfeld district. The conversion required significant technical upgrades to meet current building codes. For seismic retrofitting, the external stairwells were replaced by new stairwells closer to the central axis, while three reinforced-concrete shear walls were added, allowing for more flexible flat layouts.

The former mechanical floor in the attic was transformed into habitable space through the addition of large circular ‘bull’s-eye’ windows, a sensitive compromise with heritage authorities that preserved the façade’s ‘closed’ character. The project also integrated a sustainable energy concept, utilising a groundwater heat pump for 70% of the heating load and connecting to the city’s district heating for peak demand. A 503-square-metre photovoltaic array was installed on the roof. The surrounding landscape was preserved, retaining mature trees that provide natural shade. By treating the existing structure as a resource, the intervention



Figure 4
View of the north
façade.

saved approximately 20,000 tonnes of reinforced concrete and prevented 2,500 tonnes of CO₂ emissions compared to a new build. This successful rehabilitation turned a slated-for-demolition clinical landmark into a diverse, energy-efficient housing cooperative that respects its architectural past while serving the future social needs of the Basel community.

The process started in 2015 after a cost-benefit analysis recommended demolition, sparking resistance from architects and heritage groups. A feasibility study eventually proved that residential conversion met energy and safety codes cost-effectively. In 2018, the Baugenossenschaft Wohnen & Mehr launched a design competition focused on horizontal/vertical access and seismic concept. The Müller Sigrist and Rapp consortium won with a 'minimal intervention' approach. The planning involved a three-tier preservation framework negotiated with the cantonal monument preservation authority: Tier 1 mandated original preservation of principal façade elements; Tier 2 required maintaining the appearance of secondary components; Tier 3 allowed for interior modifications. Ownership was transferred to the cooperative in 2019.

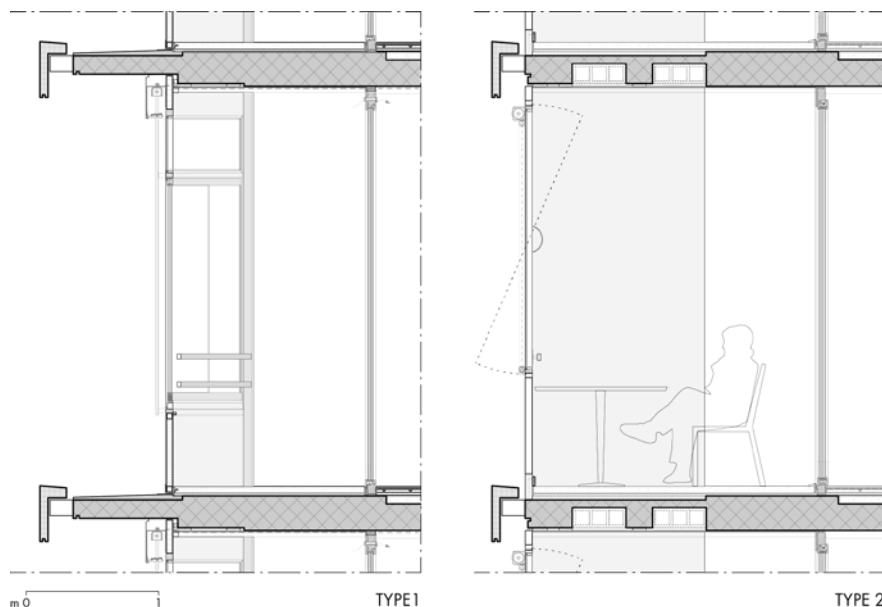


Figure 5
Detailed section of the
south façade, types 1
and 2.

Objective of the envelope intervention

To fulfil current thermal insulation and fire safety standards while preserving the iconic modernist façade through a sensitive secondary skin and high-fidelity, high-performance replicas.

Extent of the envelope intervention

Comprehensive renovation of the entire building envelope, focusing on the southern folded glass wall, the northern concrete grid, and the conversion of the windowless mechanical penthouse level.

Solutions adopted for the envelope

South: a new triple-glazed wood-aluminium skin ($U_g=0.60 \text{ W/m}^2\text{K}$) behind the preserved folded façade creates an unheated winter-garden buffer. North: the concrete grid is preserved with 160 mm internal mineral wool and triple-glazed wooden windows ($U_f=1.40 \text{ W/m}^2\text{K}$); façade U-values are $0.16\text{--}0.19 \text{ W/m}^2\text{K}$. The aluminium strip is replaced by a thermally broken replica. Roof insulation achieves $U=0.10\text{--}0.15 \text{ W/m}^2\text{K}$; the ground slab $U=0.25 \text{ W/m}^2\text{K}$. External shading is incorporated on the south façade. At attic level, former mechanical screens are replaced with an insulated habitable floor with circular openings.

Other interventions

Seismic retrofitting replaced the external stairwells with new stairwells closer to the central axis and added three reinforced-concrete shear walls. The *rue intérieure* was created in former clinical corridors. MEP systems were replaced with efficient solutions, including a groundwater heat pump and a 110 kWp rooftop PV array. The ground floor was reconfigured for social and commercial use. Mature trees were retained to create a green corridor. Flat partitions use double-stud gypsum-board construction with mineral wool insulation.

Post-intervention consumption

26 kWh/m² year

Certifications / Awards

2023 Swiss Building Award (Hochbau); 2024 Gestaltungspreis der Wüstenrot Stiftung.

Knowledge framework, methodology and traceability

The project emerged from a structured process that began with a feasibility study assessing the compatibility of residential conversion with energy, fire-safety, and seismic requirements. The 2018 competition and consultation with the heritage authority established three levels of conservation, distinguishing elements to be fully retained from

those open to modification. The resulting framework documents the objectives, constraints, and criteria adopted for the façades, structure, and interior spaces.

Technical adequacy and compatibility of the adopted solutions

The solutions are differentiated according to the specific characteristics of each façade. On the south elevation, the folded metal façade is largely retained and supplemented by a secondary internal glazed layer, creating an unheated buffer zone; on the north elevation, the prefabricated concrete grid is preserved, internally insulated, and fitted with new windows. The replication of the aluminium glazed strip and the addition of shading devices address energy requirements while preserving the overall configuration of the envelope.

Degree of reversibility

The secondary internal glazing on the south façade constitutes a potentially removable addition and allows much of the existing façade to be retained. Overall reversibility is nevertheless limited by the replacement of the windows and aluminium glazed strip on the north façade, the introduction of internal insulation, and the conversion of the technical attic, where the metal screens are removed and new circular windows are introduced.

Impact on the formal and spatial configuration

The building's silhouette, façade articulation, and principal envelope systems remain recognisable. On the south side, the secondary skin is set back from the folded glazing and preserves the external perception of the envelope; on the north, the concrete grid is retained, while the windows and glazed strip are reproduced using contemporary components. The most perceptible impact concerns the attic, transformed from a screened technical volume into an inhabited floor.

Degree of conservation of original architectural elements

The intervention preserves the prefabricated concrete grid, nearly all of the folded metal façade on the south elevation, as well as the balconies and canopies that define the building's architectural image. The retention of original elements is nevertheless selective: the north-facing windows and aluminium glazed strip are replaced, while the attic screens are removed to accommodate new openings. Conservation of the principal architectural features therefore prevails, while being combined with significant replacement and transformation.



Figure 6
Detail of the south façade with the new entrance.

BURGERWEESHUIS

The Netherlands, North Holland, Amsterdam

1955 - 1960

Aldo van Eyck, Joop van Stigt

ORIGINAL DESIGN

The Burgerweeshuis, designed by Aldo van Eyck between 1955 and 1960, is presented as a foundational manifesto of structuralist architecture. Located on the then-rural outskirts of Amsterdam, the complex was conceived as a 'house like a city' and a 'city like a house', with the aim of reconciling the domestic needs of the individual with the collective scale of urban life. The project rejected the rigid functionalist dogmas of early modernism in favour of a decentralised, non-hierarchical organisation that Van Eyck described through the 'aesthetics of number'. The spatial configuration is governed by a 3.36-metre orthogonal grid, which acts as the generating matrix for a casbah-like, labyrinthine layout. This modular system enabled an articulated plan composed of 328 small units and eight larger common spaces, each defined by its own concrete dome. The modules are clustered into four functional zones arranged around a central entrance courtyard: pavilions for younger children, pavilions for older children, administrative offices, and service wings. The transition between these areas is organised through a network of internal streets and squares, which simulate the public life of a city while maintaining the security required by an institution. The architecture is characterised by the principle of 'dual phenomena', or reciprocity, expressed in the relationship between inside and outside, open and closed, and small and large scales. Each residential pavilion is oriented towards a specific patio or garden, establishing a direct relationship with the surrounding landscape. The larger domes identify communal gathering spaces, including the festive hall and the gymnasium, and contribute to a shared identity within the repetitive modular field. The alternation of masses and voids produces a varied spatial experience, distinct from the monotony that might otherwise be associated with a modular system. Materiality was central to Van Eyck's conception of a 'home for children'. The building combines fair-faced concrete, dark-brown brickwork, and translucent glass-brick partitions. The contrast between the rougher exterior masonry and the more intimate, wood-lined interiors of the pavilions emphasised a sense of protection and domesticity. The primary load-bearing structure consists of cast-in-place concrete columns supporting precast Schokbeton architraves. These architraves integrate light slots and serve to support the roof landscape. The roof is composed of 328 small precast concrete domes

Figure 1
Aerial view of the
complex, 1960.





Figure 2
Interior view of the
living room towards
one of the courtyards,
1968.

and 8 large cast-in-place domes. Originally, these domes were left with a raw interior finish to enhance acoustics and were finished externally with sand-coloured gravel. The foundation utilises reinforced precast concrete piles. Ground floors consist of precast lightweight concrete elements over crawl spaces, accommodating the technical infrastructure. The vertical enclosure combines exposed concrete, dark-brown brickwork, and glass-brick partitions. Original fenestration used single-glazed steel frames, later replaced by hollow steel window frames with advanced double glazing. Internal partitions employ masonry and glass blocks to define pavilions while maintaining spatial continuity along the 'indoor streets' paved with quartzite; inside the pavilions, the finishes were warmer with plastered walls and vinyl flooring. Lighting and utilities were originally integrated directly into the concrete structural elements to maintain aesthetic purity. In the circulation areas, the rough materials were left exposed, emphasising material honesty.

Previous interventions

Between 1991 and 1994, Aldo and Hannie van Eyck led a major conversion of the complex for the Berlage Institute, which included the construction of the neighbouring Tripolis complex. In 1993, the building was officially designated for office use. Later, in 2005, the former director's residence was converted into a dental practice. These incremental transformations often introduced internal partitions and technical modifications that partially obscured the original structural clarity and spatial continuity of Van Eyck's design prior to the comprehensive restoration launched in 2015.

Pre-intervention general conservation conditions

By 2014, the building was in a state of extreme neglect and decay after years of vacancy following the departure of the Berlage Institute. The struc-

tural condition was critical, with leaking roofs and outdated mechanical systems. Aesthetic damage was significant due to the application of thick, opaque coatings on fair-faced concrete surfaces, compromising material integrity. Poor thermal performance led to high energy demand and a degraded indoor climate, threatening the monument's viability and necessitating an urgent, comprehensive intervention by the new owners.

Specific environmental or climatic pressures

Dutch climate conditions imposed severe pressures on the structure. Its vast exposed surface and ubiquitous thermal bridges, stemming from concrete beams and columns, led to massive heat loss and winter condensation risks. The degraded envelope suffered from leaks and draughts, while extensive glazing caused significant summer overheating stresses.

Figure 3
Exterior view of the
former children's
pavilions, 2018.



NEW INTERVENTION

2015 - 2021

WDJArchitecten (lead architect), Ex-Interiors (interior design), Atelier Quadrat (landscape design)

The 2015–2021 revitalisation of Aldo van Eyck's Burgerweeshuis represents a paradigm shift in conserving post-war modern heritage, transforming a decaying structuralist icon into a high-performance headquarters for the BPD urban area development company. After decades of neglect, the project was guided by Wessel de Jonge Architecten with surgical precision. The objective was to reconcile its rigid modular geometry and historical significance with the requirements of a contemporary, activity-based work environment. The intervention began with the removal of later, non-original extensions, partitions and suspended ceilings, restoring the building's characteristic casbah configuration and planimetric contours. A restorative feat involved the removal of a thick, greenish-grey rubbery coating that had obscured the fair-faced concrete façades. Once stripped, the Schokbeton and cast-in-place elements were repaired and impregnated with a transparent protective agent, restoring the material honesty central to Van Eyck's vision. In terms of thermal performance, the envelope underwent a significant upgrade without altering its architectural expression. The steel window frames replaced by Van Eyck in 1993 were retained but fitted with HR++ high-performance double glazing featuring sun-repellent coatings to mitigate summer overheating. Inside, the 336 concrete domes – originally problematic for their poor acoustics – were treated with a 35 mm layer of paper-based acoustic spray plaster. This layer resolved reverberation issues and allowed for the concealment of new electrical and data conduits, preserving the clean structural lines. The interior design by Ex-Interiors introduced a new layer in time, utilising a sober palette and modular panels to define workspaces within the pavilions, referencing Van Eyck's original colour as identified by Suzanne Fischer's research. The residential pavilions were transformed into office clusters, while the internal streets were reinstated as communal squares for informal encounters and the display of BPD's extensive art collection. This repurposing as a gallery space allows the public to appreciate both the art and the architecture during scheduled viewings. The transition zones between interior and exterior were revitalised through a landscape plan by Atelier Quadrat, which restored original elements like the sandpits and mirror ponds while subtly integrating modern requirements like discreet parking. The technological backbone is centred on a sustainable energy concept, including a 250 m² energy roof and an aquifer thermal energy storage (ATES) system combined with heat pumps. This approach improved the building's energy rating from Label G to Label A under EU standards, showing that even the most technically



Figure 4
Former celebration
hall, 2017.

challenging modern monuments can be adapted for the circular economy. The project received the 2018 Geurt Brinkgreve Bokaal and the 2021 DOCOMOMO Rehabilitation Award, securing the Burgerweeshuis's future as a functional work of structuralist thought. This restoration ensures a living heritage status and functional beauty for years to come. The design process was rooted in a deep understanding of the building's material history. It commenced with a quick-scan to assess technical feasibility, followed by a Historic Building Survey and colour-historical research by Suzanne Fischer. This research identified Van Eyck's logic of reciprocity and his 1960s colour palette, which informed material choices. A pivotal tool was the Transformation Framework developed by the architects with Atelier Quadrat, which classified building elements by their capacity for change.

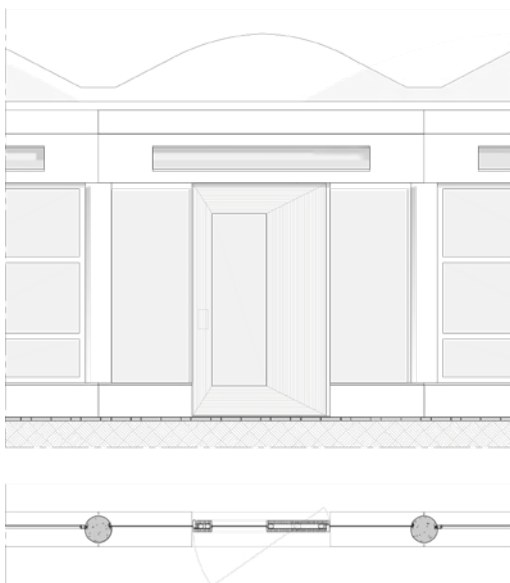
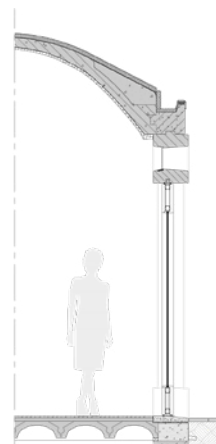


Figure 5
Plan, section and
elevation details of the
new entrance door.

Objective of the envelope intervention

To transform the monumental shell into a high-performance office envelope, reducing energy demand while preserving its structuralist character and layered materiality, including the early-1990s alterations by Aldo and Hannie van Eyck.

Extent of the envelope intervention

The intervention targeted the entire building envelope, involving the repair of all masonry and concrete surfaces, a total replacement of glazing, and full thermal upgrades to the roofing systems.

Solutions adopted for the envelope

High-efficiency HR++ glass with solar-control coatings was fitted into existing steel frames. Concrete surfaces were stripped of damaging coatings to reveal the raw finish. The 336 domes received internal 35 mm acoustic/thermal spray plaster. A major innovation was the 250 m² energy roof on the flat volume over the former staff quarters. This system features solar collectors hidden beneath dark grey PVC roofing to harvest thermal energy. This heat is transferred to an ATES system via heat pumps, achieving Label A performance without altering the building's profile.

Other interventions

Pavilions were adapted for activity-based work with new underfloor heating/cooling, while original radiators were restored in communal streets. Technical conduits and LED wiring were integrated into the new ceiling plaster to hide modern services. Surviving fixtures, including granito counters and cabinetry, were meticulously restored. The surrounding landscape was redesigned by Atelier Quadrat to restore original play elements, such as mirror ponds, while subtly integrating discreet parking.

Post-intervention consumption

206 kWh/m² year

Certifications / Awards

Energy label A (2017); 2018 Geurt Brinkgreve Bokaal; 2021 DOCOMOMO Rehabilitation Award (Metamorphosed Functions).

Knowledge framework, methodology and traceability

The project is based on a preliminary survey, historical, constructional, and colour research, and an assessment of the building's material and functional conditions. A framework of allowable transformations distinguished the elements to be preserved from those that could be adapted to new requirements. Dialogue among the designers,

owners, heritage authorities, and Van Eyck's heirs informed the decision-making process, with specific issues further investigated during construction through dedicated dossiers.

Technical adequacy and compatibility of the adopted solutions

The solutions address deterioration, heat loss, overheating, and building-services obsolescence in an integrated manner. The steel window frames installed in 1993 were retained and fitted with new solar-control insulating glazing; the concrete and brick surfaces were restored, while the roofs accommodate a system for thermal energy production and storage without altering the building's profile. Building services were integrated while minimising interference with the architectural character.

Degree of reversibility

The retention of the steel frames allows for the future replacement of the glazing, while the energy system installed on the flat roofs constitutes a distinguishable addition. Reversibility is nevertheless partial: the glazing was entirely replaced, some skylights were renewed, and the acoustic plaster applied to the underside of the domes incorporates part of the new building-services networks. Interventions to the floor and roof build-ups are likewise not removable without affecting the components involved.

Impact on the formal and spatial configuration

The intervention preserves the pavilion configuration, the continuity of the internal circulation routes, the modular concrete-and-brick system, and the articulation of the domed roofs. The new glazing retains the design and colour of the existing window frames, while the energy systems do not alter the building's profile. The removal of partitions added in the 1990s and the introduction of new glazed walls enhance the legibility and visual continuity of the interior spaces.

Degree of conservation of original architectural elements

The precast and cast-in-place structures, exposed concrete surfaces, brick and glass-block masonry, domes, and principal finishes of the common areas were preserved and restored. Built-in furnishings, lighting fixtures, and surviving floor finishes were also retained. Replacements mainly concern glazing, deteriorated components, and elements that had already been altered in previous interventions, without compromising the predominant retention of the original architectural fabric.



Figure 6
View of the court and the former children's pavilions, 2018.

Figure 7
Patio between the former children's pavilions and the office wing, 2018.

INDUSTRIAL AND
MANUFACTURING
ARCHITECTURE

ICO CENTRAL WORKSHOPS

Italy, Piedmont, Ivrea (TO)

1939 - 1949

Gino Pollini, Luigi Figini, Annibale Fiocchi

ORIGINAL DESIGN

The ICO Central Workshops were built in three phases between 1939 and 1949, all designed by Luigi Figini and Gino Pollini, as a further westward expansion of the Officine Ingegner Camillo Olivetti, from which the acronym ICO derives. Between 1934 and 1936, the same architects had already designed an initial extension to the original red-brick factory, built between 1896 and 1918. The development of the complex was completed between 1955 and 1957 with construction of the New ICO building. Extending linearly along Via Jervis, the ICO Central Workshops gave architectural form to new systems of work organisation, while the long continuous glazed north elevation became a distinctive expression of the modernity of Olivetti production. The successive construction phases maintain several consistent features, including a reinforced-concrete frame on a 4×12 m modular grid and extensive glazing that provides diffuse light to the workspaces. The columns are tapered; on the ground floor, mushroom-headed columns based on the Maillart patent are arranged on a denser 4×4 m grid.

The reinforced-concrete floor slabs are approximately 40 cm thick, reducing to 10 cm in the cantilevered section corresponding to the façade cavity. The third phase, built between 1947 and 1949, comprises two orthogonal wings. The western wing seamlessly extends the north elevation along Via Jervis to the junction with Via Monte Navale. More than 110 m long and approximately 18 m high, the façade consists of a double-skin glazed envelope with sash openings that allow two inner and two outer panels to move simultaneously. The two layers of steel framing are separated by an accessible cavity approximately 80 cm deep, conceived both to improve the thermal behaviour of the envelope and to facilitate maintenance. The inner glazing is set between pairs of columns and the floor slabs, making the structural grid legible externally. The original non-float, single-pane glass was 3 mm thick and fixed to the frames with glazing putty. On the south and west elevations, a reinforced-concrete grid stands in front of the double skin. Developed following a solar-radiation study, it blocks direct summer sun while admitting winter sunlight. The device is formed by cantilevered extensions of the floor slabs and vertical reinforced-concrete fins, supplemented by two additional inclined brise-soleil blades. On the south elevations of the bays built before the Second World War and on the east elevations,

Figure 1
Façade facing Via
Jervis.

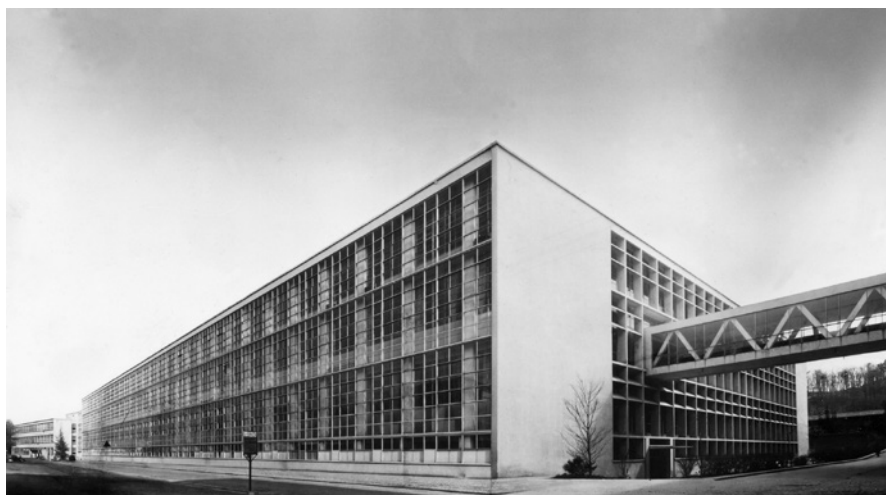




Figure 2
Exploratory investigation of deterioration on the north façade at an expansion joint.

the double-skin glazing instead incorporates vertical timber brise-soleil within the cavity. The southern wing, separated from the western wing by a recessed glazed bay, was designed by Annibale Fiocchi, then head of the Olivetti Technical Department. Its set-back glazed façade was originally screened by Venetian blinds; in 1955 these were replaced by adjustable horizontal fibre-cement brise-soleil designed by Ottavio Cascio. The infill envelope consists almost entirely of double-skin glazing. The lower sections of the façades include concrete elements and cavity brickwork finished in Terranova render and, in part, clad with 2 x 2 cm ceramic stoneware mosaic tiles, used on the plinth along Via Jarvis and on parts of the south elevation. Structure, envelope and solar-control devices thus define an industrial building in which work organisation, the control of lighting and solar gain, technical innovation and corporate identity are closely integrated.

Previous interventions

Alteration of the west façade on Via Monte Navale for construction of the bridge link to the New ICO building, which was subsequently transformed into an enclosed wing. Replacement of broken glass in the outer skin. From the mid-1970s, after production moved elsewhere, the interiors were altered by subdividing the large halls on the first, second and third floors into two rows of offices at each level, arranged along a long central corridor without natural light.

Pre-intervention general conservation conditions

The building was in poor condition following a long period of abandonment and alterations associated with adapting the spaces to new uses. The glazing system could neither accommodate thermal expansion nor prevent condensation within the cavity, resulting in corrosion of the steel frames.

Specific environmental or climatic pressures

Solar exposure

Figure 3
The façade facing Via
Jervis after restoration.



NEW INTERVENTION

2004 - 2006

Enrico Giacomelli (GStudio – double-skin glazing), Dante O. Benini & Partners Architects (adaptive reuse), Diaspro S.r.l.

