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Introduction

1 In 1947, Le Corbusier wrote a letter to the president of the Parliament Committee of the United Nations Commission in New York to express his concern about the latest evolution of the project[1], after his exclusion from the international team of designers, which included Oscar Niemeyer and Wallace Harrison. The project for the Secretariat building presented fully glazed main façades with curtain walls with an aluminium structure, consisting of two glazing separated by a space of about 30 cm, without any solar protection system[2]. In this letter, Le Corbusier highlights and explains the risks of using this technological solution, also claiming the invention of the double-glazed façade called "neutralizing wall" proposed by him in 1929 for the Ministry of the Light Industry of Moscow project and proposed again - in its general concept - by Harrison in the project for the United Nations Secretariat building:

- For those who will work in the building, conditions will be unbearable in the presence of strong solar radiation, especially in the New York summer, due to excessive thermal gains through the glazed surfaces. Harrison's solution of letting cold air pass between the two façades does not solve the problem, because it does not prevent the greenhouse effect.
- In addition to the problem of comfort, there are those relating to energy consumption for heating and cooling the building. This aspect, perhaps less relevant in the 1950s, will prove to be one of the building's most serious weaknesses over time.

2 In winter, the discomfort problem caused by the low surface temperature of the glass can instead be solved with his "neutralizing wall" and the passage of hot air in the cavity between the two glasses capable of heating the internal surface of the façade and reduce radiative exchanges with offices occupants. The double-glazed façade, however, is a complex solution, which in the end was not even applied in the Ministry of the Light Industry of Moscow and was not realized in the United Nations Secretariat building either, as it was too expensive.

3 In conclusion, Le Corbusier defines Harrison's solution as an announced technical disaster and argues that it is impossible to build a glazed building in New York without sun protection and without a "neutralizing wall".

4 The technological solution adopted for the wide glazed façades of the Secretariat building further emphasizes the problems described by Le Corbusier: for economic reasons the double façade is abandoned, and a simple, very light curtain wall is installed with an aluminium structure anchored directly to the floors. The realised façade, exceptionally light also from a perceptive point of view, strongly characterizes the aesthetics of the building, in contrast with the blind side façades cladding with marble. In this "glass palace", total transparency becomes iconic and metaphorical; it is emblematic of the modern architectural language that will influence many projects - more or less relevant - all over the world.

5 However, since the early years, the limits of the adopted technological solution clearly emerge, mostly thermal discomfort and excessive glare. The subsequent application of reflective films on the internal side of the glass does not seem sufficient to solve thermal problems and alters the image of the building. This is also causing thermal stress to the glass, which, in some cases, led it to break. Over time occur partial replacements with laminated glass of different colours, breakages of some spandrel panels and corrosion of the aluminium structure, caused by infiltrations and condensation phenomena. In 2012, the curtain wall of the 1950s was completely removed and a new double façade was installed, capable of ensuring better performance in terms of comfort, energy savings and safety. The new double façade takes up the original setting and colours and is tied to the building moment-frame structure with outrigger plates[3].

Problems of preservation of modern metal framed glazed façades

6 Le Corbusier's letter of 1947 analyzes in impressively acute way problems which not only have proved well-founded but which today - because of the current energy and environmental orientations related to the global challenge of climatic changes - are crucial in the safeguard and conservation of modern heritage. In many architectures of recognized cultural value metal frame glazed façades, innovative at the time of construction, play a central role in their architectural expression and functionality. Most of them are considered completely unsustainable for the current paradigm of decarbonization and the reduction of energy and environmental impacts of buildings. In addition, they often suffer from lack of performance from an energy and environmental point of view due to the design itself (such as the Secretariat building of the United Nations Headquarters), to possible problems in the execution phase of the

works (the innovative technological systems of modern architecture could not count on assessments over the time as traditional architecture), to decay due to lack of maintenance, to the presence of substances harmful to human health (i.e. asbestos fibres). The need of modern buildings retrofitting, according to the current standards of energy consumption efficiency and, in general, to the current essential issues of environmental responsibility, can in many cases come in conflict with the need to preserve modern architecture as a representation of our culture and our history. The rehabilitation of this architectural heritage is forced to mediate between two instances that are very often contradictory:

- Compliance with national and regional regulations on the energy-environmental performance of buildings that is strictly connected with global challenges and policies (United Nation Climate Change Conference - COP21, Paris 2015; European Green Deal) and for example in Europe by the specific directives for the decarbonization of building stock by 2050 (European Building Directive on Energy Performance EPBD of 2002, updated in 2018).
- The need to preserve the heritage of modern architecture, holder of fundamental cultural values for our society and history.