From the mid-1970s, following the relocation of typewriter production, the ICO Workshops were progressively converted into offices and storage facilities, a phase that marked the beginning of a deterioration largely caused by inadequate maintenance. Designed from 2004 and carried out between 2005 and 2006, the refurbishment of the ICO Central Workshops was promoted by a telecommunications company already occupying part of the New ICO building and seeking to consolidate its presence in Ivrea. Delivered in fifteen months as the first phase of a broader programme later extended to the New ICO building, the project enabled the building to be reused as a call centre on the first floor and offices on the second and third floors, with a canteen, storage and archives at ground level. The project aimed to restore the building's technological and functional efficiency and provide appropriate levels of comfort. The interiors were modified by improving circulation, constructing a new stair core and entrance from Via Monte Navale, bringing the building into compliance with safety and fire regulations, and upgrading the building's services. The façades, a defining element of the original design, became central to the intervention. The design process began with historical and archival research and a survey of the glazed surfaces, undertaken to reconstruct the original technical solutions, understand their operation and assess their condition and subsequent alterations. Particular attention was paid to the double-skin glazing, opening systems, solar-control devices and relationships between structure and envelope. Recovering the transparency and perceptual continuity of the façades was adopted as the guiding criterion and translated into guidelines shared by the project teams, directing the adaptive-reuse decisions and ensuring consistency with the building's architectural and technological character. Where the double skin survived, the inner glazing was replaced to meet regulatory requirements, while the outer glazing was carefully restored. The original steel frames were dismantled and reinstalled with minimal modifications to limit condensation within the cavity and accommodate thermal expansion. The sash-opening system was reinstated and motorised, remaining operational only in the outer skin. The glass was replaced with 4+4 mm laminated float glass incorporating PVB interlayers and secured with glazing beads, while preserving the visual effect of the outer surface created by the slight irregularities of the assembly. The new inner skin was constructed using bespoke thermally broken aluminium frames,

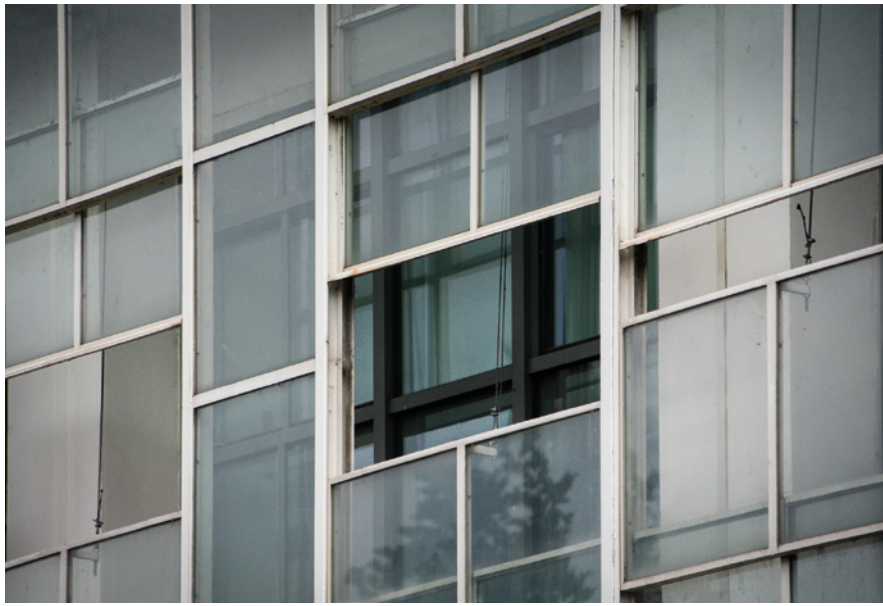


Figure 4
Detail of the façade
facing Via Jervis.

dimensioned to echo the original window systems and minimise profile depth, together with laminated, impact-resistant, low-emissivity insulating glass units. Anthracite-grey frames distinguish the new inner skin from the ivory-white outer skin and keep it visually subordinate. A single skin was adopted on the elevations facing the internal courtyards, where most of the double glazing had been replaced over time. The vertical timber brise-soleil on the internal south and east elevations were restored, replacing their cladding with white-grey lacquered MDF panels. On the south façade, the horizontal fibre-cement brise-soleil were replaced with asbestos-free fibrous elements while retaining the original bicycle-handlebar adjustment mechanism. In the opaque sections, the mosaic cladding and Terranova render were restored, preserving the original colour scheme.

1. Pulley assembly plate
2. 200×264 mm galvanised plate, 4 mm thick, for pulley assembly, welded to sheet-metal box
3. Galvanised sheet-metal box, 3 mm thick, supporting pulley assembly
4. 25×25 mm L-shaped water-stop profile, 3 mm thick
5. Ø5 countersunk screw welded to plate
6. 6 mm galvanised plate, continuously welded to 65×65×6 mm profile
7. 40×22×6 mm L-profile
8. 30×3 mm bent cold-drawn flat bar
9. 65×65 mm galvanised L-profile, 6 mm thick
10. Silicone sealant joint
11. Anchor embedded in repair concrete
12. 70×30×20 mm C-profile, 4 mm thick
13. HILTI CP-series R.E.I. 120 firestop collar
14. Perforated metal plate for pulley cables

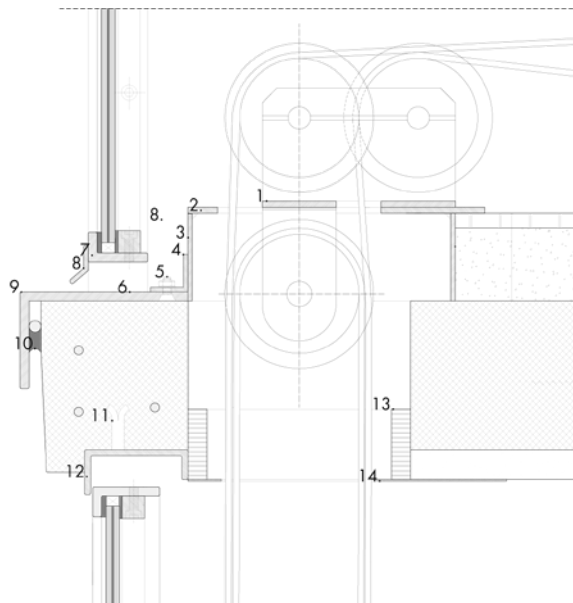


Figure 5
Detail of the pulley
restoration design.

Objective of the envelope intervention

The building was converted to a new use through a major programme of regulatory upgrading. The principles established for restoring the glazed façades also informed the design decisions throughout the intervention.

Extent of the envelope intervention

The intervention encompassed the entire transparent and opaque vertical envelope.

Solutions adopted for the envelope

In the double-skin sections, the outer surface was restored by dismantling and reinstalling the steel frames, with modifications to limit condensation and accommodate thermal expansion. The sash-opening system was reinstated and motorised, and the glass replaced with 4+4 laminated float units. The inner skin was reconstructed with thermally broken aluminium frames and laminated, impact-resistant, low-emissivity insulating glass units. In the opaque sections, the 2 x 2 cm ceramic mosaic and Terranova render were restored, preserving the original colour scheme.

Other interventions

New stair cores and escape routes were constructed, together with a new entrance from Via Monte Navale, to bring the building into compliance with fire and workplace safety regulations. Partitions introduced by later alterations were demolished to recover the spatial character of the original large halls and adapt them to the new uses. The intervention also included upgrades to the building services and circulation systems, with plant installed at roof level so as not to interfere with the building's appearance.

Post-intervention consumption

123.54 kWh/m² year

Certifications / Awards

2009 Gold Medal for Italian Architecture (Restoration of Modern Architecture – Honourable Mention); 2009 Premio IN/ARCH-ANCE (Riqualificazione edilizia).

Knowledge framework, methodology and traceability

The knowledge-gathering process was thorough and well documented. The project draws on archival sources, historical and architectural analysis, condition assessment and a window schedule. Particularly significant was the preparation of architectural guidelines by the architect from the outset, which provided a coherent reference for decisions by the other specialists. The recovery

of the façade's transparency and continuity was therefore based on shared, traceable criteria.

Technical adequacy and compatibility of the adopted solutions

The adopted technical solutions are consistent with the constructional logic of the double-skin system. Restoration of the outer façade safeguards the building's urban image and the legibility of the elevation, while upgrading the inner skin concentrates the required levels of weather-tightness, safety, thermal transmittance and comfort in bespoke profiles, thermal breaks and low-emissivity glazing. Management of cavity ventilation and the introduction of new fixings respond specifically to condensation and thermal-expansion problems. Technical and performance compatibility is therefore high, with interventions that are distinguishable but carefully controlled.

Degree of reversibility

Reversibility varies and is partial overall. It is high for the interventions on the outer skin of the envelope, where dismantling, cleaning and localised integration reduce invasiveness and facilitate maintenance. Complete replacement of the inner skin, with the associated loss of original fabric, is not reversible. These transformations are justified by safety and energy-performance requirements associated with reuse.

Impact on the formal and spatial configuration

The impact of the envelope energy upgrade on the building's formal and spatial configuration varies with the viewpoint. Externally it is limited: the subdivisions and transparency of the Via Jervis elevation remain legible, and the curtain wall retains its original lightness. Internally, the impact is more evident because of the replacement of the inner skin and the altered perception of the cavity depth, profiles and glazing of the new window systems.

Degree of conservation of original architectural elements

The conservation approach is clear, although not comprehensive. The outer envelope skin, the modular rhythm of the metal mullions and transoms, parts of the opening systems, the mosaic cladding, renders and colour schemes are retained and restored. Replacements include the inner skin, glazing, brise-soleil and components that were deteriorated or no longer compliant. The loss of original fabric is partly offset by the compatibility of the adopted solutions and by safeguarding the building's transparency and lightness.



Figure 6
The opening mechanism of the outer façade layer after restoration.

Figure 7
Bicycle-handlebar mechanism for opening the horizontal louvers on the south façade.

CARTIERA BURGO

Italy, Lombardy, Mantua

ORIGINAL DESIGN

1960 - 1964

Pier Luigi Nervi, Gino Covre

The paper-machine building at the Cartiera Burgo mill in Mantua, known as the 'suspended factory', is singular within Pier Luigi Nervi's work. Designed from 1960 and built between 1961 and 1964 with engineer Gino Covre, it was conceived to house the Beloit Italia continuous paper machine in a single column-free space 250 m long and 30 m wide, ensuring maximum production flexibility. The approximately 50-hectare site on the shore of Lago di Mezzo also included the reel warehouse, office buildings, the wood-pulp building and two Accelerator settling tanks.

The construction method follows the Nervi System, founded on principles of economy, speed and prefabrication, with reduced reliance on timber formwork. The main building's megastructure comprises two independent subsystems: a two-level reinforced-concrete base founded on Franki piles and supporting machinery and service spaces, and a suspended roof. The latter consists of an approximately 7,500 m² deck of steel lattice girders, adopting a structural scheme inspired by suspension bridges and supported by four polygonal steel catenaries anchored to two reinforced-concrete trestles.

The trestles, approximately 47 m high and 164 m apart, consist of tapered, inclined pylons arranged in a lambda configuration that makes legible the flow of forces transmitted by the catenaries. They were built using 7 cm reinforced-concrete prefabricated panels, produced on site and used as permanent formwork before being integrated with reinforcement and internal concrete pours. The steelwork, developed through consultation between the designers and client, was fabricated by Società Badoni of Lecco. Construction likewise followed an industrialised logic based on component prefabrication and coordinated operations.

The original envelope comprised an exposed-brick base surmounted by approximately 9,000 m² of steel-and-glass curtain walling. The system was designed to accommodate roof movements caused by temperature changes, up to approximately 9 cm. The 278 tapered box-section mullions, each 15.60 m high and spaced at 2 m centres, were fixed at their bases by hold-down connections and free at the top, allowing the façade and roof to move

Figure 1

Aerial view of the paper mill complex in operation, mid-1960s.

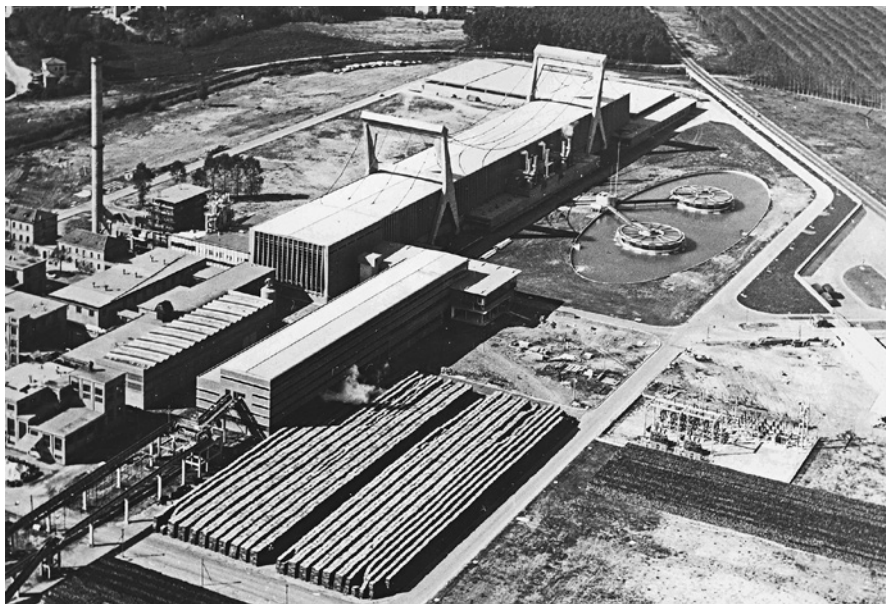




Figure 2
South façade during the installation of the vertical supports and the gas-turbine structure.

independently. Airtightness was provided by a continuous rubber gasket, while watertightness resulted from the roof covering overlapping the gutter attached to the uprights.

The glazing used Filtrasol heat-absorbing glass and Panoroc enamelled panels. Four 1.25 m-wide bands of horizontal metal brise-soleil limited solar gain on the south and west elevations, while adjustable NACO louvres in the roof space promoted natural ventilation. The reel warehouse used an orthogonally ribbed floor structure cast in ferrocement formwork mounted on mobile scaffolding. The truncated-conical Accelerator tanks were constructed using the serial 'grandmother-mother-daughter' system, combining a treatment function with sculptural expression.

Cartiera Burgo is therefore not simply an industrial enclosure but a megastructure in which architectural form, structural clarity and production requirements coincide. The transparent envelope made the manufacturing process visible from outside, transforming industrial activity into an architectural image and introducing one of the most significant technological set pieces of the second half of the twentieth century into Mantua's landscape.

Previous interventions

1974: A fire destroyed the envelope and brise-soleil; temporary repairs used inexpensive blue sheet metal. 1990s: External silos and an elevated Deculator system were installed to the north. 2001: The north and west façades were completely rebuilt with new uprights but sandwich-panel infill. Over time, numerous openings were cut through the floors for incompatible service routes, weakening the original structure.

Pre-intervention general conservation conditions

The 'suspended factory' presented aesthetic and structural problems resulting from decades of insufficient maintenance and purely functional alterations. The 1974 fire had erased Nervi's intended

transparency, replacing the glass with blue sheet metal that accelerated corrosion of the steel uprights through acidic condensation. Structurally, internal corrosion had brought the uprights close to collapse, while the trestles showed widespread carbonation and oil infiltration.

Specific environmental or climatic pressures

Located in the Po Valley, the building is exposed to winds from Lago di Mezzo and intense solar radiation on the south and west elevations. It must accommodate seasonal temperature variations that cause movements of up to 9 cm in the suspended roof. Internally, cellulose production created an aggressive microclimate of high temperatures, acidic fumes and saturated humidity.

Figure 3
South façade during
the dismantling of the
vertical supports and
panels.



NEW INTERVENTION

2015 - 2020

Massimo Narduzzo (CREA.RE), Giuseppe Ruscica

The recovery and adaptive reuse of Cartiera Burgo, carried out between 2015 and 2020, reactivated the industrial site and adapted the 'suspended factory' to the new Valmet continuous paper machine installed in place of the historic Beloit unit. Updating the production process required one row of columns to be demolished and rebuilt 65 cm from its original position to accommodate the new machine beam on the north side. The new elements were configured to remain distinguishable from the original structure, while the floors were strengthened with stainless-steel ties designed for the new static and dynamic loads.

Restoration of the two lambda trestles involved controlled-pressure water cleaning, reinforcement treatment and the repair of voids with thixotropic mortars, limiting alteration of the surfaces and existing patina. The suspended steel deck underwent mechanical cleaning and water jetting, followed by protective and paint systems; replacements were restricted to elements that were no longer safe.

The most architecturally significant operation was the reinstatement of the envelope. Removing the blue sheet metal added after the 1974 fire recovered the transparency and continuity of light envisaged by Nervi. The new system uses horizontally installed, double-skin LINIT EcoGlass U-profiled glass, providing thermal and acoustic performance suited to the new production process. Deteriorated vertical mullions and hold-down connections were replaced with steel profiles reconstructed from the 1961 drawings. Horizontal aluminium brise-soleil were reinstated on the south and west elevations, restoring solar protection and the original pattern of light and shadow.

Ventilation systems along the north façade were renewed with high-efficiency air-handling units installed on galvanised platforms and screened by a 5.10 m-high microperforated sound-absorbing barrier. The reel warehouse was returned to its original spatial character by removing incongruous partitions and installing a grey resin floor suitable for laser-guided forklifts. The Accelerator tanks and office buildings were restored, recovering their original colours and details; the curtain-wall mullions of the offices were also insulated internally. The Beloit machine control panel was retained *in situ* as evidence of the previous production process. Reactivation was accompanied by energy-recovery and generation systems, including a cogeneration plant fuelled by biogas from the on-site treatment plant.



Figure 4
North façade at
sunset.

The knowledge-gathering process combined research in the Burgo archives with laser-scanning surveys used to reconstruct the geometry and map deterioration. Diagnostic work included non-destructive tests on the reinforced-concrete trestles – Carbondent, rebound-hammer, ultrasonic and endoscopic investigations – and hardness tests and chemical analyses of the steel structures to verify their strength and weldability. The energy audit, conducted in accordance with the Ministerial Decree of 26 June 2015, compared alternative building-services scenarios. A high-efficiency water-to-water heat pump was selected for the office building, while duct modelling for the ‘suspended factory’ made it possible to integrate the new ventilation system with reduced architectural impact.

The design decisions mediated between production continuity, safety, energy efficiency and conservation of the original character. The intervention restored the legibility of the building, preserving its role in Mantua’s industrial and lakeside landscape, and received the 2021 DOCOMOMO Rehabilitation Award.

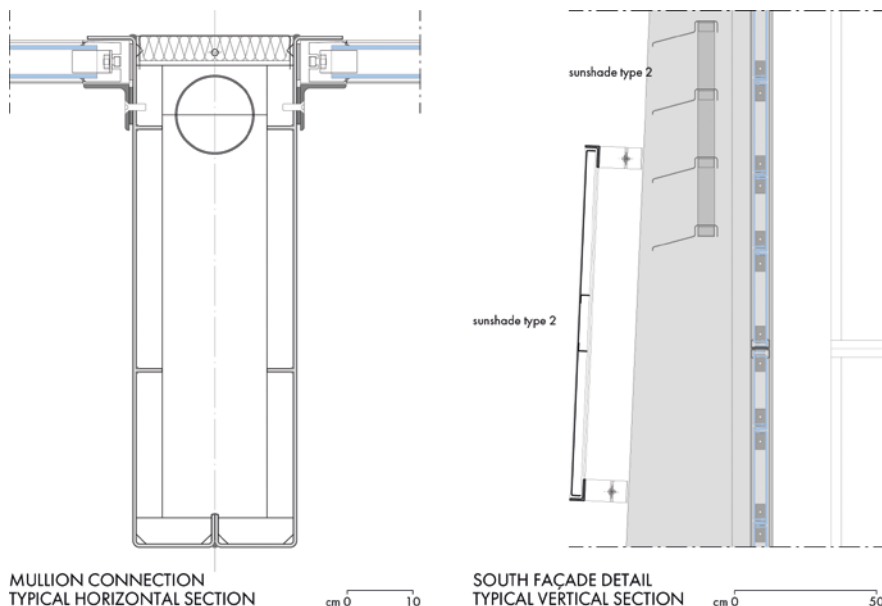


Figure 5
Typical details of the
mullions and window
frames of the south
façade.

Objective of the envelope intervention

To restore Nervi's original transparency while improving thermal performance and enabling the plant to resume production.

Extent of the envelope intervention

The intervention encompassed all glazed elevations – approximately 9,000 m² – and the entire 7,500 m² roof covering of the main continuous-paper-machine building.

Solutions adopted for the envelope

The blue sheet metal was removed and horizontally installed double-skin LINIT U-glass was introduced, with a blue-green colour and texture similar to the original. Steel uprights were reconstructed to the original design, and the NACO louvres and four bands of horizontal aluminium brise-soleil were reinstated for solar control. On the roof, a new profiled-aluminium covering was laid over the existing construction with 80 mm of insulation to protect the steel structure and improve thermal efficiency.

Other interventions

The Beloit machine was replaced with a Valmet unit; the base was adapted by rebuilding the internal columns 65 cm from their original position; the floors were strengthened; and the exposed concrete and suspended structure underwent conservation treatment, including water-jet cleaning. New high-efficiency Siemens IE3 air-handling units and a cogeneration plant were installed to generate energy on site from methane and biogas.

Certifications / Awards

2021 DOCOMOMO Rehabilitation Award (Sustained Uses).

Knowledge framework, methodology and traceability

The project is grounded in a multidisciplinary knowledge framework developed through archival research, geometric and critical surveys, analysis of previous alterations and deterioration mapping. The concrete and steel structures were investigated through on-site and laboratory testing, supplemented by checks during construction. The intervention's objectives and criteria are explicitly stated, and the documentation includes drawings, photographs, construction details and full-scale mock-ups.

Technical adequacy and compatibility of the adopted solutions

The solutions are calibrated to the complex's specific constructional and environmental characteristics. The concrete and steel roof was restored using treatments differentiated according to their deterioration, while the façades were reconstructed to the original subdivisions and profiles using double-skin U-glass. In the offices, conservation of the curtain walls was combined with internal insulation. Mock-ups and preliminary testing guided the selection of materials and details.

Degree of reversibility

Reversibility is limited by the complete replacement of the steel vertical mullions and deteriorated infill, and by the permanent adaptations required for the new continuous paper machine. Relocating one row of columns along approximately 160 m, reconstructing the machine beam and altering the floors permanently affected the original structure. Less invasive works were nevertheless also used, including added steel strengthening and solutions intended to avoid further demolition.

Impact on the formal and spatial configuration

The intervention recovers defining characteristics compromised by previous alterations, reinstating façade transparency, the bands of brise-soleil and the legibility of the trestles and suspended roof. The external image is therefore once again consistent with Nervi's design. The impact remains perceptible internally through the new machine and alterations to its supporting structure, and on the north elevation through the renewal and expansion of technical plant.

Degree of conservation of original architectural elements

The intervention substantially retains the concrete trestles, suspended roof, masonry, Accelerator tanks and much of the office curtain walling. Conservation of the machine hall façades is instead partial: surviving but irreparably deteriorated components were replaced, and the original transparency was recreated using contemporary materials and technologies. The replacements are justified by safety, deterioration and performance requirements.



Figure 6
South façade and west trestle.

A white L-shaped graphic element consisting of a horizontal line and a vertical line meeting at a right angle, positioned to the left of the text.

EDUCATIONAL AND RESEARCH ARCHITECTURE

TRIFOGLIO – POLITECNICO DI MILANO

Italy, Lombardy, Milan

ORIGINAL DESIGN

1959 - 1963

Gio Ponti, Felice Aguzzi

The construction of Building 13, commonly known as the Trifoglio, formed part of the expansion programme launched by the Politecnico di Milano in the 1950s in response to rapidly rising student numbers and the need for new spaces for mass higher education. The northern expansion of the Città Studi campus was conceived as a series of freestanding buildings connected to the historic complex and set below the level of Via Bonardi. The design dates from 1959, and construction by the Rimoldi company was completed in 1963. The work is attributed to Gio Ponti, although it was formally signed by engineer Felice Aguzzi and the Politecnico's technical office. The three-storey building stands approximately 3.5 m below street level. Its name – Italian for 'cloverleaf' – derives from its plan: three-petal pentagonal volumes connected by a central, likewise pentagonal circulation space. The three volumes extend in different directions, creating a free and distinctive figure within the campus.

The lower level opens onto the sunken outdoor space and contains student amenities, while the upper floors are used primarily for teaching. The three wings contain nine large raked lecture theatres, each seating approximately 400 people. Rejecting an orthogonal, regular composition, the plan uses a sequence of inclined walls and geometric variations to define the spaces. The rake of the seating is directly expressed in the form of the volumes, elevations and projecting sail-like roof profiles, making the lecture theatres' internal organisation legible from outside.

The central space is defined by the entrance hall and the main double-scissor staircase connecting the different levels. A large white-framed glazed wall illuminates the circulation core and establishes a visual relationship with Via Bonardi. The hall thus becomes the principal orientation point and the junction between the three wings.

The load-bearing structure is of reinforced concrete, with isolated pad foundations. The vertical structure comprises walls and columns of varying cross-section, while the reinforced-concrete floor structures have parallel downstand beams at first-floor level and intersecting beams above. The floors of the lecture theatres are inclined to follow the rake of the seating. This structural configuration directly shapes the building's massing, since the form of the lecture theatres determines the profiles of the elevations and roofs.

Figure 1
Aerial view in the
1960s.





Figure 2
The Trifoglio viewed
from the Nave.

The vertical surfaces of the upper floors are clad in small square grey ceramic tiles with a faceted, diamond-patterned surface that produces variations in light and reflection. The cladding accentuates the volumes' unified yet multifaceted character and is one of the most recognisable expressions of Ponti's architectural language. The base is finished in roughcast grey render, creating a material contrast with the ceramic surfaces above. The windows use slender steel sections, and the openings – often hexagonal and arranged in varying sequences – follow the geometry of the lecture theatres and inclined walls.

The Trifoglio is connected by footbridges both to street level and to the Nave building. This system of elevated routes bridges the difference in level from Via Bonardi and links the various campus buildings while keeping pedestrian movement separate from the sunken ground plane.

Previous interventions

Over the years, the circulation and service areas had been altered, and small rooms had been created on the ground floor. The courtyard had been asphalted and used for parking. In 2008 the external ceramic cladding was restored: Team Work Italy reproduced the original 5 × 5 cm grey diamond-patterned tiles, initially manufactured by Ceramica Joo, to replace elements that had detached or broken as a result of hygrothermal fluctuations.

Pre-intervention general conservation conditions

The principal problems concerned non-compliance with current regulations; corrosion of the reinforcing steel was also reported.

Specific environmental or climatic pressures

The building's location in Milan exposes it to summer heatwaves intensified by the urban heat-island effect, with potential consequences for thermal comfort in the lecture theatres.

Figure 3
Exterior after the
intervention.



NEW INTERVENTION

2017 - 2020

COPRAT (developed design), AEGIS S.r.l. (detailed design), RPBW (masterplan)

The refurbishment of the Trifoglio forms part of the transformation of the Via Bonardi Campus defined by Renzo Piano's masterplan. The renovation of Building 13 was preceded by a research and investigation process involving faculty members from the Politecnico di Milano. Archival research in the university's offices provided a deeper understanding of the building's history and architectural character. Investigative openings were made to identify concealed structural elements, while laser-scanning surveys and investigation results were incorporated into an as-built BIM model developed by the Politecnico and made available to the designers. This work also informed the decision to subject one of the nine lecture theatres to a conservation-led restoration, retaining its configuration, finishes and original furnishings.

The project involved refurbishing the building and bringing it into regulatory compliance, including seismic and fire-safety upgrades, removal of architectural barriers and improved usability for students. In the new configuration, the Trifoglio assumes a central role within the campus's open spaces, which were transformed from asphalt parking into a green pedestrian environment. The main entrance was moved from street level to the lower level, approximately 3.5 m below, strengthening the relationship between the building and the new campus ground plane.

Eight of the nine lecture theatres were functionally and spatially upgraded, while the ninth underwent a conservation-led restoration that recovered its furnishings and preserved its historic atmosphere. On the upper floor, two lecture theatres and the circulation hall were combined to create the Giampiero Pesenti Great Hall, a space designed to accommodate different configurations. Targeted structural works were required to open up the new space while keeping the three-petal layout recognisable.

The functional reorganisation included relocating the plant rooms to an underground energy centre north of the building. The released areas became study spaces, relaxation areas, teaching spaces and student services. The entrance hall was refurbished and circulation enhanced with new stairs and a lift, which the building had previously lacked. A new external stair on the north side and an internal escape stair improved evacuation routes and access between levels. The building services were renewed, with the exception of several existing mechanical-ventilation ducts retained in place. The new centralised system provides winter heating and summer cooling through controlled mechanical ventilation and fan-coil



Figure 4
Exterior view of the
classrooms' hexagonal
windows.

units and is connected to the campus energy network. Room-by-room controls allow operation to be adapted to the use of individual lecture theatres and shared spaces.

The reinforced-concrete structures underwent work to improve seismic behaviour and address localised deterioration. The intervention on the envelope remained targeted, focusing on the glazed surfaces and ground floor slab. Existing windows were replaced with new units that reproduce the slender profiles of the original steel windows and incorporate low-emissivity insulating glazing. On the east side of the main petal, curtain-wall areas containing opaque panels were converted to full-height glazing. A ventilated crawl space with EPS insulation was created at ground-floor level. Overall, the adopted solutions improved comfort and energy performance without substantially altering the building's external appearance.



Figure 5
Interior detail of the
hexagonal windows.

Objective of the envelope intervention

The intervention aimed to refurbish the building functionally and bring it into regulatory compliance, chiefly in relation to general safety, fire safety, building services, seismic performance and accessibility.

Extent of the envelope intervention

With regard to the envelope, the intervention was targeted at the transparent surfaces and the ground floor slab.

Solutions adopted for the envelope

Existing windows were replaced with new units reproducing the slender profiles of the original steel windows and incorporating low-emissivity insulating glazing. On the east side of the main petal, several opaque curtain-wall panels were replaced with full-height glazing. The ground floor slab was upgraded by creating a ventilated crawl space and installing EPS insulation panels.

Other interventions

The works included functional and circulation reorganisation, fire-safety upgrading and seismic improvement, together with repairs to localised deterioration in the reinforced-concrete structure. Building services were completely renewed through a centralised winter-heating and summer-cooling system with controlled mechanical ventilation and fan-coil units, connected to the campus energy network.

Post-intervention consumption

247.94 kWh/m² year

Certifications / Awards

Energy performance class D (APE, 2023).

Knowledge framework, methodology and traceability

The project is supported by surveys, architectural drawings and specialist reports describing the building's historical, typological, constructional, structural, building-services and energy characteristics. The objectives of conserving the architectural image, achieving regulatory compliance, adapting the building to new functions and improving comfort are explicitly stated. The design process is therefore structured and multidisciplinary, with the intervention's principal aims clearly identified.

Technical adequacy and compatibility of the adopted solutions

The adopted solutions are calibrated to the affected portions of the envelope. The new windows reproduce the design of the existing elements while using components with improved performance, and the wall insulation is supported by thermal and hygrothermal assessments. The design demonstrates attention to performance compatibility, formal continuity with the existing building and control of the main risks associated with the envelope's behaviour.

Degree of reversibility

The intervention has limited reversibility. Replacing the windows entailed removing the existing components, while the ventilated crawl space and new insulation build-ups permanently altered the ground-bearing floor. Converting several opaque panels to full-height glazing and creating new openings in the elevations are likewise permanent interventions. The partial dismantlability of some components does not alter the predominantly irreversible character of the transformations.

Impact on the formal and spatial configuration

The intervention retains the legibility of the three-petal configuration, the articulation of the volumes and the role of the reinforced-concrete structure in defining the architectural image. The new windows reproduce the proportions and subdivisions of the existing elements, limiting changes to the elevations. The impact is nevertheless perceptible where opaque panels were converted to full-height glazing, in the new openings, and in the reconfiguration of the entrance and ground floor. These changes locally affect the relationship between solid and void and the perception of the spaces without compromising the overall recognisability of the work.

Degree of conservation of original architectural elements

The intervention retains several elements central to the building's architectural identity, including its volumetric configuration, reinforced-concrete structure, double-scissor staircase and part of the external cladding. In lecture theatre T.1.1, the stepped profile and existing benches were also retained and restored. Conservation of the envelope is selective, since the windows were replaced and several panels and façade areas altered. The replacements address energy, functional and regulatory requirements while seeking formal continuity with the existing building.



Figure 6
The staircase and large ground-floor windows.

Figure 7
View of the main façade.

SALK INSTITUTE

United States, California, La Jolla

ORIGINAL DESIGN

1960 - 1965

Louis Isadore Kahn, August Komendant (structural engineering), Fred Dubin (mechanical engineering), Earl Walls (laboratory design), Roland Hoyt (landscape design), Luis Barragán (architectural consulting), Jack MacAllister (architectural design), Edison Price (lighting design)

The Salk Institute for Biological Studies (1960–1965) represents Louis Kahn's realised ideal of a scientific community, meticulously designed to balance collaborative research with individual meditation. Situated on a dramatic coastal bluff in La Jolla overlooking the Pacific Ocean, the complex was originally conceived as a tripartite master plan including research facilities, a Meeting House, and residential quarters. Due to significant budget restrictions, only the Laboratory Complex was realised, consisting of two nearly identical wings flanking a central travertine plaza. This plaza, described by Mexican architect Luis Barragán as a 'façade to the sky', directs the gaze towards the ocean horizon via a narrow marble rill that bisects the space. The architectural language is defined by the rigorous separation of 'served' and 'servant' spaces and a profound contrast between monumental pozzolanic concrete and handcrafted teak. The complex is organised into three primary functional components: the flexible laboratory wings, the 36 individual study towers, and the west office wings. The laboratories are unobstructed, column-free spaces made possible by 2.74 m deep concrete Vierendeel trusses that create full-height interstitial floors for mechanical and electrical services. These wings are enclosed by floor-to-ceiling Type 316 stainless steel and glass curtain walls, representing what Kahn termed the 'architecture of the workbench'. In contrast, the study towers and the west office wings utilise 203 prefabricated teak window wall assemblies. These wood elements provide a human scale and allow researchers to modulate light, air, and privacy through a sophisticated system of sliding shutters, louvres, and bronze-framed insect screens. The study towers are detached from the main lab blocks and elevated above open-air arcades to foster spontaneous encounters among scientists. Below the plaza level, a series of sunken gardens and light wells bring natural illumination and views to the lower laboratories, maintaining the complex's 'fortified' and monumental appearance from the surrounding mesa. The landscape, featuring groves of eucalyptus trees, is integral to the site's contemplative atmosphere and was coordinated with architect Roland Hoyt. Although the Meeting House and Housing were never built, the realised Laboratory Complex

Figure 1
View of the central
plaza towards the
ocean, 1983.

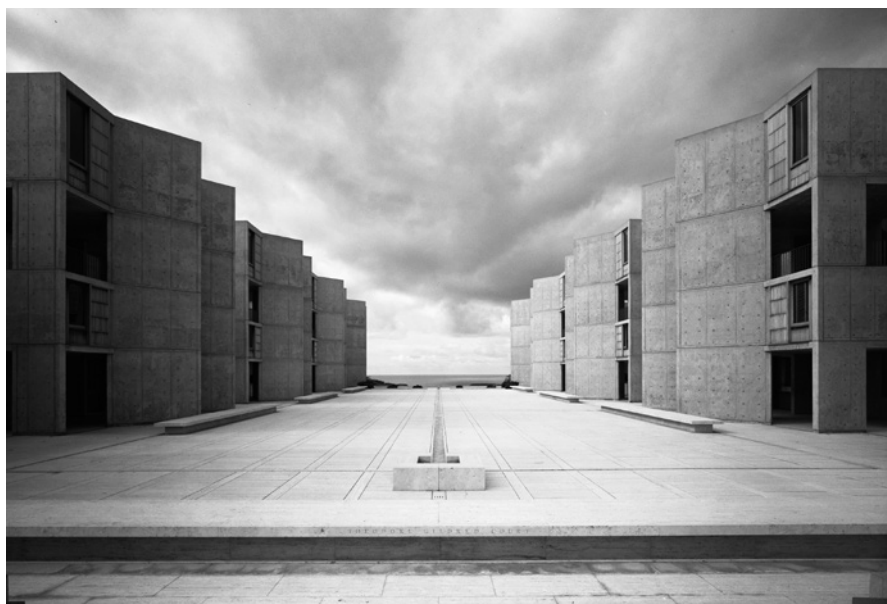




Figure 2
View of the study
towers, 1985.

remains a global landmark of Modernism where tectonic honesty achieves a timeless spiritual quality. The Institute's technological system is a masterwork of structural and mechanical integration. The primary structure consists of cast-in-place monolithic concrete utilising a pozzolan-blended cement (Riverside Special Blend) to achieve durability and a light-coloured, stone-like finish. The laboratories are supported by post-tensioned, 2.74 m deep concrete Vierendeel trusses spanning 19.81 m on a 6.10 m grid, allowing for column-free research spaces. These trusses serve as the 'servant' backbone, housing 1.22-metre-diameter air ducts and electrical cabling within their voids, which are accessible via dedicated technical floors. In contrast, the west office wings utilise closely spaced transverse beams, while the Study Towers rely on exposed structural slabs. The envelope features two distinct systems: the laboratories are enclosed in Type 316 stainless steel and glass storefronts chosen for corrosion resistance in the saline air. The studies and office wings are punctuated by 203 prefabricated teak window wall assemblies. These units were constructed with white fir framing and transite asbestos-cement sheathing, clad in Southeast Asian teak siding. They incorporate brass tracks for sliding sashes and bronze-framed insect screens. The central plaza is paved with Italian travertine set in a coloured mortar bed with 3.2 mm joints.

Previous interventions

From 1967, teak was cleaned on a 2–3 year cycle using bleach and wire brushes. In the 1990s, TE-KA cleaners and Tip Top Teak sealer were applied, causing red discolouration. Key additions include the East Buildings (1995) and the southern administrative expansion (1997), designed by MacAllister and Rinehart. Between 1993 and 1998, mechanical and electrical systems were renewed. In 2011–2012, a major systems renewal added a central plant upgrade and a 541 kWp rooftop solar photovoltaic array.

Pre-intervention general conservation conditions

By 2013, the window assemblies exhibited severe weathering after 50 years of marine exposure. Surveys revealed widespread black fungal biofilm

from nearby eucalyptus trees and red discolouration from past inappropriate sealers. Because of budget cuts in 1963, copper flashings and weatherstripping were omitted, causing chronic moisture infiltration. This led to extensive drywood termite damage to the untreated white fir internal framing. Structural fasteners suffered from marine corrosion, and teak siding panels were eroded up to 20%, compromising the stability of the enclosure.

Specific environmental or climatic pressures

The site faces extreme environmental stressors on its coastal mesa bluff. High UV radiation causes surface bleaching and lignin degradation. Persistent salt spray and sea fog induce iron staining and fastener corrosion. Proximity to eucalyptus groves leads to black fungal biofilm colonisation through airborne spores.

Figure 3
View of the
west-facing elevations
before work began,
2013.



NEW INTERVENTION

2013 - 2023

Getty Conservation Institute (scientific research and diagnostics), Wiss, Janney, Elstner Associates, Inc. (conservation architecture and engineering), Inskip Gee Architects (CMP), Liz Sargent HLA (historic landscape architecture)

The recent interventions at the Salk Institute (2013–2023) represent a fundamental shift towards a conservation-based stewardship model, codified in the 2017 Conservation Management Plan (CMP). This holistic framework guides the preservation of the site's cultural significance while supporting its evolving needs as a living research community. A primary focus of this period was the Teak Window Conservation Project (2013–2017), a collaborative effort between the Salk Institute, the Getty Conservation Institute, and Wiss, Janney, Elstner Associates. This major project addressed the severe material degradation of 203 prefabricated teak window wall assemblies located in the individual study towers and the west office wings. Comprehensive investigative probes and laboratory analysis revealed that the deterioration was caused by long-term marine exposure and original design omissions. Key findings indicated that 1963 budget cuts led to the exclusion of copper flashings and weather stripping, resulting in chronic moisture infiltration and subsequent drywood termite (*Incisitermes* spp.) damage to the untreated white fir internal framing. The intervention strategy followed a rigorous hierarchical approach of minor, moderate, and major repairs to maximise the retention of original historic fabric. Sodium percarbonate was used to clean the wood and remove black fungal biofilms and past red-tinted sealers, restoring Kahn's intended variegated silver-grey patina. To correct original deficiencies, new stainless steel flashings and secondary drainage systems were installed behind the cladding, ensuring the teak's longevity for another 50 to 70 years. This methodology allowed over 66% of the original 1965 Southeast Asian teak to be conserved *in situ*, preserving material authenticity and rare natural resources. Parallel to the wood conservation, the Getty Foundation's 2018 *Keeping It Modern* initiative awarded a grant for the conservation of the institute's iconic pozzolan concrete façades. Completed in 2023, this five-year project focused on identifying mechanisms of surface erosion and staining, utilising specialised pozzolan mortar repairs that match the original monolithic texture and colour while strictly adhering to a 'repair-only' policy to protect the walls. The institute also integrated modern sustainability standards by managing existing campus upgrades within the CMP framework (co-authored with Inskip Gee Architects). These include the maintenance of the 541 kWp rooftop solar photovoltaic array and building systems renewal completed in 2012,



Figure 4
Front view of the study
towers, 2017.

alongside a transition to high-efficiency LED technology within the original Edison Price light fixtures to achieve energy savings of up to 75%. Finally, the establishment of an Architecture Endowment Fund ensures the long-term maintenance of character-defining features such as the travertine plaza and the marble watercourse. This stewardship model demonstrates how modern architectural icons can be preserved as functional institutions while honouring their original tectonic integrity and the philosophical hierarchy of ‘served’ and ‘servant’ spaces. The Getty-led conservation design process (2013–2023) followed a scientific and interdisciplinary method. It began with a knowledge framework: archival research at the Louis I. Kahn Collection (UPenn), site surveys, and investigative probes of 203 assemblies to diagnose internal drywood termite damage and moisture infiltration. Energy diagnosis involved modelling and evaluation of high-efficiency LED technology to improve sustainability while maintaining the original Edison Price lighting design and minimising the site’s carbon footprint. Decision-making included evaluating alternative scenarios – from total replacement of the teak to minimal intervention – through a trial mock-up programme on the lab roofs.

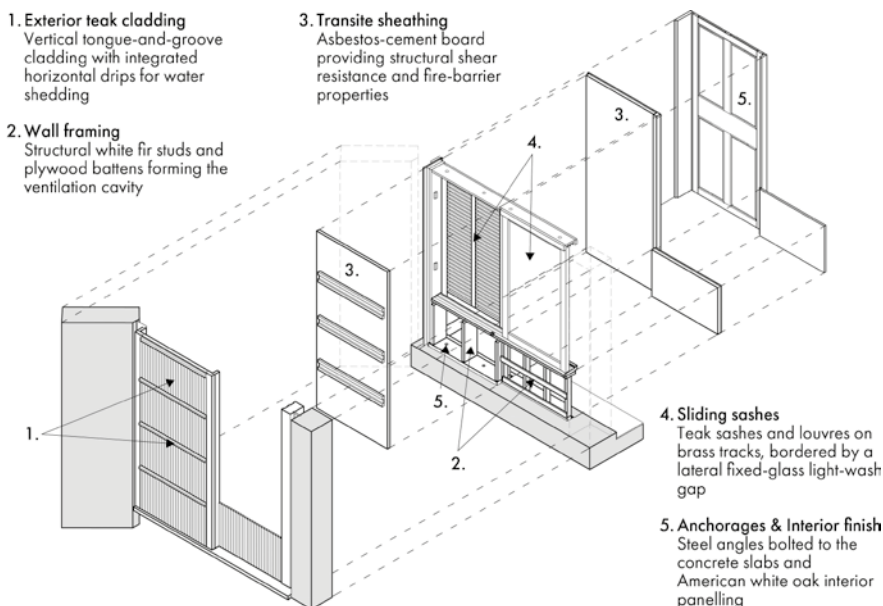


Figure 5
Exploded axonometric
drawing of the original
construction of a
window wall in the
north study towers.

Objective of the envelope intervention

To preserve the cultural significance and material integrity of the teak and concrete façades while correcting original design flaws to ensure long-term durability in a harsh marine climate.

Extent of the envelope intervention

Full restoration of 203 teak units, specialised repairs of pozzolanic concrete façades (2018–2023), conservation of stainless steel storefronts, and maintenance of the ‘fifth elevation’ roofs.

Solutions adopted for the envelope

Teak: sodium percarbonate cleaning; three-tiered repair hierarchy; and new internal stainless steel flashings. Concrete: compatible pozzolanic mortar patches matching original monolithic texture and colour. Stainless steel: implementation of specialised cleaning protocols to mitigate marine salt corrosion. Glazing: installation of high-performance light-control films and replacement with tempered safety glass where required. ACM: specialised abatement of hazardous asbestos transite sheathing during major removals. Reinstallation of original oak millwork.

Other interventions

Beyond primary envelope restoration, the Institute integrated modern sustainability and systems management within the CMP framework. The 2012 infrastructure upgrade expanded the electrical base load to 4.2 MW to accommodate intensive research needs, supported by the existing 541 kWp rooftop solar photovoltaic array. Long-term efficiency was enhanced by transitioning to high-efficiency LED technology within original Edison Price light fixtures, yielding energy savings of 75%. A dedicated Architecture Endowment Fund was formally established to safeguard stewardship.

Certifications / Awards

2017 California Preservation Foundation President’s Award.

Knowledge framework, methodology and traceability

The project is grounded in historical and documentary research, assessment of character-defining features, detailed surveys, direct inspection of individual components, and analyses of the wood, microorganisms, and previous treatments. The solutions were developed through full-scale mock-ups, organised into three levels of intervention, and subsequently translated into construction drawings and technical specifications. The process allows the adopted criteria and the ratio-

nale underlying the design decisions to be clearly reconstructed.

Technical adequacy and compatibility of the adopted solutions

The solutions are calibrated to the condition of each individual teak module and distinguish among *in situ* cleaning and repair, limited replacement, and reconstruction using compatible materials. The introduction of flashings, seals, and protective measures against moisture and wood-boring organisms improves watertightness and component durability without altering the façade design. Glazing and asbestos-containing panels are replaced only where necessary, while retaining as much as possible of the original teak, hardware, and interior finishes.

Degree of reversibility

The intervention prioritises *in situ* repair and limits replacement to the most severely deteriorated components, allowing part of the teak elements, hardware, and interior finishes to be retained and reinstalled. In the most compromised modules, however, dismantling and reconstruction require the replacement of frames, panels, and glazing. The introduction of flashings, seals, and protective measures also permanently modifies certain construction details. Reversibility is therefore partial and varies according to the level of intervention.

Impact on the formal and spatial configuration

The intervention preserves the façade composition, the rhythm of the timber modules, the relationship between teak and concrete, and the operation of shutters, screens, and sliding louvres. Replacements are carried out using materials and profiles corresponding to the existing elements, while cleaning and surface treatments reduce the chromatic alterations accumulated over time. The technical modifications remain largely imperceptible and do not alter the spatial configuration of the complex.

Degree of conservation of original architectural elements

The intervention largely preserves the teak cladding, frames, sliding shutters, louvres, and screens, differentiating the treatment according to their state of conservation. Recoverable elements are cleaned, restored, and retained in place or reinstalled, while replacement is limited to components that are severely eroded, damaged by termites, or no longer safe. Hardware and interior oak finishes are also retained in modules subject to the most extensive levels of intervention.



Figure 6
South-east view of the study towers overlooking the plaza,
2017.

Figure 7
North-west view of the study towers overlooking the plaza,
2017.



RELIGIOUS ARCHITECTURE

NOSTRA SIGNORA DELLA MISERICORDIA CHURCH

Italy, Lombardy, Baranzate (MI)

1956 - 1958

Angelo Mangiarotti, Aldo Favini, Bruno Morassutti

ORIGINAL DESIGN

The Church of Nostra Signora della Misericordia in Baranzate, designed by Angelo Mangiarotti and Bruno Morassutti with Aldo Favini as structural engineer, was built between 1956 and 1958 as part of a programme promoted by Archbishop Giovanni Battista Montini to construct new churches on Milan's outskirts. Conceived for what was then the rural hamlet of Baranzate di Bollate, the project explores the place of worship through radical typological and constructional experimentation. Closer in scale to a chapel or oratory than to a monumental parish church, it takes technology as the foundation of its architecture, entrusting the definition of sacred space to structural clarity, prefabrication and light.

The building stands within a rectangular enclosure measuring approximately 30 × 60 m, bounded by a curved, battered wall of concrete and river pebbles. The enclosure separates and protects the place of worship from its surroundings and bears Gino Cosentino's fourteen Stations of the Cross on its inner face. The worship hall, a prismatic volume approximately 14 × 28 m, rests on a semi-basement base and is raised about 2 m above ground level, to which it is connected by a grassed slope. Beyond the enclosure threshold, the route divides into two adjacent stairs: one ascends to the hall and the other descends to the lower spaces, which originally contained the baptismal font, a chapel, sacristy and service rooms. Entering from below and then rising from the subdued light of the semi-basement into the hall's diffuse brightness formed an integral part of the liturgical experience.