7 In this situation of contrast, the "inefficient" curtain walls inspired by the iconic concept of the “glass palace” - so significant for the language of modern architecture - occupies the most uncomfortable position.

8 The recent publication “Reglazing Modernism Intervention Strategies for 20th-century Icons”[4] illustrates, through emblematic case studies of interventions in the last 15 years, the different attitudes, and orientations towards rehabilitation of metal-framed glazed façades. It helps designers and persons involved in their protection, by giving them the cultural bases to consciously address the problem of conservation and performance adjustment. For internationally recognized modern works, it is essential to find a compromise between conservation and performance retrofitting. Much more uncertain is the situation of the “minor” works of the widespread modern heritage, that are significant but not subject to specific guidelines for protection.

9 In Italy, for example, the current structure of architectural heritage protection is based on the Code of Cultural Heritage and Heritage Landscape since 2004 and on the action of the Superintendencies dependent on MiC (Ministry for Culture), which authorize interventions for the transformation of buildings subject to restrictions. For many architectures of the twentieth century there is a very important limit for their protection by law: they cannot obtain the "declaration of cultural interest" and therefore be subject to the protection of the Public Works Superintendencies of a living author or whose execution dates back to less than 70 years. This limit to the possibility of imposing a protection constraint does not exist in many countries such as France and Belgium and in Italy constitutes a strong risk to the possibility of preserving the cultural demands expressed by the architectural language and modern technologies of the second half of the 20th century. It is also important to note that in Italy, in this period of crisis in the construction sector, most of the building interventions concern the rehabilitation of existing building stock rather than new constructions, with a considerable boost given by the incentives for energy efficiency measures. Economic incentives (which make it possible to recover up to 60% of the expenditure in 10 years) are granted when the renovation interventions allow to improve the energy performance of the building-plant system, also respecting the thermal insulation requirements of the different building envelope components (walls, roofs, windows,

floors). In this framework of reference, modern architectures not subject to protection often face radical transformations, purely functional to energy saving, considering that it is almost impossible that in their original state they meet the minimum requirements for thermal insulation nowadays set by law.

10 The replacement of modern metal framed glazed façades seems to be inevitable. If it is difficult to define one right approach to the search for a compromise between conservation and performance retrofitting, it is always possible and indeed fundamental to expand the knowledge on the different possibilities of intervention, critically documenting case studies and real experiences.

11 The case studies illustrated below represent different intervention approaches for the rehabilitation of the glazed components of Italian office buildings considered significant for the architecture of the twentieth century and important for the definition of the modern architectural language, even if they do not represent internationally known icons such as the United Nations Secretariat building.

12 The intervention on the façade of the Siptel building in Turin is a real retrofit, aimed at improving energy performance, some original elements are retained, modifying it in a functional way for the purpose.

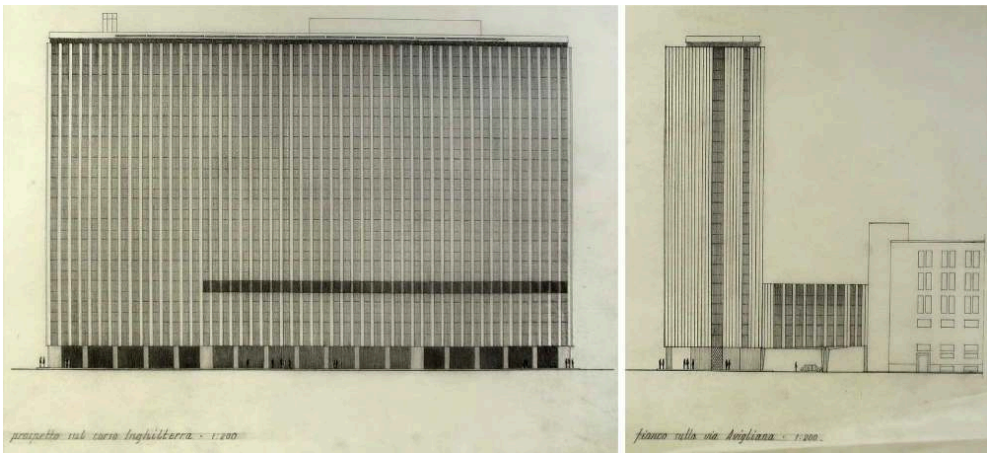
13 The intervention on the former Campari headquarters in Milan instead completely replaced the curtain wall, proposing a new, different façade that somehow tries to reinterpret the original one.

14 Palazzo Galbani in Milan and the RAI skyscraper in Turin have curtain walls in their original state, maintained in the first case during the renovation of the building and in the second case at risk, in the uncertain future transformations.

The façade of the “Horizontal Skyscraper” SIPTEL in Turin

15 Between 1967 and 1970, the SIPTEL (Italian Society for Telephone Operations) office building designed by Ottorino Aloisio (1902-1986) was built in Corso Inghilterra, Turin. The main volume of 15 floors is designed like a "blade" over an entire block (just under 90 m), it has a reinforced concrete structure, visible in the first level, a simple internal organization, and façades with a regular pattern and modularity[5]. The main façade is characterized by a modular composition with vertical pilasters that divide into three parts the free span of the pillars [fig. 1].

Figure 1



SIPTEL office building in Turin (Italy), architect Ottorino Aloisio (1967-1970). Elevations on Corso Inghilterra (left) and Via Avigliana (right), 1966. Drawings kept at the Civici Musei del Comune di Udine, Galleria d'Arte Moderna di Udine - GAMUD, Gallerie del Progetto, Archivio Ottorino Aloisio (Cart. "Palazzo Sip. Studi, 1966").

16 The gray anodized aluminium windows and the parapets are placed on a set-back plan between the pillars, which are cladded in blue clinker. The opaque modules of the façades are made with insulating panels covered with "smoked" glass. The rigorous composition of the façade, simple and monumental, is the result of deep formal research by the architect, who decided to soften the repetition of the vertical pattern with an asymmetrical horizontal "cut" created by a ribbon window. The side façades are also cladded in clinker and have vertical cuts made through the columned windows set back from the façade line. Towards the end of the 1970s, the clinker tiles were replaced with a pigmented plaster due to some detachment and consequent safety problems. Aloisio's façade design changed, but the same balance between the masses and colours was maintained. In 2005, after the transfer of ownership to the Province of Turin (today the Metropolitan City of Turin), a functional rehabilitation and adaptive reuse project was undertaken, according to the current accessibility, safety, and energy efficiency requirements [fig. 2].

Figure 2

SIPTEL office building in Turin, Italy. Comparison between the original building - above (photos taken from M. Pozzetto, *Vita e opere dell'architetto udinese Ottorino Aloisio*, Torino, 1977, p. 193-202) - and after the restoration.

© unknown photographers (top) © Lorenzo Savio and Tanja Marzi (bottom).

17 The project aims to improve the energy performance of the building system with important interventions on the façades: external thermal insulation is applied with a new metal cladding of the pilasters, windows are replaced, insulation and photovoltaic panels are added to the parapets. This first proposal clearly and effectively follows the principles of a good energy retrofit intervention with no consideration for the original architectural composition, of which it deletes the verticality of the pillars, the horizontal cut of the ribbon windows, and the vertical cuts in the side façades. The parapet becomes only functional to support the photovoltaic panel, an excellent opportunity for the building's energy balance, which ignores Aloisio's formal research and the fine contrast between blue clinker, transparent and smoked glass. During the project, the Rosani studio (in charge of the architectural design) elaborated several versions of the façade with different compositions of the blue and white colours of the new metal cladding. The building, despite the death of Aloisio in 1986, has never been placed under protection with a declaration of cultural interest, for this reason, only the Building Commission of Turin Municipality and not the *Soprintendenza*, can take a stand on the project. At first, the Commission asked to better integrate the project, with documents demonstrating the chromatic relationship between the cladding and photovoltaic panels, and suggested moving the photovoltaic to the south side façade. Subsequently, the designer gave up integrating photovoltaics into the façade; then the Commission required a new architectural façade solution aimed more at respecting the original solution, based on verticality, and asked to restore the vertical cut on the south-west side façade.

18 The intervention carried out maintains the structure of the pillars and the plaster of the 1970s. The external wall is cladded from outside with pre-painted aluminum alloy panels. Those new elements have from inside to outside: one sheet of aluminum alloy in contact with the existing wall, extruded polyethylene core, external aluminum alloy separated from the insulation for a few centimeters to allow for ventilation, but without constituting a real ventilated façade[6].