The rectangular hall is free of significant partitions and entirely devoted to the congregation. Its load-bearing structure is concentrated in four tapered reinforced-concrete columns supporting two *in situ* transverse primary beams. Six secondary longitudinal beams span between them, each composed of thirty prefabricated reinforced-concrete X-section segments assembled and post-tensioned on site using Favini's patented system. Prefabricated panels, stiffened by intersecting ribs, span between the beams to complete the roof and create a strongly modelled geometric pattern of light and shadow across the soffit. The roof structure thus becomes an architectural order, while the X-shaped beam sections provide a figurative termination to the volume on the short elevations.

Figure 1
Night view of the
south-east entrance
façade, 1958.



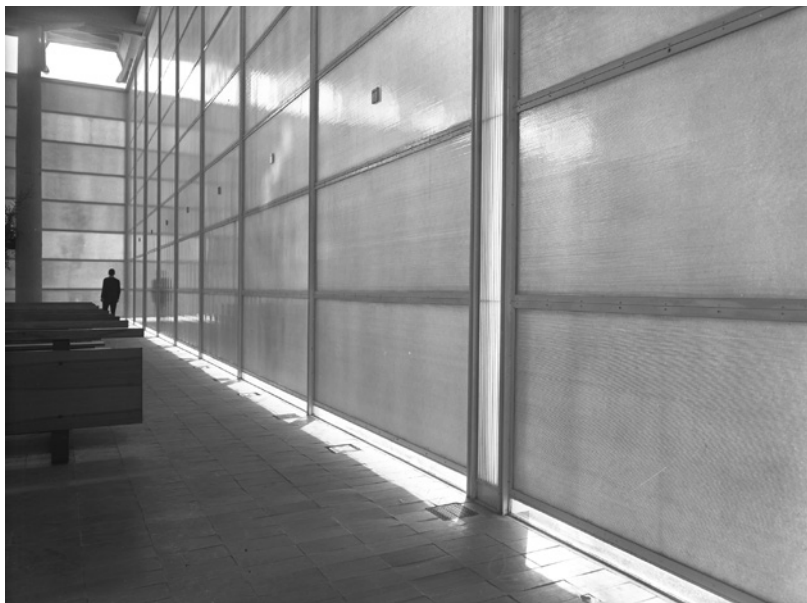


Figure 2
Detail of the glazed
building envelope,
1958.

The perimeter envelope is independent of the main structure and consists of lightweight steel framing made from welded open sections, to which modular translucent panels are fixed. In the original configuration, each panel comprised two sheets of ribbed glass enclosing a layer of polystyrene, which provided insulation, solar screening and light diffusion. A narrow glazed strip separated the infill from the roof, reinforcing the perception of the roof as an autonomous element suspended over the hall. The contrast between the mass of the concrete roof and the lightness of the translucent cladding defines the building's character. By day, the polystyrene filtered the light, transforming the walls into white opalescent surfaces and distributing uniform illumination throughout the hall; by night, the internally illuminated volume appeared as a translucent lantern in the peripheral landscape. Structure, envelope and liturgical route thus combined to create an essential, immaterial space in which engineering and architecture coincided. The church is also an early example of experimentation with hybrid techniques, prefabrication and serial assembly as form-generating principles.

Previous interventions

In 1979, following a bomb attack, the original cladding of the worship hall was demolished. Between 1979 and 1980 a new envelope was constructed to a design by Bruno Morassutti and Aldo Favini with Angelo Mangiarotti, using wired glass, multiwall polycarbonate and an intermediate polyurethane mat. The bell tower, designed by Morassutti and Favini, was added during the same period. Further building-services installations and furnishings followed in later years, together with proposals for extension and upgrading.

Pre-intervention general conservation conditions

Before the intervention, the building was in a critical state of conservation, chiefly because of the severe deterioration of the translucent envelope and the inadequacy of the 1979 replacement

solution. The cladding had degraded and could no longer ensure comfort or usability. The internal exposed concrete appeared blackened, while the prestressed roof was generally in good condition, with limited exposure of reinforcement in the primary beams.

Specific environmental or climatic pressures

The translucent envelope was highly exposed to solar radiation, causing overheating and material deterioration. Further challenges arose from the glazed hall's large heat-transfer area and the transformation of its setting from countryside into a metropolitan conurbation.

Figure 3
The liturgical hall upon
completion of the
works, 2015.



NEW INTERVENTION

2004 - 2015

SBG Architetti (Giulio Barazzetta – lead architect), Anna Mangiarotti and Ingrid Paoletti (building technology), Tito Negri (structural engineering), Giancarlo Chiesa and Mario Maistrello (building services design), Angelo Mangiarotti, Bruno Morassutti and Aldo Favini (design supervision)

The restoration and upgrading of the Church of Nostra Signora della Misericordia sought to recover its original architectural character and adapt the building to contemporary patterns of use and comfort standards. The project took the configuration inaugurated in 1958 and the work of Angelo Mangiarotti, Bruno Morassutti and Aldo Favini as its reference, interpreting restoration as a rewriting of the modern work grounded in the integration of structure, translucent envelope and light.

The need for intervention arose chiefly from the severe deterioration of the worship hall cladding. The original envelope, demolished after the 1979 bomb attack and replaced with wired glass, multiwall polycarbonate and a polyurethane mat, was by then technically and perceptually inadequate. Its state precluded effective conservation treatment, whereas the prefabricated, prestressed reinforced-concrete roof remained in good condition, as confirmed by the 2002 structural load test. The project treated the envelope as the central focus of the restoration, both because of its role in defining the building's image and because of its effect on energy behaviour and indoor comfort. The new façade was conceived as a dry-assembled steel system, with profiles consistent with the original framing but produced using more durable techniques and finishes. The deteriorated panels were replaced with triple insulating glazing incorporating screen-printed surfaces, low-emissivity glass and solar control. The system was developed to reproduce the opalescent effect of the 1958 envelope while improving thermal transmittance, solar-radiation control and environmental conditions within the hall. Replacing the cladding while maintaining the character of the steel-and-glass structure was treated as essential to preserving the relationship between the lightness of the infill and the mass of the roof.

The replacement of the envelope was accompanied by building-services upgrades and improvements to heating and lighting, together with hygrothermal assessment. The new services were sized in relation to the façade's performance and the spaces' actual patterns of use, established through consultation with the parish community. The floor slab of the worship hall was strengthened to accommodate new service networks, while only minimal cleaning and repairs were carried out on the concrete structure at the few points where reinforcement was exposed in the primary beams. New service areas were also created on



Figure 4
Detail of the new
building envelope.

the lower level without diminishing the centrality of the worship hall or the route from the semi-basement's subdued light into the brightness of the glazed volume.

The design process, initiated by Bruno Morassutti, ensured continuity with the original authors through a multidisciplinary team comprising the original designers and specialists in architecture, structures, technology and building services. The solutions were developed through surveys, condition assessments, performance studies, simulations, mock-ups and laboratory tests, with particular attention to the glazed façade. The project responded to the 2003 ministerial heritage designation, which recognised the church's monumental value and linked its restoration to continuity with the authors' design.

The intervention returned a fully usable building to the community while preserving its principal spatial, constructional and perceptual values: the contrast between the subdued light of the base and the brightness of the hall, the opalescent volume of the worship space and the nocturnal perception of the church as a translucent lantern.

1956-1958

1979-1985

2012-2014

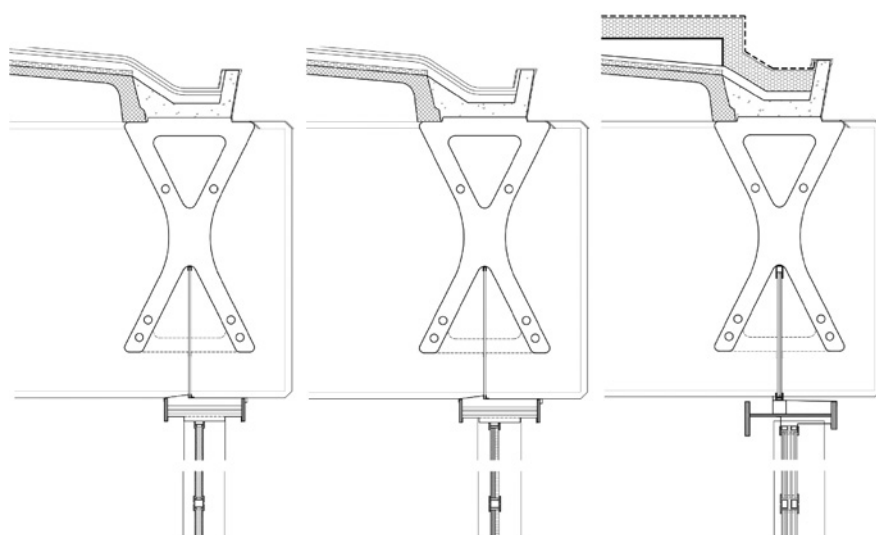


Figure 5
Detailed section of the
roof and glazed wall
as originally built
(1956–1958), after
the replacement of the
cladding (1979–
1985), and following
the latest intervention
(2012–2014).

Objective of the envelope intervention

To restore the church's original architectural character and the hall's opalescent image, recovering its full use for worship and community life. The project also sought to adapt the building to contemporary use, improve indoor comfort and energy performance and integrate new building services.

Extent of the envelope intervention

The intervention encompassed the entire above-ground envelope of the worship hall, with complete replacement of the translucent façade and renewal of the covering and functional layers of the flat roof.

Solutions adopted for the envelope

The existing façade system was removed and replaced with new dry-assembled steel framing, with full-height mullions and mechanical fixings. The glazed panels use triple screen-printed, low-emissivity, solar-control glazing designed to reproduce the original opalescent effect while improving thermal transmittance, solar-radiation control and indoor comfort. The solar factor of the new build-up is approximately 10%. On the flat roof, the existing layers were removed and a new separating layer, falls screed in cellular concrete, thermal insulation, waterproofing and sheet-metal flashings were installed.

Other interventions

Repairs were carried out to the exposed reinforced concrete, together with structural strengthening, particularly to the hall floor slab to accommodate the new services. The semi-basement was reorganised with new partitions, floors, ventilated crawl space, windows, rooflights and window wells. Heating and cooling systems with radiant panels and primary air were also installed, together with a new energy centre, geothermal exchange wells, water storage tanks, electrical systems, lighting, controls and external works.

Certifications / Awards

2013–2015 10th Casalgrande Padana Grand Prix (Buildings for Public Functions and Services, Industrial Buildings – Second Prize); 2018 Gold Medal for Italian Architecture (Conversion and Restoration – Honourable Mention).

Knowledge framework, methodology and traceability

The project is grounded in a multidisciplinary knowledge framework developed through historical and critical research, surveys, analysis of materials and deterioration, structural assessments,

building-services studies and direct consultation with the original authors. The objectives and limits of transformation are explicitly defined in relation to the church's architectural and use value. Decisions are well substantiated and extensively traceable.

Technical adequacy and compatibility of the adopted solutions

The solutions are specifically calibrated to the church's constructional and perceptual character. The new façade uses dry-assembled steel framing and multilayer glazed panels, developed through successive mock-ups to improve insulation, solar control and durability while recreating the original opalescent effect. Thermal breaks are limited to the glass and secondary frames in response to the structural and aesthetic requirements of the load-bearing profiles.

Degree of reversibility

Overall reversibility is limited by the complete replacement of the glazed façades and associated framing, the reconstruction of the roof build-ups, and the demolition required to reorganise the semi-basement and integrate building services. The dry assembly of the new façade components facilitates their future dismantling but does not compensate for the loss of the previous elements or for the permanent alterations to floors, walls and finishes.

Impact on the formal and spatial configuration

The intervention retains the legibility of the volumetric configuration, the relationship between the raised hall and the enclosure, the concrete structure and the luminous character of the envelope. The new façade reproduces the subdivisions, profiles and opalescent effect but replaces the original materiality with a contemporary glazed system of different depth and luminous quality. The new ramp and openings in the base are distinguishable.

Degree of conservation of original architectural elements

The intervention retains the architectural elements that most strongly define the work's identity, including the prefabricated concrete structure, the spatial organisation of the hall, the base and its relationship with the enclosure. Conservation of the envelope is instead predominantly figurative: the glazed façades and steel framing, already altered and severely deteriorated, were entirely replaced with contemporary components that reinterpret their design and opalescent quality.



Figure 6
Glass wall to the right when facing the altar.

Figure 7
Night view of the main façade.



CULTURAL AND RECREATIONAL ARCHITECTURE

PADIGLIONE AGNELLI

Italy, Piedmont, Turin

1947 - 1954

Pier Luigi Nervi, Roberto Biscaretti di Ruffia

ORIGINAL DESIGN

The Padiglione Giovanni Agnelli is the outcome of a complex process of development that began in 1937, when Ettore Sottsass Sr. won the competition for the Palazzo della Moda in Valentino Park. The building opened the following year for the Turin and Autarky exhibition and was severely damaged by bombing in 1942–1943. In 1947, the Nervi e Bartoli company won the design-and-build competition for the new exhibition hall, based on a scheme by Roberto Biscaretti di Ruffia and extensively reworked by Pier Luigi Nervi. The first section of Hall B was completed in 1948; the 1953–1954 extension removed the central garden, lengthened the nave and established the present-day pavilion.

The building complex has a basilican plan measuring 94 × 118 m. Pavilion 2 comprises a central nave with a clear span of 81 m, free of intermediate supports and covered by an undulating vault formed by transverse arches. Each arch consists of thirteen double-curved precast ferrocement units, produced on site, lifted and positioned on movable tubular centring, and then connected monolithically by cast *in situ* reinforced-concrete ribs along the crests and troughs of the waves. Ferrocement, consisting of wire mesh and small-diameter bars embedded in high-strength cementitious mortar, made it possible to produce thin, lightweight, repetitive elements that served both as load-bearing components and permanent formwork.

The thrusts of the vault are taken by large, inclined cantilever columns of variable cross-section, set at 7.5 m centres, supported on pad footings and branching at the top into fan-shaped elements. At the eastern end, the nave terminates in a semicircular apse of 60 m in diameter. The half-dome consists of ten types of diamond-shaped precast ferrocement tiles connected by a grid of exposed reinforced-concrete ribs. The system has an overall structural thickness of only 7 cm. The thrusts of the dome are resisted by a flat annular slab and a system of structural walls. On the western elevation, facing Corso Massimo d'Azeglio, Pavilion 2B retains the two-storey rectangular wing built in 1938. During the 1954 extension, Nervi demolished its original columns and suspended the floor slabs from the structure of the new frontispiece by means of hangers, thereby maintaining the continuity of the portico. The external walls are of cavity construction, with a solid-brick outer leaf, an inner

Figure 1
Photograph of the
façade facing Corso
Massimo d'Azeglio,
1954.





Figure 2
Historical photograph
of the interior of
Pavilion 2.

layer of hollow clay blocks and transverse ties; the cladding consists of mechanically fixed, light-coloured travertine slabs measuring 100 × 100 cm and 3 cm thick. The first-floor ribbon windows and continuous glazing in metal frames emphasise the horizontality of the elevation. Beneath the apse and part of the nave lies Pavilion 4, an underground volume at level -6.00 m, with a reinforced-concrete frame designed to carry the loads of the plaza above. Inside, side galleries and 13 m-deep mezzanines increase the exhibition area. Natural light is provided by double-pitched rooflights positioned along the crests of the vault and by the large, glazed apse overlooking the River Po and Valentino Park.

The building is one of Italy's most significant experiments in structural prefabrication. The correspondence between architectural form, structural behaviour and construction process transforms the pattern of ribs, waves and tiles into an expressive motif, achieving a synthesis of rationalist rigour and engineering innovation. Since 2020, the complex has been under statutory protection pursuant to Legislative Decree 42/2004, the Italian Code of Cultural Heritage and Landscape.

Previous interventions

The complex received no systematic maintenance, apart from targeted investigations in 2003. The most substantial intervention was carried out for the 2006 Winter Olympics and introduced temporary volumes and disfiguring additions. These included the steel-and-glass entrance structure to Pavilion 2B, external steel stairs and landings along the apsidal gallery, and a tangle of building-services ductwork across the vault. Functional alterations were also made internally, including the installation of escalators and plasterboard partitions, which changed the historic layout.

Pre-intervention general conservation conditions

The building showed severe deterioration caused by water ingress through the roofs and by unlawful occupation, which had resulted in vandalism and the theft of copper components. The internal

finishes, floors, and suspended ceilings were in very poor condition. The original window systems were obsolete and offered no meaningful thermal performance, while the travertine cladding was marred by dirt, graffiti, and mechanical cuts. The apsidal gallery also presented structural problems, while asbestos and man-made vitreous fibres were identified in the building services and the ground.

Specific environmental or climatic pressures

The adaptive reuse of the building as a library introduces environmental and climate pressures. These include high levels of traffic noise and, in Hall B, reverberation times of up to 10 seconds, which are critical to the effectiveness and safety of the voice alarm system (EVAC). Further climate pressures arise from heatwaves and from intense rainfall. The new use requires continuous temperature and relative-humidity control.

Figure 3
Project rendering of the
façade facing Corso
Massimo d'Azeglio.



NEW INTERVENTION

2022 - 2026

Technical and economic feasibility design (PFTE): Rafael Moneo & Isolarchitetti (architectural design), ICIS (lead consultant and structural design), MCM Ingegneria (building services design), Onleco (acoustic and energy design); Executive design (integrated contract for Cobar): ABDR Architetti Associati (lead consultant and architectural design), MJW Structures (structural design), Manens (building services, acoustic, energy and fire safety design)

The intervention transforms Pavilions 2, 2B and 4 of Torino Esposizioni into the new Central Civic Library, as part of the programme Torino, il suo parco e il suo fiume: memoria e futuro, financed through Italy's Complementary Investment Plan to the National Recovery and Resilience Plan (PNRR). Taking the 1954 configuration as its reference, the project restores its legibility by removing incongruous additions, including the glazed entrance hall on Corso Massimo d'Azeglio, external fire-escape stairs and services ductwork on the vault.

The principal change to the layout is the construction within Hall B of an underground court measuring approximately 67 x 70 m. This creates book storage, laboratories and publicly accessible spaces at the lower level without altering the external volume. The lateral mezzanine wings are adapted with sound-insulating glazed partitions enclosing themed study rooms, while timber stepped seating is inserted on the upper levels. The apse becomes a large reading conservatory opening towards Valentino Park. In Pavilion 2B, the historic colour schemes are reinstated, with acoustic devices and raised access floors over a ventilated underfloor void. Structural strengthening addresses the undulating vault and the ferrocement apsidal half-dome. The reinforcement is applied mainly to the extrados using FRCM systems with basalt-fibre or steel meshes to increase structural capacity and improve seismic behaviour in accordance with the Italian Technical Standards for Construction. The works also include repairs to areas affected by carbonation, reinforcement corrosion, loss of bond, and detachment of the surface layers.

The energy upgrade systematically addresses the building envelope. The roofs are insulated with polyisocyanurate (PIR) foam panels and protected by white membranes with an SRI of at least 82 on the flat areas and by light-coloured aluminium sheeting on the curved sections. The historic window systems and those installed in 2006 are replaced with new, slender, thermally broken steel units reconstructed from the original drawings and archival photographs. The building-services systems are renewed through an open-loop ground-source heat-pump plant supplied by four abstraction wells and four reinjection wells, with radiant panels integrated into the floors.



Figure 4
Project rendering of the
apse and family area.

The design process began with the 2017–2018 feasibility study and continued with the PFTE (technical and economic feasibility design) developed by Rafael Moneo, Isolarchitetti, ICIS, MCM Ingegneria and Onleco. In 2023, the design-and-build procurement led to the detailed design for Cobar, prepared by ABDR Architetti Associati, MJW Structures and Manens. Under the coordination of SCR Piemonte, the work was developed in a BIM environment to integrate restoration, structural strengthening, excavation of the underground court, and building services. The investigation and assessment phase drew on the Conservation Plan prepared by the team led by Rosario Ceravolo at the Politecnico di Torino, in collaboration with the Pier Luigi Nervi Project Foundation and with support from the Getty Foundation through the *Keeping It Modern* programme. Consultation with the Soprintendenza (heritage authority) informed the definition of window systems, finishes, and the treatment of earlier alterations. The diagnostic phase included instrumental investigations, material testing and an environmental characterisation plan for the management of excavated soil and the removal of asbestos and man-made vitreous fibres. The project also complies with the Do No Significant Harm (DNSH) principle and the Italian Minimum Environmental Criteria (CAM).

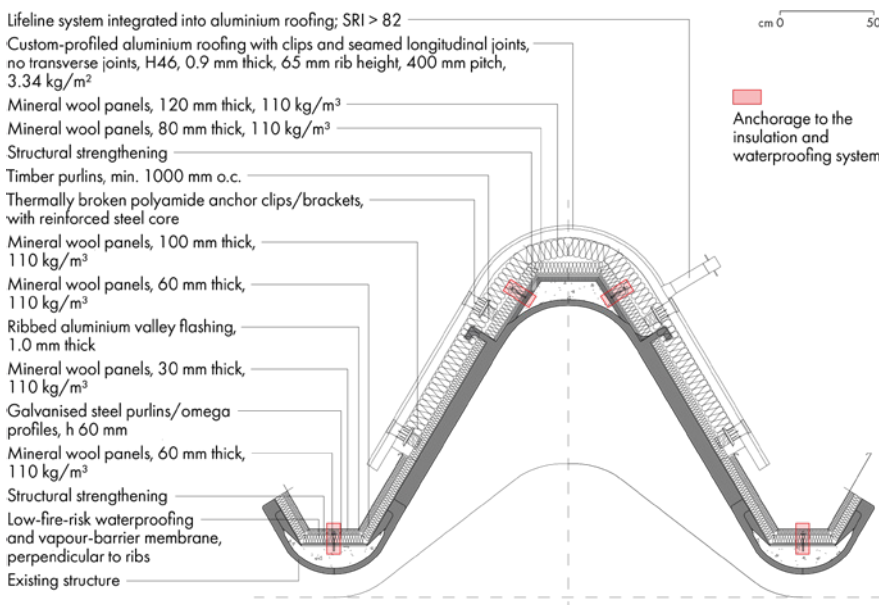


Figure 5
Detail of the
prefabricated
undulating roof
element, section
through the windows.

Objective of the envelope intervention

To achieve high standards of energy efficiency and thermal and acoustic comfort while ensuring the maximum preservation of the architectural character and original materials.

Extent of the envelope intervention

Comprehensive intervention on all opaque and glazed façades, Nervi's vault, the apsidal half-dome and the flat roofs of Pavilion 2B.

Solutions adopted for the envelope

The intervention on the building envelope provides comprehensive thermal insulation of the opaque surfaces using polyisocyanurate (PIR) insulation panels. The flat roofs have white reflective membranes, while the curved roofs are clad in aluminium sheeting. All window systems are replaced with thermally broken steel profiles and low-emissivity glazing, reconstructed to the historic design. The rooflights are renewed with new motorised EFC systems.

Other interventions

Excavation of the new central underground court is the most substantial work. This is followed by seismic improvement using FRCM composites and an open-loop ground-source heat-pump system with eight wells in total. Heating is provided through the floor. The apsidal gallery and Nervi's original stairs are restored, while new lifts are inserted into totem-like volumes. The interiors receive sound-absorbing treatments in display cases and integrated LED lighting. Removal of asbestos-containing materials and man-made vitreous fibres, together with new ochre-coloured external paving, completes the regeneration of the complex.

Pre-intervention consumption

227.01 kWh/m² year

Post-intervention consumption

131.75 kWh/m² year

Certifications / Awards

LEED v4 BD+C certification (Silver target).

Knowledge framework, methodology and traceability

The project is founded on a broad, multidisciplinary knowledge framework that integrates a historical and critical reconstruction of the building's development 'from Sottsass to Nervi', archival research, geometric and material surveys, diagnostic investigations and structural assessments. This process drew on the studies and methodological guidance developed in the Conservation Plan for the Torino Esposizioni pavilions. Developed

from the feasibility study through the PFTE and subsequently into the detailed design in BIM, the process clarifies objectives, constraints and the permissible scope of change. Consultation with the Soprintendenza further ensures good traceability of design decisions.

Technical adequacy and compatibility of the adopted solutions

The measures adopted to improve the performance of the building envelope are consistent with the pavilion's constructional and visual character and are integrated into a conservation and reuse project. The technical choices maintain the legibility of the elevations, the roof and the vast interior, ensuring that the energy upgrade does not become visually dominant.

Degree of reversibility

The degree of reversibility is limited. Converting an unheated pavilion into a permanently conditioned building entails the introduction of build-ups and building-services components that cannot readily be removed. The demolition of recent elements and the new underground court are justified by the adaptive-reuse project but confirm the high degree of transformation.