19 The coverings of the parapets and lintels are dismantled to remove the fiber cement panels, and covered like the pillars but using light blue aluminum alloy elements. The predisposition for photovoltaic integration is maintained for the parapet. The new doors (ground floor) and windows are made of 6060 aluminum alloy profiles with thermal break and low-emission insulating double glazing[7].

20 The horizontal asymmetrical "cut" disappears and becomes the upper limit of a glass cladding that highlights the structural elements and further alters the original pattern.

21 Overall, the intervention is effective as an "energy retrofit" but highlights a dangerous attitude, in which the original project (published, recognized by critics, and appreciated precisely for the formal and compositional research of the façades) can be modified without too many problems and functional for other purposes.

The curtain walls of the “La Serenissima” Campari office in Milan

22 In 1964 the construction of the new Campari office building called La Serenissima was completed in Turati street, Milan. The project by the architect brothers Ermenegildo (1918-2013) and Eugenio Soncini (1906-1993), consists of 4 blocks (3 offices and one residential) that close an internal courtyard and it is strongly characterized by the permeability of the ground floor and by the curtain-walls on the via Turati and Cavalieri. The curtain wall on via Turati has a modular layout defined by the visible metal structure: “Parsol” bronze Securit crystal is used in the closures of the ground floor and in the windows that can be opened by rotation on a central axis (with “Thermopane” insulating glass), colored “Emalit” crystal in the parapets [fig. 3]. The façade is tinted, but fully glazed and illuminates the large open spaces of the offices [fig. 4]. The curtain wall on Via Cavalieri has mainly opaque panels but with external glazing that reflects the façade of the «Ca’ Brutta», a residential building with a monumental character completed in 1921 based on a project by the architect Giovanni Muzio (1893-1982) and restored in a philological way in 2016 [fig. 5]. All the curtain-wall systems were produced by A. Bombelli, a company set in Milano Lambrate which collaborated with many important architects of the early and second 20th century in Milan and throughout Italy, producing innovative façade and windows systems[8]. As in the Siptel building, we are faced with a highly emblematic building of modern architectural production, but not protected, for which transformation interventions are allowed.

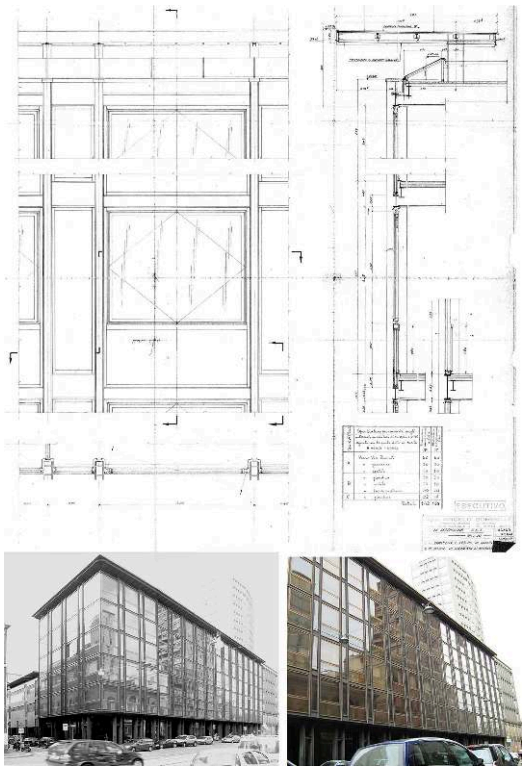
Figure 3

The main façade of the Serenissima on via Turati in Milan (Italy) and the specifications of the glazing system. Excerpt from "La "Serenissima" a Milano", *Trasparenze*, no 3, September 1970.
© unknown photographer.

23 The Serenissima, after its decommissioning and a period of abandonment, was purchased in 2008 by Morgan Stanley who began a refurbishment project that transformed it into rental space, after a competition won by the Milanese firm Park Associati, which had already intervened in the recovery of the Generali building in via Tiziano 32 in Milan (completed in 2008).