Impact on the formal and spatial configuration

The energy upgrade largely preserves the recognisability of the pavilion's external appearance, assisted by the removal of additions and the controlled reinstatement of historic patterns, profiles and colour schemes. The most significant impact relates to the new external roof covering, which introduces a perceptible change in the material reading of the envelope. The upgrades to the rooflights, window systems, and entrances follow a principle of visual continuity. Internal transformations, including the new underground court, introduce new modes of use without compromising the legibility of the great nave, vault and apse.

Degree of conservation of original architectural elements

Removing later additions considered incongruous reinforces the legibility of the original configuration. Conservation of the building-envelope components is only partial, however, since window systems, rooflights, balustrades and several finishes are replaced or reconstructed to meet performance and regulatory requirements, address deterioration and enable adaptive reuse. Priority is therefore given to preserving the principal architectural elements and compositional continuity rather than to the complete retention of the original fabric.



Figure 6
Project rendering, interior axial view.

Figure 7
Construction-site photograph, interior axial view.

PADIGLIONE NERVI

Italy, Piedmont, Turin

ORIGINAL DESIGN

1947 - 1950

Pier Luigi Nervi

Pavilion 3A, historically known as Hall C at Torino Esposizioni, is one of the most significant expressions of Pier Luigi Nervi's structural, constructional and aesthetic research in the post-war period. Conceived to expand the complex's exhibition facilities, the new structure forms a rectangular building of 3,858 m², organised around a single large space free of intermediate supports and intended for trade fairs and exhibitions.

The design is generated by a cloister vault whose soffit is articulated by a dense lattice of intersecting ribs arranged in a rigorous diamond pattern. The system was constructed using thin, lightweight precast ferrocement tiles, laid on centring and connected monolithically by cast *in situ* reinforced-concrete ribs. Ferrocement, consisting of wire mesh and small-diameter reinforcement embedded in cementitious mortar, reduced the structure's self-weight, limited the use of conventional formwork and rationalised the construction process. The tiles also served as permanent formwork for the completion pours.

The ribbed lattice performs a load-bearing function while also defining the architectural character of the space. The geometric pattern of the soffit accentuates the continuity of the vault, modulates natural light and assists the diffusion of sound. The roof thus operates as a unified structural, luminous and perceptual device.

The loads from the vault are collected by four large inclined reinforced-concrete arches, which transfer the forces to the perimeter supports and leave the internal floor entirely unobstructed. These arches establish the monumentality of the interior and make its structural behaviour legible. Along the sides, the perimeter galleries are supported by undulating precast ferrocement beams that stiffen the edge of the roof and originally accommodated stepped seating and elevated circulation routes for visitors.

Concentrating the load-bearing functions in the arches and edge structures frees the external walls, allowing the use of extensive continuous glazing with slender metal frames. The transparency of the envelope originally established a strong visual permeability between the hall and Valentino Park, while the diffuse light enhanced the geometry of the structure. External

Figure 1
Axial view of the hall
interior, historical
photograph.



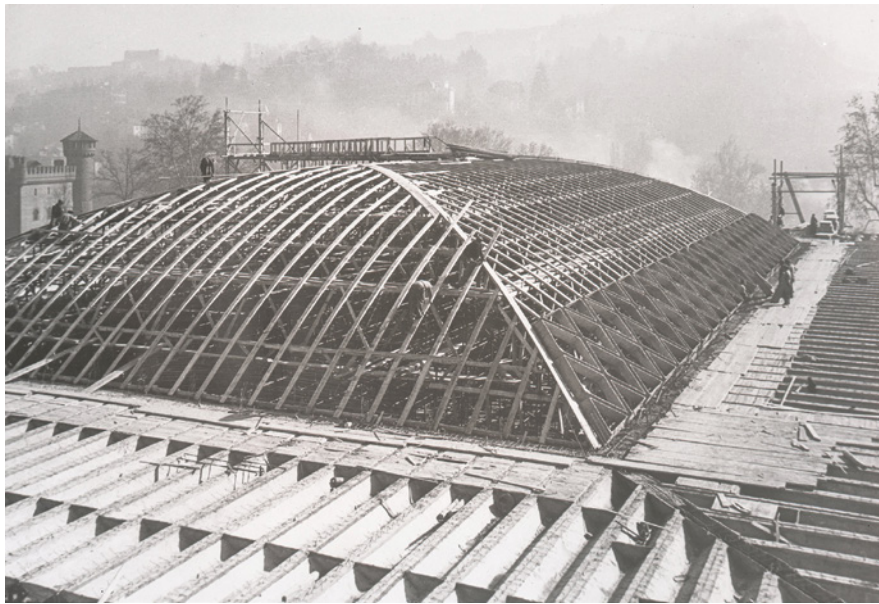


Figure 2
Exterior view of the
roof under
construction, historical
photograph.

stepped terraces connected the slope of the site with the internal floor level, facilitating access and integrating the building into the park.

The entrance gallery forms a transitional space between the exterior and the main nave. A large overhead opening, articulated by a slender lattice of concrete ribs, illuminates the foyer and heightens its monumental character. Inside, the helical staircase demonstrates Nervi's ability to shape concrete by integrating structural function with sculptural expression. Grey Carnico marble floors and restrained window and door frames completed a material palette based on the contrast between reinforced concrete, ferrocement and glass.

Pavilion 3A was conceived not as a simple exhibition container but as an organism in which structure, construction process and architectural form coincide. Lightweight prefabrication, rational site organisation, the clarity of the structural system and the control of light become expressive instruments of the work's spatial quality.

Previous interventions

Over the decades, the pavilion underwent inconsistent alterations driven by emergency requirements. Between the 1960s and the 1980s, the complex hosted trade-fair events using temporary installations that subsequently became permanent. The most invasive intervention dates from the 2006 Winter Olympics, when glazed openings were infilled or painted over to make the spaces opaque. Prefabricated toilet blocks and non-compliant ramps were inserted in the entrance gallery, disrupting its spatial continuity and obscuring the original structural system.

Pre-intervention general conservation conditions

The building was in a critical state of conservation, having lost its original visual permeability and luminosity. The concrete surfaces showed carbon-

ation and cracking caused by structural movement and inadequate maintenance. The historic grey Carnico marble flooring was fragmented and deteriorated, partly as a result of later exposed building-services installations. The insertion of service volumes and incongruous elements had compromised the legibility of Nervi's vault and the architectural value of the building.

Specific environmental or climatic pressures

High levels of noise pollution and critical reverberation times compromise the safety of the voice alarm system (EVAC). Climate pressures include heatwaves and intense rainfall, compounded by the high thermal losses through the original envelope and rooflights. Large temperature fluctuations must be mitigated to provide the indoor comfort required by the new educational use.

Figure 3
Project rendering of the
exterior from Via
Petrarca.



NEW INTERVENTION

2022 - ongoing

Masterplan Team – Politecnico di Torino (Antonio De Rossi, Carlo Deregibus – concept and architectural design), ICIS (lead consultant and general coordination), Ai Studio / Ai Engineering (building services design and sustainability), Violetto Ingegneria and Fabio Manzone (structural engineering), GAE Engineering (fire safety and H&S coordination)

The restoration and adaptive reuse of Pavilion 3A form the centrepiece of the Politecnico di Torino's new Architecture Campus in Valentino Park. The aim is to transform Hall C into a hub for teaching, research and events, accommodating up to 600 people while reconciling the conservation of Nervi's structure with the University's need for functional flexibility.

The design strategy takes the conservation of the large hall's unified spatial character and the enhancement of the diamond-patterned ferrocement vault as its guiding principles. Structural strengthening consists of targeted measures to improve seismic behaviour, integrated into the columns and large inclined arches so as not to alter the perception of their original sections. Historic surfaces and elements are restored in accordance with the Conservation Plan, with particular attention to structural legibility and the compatibility of the interventions.

The new internal layout adopts a 'boxes within the pavilion' principle: two independent glazed volumes, with lightweight, reversible steel frames, provide 2,985 m² of model-making workshops, study rooms and support spaces. These new, energy-independent and transparent structures maintain visual permeability between the educational activities, the monumental interior and the landscape, while preserving the legibility of the nave's continuity.

The elevations are returned to their historic configuration by removing incongruous additions, including the infill introduced for the 2006 Winter Olympics. The existing window systems are replaced with new slender metal profiles calibrated to the tripartite rhythm of Nervi's envelope, together with solar-control selective glazing, body-tinted green in accordance with historical evidence. The monumental entrance gallery is restored by rehabilitating the overhead rooflights and reopening the original niches, while the former proscenium is adapted to accommodate a café and social spaces.

Environmental comfort is provided by systems with limited visual impact. Winter heating and summer cooling use radiant floor panels; ventilation ducts and data networks are integrated beneath the floor or within fixed furnishings. Acoustic performance in the large volume is improved by applying sound-absorbing plaster to the recessed fields between the ribs of the



Figure 4
Project rendering of the hall in its study-room configuration.

vault, preserving its geometry. The artificial lighting follows the structural pattern, with LED sources arranged along the ribs and a central strip of light.

On the Via Petrarca side, the removal of fencing installed in the 1980s and the construction of continuous stepped seating in precast concrete modules transform the service area into an open public space, strengthening the relationship between the University and the park.

The project forms part of the Politecnico di Torino Masterplan for the Architecture Campus. The investigation phase integrated digital survey, historical analysis and structural diagnostics, drawing on the Conservation Plan prepared by the team coordinated by Rosario Ceravolo, together with the Pier Luigi Nervi Project Foundation and with support from the Getty Foundation through the *Keeping It Modern* programme. The energy assessment, developed within the University's 2040 Decarbonisation Plan, used dynamic modelling to verify envelope and building-services performance in accordance with the ITACA Protocol. Alternative scenarios were compared using architectural- and landscape-compatibility matrices, leading to a solution based on reversibility, transparency and minimal interference with the pavilion's monumental value.



Figure 5
Detail of the junction between the arch and the ribbed roof during construction, 2026.

Objective of the envelope intervention

Philological restoration and enhancement of the distinctive character of Nervi's vault through the energy upgrade of the envelope and reinstatement of its original transparency.

Extent of the envelope intervention

The intervention encompasses the entire volume of Pavilion 3A, including the long glazed elevations, the short elevation on Via Petrarca, the entrance gallery, and the extensive surface of the vault.

Solutions adopted for the envelope

Complete replacement of the existing window systems with new units featuring slender thermally broken metal profiles, designed in accordance with the original tripartite composition of the elevations. Installation of high-performance selective solar-control glazing to reduce heat losses and summer heat gains. Reconstruction of the perimeter walls to improve the hygrothermal performance of the envelope, with targeted structural reinforcement to improve seismic behaviour. Restoration and performance upgrade of the overhead rooflights, while retaining their role in providing natural light to the interior.

Other interventions

Insertion of two independent and reversible glazed volumes for workshops and study rooms. Structural strengthening and anti-carbonation protection of exposed concrete. Application of acoustic plaster to the fields of the vault. Installation of a radiant floor system and integration of building-services networks. Reinstatement of the original lighting design. New marble finishes and movable curtains in the teaching spaces. Reconfiguration of the Via Petrarca frontage with precast stepped seating, removal of fencing and new planting.

Knowledge framework, methodology and traceability

The project is based on a multidisciplinary knowledge framework comprising historical and archival research, digital survey, material and structural analyses, energy assessment and seismic-vulnerability evaluation. The Conservation Plan identifies values, critical issues and intervention criteria, guiding the comparison of alternative solutions. The decisions are substantiated and documented in relation to the architectural, constructional and material characteristics of the building.

Technical adequacy and compatibility of the adopted solutions

The solutions are calibrated to the pavilion's specific constructional, material and perceptual characteristics. Localised structural reinforcement, treatment of the concrete surfaces, roof insulation, rehabilitation of the rooflights and integration of building services preserve the legibility of Nervi's structure. The new window systems and selective glazing improve envelope performance while reinstating the rhythm of the openings.

Degree of reversibility

The overall degree of reversibility is limited. The new internal boxes and certain lightweight structures use dry construction systems that are inspectable and potentially removable. However, reconstruction of the perimeter walls, including the replacement of parts of the enclosure and the insertion of new high-performance build-ups, permanently alters the envelope. The replacement of the window systems, the new roof build-ups, the radiant system, surface treatments and structural reinforcement also entail permanent or not readily reversible changes.

Impact on the formal and spatial configuration

The impact of the envelope upgrade on the interior is limited: the unity of the nave, the continuity of the vault, the sequence of arches and the diamond pattern remain legible. The changes are more perceptible on the elevations, which are reconfigured with new window systems, selective glazing and tripartite openings. The new low, transparent internal volumes and the redesign of the Via Petrarca frontage arise instead from the adaptive reuse and introduce a partial reinterpretation of the previous arrangement.

Degree of conservation of original architectural elements

The intervention conserves and restores the original architectural elements that most strongly define the pavilion's identity, particularly the reinforced-concrete structure, the vault, the arches, the diamond-patterned ferrocement elements and the rooflights. Conservation of the envelope components is only partial, however, because the window systems and doors are replaced, sections of the perimeter walls are reconstructed and new build-ups are added to the roof. Although justified, these replacements prioritise compositional continuity over the retention of original components.



Figure 6
Project rendering of the hall in its conference configuration.

Figure 7
Axial view of the hall interior during construction, 2026.

TEATRO NUOVO

Italy, Piedmont, Turin

ORIGINAL DESIGN

1936 - 1950

Ettore Sottsass Sr., Roberto Biscaretti di Ruffia

Teatro Nuovo in Turin, formerly the Teatro della Moda, is one of the most significant examples of modern architecture in the city. The building originated as part of the Palazzo della Moda, designed by Ettore Sottsass Sr. between 1936 and 1939 for the southern area of Valentino Park along Via Petrarca. The original design centred on a stage with two proscenium openings, serving both the indoor auditorium and an open-air arena overlooking the park. Although initially conceived with a horseshoe plan, the auditorium was built to a rectangular plan without a balcony, reflecting the geometric and rationalist rigour of the complex. The elevation on Corso Massimo d'Azeglio featured a monumental portico with eight cylindrical columns and travertine cladding.

Bombing in 1943 almost completely destroyed the ceilings, roofs and interior furnishings. Reconstruction between 1948 and 1950 under Carlo and Roberto Biscaretti di Ruffia went beyond restoring Sottsass's building and substantially reconfigured its interior. Carlo oversaw the site's reorganisation for the Turin Motor Show, while Roberto developed the theatre's architectural and technical design. Capacity increased to 1,544 seats through a suspended balcony supported on cantilevered steel trusses of angle sections, with a reinforced-concrete slab above and hollow-clay-tile soffit below.

The load-bearing structure combines brick masonry and reinforced-concrete columns. Self-supporting SAP floors of reinforced clay elements accelerated post-war reconstruction. The traditionally built perimeter walls, clad externally in travertine, provided some thermal inertia but lacked insulation by present-day standards. Transparent envelope elements consisted of single-glazed metal-framed windows.

Particular attention was paid to acoustics. Auditorium surfaces were clad in Lipari pumice, a porous sound-absorbing material, and shaped into broad stepped profiles linking walls and ceiling. Designed by Roberto Biscaretti di Ruffia, they promoted sound diffusion towards the stalls and balcony, correcting the volume's acoustic response without applied devices unrelated to its architectural configuration.

Figure 1
View of the foyer with
the balcony, 1961.





Figure 2
View of the auditorium
towards the stage,
1961.

The entrance hall and foyer acquired an elegant character through chequerboard floors in white Calacatta and green Cipollino marble and two monumental staircases with sinuous balustrades. Grey linoleum in the auditorium also reduced footfall noise. Lighting comprised fluorescent tubes in public spaces and a Fortuny dome above the stage, creating variable lighting effects on the backdrops.

The stage system included a fly tower approximately 27 m high, with a timber gridiron and machinery for moving panoramas, and an orchestra pit for around 100 musicians with two electromechanically operated movable platforms. Rehearsal rooms and technical workshops occupied the lateral wings. In 1950, construction of Pier Luigi Nervi's Hall C led to demolition of the open-air auditorium, severing the theatre's direct relationship with the park. The resulting building combines Sottsass's rationalist shell with a post-war interior shaped by new structural, acoustic and stage technologies.

Previous interventions

Between 1950 and the current intervention, the building underwent two significant phases of alteration. For Italia 61, bas-reliefs by Roberto Terracini and Venini chandeliers based on a design attributed to Carlo Scarpa were installed. In 1997, Studio Libidarch carried out an extensive adaptive-reuse for the Germana Erba dance high school. New floor slabs were inserted in the foyer and partitions added within the lateral wings, altering the perception of the original volume and reducing the main auditorium's capacity to approximately 1,000 seats to meet regulatory requirements.

Pre-intervention general conservation conditions

Before the new intervention, the building showed marked material deterioration and had been disused since 2022. Mechanical and electrical systems were decommissioned or obsolete and did not meet current safety and energy-efficiency regulations. The envelope showed widespread water ingress through deteriorated flat roofs and corrosion of metal windows. Internally, the original spatial character was compromised by 1990s additions, while marble finishes and auditorium plaster decoration required urgent conservation.

Specific environmental or climatic pressures

The building is located in Italian climate zone E, with cold winters and a design minimum temperature of -10 °C. Passive strategies are also required to control summer overheating because of the high thermal inertia of the travertine-clad masonry. The growing urban heat-island effect increases the thermal load on the bituminous roofs.

Figure 3
Project rendering of the
façade facing Corso
Massimo d'Azeglio.



NEW INTERVENTION

2022 - ongoing

Technical and economic feasibility design (PFTE): Rafael Moneo & Isolarchitetti (architectural design), ICIS (lead consultant and structural design), MCM Ingegneria (building services design), Onleco (energy design), Prof. R. Pisani (acoustic design); Executive design (integrated contract for Cobar): ABDR Architetti Associati (lead consultant and architectural design), MJW Structures (structural design), Manens (building services, energy and fire safety design), Byobite (acoustic design)

The refurbishment of Teatro Nuovo in Turin transforms the historic building into a cultural hub for the performing arts, combining conservation of modern architecture, functional upgrading and urban regeneration. Developed from the technical and economic feasibility design by Rafael Moneo and Isolarchitetti and advanced at detailed-design stage by ABDR Architetti Associati, the project aims to recover the theatre's architectural identity and bring it into line with contemporary standards of safety, accessibility, comfort and energy performance.

The principal methodological action is the removal of accretions and incongruous additions, particularly those introduced in the 1990s, which had compromised the legibility of the interior. The foyer is restored to its full height by removing the intermediate floor slabs, and the two monumental staircases are reintegrated into the sequence of major public spaces. In the main auditorium, the acoustic shell designed by Roberto Biscaretti di Ruffia is reconstructed in accordance with the original design, while the stalls are reprofiled to improve sightlines, accessibility and comfort for the planned audience of 1,021.

New underground spaces beneath the stage accommodate the orchestra pit and technical rooms, increasing the flexibility of the stage machinery. The lateral wings are adapted to contain dressing rooms, rehearsal rooms and offices, ensuring independent circulation for educational areas, service spaces and public routes. Structural strengthening focuses particularly on the fly tower and is coordinated with the conservation of historic decoration, plaster mouldings, original marbles and Venini chandeliers.

The energy upgrade includes ground-source heat pumps and a photovoltaic system to reduce energy use and emissions. The travertine façades are restored, and the window systems are replaced with new thermally broken steel profiles that reproduce Sottsass's original design. The roof waterproofing and insulation build-ups are renewed using high-reflectance white mineral-surfaced membranes, helping to limit summer overheating. External works along Via Petrarca improve pedestrian continuity with the plaza and Valentino Park.



Figure 4
Project rendering of the
foyer and the buvette
beneath the balcony.

The design process began in 2022 with the PFTE prepared by the multidisciplinary team led by Rafael Moneo and Isolarchitetti. In 2024, following award of the design-and-build contract to Cobar S.p.A., ABDR Architetti Associati began the detailed design. Multidisciplinary coordination was developed in a BIM environment to integrate conservation, ground-source systems and structural strengthening within the statutorily protected building. Consultation with the Soprintendenza (heritage authority) guided the recovery of Biscaretti di Ruffia's decoration, the marbles and historic lighting fixtures. The detailed design updated the energy and structural assessments and defined the final construction strategy in accordance with the Italian Minimum Environmental Criteria (CAM), the Do No Significant Harm (DNSH) principle and the targets for improving the energy rating. The theatre is scheduled to reopen to the city in 2027 as a flexible venue for performance, education and cultural experimentation.



Figure 5
Project rendering of the
foyer, viewed from the
staircase leading to
the balcony.

Objective of the envelope intervention

Energy upgrade and conservation through insulation of the envelope and the integration of renewable energy sources, in accordance with the statutory protection of the historic building.

Extent of the envelope intervention

Comprehensive intervention on the entire building envelope, including complete replacement of the external window systems and systematic reconstruction of all insulated and waterproofed roof build-ups.

Solutions adopted for the envelope

The roofs are insulated with polyisocyanurate (PIR) panels protected by reflective membranes to reduce the heat-island effect ($SRI \geq 82$). The opaque walls are insulated internally with mineral wool to preserve the historic travertine façades. The window systems are replaced with new thermally broken metal profiles and selective low-emissivity glazing, providing high levels of thermal and acoustic performance without altering the original rationalist appearance.

Other interventions

The works include structural strengthening of the façade and fly tower and restoration of the two-tone marble finishes and historic staircases. The floor slab added in the 1990s is removed to reinstate the full-height foyer; a new underground level is created for the orchestra pit, and the auditorium's acoustic shell is faithfully reconstructed using poplar plywood cladding. The intervention also includes the restoration and repositioning of the Venini chandeliers and Terracini bas-reliefs, together with a new elevated dance rehearsal room.

Pre-intervention consumption

367.41 kWh/m² year

Post-intervention consumption

132.27 kWh/m² year

Certifications / Awards

LEED Silver criteria (design target, official certification not pursued for financial reasons).

Knowledge framework, methodology and traceability

The project is based on a comprehensive knowledge framework integrating a historical and critical reconstruction of Teatro Nuovo, analysis of previous transformations and alterations, assessment of deterioration and technical and performance obsolescence, energy and structural studies, and BIM coordination. The design decisions are con-

sistent with the statutory protection regime, the requirements of the Soprintendenza and the aim of recovering the work's defining characteristics, including the foyer, acoustic shell, marbles, decorative scheme and significant historic layers.

Technical adequacy and compatibility of the adopted solutions

The adopted solutions are generally compatible with the building's architectural character. Internal insulation preserves the visual continuity of the travertine cladding, while the new thermally broken steel window systems reproduce the existing design and limit changes to the elevations. Reconstruction of the roofs, the cool-roof system and renewable-energy installations contribute to improved performance.

Degree of reversibility

The envelope intervention is extensive and entails complete replacement of the window systems, systematic reconstruction of the roofs, insertion of new build-ups in the ground floors, and internal insulation of the walls and portico soffit. Overall reversibility is therefore low, although the decisions are justified by deterioration, functional upgrading and performance improvement.

Impact on the formal and spatial configuration

The envelope measures have a limited impact on the building's external appearance. The travertine cladding preserves the material continuity of the elevations, while the monumental portico retains its spatial and urban role in the composition of the façade. The principal divisions remain legible, and the new window systems reproduce the original design. Internally, the impact is more pronounced: insulation, new construction build-ups and upgrading measures are combined with the reprofiling of the auditorium and reorganisation of the spaces. Removing the additions introduced in the 1990s nevertheless improves the legibility of the foyer.

Degree of conservation of original architectural elements

The travertine cladding, full-height foyer, two-tone marbles, staircases, and the 1961 additions, including the Venini chandeliers and Terracini bas-reliefs, are retained and restored, while the Biscaretti di Ruffia acoustic shell is faithfully reconstructed. The weaker technical components of the envelope, however, particularly the metal window systems, roofs and ground-floor build-ups, are replaced or extensively renewed for energy, regulatory or conservation reasons.



Figure 6
Project rendering of the auditorium towards the stage.



Figure 7
Project rendering of the auditorium viewed from the stage.

ALESSANDRIA MUNICIPAL THEATRE

Italy, Piedmont, Alessandria

ORIGINAL DESIGN

1958 - 1977

Eng. Quagliata (competition design), Giancarlo Canegallo, Angelo Paleari (municipal technical office)

The construction of the Municipal Theatre formed part of the renewal of Alessandria's cultural facilities initiated after the Second World War. In 1958, the municipality launched a national competition for a new theatre; engineer Quagliata's proposal provided approximately 1,800 seats. From 1964 onwards, the Municipal Technical Office, led by Giancarlo Canegallo, revised the design: capacity was reduced to approximately 1,200 spectators and the programme was expanded, turning the building into a multipurpose cultural centre for opera, drama, cinema, concerts, conferences and community activities. Built between the late 1960s and 1977, the complex opened in 1978.

The building stands at the edge of the public gardens, near the railway station, establishing a relationship with both the park and the urban fabric. Its composition is generated by an assemblage of volumes differentiated by height, form and function: the foyer, auditorium, galleries, stage areas, ancillary spaces and plant rooms are all legible externally. Rising above them is the fly tower, the tallest and most compact element and the complex's principal visual landmark. The elevation facing the park has an open, civic character: the entrance is marked by a canopy, while glazing, concrete walls and volumes with curved corners articulate the building mass. The side and rear elevations are more enclosed, punctuated by regularly spaced openings and ribbed-concrete surfaces. This material treatment, also applied to the curved elements, visually unifies the different volumes; the plinths and external landscaping are finished in serizzo stone.

The full-height foyer leads into the main auditorium, which comprises the stalls, two galleries, side boxes and a civic box. The orchestra pit, large stage and two side-stage areas enabled the venue to host opera, drama, cinema, concerts and public events. In the basement, a second auditorium seating approximately 270 people accommodated arthouse cinema, experimental theatre and conferences. Smaller halls, dressing rooms, chorus dressing rooms, workshops, scenery stores, storerooms, archives, offices, a library, bar, plant rooms and caretaker's accommodation completed a complex designed for use outside performance times.

Figure 1
Main elevation.





Figure 2
Detail of one of the smaller openings with a pitch-pine window frame.

The load-bearing structure, constructed entirely of reinforced concrete, is divided into blocks separated by structural joints and comprises columns, walls, beams and deep beams sized in relation to the auditorium and fly tower. Intermediate floors are predominantly of clay-block-and-concrete construction, with solid slabs in some areas; most basement floors are supported on ground-bearing reinforced-concrete structures. The main auditorium is roofed by a precast structure comprising reinforced-concrete lattice girders and simply supported ribbed units. The other flat roofs, set at different levels, employ clay-block-and-concrete slabs, lightweight falls and bituminous waterproofing, with zinc-sheet flashings.

The perimeter walls consist of reinforced-concrete walls of varying thickness, with either a smooth or ribbed finish. In many spaces they are internally lined with hollow-clay-block leaf walls and a thin layer of expanded polystyrene insulation. The original pitch-pine windows, with single glazing, are set within the depth of the walls and coordinated with the façades' modular design. Internal partitions combine clay-block walls, concrete walls and sound-absorbing linings.

Environmental control was provided by a centralised system with two gas-fired boilers and chillers. The theatre spaces were served by all-air systems with air-handling units and ductwork, while offices, dressing rooms and ancillary spaces used radiators and fan-coil units. The building also incorporated water-supply, sanitary, electrical and fire-safety systems, lifts and an electrical substation. Architecture, structure and building services thus combined to create a major cultural facility expressing the civic ambitions of the 1960s and 1970s.

Previous interventions

The Municipal Theatre was closed to the public as a precautionary measure on 2 October 2010, following the detection of asbestos-fibre contamination. Asbestos was removed from furnishings, internal wall and ceiling finishes, and building-services ductwork between 2010 and 2016.

Pre-intervention general conservation conditions

Before the intervention, the theatre, closed since 2010, was in a critical state of conservation due to its prolonged disuse. Water ingress from the roofs had caused areas of plaster to detach, sus-

pending ceilings to collapse, and widespread deterioration of finishes and windows. The building also suffered from obsolete services, poor energy performance of the envelope and localised structural vulnerabilities, particularly in the precast roof over the auditorium.

Specific environmental or climatic pressures

The urban context is characterised by high humidity, winter fog, summer overheating, air pollution and traffic. The adjacent tree-covered park locally mitigates the urban heat-island effect and solar exposure.

Figure 3
Main elevation during
the works.



NEW INTERVENTION

2021 - ongoing

RossiProdi Associati, Ai Studio / Ai Engineering

The design process began in 2021 with a two-stage competition launched by the Municipality of Alessandria to transform the Municipal Theatre, closed since 2010, into a cultural and tourism hub. The proposal submitted by the team led by RossiProdi Associati, which won the competition in 2022, seeks to restore to the city a place central to civic life, suited to contemporary uses while respecting its identity. The design draws on surveys, structural investigations, and energy, acoustic and fire-safety analyses. To align implementation with the available resources, the works are divided into three functional packages and a further package for completing the auditorium. The first, funded through Italy's National Recovery and Resilience Plan (PNRR) and the Fund for Non-Deferrable Works, includes the principal structural works, upgrading of the envelope, refurbishment of the main auditorium, the services required for its operation and the central plant; funding from the GSE supports completion of the energy-efficiency measures and the refurbishment of the Ferrero auditorium, foyer and bar.

The intervention retains the principal characteristics of the building inaugurated in 1978, while recomposing its image through a new horizontal plane that varies in height around the perimeter, links the different volumes and screens the rooftop plant. This metal cladding does not entirely replace the façades: the original material character of the ribbed-concrete surfaces is retained and insulation is installed internally, while external wall insulation is applied to the smooth areas. Some portions of the building and the new plant enclosures are defined by a ventilated façade clad in aluminium composite panels.

The energy upgrade encompasses walls, roofs, ground-bearing floors, windows and construction junctions. The roofs are insulated and re-waterproofed; the basement floors are insulated and, in some areas, supplemented by a ventilated underfloor void. Deteriorated, poorly performing windows are replaced with thermally broken aluminium units incorporating low-emissivity, solar-control and acoustic double glazing. Natural smoke and heat exhaust ventilators are also installed on the roof.

In structural terms, the design seeks to improve seismic performance and adapt the building to its new functions through local strengthening, alterations and openings in the floor slabs, new steel lift shafts and a connecting walkway. Particular attention is paid to the auditorium's precast roof, comprising reinforced-concrete lattice girders and ribbed units: a composite structural topping, reconstruction of the bearings and new steel connections reduce its seismic vulnerability and the risk of displacement.



Figure 4
Theatre foyer during
the works.

The functional adaptation makes the spaces more flexible and accessible. The layout, acoustics and building services of the main auditorium are upgraded, with alterations to the stalls and provision for retractable tiered seating. Basement and ancillary areas accommodate cultural, educational, exhibition and support activities, extending use of the complex beyond the theatre programme. The works also provide step-free accessibility and fire-safety upgrading.

The building-services systems are completely renewed. The central heating system is connected to the city's district-heating network, while cooling is provided by high-efficiency chillers. Demand-controlled mechanical ventilation, with heat recovery and variable airflow, adjusts the air-change rate to the use of each space. LED lighting and building services are integrated into a centralised building management system; a photovoltaic array is planned for the roof, together with an emergency generator. The intervention thus seeks a balance between conserving the building's identity, ensuring that new additions remain legible, and improving performance, creating the conditions for the theatre's continuous, inclusive and more energy-efficient use.



Figure 5
One of the smaller
openings with the new
window frame.

Objective of the envelope intervention

To improve energy efficiency and indoor comfort, reducing heat loss and thermal bridging while preserving the building's architectural character.

Extent of the envelope intervention

The intervention extends to all perimeter walls and walls adjoining unheated spaces, roofs, ground-bearing floors and windows.

Solutions adopted for the envelope

Walls insulated internally with rock-wool linings on the ribbed-concrete façades, and externally with EPS on the smooth areas. A new insulated ventilated façade with Alucobond cladding is applied to portions of the existing building and to the new rooftop plant enclosures. Roofs are insulated with PIR panels and re-waterproofed using a light-coloured bituminous membrane. Ground-bearing floors are insulated with EPS or PIR and, in part, incorporate a ventilated underfloor void. New thermally broken aluminium windows incorporate low-emissivity, solar-control and acoustic double glazing.

Other interventions

Functional adaptation of the internal spaces and fire-safety and seismic upgrading, including local strengthening, alterations to floor slabs, the roof and tiered seating, and the installation of lifts. Renewal of building services: district heating, cooling with chillers, mechanical ventilation with heat recovery, LED lighting and BMS control. Installation of an approximately 110 kWp photovoltaic array, an emergency generator, and natural smoke and heat exhaust ventilators. Acoustic and functional upgrading of the auditorium and creation of new cultural, educational and support spaces.

Pre-intervention consumption

415.4 kWh/m² year

Post-intervention consumption

50.52 kWh/m² year

Certifications / Awards

Nearly zero-energy building (nZEB).

Knowledge framework, methodology and traceability

The design is based on a multidisciplinary body of knowledge comprising historical and documentary research, surveys, condition assessments, structural investigations, and energy, acoustic and fire-safety evaluations. The energy audit reconstructs the behaviour of the existing building and compares different intervention scenarios. Reports, construction build-ups, schedules and

details clearly identify the adopted solutions and their relationship with the various original systems.

Technical adequacy and compatibility of the adopted solutions

The solutions are differentiated according to the characteristics of the envelope: internal insulation on the ribbed-concrete surfaces, external wall insulation on the smooth areas, and a ventilated façade on selected portions and the new plant enclosures. The design coordinates walls, windows, roofs, floors and junctions, verifying their hygrothermal performance. The strategy addresses high heat loss and water ingress while keeping the most distinctive ribbed surfaces visible.

Degree of reversibility

Overall reversibility is limited. The internal linings and ventilated façade include components that are at least partly demountable, but the external wall insulation, new roof and floor build-ups, thermal-bridge treatments and complete replacement of the windows permanently alter the envelope. The fixings for the metal screens and interventions to their supports also reduce the possibility of reinstating the previous configuration without further work.

Impact on the formal and spatial configuration

The intervention introduces a clearly perceptible transformation of the external appearance. Extending around the perimeter and varying in height, the new metal plane links the different volumes and screens the services and new plant enclosures, superimposing a new order on the original composition. The volumetric articulation, fly tower and extensive areas of ribbed concrete remain legible, but the cladding significantly alters the building's profiles, finishes and overall perception.

Degree of conservation of original architectural elements

Conservation of the envelope is selective. The ribbed-concrete surfaces remain visible and are insulated internally; the concrete walls and articulation of the building volumes are retained. The smooth surfaces, however, are covered with external insulation, while all the original windows, predominantly in pitch pine, are replaced. Roofs and waterproofing are renewed, and new metal façades clad selected portions. Structural elements and the most distinctive surfaces are therefore retained, but significant original components are lost.



Figure 6
Roof of the theatre auditorium with the new smoke vents.

Figure 7
Side elevation with new volumes and sections clad in a metal envelope.

PADIGLIONE TAVOLARA

Italy, Sardinia, Sassari

1951 - 1956

Ubaldo Badas

ORIGINAL DESIGN

The Padiglione Tavolara stands in Sassari's public gardens and was designed by Ubaldo Badas, in collaboration with the artist Eugenio Tavolara, beginning in 1951. Like other works by Badas, it arose from the integration of architectural design and artworks conceived as integral components of the building.

The two-storey complex comprises two volumes linked by an intermediate space. The exhibition-hall block has a trapezoidal, three-aisled plan and a longitudinal layout; it is flanked to the north-east by a reflecting pool and connects axially to the square volume of the courtyard. The latter is surrounded by workshops and has an accessible terrace sheltered by a canopy. The exhibition hall, measuring approximately 800 m², widens towards the rear and cantilevers by about four metres on its three free sides above the storage area below. The courtyard forms the focus of the workshop block, which is arranged along a ring-shaped circulation route, while the upper terrace was conceived as an outdoor resting area shaded by pergolas.

The area adjoining the hall is occupied by two successive transitional elements: the transverse gallery and the stair volume, built in reinforced concrete and steel. The gallery crosses the complex from side to side and serves as an entrance route into the gardens; it provides access to the ceremonial hall, the exhibition space and the terrace, and, via an internal ramp, to the workshop level. The covered external ramp, projecting towards the park, introduces the sequence of interior spaces.

The entire complex is dominated by inclined geometries in both vertical and horizontal elements: sloping planes, converging and diverging walls, leaning or forked columns alter the perception of the architectural space. The composition is based on the interplay between enclosed rooms, mainly on the lower level, and spaces opening towards the park on the upper floor, mediated by transitional elements such as the covered ramp suspended above the reflecting pool.

The load-bearing structure consists of reinforced-concrete frames with columns of varying cross-section and inclination. In the exhibition hall, each frame has a different configuration in response to the span and the undulating profile of the roof; the beams are shaped according

Figure 1
View of the pavilion's south side, showing the reflecting pool, access ramp and one of the decorative panels; period postcard.



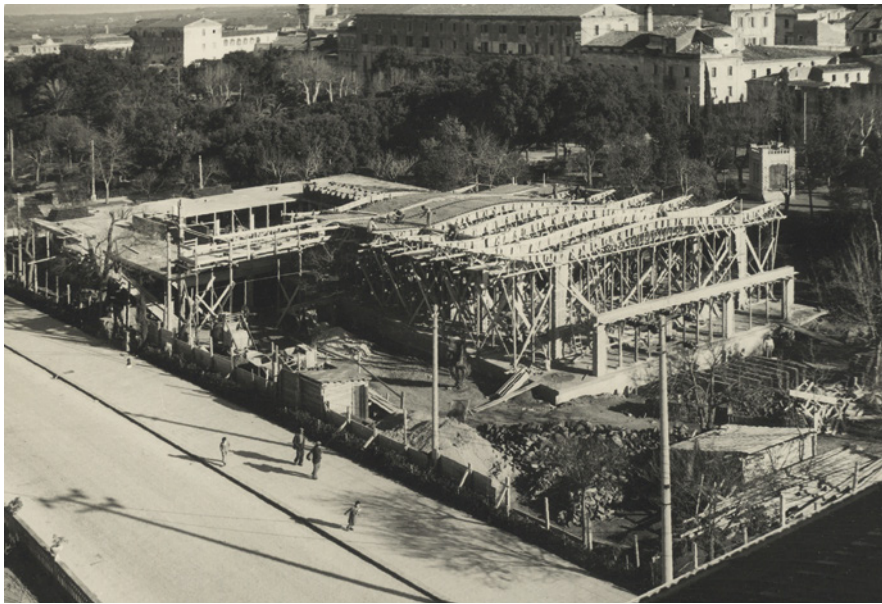


Figure 2
The pavilion under construction, March 1954 (ASCSS, Historical Archive of the Municipality of Sassari, Modern Archive, Correspondence and Records, Series 6, Folder 30A, File 9, fol. 2).

to the bending-moment diagram, while the columns lean outwards and are clad in marble slabs. The beams are concealed by a suspended ceiling of curved timber slats that follows the roof's undulating form. The sequence of non-identical frames plays a decisive role in defining the space and expresses the building's structural character. The splayed side walls and curved roof heighten the hall's perspectival expansion towards the rear. Around the courtyard terrace, the canopy columns are V-shaped, while those supporting the external ramp are forked. The floors are composite clay-block and concrete slabs built with precast joists.

The lateral enclosures consist either of reinforced-concrete walls or extensive glazing in metal frames. The large glazed wall of the exhibition hall is formed by tubular steel mullions and slightly inclined glass panes, supported on shaped steel flats and arranged to allow air to pass through.

Indoor climate control relies on passive strategies rather than mechanical systems, drawing on the building's orientation, the choice of materials and colours, natural ventilation, and the use of solar shading, pergolas and canopies. In the exhibition hall, the obliquely arranged louvred glazing admits air cooled by the body of water to the north-east, while solar screens on the opposite elevation limit solar gain yet allow air to pass. By integrating orientation, shading and cross-ventilation, the design makes passive environmental control an essential architectural component.

Previous interventions

An intervention in the 1980s, designed by Vico Mossa, altered the natural-ventilation system by adding a second internal glazed wall and installing air conditioning. The external units were placed on the roof, changing its silhouette. Deteriorated areas were refurbished and architectural and decorative elements were replaced or added; in the central courtyard, the full-height windows and glazed doors were replaced with units of a different form. In the 1990s, heavy railings were erected around the site for security reasons.

Pre-intervention general conservation conditions

The building was in a deteriorated condition owing to a lack of maintenance and to interventions that altered architectural solutions central to Badas's design, above all the natural-ventilation system. The external pool had been filled in, and external timber elements, including pergolas and solar screens, had been lost.

Specific environmental or climatic pressures

High solar exposure and summer heatwaves create a risk of overheating in the extensively glazed spaces and require effective shading and natural ventilation.

Figure 3

The exhibition hall's glazed wall overlooking the reflecting pool restored during the intervention.



NEW INTERVENTION

2009 - 2014

Studio di Architettura Cenami-Simonetti-Ticca, Mossa e De Rosa Architetti Associati, Roberto Grenga, Francesco Simonetti Cenami

The restoration of the Padiglione Tavolara was preceded by an extensive investigation programme. A research team from the University of Rome Tor Vergata, coordinated by Professor Sergio Poretti, reconstructed the history of the building, its construction process and its transformations over time through direct analysis, surveys and the study of archival documents. The findings were published in the volume edited by Poretti and Gizzi in 2007 and subsequently informed a set of guidelines used as the basis for the preliminary design included in the tender documents. During the detailed-design phase, the team led by Piersimone Simonetti developed a more detailed understanding of the building through the examination of written, graphic, photographic and film records and direct inspection of the fabric, distinguishing original elements from later alterations and identifying the architectural characteristics to be conserved or reinstated.

The project focused on restoring the building and bringing it back into use, removing alterations introduced over time – including internal partitions and infill to openings and parapets – and upgrading it to meet the building-services and regulatory requirements of its new function. The works sought to improve accessibility by removing physical barriers, and to enhance hygrothermal comfort, safety and energy efficiency, while limiting the impact of new installations on the original image and spaces.

A central intervention concerned the exhibition hall's large louvred glazed wall, an essential component of both the architectural composition and the original natural-ventilation system. The translucent glass panes were dismantled, cleaned and reinstalled, while the iron frame was replaced by a new stainless-steel structure of similar design, configured to accommodate a second internal pane approximately 8 mm thick and thereby form an insulating glass unit. Removing the internal secondary glazing added in the 1980s restored the operation of the permeable glazed wall, although its use was limited to the transitional seasons. In the other rooms, the original gaps between the frames and masonry were not reinstated; the new windows and doors use thermally broken steel frames and insulating glazing.

The exhibition-hall roof was insulated with wood-fibre panels and converted into a ventilated roof, finished with zinc-titanium sheet. Floors, finishes and internal and external opaque surfaces were also restored; the pools and fountains were reinstated; and deteriorated structural



Figure 4
Detail of the roof.

areas were repaired by treating the reinforcement and reinstating the concrete cover. The deteriorated timber solar screens on the terrace and access tunnel were replaced with new white-painted stainless-steel elements.

The highly intrusive building services added in the 1980s and 1990s were removed in their entirety and replaced with visually discreet solutions. Distribution networks were concealed within construction depths, and equipment was integrated into the floor or suspended ceiling to reduce interference with the perception of the spaces. Overall, the intervention sought a balance between conserving the architectural character, recovering the original passive strategies, and meeting contemporary requirements for use, safety and energy performance.

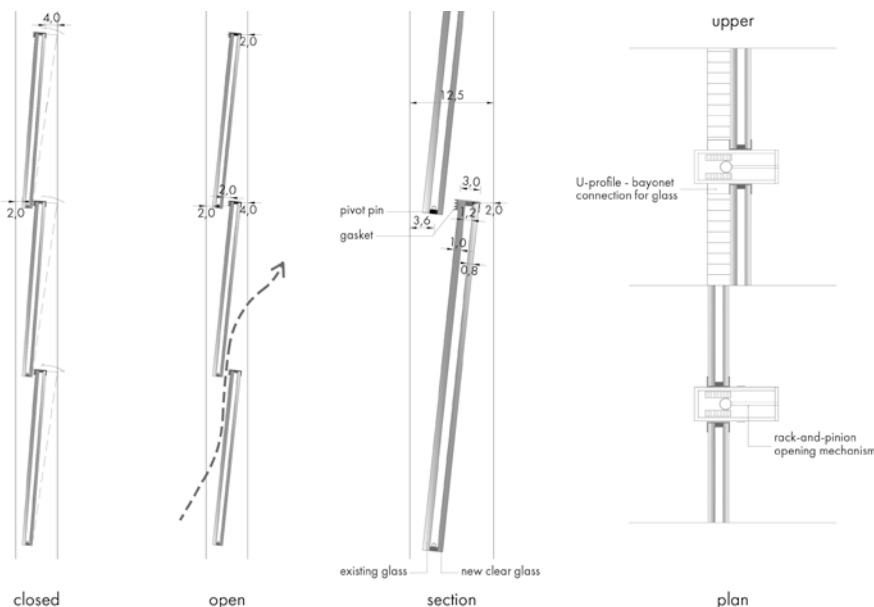


Figure 5
Section through the exhibition hall's glazed wall, showing the addition of a second glass pane and the modification of the opening mechanism (AR26 project drawing).

Objective of the envelope intervention

The intervention aimed to convert the building for permanent use, resolving issues relating to occupant comfort while removing alterations made to the original configuration.

Extent of the envelope intervention

The intervention addressed the transparent vertical surfaces and roofs; no work was carried out on the opaque vertical envelope.

Solutions adopted for the envelope

Restoration and optimisation of the large louvred glazed wall by replacing its frame and adding a second internal pane to form an insulating glass unit, thereby improving thermal performance while preserving the operation of the original system. Replacement of the other windows and doors with new thermally broken steel units with insulating glazing. Roof insulation using wood-fibre panels, conversion to a ventilated-roof build-up, and a new external zinc-titanium covering.

Other interventions

Complete reconfiguration of the building services, including the installation of heat pumps and the positioning of the fire-suppression system storage tank outside the pavilion volume. Restoration of surface finishes and repair of deteriorated reinforced-concrete structural elements by treating the reinforcement and reinstating the concrete cover. Removal of fill from the external pools and restoration of their original configuration.

Post-intervention consumption

177.6 kWh/m² year

Certifications / Awards

Energy performance class B (APE, 2017).

Knowledge framework, methodology and traceability

The design process was founded on a robust knowledge base consistent with the principles governing the study of historic buildings. Historical and technical analysis, examination of the pavilion's transformations, and recognition of its material and constructional characteristics guided the project towards a conservation-based approach intended to restore the legibility of the building's architectural, material and chromatic qualities.

Technical adequacy and compatibility of the adopted solutions

The envelope solutions are consistent with the pavilion's constructional and environmental logic and do not amount to the standardised application of energy-efficiency measures. The project improves the performance of the glazed surfaces, windows and doors, and the roof, while preserving the legibility of the relationship between the lightweight envelope, natural ventilation, and visual continuity between inside and outside. Technical compatibility is high because the new build-ups and replacement components are calibrated to the original architectural characteristics.

Degree of reversibility

The intervention is partially reversible. Some envelope solutions, such as the new glass panes and certain lightweight finish components, can potentially be dismantled or replaced without extensive alteration of the structure. However, replacement of the frames, construction of the new roof build-up and material integrations associated with performance improvements cannot readily be reversed in the strict sense. The assessment is therefore intermediate, as the project combines removable components with works that permanently alter the constructional fabric of the envelope.

Impact on the formal and spatial configuration

The overall impact on the formal and spatial configuration is limited. The removal of incongruous infill, parapets and building services has strengthened the legibility of the large open spaces, the relationship between inside and outside, and the connection with the reflecting pool. The changes – including double glazing, new frames and the insulated roof – are perceptible but do not substantially alter the spatial configuration or the recognisability of Badas's original composition.

Degree of conservation of original architectural elements

The intervention achieves a high degree of conservation of the original architectural character, retaining and restoring the legibility of the surfaces, integrated artworks, spatial continuity, the relationship between inside and outside, and the connection with the reflecting pool. The replacement of the frames and some external components and the introduction of a new roof build-up affect the material fabric of the envelope, but these works are limited in scope and justified by safety, deterioration and performance requirements, without compromising the overall recognisability of the building.



Figure 6
The canopy over the terrace after the intervention.



Figure 7
The central courtyard, overlooked by full-height windows.

SCHAROUN THEATRE

Germany, Lower Saxony, Wolfsburg

ORIGINAL DESIGN

1965 - 1973

Hans Scharoun, Margit Scharoun (project coordination after Scharoun's death), Bernhard Heiliger (acoustic sails design), Alexander Camaro (foyer glazing design)

The Scharoun Theatre in Wolfsburg, designed by Hans Scharoun and completed posthumously in 1973, is a masterpiece of organic architecture. Situated on the north-eastern slope of the Klieversberg, it integrates into the landscape, with the woodland behind it serving as a natural backdrop. The foundations comprise reinforced-concrete footings and concrete piles adapted to the sloping terrain. In contrast to the right angles and industrial seriality associated with the Bauhaus, the composition adopts a free, irregular and linear layout, formed by distinct volumes that accommodate the movement of visitors.

The building is divided into three functional areas, progressing from public and representative spaces to private and administrative ones. The route begins in the south-eastern wing, where a broad canopy leads to the box office and a low-ceilinged reception area, from which the eighty-metre-long main foyer is reached. The lower wings, housing the foyer and offices, are covered by steel trapezoidal sheets supported by steel beams. The flat roofs comprise a synthetic waterproof membrane, 6 centimetres of polystyrene insulation and aluminium perimeter profiles.

One side of the foyer is fully glazed from floor to ceiling and opens towards the park, the city and, in the distance, the Volkswagen factory, establishing a connection between the cultural space and the industrial landscape. The glazed wall contrasts with the double-leaf external walls, composed of a concrete core and stone cladding. The plinth is clad in travertine, while the stage tower is faced with dark-grey Ceppo di Gré stone panels backed by 4 centimetres of mineral-wool insulation. In the foyer, finishes and technical systems contribute to the configuration of the space: the ceilings incorporate suspended acoustic panels, the green carpet is laid over a cement screed, and custom-made downlights follow a free arrangement that accompanies the route through the building.

At the centre of the architectural composition is the main auditorium, conceived as a 'building within a building'. The surrounding corridors serve both as escape routes and as acoustic barriers against external noise. The vertical load-bearing structure consists primarily of reinforced-concrete walls, which support a heavy roof slab of the same material over the stage tower. This configuration meets the structural, acoustic and safety requirements of the stage complex.

The trapezoidal auditorium comprises a gently sloping stalls area, side boxes and a cantilevered balcony. It has a seating capacity of 745, which can be increased to 833 by covering

Figure 1

View from the north showing the foyer, stage tower, and administration wing, 1973.





Figure 2
Interior view of the
auditorium, historical
photograph.

the orchestra pit. The interior is characterised by ash-wood wall panelling, green carpeting and red-upholstered seats. The integration of architecture and building services is particularly evident in the ventilation system: fresh outside air, supplied by a system connected to the municipal district-heating network through heat exchangers, enters the auditorium through the hollow seat backs, which act as individual air ducts, and is subsequently extracted through the ceiling. This solution ensures audience comfort without introducing visually intrusive technical elements. A distinctive feature is the large window of approximately 70 square metres located beside the stage. During rehearsals, it allows natural light to reach the stalls; during performances, it is concealed by a curtain, thereby departing from the traditional theatrical model of the 'black box'.

The auditorium ceiling is constructed in Rabitz as a thin, non-load-bearing membrane consisting of plastered wire mesh only 2.5 centimetres thick. Its distinctive form contributes both to the acoustic quality and to the aesthetic character of the interior. The dimmable downlights follow a free, poetic arrangement that evokes a starry sky during performances.

Previous interventions

Since its completion in 1973, the Scharoun Theatre in Wolfsburg did not undergo any major structural, technical, or architectural renovations. The building was maintained in a remarkably intact state, reflecting its original configuration and material composition. Only minor cosmetic repairs, routine maintenance, and localised touch-ups (Schönheitsreparaturen) were executed over its first forty years of operation. Consequently, while the building remained highly authentic, its technical systems, stage machinery, and building services gradually deteriorated and became obsolete by the 2010s.

Pre-intervention general conservation conditions

Prior to the 2014–2016 restoration, the theatre was in a well-preserved but heavily aged condition. Forty years of continuous use had caused

substantial wear and tear. While the structural concrete frame was sound, the interior suffered from aesthetic and functional issues. The foyer's acoustic ceiling panels were discoloured and deteriorating, and the auditorium's original ash wood wall veneers had been covered with an inappropriate white glaze. The stage machinery and technical services were completely obsolete, and the ventilation system caused uncomfortable cold draughts and system noise.

Specific environmental or climatic pressures

The theatre faces distinct environmental pressures due to its exposed hillside location on the Klieversberg. Its expansive single-glazed foyer façade and uninsulated travertine plinth walls experienced severe winter heat losses and summer solar heat gains. Additionally, the original flat roofs lacked adequate insulation and thermal protection.

Figure 3
Exterior view of the
entrance area, the
foyer and the stage
tower, 2016.



NEW INTERVENTION

2012 - 2016

Brenne Architekten (general planner and lead architect), Ingenieurbüro Rüdiger Jockwer (structural engineering), Theater Engineering (stage technology), Ingenieurgesellschaft Meinhardt Fulst (technical building services), energydesign braunschweig (energy concept and building physics), Planungsgruppe Geburtig (fire safety and H&S coordination)

Between 2014 and 2016, the Scharoun Theatre in Wolfsburg underwent a programme of conservation and upgrading coordinated by Brenne Architekten. The project preserved the 1973 building's architectural and material character while discreetly improving energy performance, services and safety.

The upgrading of the building envelope focused primarily on the roofs and windows. Owing to water infiltration, internal separation within the roof build-up and fire-safety requirements, the flat roofs were completely renewed. The original 6 centimetres of polystyrene insulation were replaced with approximately 20 centimetres of mineral wool, while the light-grey synthetic roofing membrane was reproduced using a product supplied by the original manufacturer. The original roof edge was restored and approximately 90% of the aluminium profiles were reused. The original metal frames were overhauled and resealed; neutral-coloured double glazing improved thermal and solar-control performance. In the auditorium's box window, located in the rear wall and comprising two glazed planes set 1.5 metres apart, only the outer glazing was replaced. The junction with the surrounding wall was also sealed, while the historic ornamental glass on the inner plane was retained.

The travertine and Ceppo di Gré façades were conserved *in situ*, cleaned and locally repaired without adding a continuous layer of insulation. In the offices, the Thermocrete walls, which proved to have poor insulating properties, were internally insulated with calcium-silicate boards. For architectural and conservation reasons, this solution was not adopted in the foyer. A thin layer of insulation was also added to the exposed concrete sections at the base of the façades.

In the auditorium, the white glaze applied at a later date to the ash-veneered wall panels was removed. The 825 seats were restored and reupholstered in red fabric. The original ventilation system supplying air through the hollow seat backs was retained and improved with special nozzles that optimise air distribution while reducing draughts and noise. The non-load-bearing Rabitx ceiling, consisting of plastered wire mesh only 2.5 centimetres thick and incapable of supporting foot traffic, required rope-access specialists to upgrade its suspension system and install the necessary technical equipment. The original lighting frames and



Figure 4
Exterior view of the stage tower and the administration wing, 2016.

reflectors were retained, while the light sources were replaced with lower-energy dimmable units selected to preserve the original lighting effect.

The original stage layout and functional mechanical components were retained; machinery, drives and controls were renewed or supplemented. A new water-cooled chiller uses the 400 m³ firefighting-water cistern for regenerative heat dissipation into the ground, eliminating the need for an external cooling unit. Accessibility and service provision were improved through new volumes, largely built into the hillside to limit their impact on the façades.

The project was based on a structured process of investigation and decision-making. The building logbook provided a systematic record and formed the basis for an assessment of significance, which helped reconcile the requirements of the client, users, and heritage authorities. These tools informed a programme of works and a constraints plan covering all areas of the theatre. Six categories of intervention were identified: restoration, renovation, redesign, addition, upgrading of technical infrastructure, and redesign of the external areas. The continuous comparison of alternative solutions allowed individual measures to be assessed in relation to the building's overall energy balance.

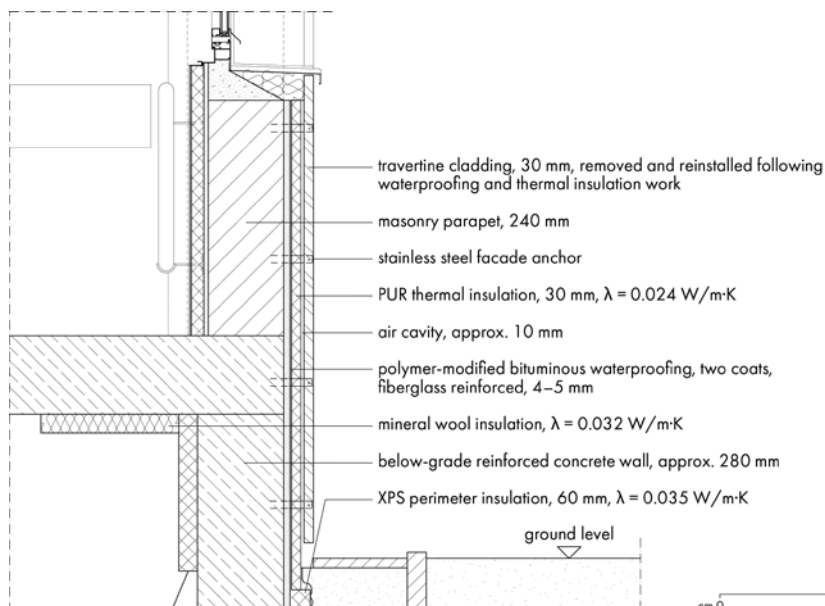


Figure 5
Detail of the administration wing façade.

Objective of the envelope intervention

The objective was to improve energy efficiency, reduce heating consumption by 30%, and correct uncomfortable seating draughts, all while strictly preserving the theatre's protected historic appearance.

Extent of the envelope intervention

The intervention encompassed all the flat roofs, which were completely insulated; the glazing in the foyer and offices, which was replaced with double-glazed units while retaining the original frames; and the selective internal insulation of the office perimeter walls and certain sections of the plinth.

Solutions adopted for the envelope

The envelope was upgraded through conservation-compatible measures. The flat roofs were insulated with a vapour barrier, 20 cm of mineral-wool insulation and a synthetic membrane. The original metal window frames were retained, overhauled and fitted with new seals; the glazing was replaced with double-glazed units providing improved thermal and solar-control performance. In the auditorium's box window, only the outer glazing was replaced, reducing heat loss and noise. The office walls were internally insulated with calcium-silicate boards.

Other interventions

Efficient stage machinery was retained, while machines, drives and controls were renewed or supplemented. Heat recovery was added to the ventilation system; special nozzles in the seat backs improved air distribution and reduced draughts and noise. A new chiller uses the 400 m³ firefighting-water cistern for regenerative heat dissipation. Much of the lighting was converted to LED. New volumes, largely built into the hillside, were added at the rear for building services, storage and toilets.

Pre-intervention consumption

214 kWh/m² year

Post-intervention consumption

161.4 kWh/m² year

Certifications / Awards

2018 FeuerTRUTZ Network Brandschutz des Jahres – Brandschutzkonzepte (Sanierung von Bestandsbauten).

Knowledge framework, methodology and traceability

The project is based on a structured knowledge process integrating the study of the building, the

analysis of its architectural and construction characteristics, and the assessment of its energy performance. The Gebäudebuch, the Wertebilanz and the subsequent Bindungsplan made it possible to calibrate the interventions according to the significance of the different building components. Thermographic surveys, laboratory analyses and the comparison of alternative solutions supported the design decisions.

Technical adequacy and compatibility of the adopted solutions

The solutions are differentiated according to the construction characteristics and architectural significance of the various parts of the envelope. Roof insulation was upgraded by increasing the thickness of the insulating layer, while the original metal frames were retained and improved with new gaskets and insulating glazing units. Internal insulation was limited to offices and selected portions of the plinth, avoiding interventions on the stone-clad façades and in spaces where it would have altered the architectural character.

Degree of reversibility

The intervention retains the metal frames and a substantial proportion of the façade components, while the new glazing units and gaskets can be replaced without altering the original window frames. Reversibility is more limited in the roofs, where the existing build-up was replaced with a new insulated assembly, and in the office walls affected by internal insulation. Overall, permanent alterations are confined to the parts directly involved in the upgrading works.

Impact on the formal and spatial configuration

The energy-efficiency measures leave the overall perception of the building substantially unchanged. The increase in roof insulation was also carried out without altering the perimeter configuration, reusing most of the existing aluminium profiles. Internal insulation mainly affects secondary spaces and does not modify the configuration of the principal interiors.

Degree of conservation of original architectural elements

The intervention extensively preserves the elements that characterise the building. Approximately 90% of the perimeter aluminium profiles of the roofs were preserved and reused. Replacements mainly concern the glazing and the roof build-ups, while in the large auditorium window only the outer glazing was replaced, preserving the internal ornamental glass.



Figure 6
Interior view of the auditorium, 2016.

GUGGENHEIM MUSEUM

United States, New York, New York City

ORIGINAL DESIGN

1943 - 1959

Frank Lloyd Wright, William Wesley Peters (Taliesin Associates – structural and engineering details), Mendel Glickman and Jaroslav Joseph Polivka (structural engineering)

Frank Lloyd Wright's Solomon R. Guggenheim Museum, completed in 1959, is an icon of twentieth-century Modern architecture. Conceived as a 'temple of spirit', it was designed to display non-objective art in a radically new museum setting. Its identity emerges from the combination of experimental geometry, an innovative exhibition programme, and the unusual application of industrial materials and construction processes to architecture for the arts.

The composition consists of two distinct structures: the spiral Rotunda and the smaller polygonal volume originally known as the Monitor. The Rotunda develops around a continuous helical ramp that widens progressively as it rises and encircles a 29.3-metre-high central void capped by a glass-domed skylight. This configuration creates an uninterrupted exhibition route: visitors view the artworks while proceeding along the ramp and move between levels without relying on a traditional sequence of galleries and stairs. The central void, overhead light, and continuous circulation contribute to a unified perception of the interior.

Wright's principle of 'organic architecture' is expressed through the building's monolithic character and the continuity of its forms, conceived as parts of a single living organism. The load-bearing system combines a reinforced cast-in-place concrete frame with a continuous shell. To achieve the Rotunda's plastic, uninterrupted curves, Wright used spray-applied concrete, employing the technique then known as gunite or shotcrete, which was advanced for the period. The material was projected against inclined, curved plywood formwork to create 12.7-centimetre-thick exterior walls. The boards left a pattern of horizontal and vertical impressions on the cementitious surface that, during recent restoration work, was recognised as culturally significant evidence of the original construction process and the building's authenticity of craftsmanship. The technique also gave the structure visual and structural unity, materially embodying Wright's theory of organic architecture.

To preserve the smooth, unornamented geometry, the exterior walls were constructed without expansion joints. This decision ensured the continuity of the shell but caused the surfaces to respond to thermal movement through the gradual formation of natural cracks. Protection

Figure 1
View of the museum
from 89th Street,
1959.





Figure 2
Exterior view of the
museum during
construction, 1957.

was provided by Cocoon, an innovative high-build elastomeric vinyl coating originally developed for the temporary mothballing of naval vessels. Applied in multiple layers in a buff or light yellow-brown colour to a dry-film thickness of approximately 0.45 mm, the product was designed to bridge minor cracks and create a continuous, jointless, vapour-proof skin.

Connected to the Rotunda by balconies, the Monitor was originally designed to accommodate administrative offices but was later converted into exhibition space, now known as the Thannhauser Gallery. Its floor-to-ceiling window walls, supported by galvanised steel frames, provide natural light and outward views while serving as character-defining elements of the building. The original units consisted of single glazing set within non-thermally broken frames with a painted metallic finish.

The glazing system also includes central and perimeter skylights constructed with aluminium frames and hammered wire glass. Natural light, filtered from above and through the glazed walls, contributes to the definition of the route and reinforces the relationship between the museum's volumes. Inside, suspended cement-plaster soffits applied over metal lath shape the ceiling surfaces and continue the plastic continuity of the whole.

Previous interventions

In 1968, a four-storey concrete-framed tower addition was completed, designed by William Wesley Peters of Taliesin Associates. Between 1989 and 1992, Gwathmey Siegel & Associates performed a major renovation and expansion, which included the completion of an eight-storey steel-framed addition. This work also involved removing interior partitions in the Monitor building to create the Thannhauser Gallery and installing concealed rigid insulation in walls. A terrace canopy was added in 2001 and removed during the restoration.

Pre-intervention general conservation conditions

By late 2004, the Guggenheim exhibited significant signs of deterioration. The exterior monolithic shotcrete shell showed multiple cracks, coating failures, and soiling. The absence of original

expansion joints led to structural movement and horizontal cracking in response to thermal loads. Probes revealed corrosion of embedded steel T-beams and reinforcement discontinuities in the upper Rotunda walls. Uninsulated single-glazed steel windows and aluminium skylights suffered from excessive seasonal condensation, which compromised humidity stability and restricted museum use during winter months.

Specific environmental or climatic pressures

NYC temperature fluctuations causing thermal movement in monolithic structures built without expansion joints led to extensive cracking. Warm interior humidified air meeting cold uninsulated surfaces in winter led to massive condensation. Wind and rain exposure on outward-pitched parapets increased moisture loading, leading to liquid water weeping.

Figure 3
View of the museum
from 89th Street,
2010.



NEW INTERVENTION

2004 - 2008

WASA/Studio A (Pamela Jerome and Angel Ayón – architectural conservation), Robert Silman Associates (structural engineering), Integrated Conservation Resources (conservation science), William B. Rose & Associates (building envelope design), Atkinson Koven Feinberg (mechanical engineering)

The 2004–2008 restoration of the Solomon R. Guggenheim Museum was a holistic multidisciplinary effort focused on structural stabilisation and the upgrade of the building envelope's thermal and hygric performance. The project commenced with an exhaustive assessment phase, utilising advanced laser surveys to produce a three-dimensional digital model for movement analysis and extensive archival research into Wright's original design intent. Significant structural interventions were implemented on the sixth-floor Rotunda walls, where the team identified discontinuities in horizontal reinforcement and corroded steel. To improve structural performance without erasing original formwork marks – deemed significant value-carrying features of craftsmanship – engineers installed a basket-weave pattern of carbon-fibre-reinforced polymer (CFRP) on the interior face of the walls. This approach prioritised the preservation of the as-built historic fabric over the architect's unrealised intent for smooth surfaces.

Addressing the building's pervasive cracking required the insertion of discrete remedial exterior control joints at key locations, designed to accommodate thermal expansion while maintaining the spiral geometry's integrity. The restoration of concrete surfaces involved the scrupulous survey and removal of up to eleven layers of failing paint, followed by concrete repair using polymer-modified cementitious patching composites specifically tested for compatibility with the original gunite. The shell was then protected with a state-of-the-art coating system that mimicked and enhanced the properties of the original 1959 Cocoon finish.

To resolve long-standing issues with seasonal condensation, a major glazing upgrade was undertaken. After unsuccessful attempts to design retrofits for saving original fabric, the team removed all single-glazed galvanised steel window walls and aluminium skylights. These were replaced with custom-made thermally broken systems that replicate the original appearance and sightlines. The new unprecedented thermally broken steel window system, matching the original profiles, utilises double-glazed insulating glass units with warm-edge technology and argon infill to meet modern museum performance standards. Similarly, new thermally broken aluminium skylights were installed with enhanced weather-tightness and UV protection, while daylighting was minimised to ensure a stable interior exhibition environment. Mechanical, electrical, and plumbing upgrades were simultaneously implemented



Figure 4
View from below of
the entrance and the
Rotunda, 2012.

to improve overall infrastructure and environmental control. The decision-making process for the intervention was guided by a set of preservation principles that balanced authenticity of fabric with design intent and continued functional needs. The design process spanned over two years of intensive condition assessment and multidisciplinary research. The project team utilised state-of-the-art laser surveying to document interior and exterior surfaces, creating a detailed 3D digital model for finite-element structural analysis. Archival research involving the Taliesin and Getty archives provided critical data on original construction methods. Materials testing included analysis of over 100 paint samples and the evaluation of repair products from six major manufacturers. Laboratory studies subjected test panels to accelerated weathering, adhesion testing, and water vapour transmission measurements. Two rounds of full-scale mock-ups were implemented on the building and monitored over a one-year period to verify the performance of repair systems. Energy modelling using LBNL software was employed to assess condensation resistance and thermal performance for over a dozen glazing upgrade options.

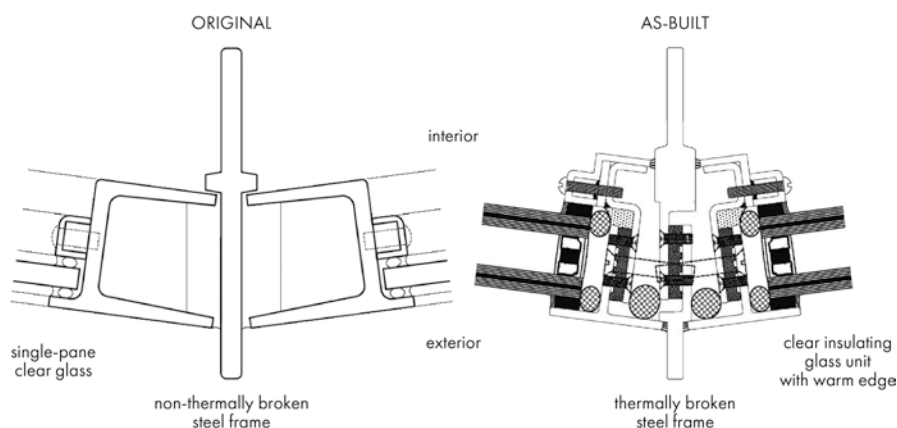


Figure 5
Typical detail of the
original window wall
(left) and its
replacement (right).

Objective of the envelope intervention

Mitigate structural cracking, prevent moisture ingress, and eliminate seasonal condensation on glazed surfaces, while preserving the building's iconic architectural character and the formwork marks that document its original craftsmanship.

Extent of the envelope intervention

Comprehensive restoration and performance upgrade of the Rotunda and Monitor envelopes.

Solutions adopted for the envelope

Interior application of carbon-fibre-reinforced polymer (CFRP) strips to the sixth-floor ramp walls and insertion of remedial exterior control joints. Removal of deteriorated coating layers and localised concrete repair using polymer-modified cementitious patching materials. Installation of custom-made thermally broken steel window systems replicating the original profiles, with argon-filled insulating glass units and low-emissivity coatings, together with new thermally broken aluminium skylights. Application of a high-build elastomeric vinyl coating reproducing the original finish. Installation of an interior air barrier and cellular-glass insulation in localised repair areas to improve thermal control. Replacement of uninsulated components with high-performance systems validated through comparative laboratory testing.

Other interventions

MEP infrastructure upgrades were implemented to enhance interior climate control and environmental stability for artwork preservation. The project included downsizing mechanical equipment made possible by the envelope's improved thermal performance. Interior restoration work involved cleaning and repairing interior plaster finishes to conceal the new structural reinforcements and address previous deterioration.

Certifications / Awards

2008 ICRI Project Awards (Historic – Award of Merit); 2008 SEAoNY Distinction in Structural Engineering Award; 2009 ACEC New York Engineering Excellence Platinum Award; 2009 AIA NYS Honor for Architectural Excellence in Historic Preservation; 2009 AIA Westchester/Mid-Hudson Chapter Honor Award; 2009 ICRI Project Awards (Low-Rise – Award of Excellence); 2009 New York Landmarks Conservancy Lucy G. Moses Preservation Award; 2009 Preservation League of New York State Excellence in Historic Preservation Award.

Knowledge framework, methodology and traceability

The project is grounded in archival research, laser-scanner surveys, structural analyses, material investigations and energy modelling. Glazing solutions and techniques for repairing concrete and exterior surfaces were assessed through laboratory testing and building mock-ups monitored over time. These phases allow the criteria and rationale behind the selected solutions to be clearly reconstructed.

Technical adequacy and compatibility of the adopted solutions

The solutions address concrete deterioration, water infiltration and condensation while preserving the building's character. Internal strengthening retains exterior formwork traces; new thermally broken windows and skylights reproduce the original divisions. Mortars and coatings were selected through compatibility and durability testing.

Degree of reversibility

Reversibility is limited by wall strengthening with composite-material strips, joints introduced in exterior surfaces, and removal of accumulated paint layers. Windows, glazing and skylights were entirely replaced, while waterproofing, insulation and new coatings permanently altered the envelope assemblies. Future replacement of glazing and gaskets applies only to selected components of the new system.

Impact on the formal and spatial configuration

The intervention retains the helical form, continuous curved surfaces and glazing pattern. New windows reproduce the original divisions, while expansion joints have limited visual impact. Reduced daylight from the new skylights slightly changes interior perception without altering spatial organisation.

Degree of conservation of original architectural elements

The intervention preserves the concrete structure, helical ramp, exterior surfaces and traces of original construction techniques. Envelope retention is partial, since steel windows, glazing and skylights were replaced to address condensation and ensure appropriate environmental conditions for the museum. New components reproduce the design and proportions of the pre-existing ones, but still entail replacement.



Figure 6

Interior view of the thermally broken steel replacement window wall on the third floor, in the space converted into a café, 2016.

Figure 7

Interior view of the Rotunda and the replacement skylight, designed to match the original, 2018.



CONCLUDING ESSAY

INTERVENTIONS ON THE BUILDING ENVELOPE OF ARCHITECTURE FROM THE SECOND HALF OF THE TWENTIETH CENTURY: EXPERIENCES AND REFLECTIONS FROM THE EeTAC RESEARCH PROJECT

Marta Casanova, Federica Pompejano

The analysis of the case studies of the research project *EeTAC – Energy Efficiency and Conservation of Contemporary Architecture: Preservation, Quality, and Innovation of the Building Envelope* highlights a recurrent condition in the architecture of the second half of the twentieth century: many envelope elements, now recognised as significant, were conceived in a phase of intense technical experimentation and industrialisation of the construction process. It is precisely the most innovative components, often decisive for the character of the building, that in several cases display a shorter service life than that of the load-bearing structures. The need to conserve them is today compounded by requirements of safety, comfort and energy efficiency that are very different from the original ones. The conservation of these works of architecture must therefore contend with the obsolescence of initially innovative materials and with the modifications produced by use over time, which raise specific methodological problems (Normandin & Macdonald, 2013, p. 1). This condition calls into question the idea that the envelope is a mere support onto which efficiency measures may be applied. Performance derives from the behaviour of the building envelope, determined by the characteristics of the materials and by the way in which the architectural components are assembled in relation to the specific conditions of use and exposure. An intervention may therefore keep the overall form and volume recognisable while profoundly altering the fabric or the functioning of the original envelope.

The theoretical framework developed in recent decades has shifted attention towards cultural significance and the attributes through which it is expressed. Havinga, Colenbrander and Schellen distinguish between the values that explain why an architectural work is relevant and the attributes through which those values become recognisable, arguing that, in order to govern a transformation, it is necessary to identify precisely which parts may change and to what extent (Havinga et al., 2020, pp. 282–283). The Madrid–New Delhi Document identifies design, spatial relationships, construction systems, materials and the technical aspects among the tangible attributes, and it further recalls the importance of the structural and technological innovations that occurred in the twentieth century (ICOMOS ISC20C, 2017, p. 4). The notion of the management of change thus acquires an operational meaning since it belongs to the conservation process, while its effects on authenticity, integrity and cultural significance require explicit evaluation. The document recommends cautious interventions, limited in extent and, as far as possible, reversible (ICOMOS ISC20C, 2017, p. 8).

The EeTAC project addresses these issues through the analysis of thirty case studies from the second half of the twentieth century, twenty Italian and ten international, and the *ex post* evaluation of the related energy-efficiency interventions. The selection compares different building envelopes and intervention strategies, offering a qualitative reading of the solutions adopted. Energy improvement is examined alongside its effects on the fabric and on the architectural character of each building, in order to understand whether the transformations respect the relationships through which



Figure 1
Replacement of the
windows in the apse
of the Padiglione
Agnelli in Turin.

its cultural significance is expressed. The concluding assessments show that, in the majority of the selected case studies, transformations that were difficult to reverse were also preceded by in-depth investigations. This knowledge-based process makes it possible to reconstruct the rationale behind replacements and decisions, as well as to allow the comparison between the alternatives considered, clarifying why a permanent transformation was deemed necessary.

From Knowledge to Design Choices

Knowledge constitutes an integral part of the architectural design in the context of the energy efficiency intervention, because it makes it possible to identify the elements that should be conserved and to define the limits of the modifications. Bond and Worthing argue that the cultural significance of the building and its components should be understood before intervention strategies are defined; in the initial phase of the evaluation, the pressures of the new programme should remain separate from the judgement on values, so as not to steer it towards an already chosen solution (Bond & Worthing, 2016, pp. 128–130). In the cases examined, this occurs when surveys, archival research, diagnoses and *in situ* testing led to differentiated responses.

Understanding the original configuration is the first task of the knowledge-building process and requires a distinction between what was envisaged in the design and what was actually built. The variants introduced during the construction phase and the modifications that have occurred over time belong to the constructional history of the building, while shortcomings that have emerged during use must likewise be traced back to their respective periods and causes before the design choices are defined. The investigation must also identify the characteristics on which the documentary value of the building envelope depends, relating its visible form to the way in which it was built and functioned over time. On this basis, different intervention hypotheses can be compared and their effects on the elements to be conserved can be assessed.

The ICO Central Workshops in Ivrea constitute one of the clearest examples. The restoration of the façades retains the external iron-and-glass envelope, reinstates the sash/guillotine-opening system and conserves mosaics and rendered finishes. A new internal skin with thermally broken aluminium frames and double-glazed units satisfies most contemporary performance requirements. The brise-soleil are restored

or replaced according to their conditions. The new design thus distinguishes the layer that preserves the historical value from the one intended to accommodate performance upgrading. The solution avoids an undifferentiated replacement of the curtain wall while keeping the operating principle of the original façade legible.

The same link between knowledge and design choice emerges in the energy-efficiency intervention on Villa Rossi, Banchette (TO), where material analyses, decay surveys, and archival research guide localised interventions, as well as in the Padiglione Tivolara, which was preceded by research on the constructional history and the subsequent transformations of the building over time. In the project for Torino Esposizioni, the design process explicitly set out the objectives, constraints and margins of transformation. Even where the works do not correspond to the principle of the minimum material intervention, a knowledge-based approach makes it possible to verify the reasons for which an element is conserved, modified or replaced.

In some international cases, the investigations produce findings and indications that continue to inform subsequent phases. In the case of the Cité du Lignon, the study of the alternative solutions and the testing on prototypes made it possible to plan the interventions while keeping the dwellings in use and allowing the inhabitants to remain in their homes. The case of the Salk Institute shows how research on materials and mock-ups guided the hierarchy of repairs, limiting replacements and providing indications for future maintenance. Thus, the documentation produced continues to support decision-making over time.

However, the expression 'good practices' calls for a degree of caution. The thirty case studies document responses linked to specific conditions, whose transfer to other buildings necessarily requires a new knowledge-based process and a fresh verification of the existing conditions. When the architectural components prove still to be repairable, the design may conserve them; when the available products alter the original design, custom-made pieces may be produced and tested through prototypes. The distinction between the existing historical additions and the modifications introduced by the energy efficiency intervention also eases the identification of the decisions taken. Moreover, process documentation clarifies what has been removed and distinguishes the conserved parts from the newly added ones. This approach is consistent with significance-based management, according to which the analysis should identify the elements that embody recognised values and assess their sensitivity to change (Bond & Worthing, 2016, pp. 85–87, 116–117).

Material Fabric and Identity

The replacement of transparent components recurs in several of the cases analysed by the EeTAC project, but it is approached with different criteria according to the value attributed to the original elements. When these are still conserved and document or provide evidence of a significant construction technique, their retention constitutes a priority objective. In the cases where the original material fabric is compromised or has already been lost, the intervention may seek to recover the architectural and environmental characteristics that defined the building envelope. It is therefore necessary to specify which aspects have been conserved and to consider the material loss resulting from the transformation.

In the project for the reuse of Pier Luigi Nervi's pavilions at Torino Esposizioni, the vaults and the apsidal half-dome constitute the principal elements to be preserved, while windows and door frames, skylights, parapets and various finishes are replaced or reconstructed. The continuity of the façades, roof and interior space is pursued through the careful control of the spatial articulation, the profiles and the colour schemes, notwithstanding a significant alteration of the material fabric of the

building envelope. Considering the shift from an unheated pavilion to a permanently air-conditioned building, reversibility is also limited. Although it entails substantial transformations, the project maintains a predominantly conservation-led approach, since the new components remain subordinate to the preservation of the spatial organisation and to the synthesis between structure and architectural form.

The intervention on the RAI Headquarters building on Viale Mazzini in Rome poses the question in different terms. The project conserves the metal structure and aims to recover the lightness and transparency of the building conceived by Francesco Berarducci, which had been altered by the additions made over time. The energy-efficiency intervention entails the complete strip-out of the architectural and building-services elements, asbestos remediation and an extensive reconstruction of the building envelope, with the new façades reproducing the rhythm and proportions of the previous original ones. Compared with the Torino Esposizioni project, this case study gives greater importance to the continuity of the overall configuration and reduces the existence of the original components to a more substantial extent. The comparison therefore calls for a distinction between the recognisability of the architectural image and material conservation, and a clarification of the relative importance assigned to each in the evaluation of the intervention. Since by the time this essay is being written the implementation of construction works is still in progress in both buildings, these considerations concern the design strategies and will have to be verified against the completed intervention.

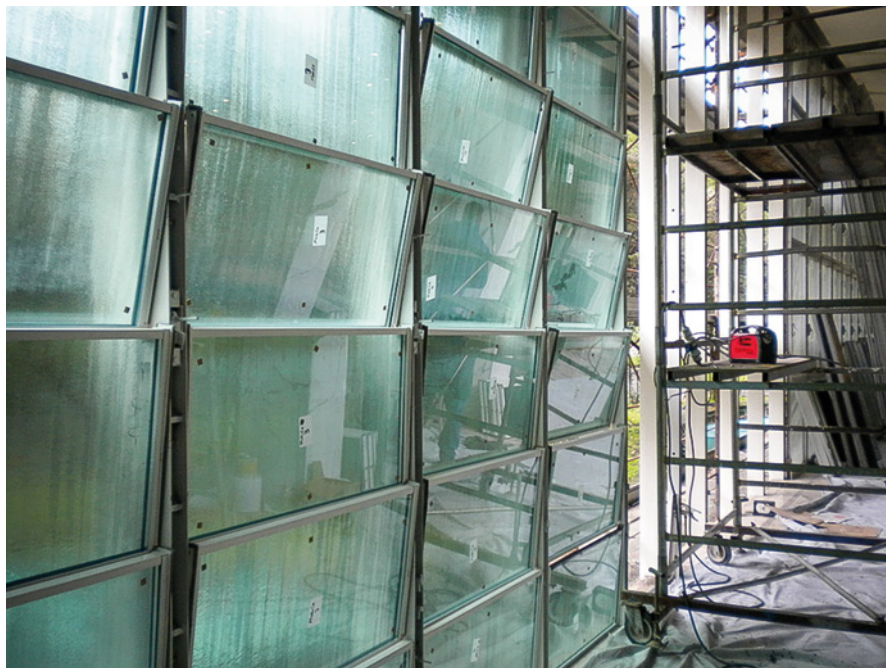
The case of the Church of Nostra Signora della Misericordia, located in Baranzate, is different. The original translucent cladding had been replaced in 1979 and was in a state of severe decay. The intervention begun in 2004 therefore took as its reference point a building envelope whose original fabric had already been partly lost. The question of authenticity concerns, above all, the recovery of the quality of the luminosity and of the relationship between the concrete structure and the translucent wall, aspects that were already decisive in the conception of Mangiarotti, Morassutti, and Favini. The architectural character is thus sought in the reinstatement of the diffused light and of the relationship between structure and envelope. This case, therefore, shows that, sometimes, the maintenance or recovery of the architectural image does not necessarily entail the conservation of the constructional material evidence.

The example of the Grattacielo Pirelli, in Milan, offers a term of comparison: the repair and re-assembly of the frames conserve a substantial part of the original components and construction techniques, while circumscribed additions made it possible to improve their performance. In modern architecture, materials, profiles, joints, thicknesses and methods of assembly may document industrial processes and technical experimentations relevant to the cultural significance of the building. Replacement with newly produced components may keep the configuration recognisable, but it entails the loss of the information contained in the material fabric and in the construction details. The importance attributed to these aspects is reflected in the Madrid–New Delhi Document, which includes construction techniques, materials and structural innovations among the significant elements of twentieth-century heritage (ICOMOS ISC20C, 2017, p. 4).

Intervention Strategies for the Existing Building Envelope

Performance improvement requires decisions to be made about which parts of the building envelope should be addressed by the intervention and how. Limited visibility of the works does not necessarily correspond to limited alteration of the material fabric, while an intervention applied externally may visibly modify the configuration of the façade. The choice also depends on how the building is used during

Figure 2
Detail of the glazing of
the Padiglione
Tavolara in Sassari
during construction
works.



the implementation of construction works: for instance, in inhabited residential complexes, where dwellings cannot be temporarily vacated, work from the interior may be ruled out, directing the project towards solutions that can be implemented from the exterior.

The residential buildings of the Madonna Bianca Neighbourhood in Trento show how the need to keep the dwellings in use may steer the modes of intervention on the building envelope. The external thermal insulation was designed specifically for the complex and employs prefabricated sandwich panels dimensioned and proportioned in relation to the original panels. The solution facilitated work from the exterior and the consolidation of the infill panels without entering the dwellings. The image of the 'tower' remains recognisable thanks to the control of the finishes and the geometries, but at close range the depth of the openings, the profiles and materials change. The structure, the outline, and the rhythm of the façades persist, while various components of the building envelope are replaced or incorporated into the new system. The cladding, designed according to the modularity of the building, contains the alterations that would have resulted from the application of a standardised external insulation system and keeps the original compositional order recognisable.

A different intervention approach emerges in the case of Villa Rossi, where the upgrading makes use of the spaces already available within the envelope and mainly affects the cavities, the under-window recesses and the roof. The use of blown cork, aerogel and phase-change material panels is accompanied by the revision of the roof ventilation, while the Wagner timber window frames are restored and integrated with low-emissivity glass. In this way the external surfaces, the claddings and the brise-soleil remain substantially unchanged and a significant proportion of the original fabric is conserved. The insertion of the new materials into the existing cavities limits the impact on the image of the building, but makes their removal and, in some points, subsequent inspection more difficult. The conservation of the visible surfaces therefore does not necessarily coincide with the reversibility of the intervention.

The Padiglione Tavolara, in Sassari, introduces the theme of the environmental functioning of the envelope. The large 'louvre-type' glazed wall, i.e. *vetrata 'a persiana'* in the Italian language, contributed to the natural ventilation of the hall through the

inclination and opening of the panes, at the same time regulating the entry of light and the relationship with the external pool and the park. In the restoration, the original translucent panes were dismantled, cleaned and re-installed; the iron frame, by contrast, was replaced by a stainless-steel structure, similar in design and prepared for the insertion of a second, internal pane. The removal of the secondary glazing added in the 1980s, which prevented the movement of the openings, also reinstated the natural ventilation, whose use is nonetheless limited to the intermediate seasons. The intervention therefore modifies the construction system and improves its thermal performance, while conserving part of the original material fabric and recovering the functioning of the glazed wall. The case shows how the value of the building envelope may also depend on the relationships that it establishes between the internal conditions and the external environment, as well as on its configuration.

The possibilities offered by internal intervention encounter different limits depending on the existing construction. In the case of Park Hill, the concrete structure meets the façade at the floor slabs and the cross-walls, creating numerous thermal bridges and making it difficult to ensure the continuity of the insulation. The space available within the rooms further limits the thickness that can be applied and requires specific solutions for the various construction junctions. The comparison with the intervention at the Cité du Lignon shows how the choice between internal and external intervention also depends on the configuration of the building and on the conditions of use.

The energy data collected by EeTAC take different forms in relation to the available sources and to the phase in which they were produced. Where homogeneous values from before and after the energy-efficiency intervention were present, these allowed the extent of the improvement to be documented; in the other cases, the design data clarified the performance objectives and the solutions adopted. Reading them together with the transformations of the building envelope makes it possible to relate them to the effects on the fabric, the configuration and the functioning of the building. For the interventions still in progress, only design data were available; in other cases, the available measurements did not allow homogeneous comparisons. For the completed cases, systematic monitoring will be able to verify the correspondence between the expected performance and that actually achieved.

Compatibility and Reversibility

Reversibility, understood as the possibility of returning the building to its previous state without producing losses, is rarely achievable in interventions on the building envelopes of the second half of the twentieth century. The functioning of the envelope depends, in fact, on the interaction between different components and materials, whose updating often entails modifications that cannot be eliminated without affecting, once again, the existing parts. Nevertheless, the case studies analysed do not make the criterion of reversibility any less relevant but rather suggest an application of it commensurate with the actual conditions of the intervention. What then becomes important is the possibility of dismantling or replacing individual components, the accessibility of the interfaces and the documentation of the added parts, so that the solutions adopted can be understood, maintained and, where appropriate, updated over time.

Compatibility concerns the way in which the new parts interact with the existing conserved ones from the constructional, hygrothermal and perceptual points of view. It does not depend solely on the conditions ascertainable at the completion of the energy-efficiency intervention, but also on the subsequent behaviour of the building envelope and on the possibility of intervening without causing further losses, also in the future.

Finally, durability and maintenance are decisive. The programming of interventions developed for the Salk Institute and the Cité du Lignon shows how the knowledge acquired in the preparation of the interventions can continue to guide future maintenance works.

The Madrid–New Delhi Document calls for a cautious management of the modifications. The comparison between the case studies selected by EeTAC shows that the limitation of the loss of attributes conveying cultural significance depends on the possibility of conserving the components that are still recoverable, on the justification of the replacements and on the relationship established between the existing building envelope and any added parts. On this basis, minimum intervention is not measured solely through the extent of the works carried out, but in relation to the effects produced on the elements – that is, the attributes – that express the values of the building and contribute to its cultural significance. A more extensive intervention may be justified when it is necessary in order to conserve such attributes and to guarantee the continued use of the building, provided that less invasive solutions have been evaluated and that the extent of the modifications is proportionate to the requirements identified.

Conclusions

The comparison between the thirty case studies analysed by the EeTAC research project shows how the energy-efficiency intervention approaches depend on the specific characteristics of the building envelope. In the cases examined, the original materials and components are often fragile or already altered, while the architectural character continues to depend on the system of relationships of which they form part. The design of new interventions and, particularly, the design of energy efficiency interventions must therefore establish which transformation is compatible with the pre-existing building, its characterising attributes and the use that it will have to maintain or accommodate.

The question concerns a very large part of the Italian built heritage. As Franco and Musso recall in their contribution in this volume, approximately 30% of the stock predates 1945 (Franco & Musso, 2026); the heritage built after that date represents the prevailing share and includes many residential buildings erected before the energy-conservation regulations of the 1970s and 1980s. Moreover, the Directive (EU) 2024/1275 further entrusts the Member States with the preparation of national renovation plans capable of leading the building stock towards decarbonisation by 2050 (European Union, 2024). The buildings of the second half of the twentieth century will therefore be increasingly affected by energy-efficiency interventions, even when they present architectural characteristics that require specific precautions.

The central issue concerns the relationship between the different attributes of the architectural work. Form, fabric, technique and environmental behaviour may assume different importance and come into conflict during the design of the intervention. The conservation choices are clear and evident when the design states which characteristics it intends to preserve and traces the technical solutions adopted back to these priorities. By contrast, the relationship becomes problematic when the permanence of the architectural image is assumed as sufficient proof of the conservation of the building's cultural significance. The permanence of the components, in turn, must be considered in relation to the durability of the materials and to the possibility of keeping the building in use. Hence, the EeTAC comparative reading allows to recognise these conflicts and to understand the priorities adopted in the various interventions.

While it does not indicate a solution valid for all buildings, the research provides a qualitative interpretation of the transformations that may affect the building envelopes

of the second half of the twentieth century and of the challenges posed by their energy improvement. The *ex post* evaluation constitutes one of the tools developed to organise and relate the objectives of the interventions, the modifications introduced and their effects on the existing parts. Its application enables to understand which attributes and characteristics were deemed significant, even when this choice is not explicitly stated, and to verify the reasons for the replacements and the comparison between the alternatives considered.

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APPENDIX

IMAGE CREDITS

Cover

Marta Casanova

The Building Envelope in the Second Half of the Twentieth Century: Performance and Identity

Figs. 1–2. Marta Casanova

Built Heritage and the Energy Transition: European Policies, Conservation and Compatibility

Fig. 1. Sara Casanova

Modern Heritage as a Resource beyond Energy Retrofit

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The Challenge of Change: Conserving Twentieth-Century Architectural Heritage

Figs. 1–2. Marta Casanova

Restoration Techniques for Conserving Building Envelopes from the Second Half of the Twentieth Century

Fig. 1. Zeynep Inan Ocak

Fig. 2. Marta Casanova

Alessandria Municipal Theatre

Fig. 1. Comune di Alessandria

Figs. 2–7. Marta Casanova

Burgerweeshuis

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Forte Quezzi INA-Casa Neighbourhood – Building A

Figs. 1–2. Archivio Privato Famiglia Daneri

Figs. 3–7. Marta Casanova

Fuel Service Station – Le Fucine

Figs. 2–4, 6–7. Zito Artico Fracassi

Fig. 5. Archest

Glass House

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Kleiburg

Figs. 1–2. Stadsarchief Amsterdam

Figs. 3–4. Stijn Poelstra

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Madonna Bianca Neighbourhood

Figs. 1–2. Archivio ITEA – Provincia autonoma di Trento

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Fig. 4. Marta Casanova

Fig. 5. Campomarzio and Studio Bombasaro

Nostra Signora della Misericordia Church

Figs. 1–2. Università Iuav di Venezia, Archivio Progetti, Giorgio Casali Fonds

Figs. 3–4, 7. Courtesy of Fondazione Aldo Pio Favini e Anna Gatta – Photographs by Marco Introini

Fig. 5. SBG architetti

Fig. 6. Photograph by Max Mandel

ICO Central Workshops

Fig. 1. Associazione Archivio Storico Olivetti

Figs. 2–3, 5–7. Studio Giacomelli Architetti

Fig. 4. Marta Casanova

Padiglione Agnelli

Fig. 1. Archivio Privato Ravelli, courtesy of Pier Luigi Nervi Foundation

Fig. 2. Università degli Studi di Firenze, Biblioteca di Scienze Tecnologiche – Archivi di Architettura, Pier Luigi Nervi Fonds (024-2084) – Photograph by Riccardo Moncalvo

Figs. 3–4. Isolarchitetti – Renderings by Ivan Lombardo

Fig. 5. Isolarchitetti / Rafael Moneo

Fig. 6. Isolarchitetti / Rafael Moneo – Rendering by Riccardo de Vincenzo

Fig. 7. Isolarchitetti – Photograph by Fabio Oggero

Padiglione Nervi

Figs. 1–2. Università degli Studi di Firenze, Biblioteca di Scienze Tecnologiche – Archivi di Architettura, Pier Luigi Nervi Fonds (024-2082, 024-2775)

Figs. 3–4, 6. Masterplan Team – Politecnico di Torino

Figs. 5–7. Marta Casanova

Padiglione Tavolara

Fig. 2. ASCSS – Archivio Storico del Comune di Sassari, Archivio Moderno

Figs. 3–7. Piersimone Simonetti

Park Hill

Fig. 1. RIBA Collections – Photograph by Bill Toomey

Fig. 2. Architectural Press Archive / RIBA Collections – Photograph by Reginald Hugo de Burgh Galwey

Figs. 3–4, 6. Mikhail Riches – Photographs by Tim Crocker

Fig. 5. Mikhail Riches

RAI Headquarters

Fig. 1. MAXXI, Rome. MAXXI Architecture and Contemporary Design Collection, Francesco Berarducci Fonds, F58065

Figs. 2, 4. Marta Casanova

Figs. 3, 5–6. ACPV Architects

Salk Institute

Fig. 1. Library of Congress, Prints & Photographs Division, Balthazar Korab Collection (LC-DIG-ds-11540) – Photograph by Balthazar Korab

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Scharoun Theatre

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Fig. 2. StadtA WOB, S8 – Photograph by Fritz Rust

Figs. 3–7. Brenne Architekten

Teatro Nuovo

Figs. 1–2. Archivio Storico della Città di Torino, Fototeca Fonds (25B03_30, 25B03_40) – Photographs by Aldo Moisis

Figs. 3–6. Isolarchitetti / Rafael Moneo – Renderings by Riccardo de Vincenzo

Fig. 7. Isolarchitetti – Rendering by Ivan Lombardo

Treno della Barca

Figs. 1–2. Archivio fotografico ACER Bologna

Figs. 3–6. Simonetta Acacia

Trifoglio – Politecnico di Milano

Figs. 1–2. Archivio Generale del Politecnico di Milano

Figs. 3–7. Sara Casanova

Velasca Tower

Figs. 1–2. Fondazione BEIC, Paolo Monti Fonds – Photographs by Paolo Monti, CC BY-SA 4.0

Figs. 3–7. Marta Casanova

Via Leopardi Building

Figs. 1–2. Construction: Impresa Gadola, Milan

Figs. 3–6. Marta Casanova

Villa Rossi

Fig. 1. Archivio Privato Famiglia Tarpino

Figs. 2, 5–7. Studio Giacomelli Architetti

Figs. 3–5. Paolo Mazza

Interventions on the Building Envelope of Architecture from the Second Half of the Twentieth Century: Experiences and Reflections from the EeTAC Research Project

Fig. 1. Marta Casanova

Fig. 2. Piersimone Simonetti

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Energy Efficiency and Conservation of Late Twentieth-Century Architecture addresses a crucial issue for recent architectural heritage: how to improve its energy performance without compromising its distinctive characteristics and cultural significance. The volume, resulting from the EeTAC research project developed by the University of Genoa in collaboration with DOCOMOMO International, examines this challenge through interdisciplinary contributions and the critical analysis of thirty case studies. Attention is devoted to the building envelope, an architectural component in which energy-performance requirements and conservation needs directly intersect. The case studies are complemented by interdisciplinary essays that broaden the reflection on the conservation of modern heritage. The volume provides a critical basis for understanding and interpreting implemented interventions and for contributing to the still-open debate on conservation approaches and the ex-post evaluation of energy-efficiency interventions in late twentieth-century architecture.

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