24 The refurbishment carried out between 2010 and 2012, maintains the existing volume and structure by modifying the ground floor, the internal layout, the façades, and the internal courtyard[9]. The building obtained the Leed (Leadership in Energy and Environmental Design) Gold certification also thanks to the complete redesign and replacement of the 1960s building envelope (curtain wall of the external and internal façades), which, like many other contemporary examples, is completely inadequate to current energy standards, due to its large glass surfaces and the numerous thermal bridges corresponding to the exposed structural frame[10].

Figure 4



The executable project of the curtain wall of the Serenissima in Milan (Italy) by Angelo Bombelli in 1964. The main façade after the construction of the building (left) and before the last renovation (right), 1960s.

Figure 5

The façade of the Serenissima on via Cavalieri in Milan (Italy) before the intervention reflecting the Ca' Brutta.

25 The new façade on via Turati keeps the structure visible, as well as in the original composition by the Soncini brothers, but replaces the curtain wall with a high thermal and acoustic insulation performance façade in prefabricated aluminium modules [fig. 6]. The modules are installed on the internal edge of the structure, avoiding all the thermal bridges. The useful area lost with the setback of about 35 cm, is partly regained by closing portions of the ground floor, in which new commercial spaces are created[11]. The new modules change the appearance of the façade by introducing opaque portions, functional to the integration of systems and the different internal division of spaces, necessary for the new use as a rental space. The façade towards the Cà Brutta was also completely replaced, but the original composition and the reflection theme of Muzio's masterpiece were fully maintained, using gray back-painted glass panels as finish-work.

26 The redesign of the external façades can be considered a compromise between the conservation of the original layout, modified, but with critical attention to maintaining the main compositional lines, and the functional adaptation to the new use of the building and the needs of energy efficiency[12].

Figure 6

The main facade of the Serenissima (top) and the facade in via Cavalieri (bottom) after the intervention in Milan (Italy), 2012.

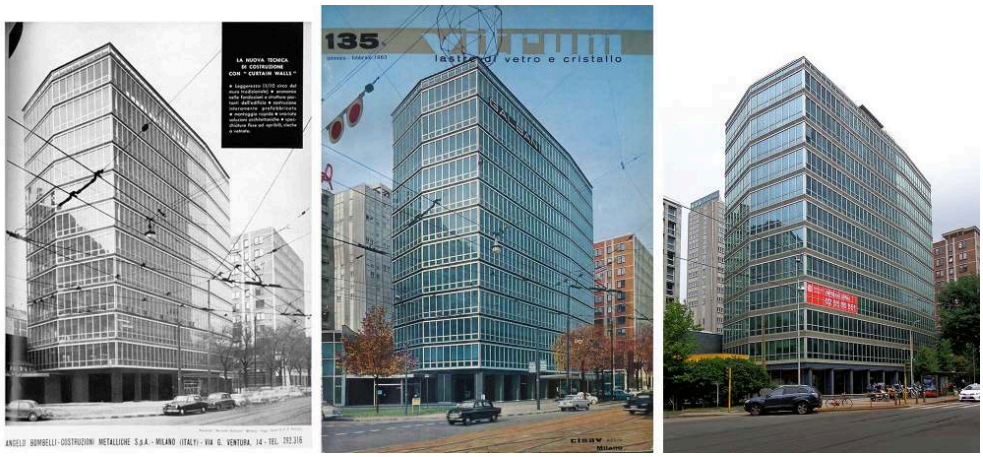
The curtain wall of Palazzo Galbani in Milan

27 Palazzo Galbani complex was built in Milan from 1956 to 1959 on direct assignment as the representative office building of the Galbani Company. This project is the result of the close collaboration between Eugenio and Ermenegildo Soncini with Giuseppe Pestalozza, and Pier Luigi Nervi (1891-1979) for the structural design. It was dimensioned according to the volumetric prescriptions established by the detailed plan of the Milan Business Center, drawn up in the implementation of the General Town Plan of 1953.

28 It consists of a 12-floor office building [fig. 7], an elongated octagonal tower, and two low wings, one to the South (which hosts a bank) and the other to the North (which provides the entrance hall for a restaurant located on the first floor of the main building)[13].

29 The typical standard floor, completely free from pillars (one of the first examples in Italy for office buildings), has free spans over 15 mt wide which allow maximum distribution flexibility, so that the main hall of about 300 m2 (15 x 21 mt) can be divided according to the required needs with movable partition walls developed according to a modular scheme of 92 x 92 cm. Thus, the usable space is more than 70% of the total, as compared to 50-55% usually available in office buildings with traditional structures.

Figure 7

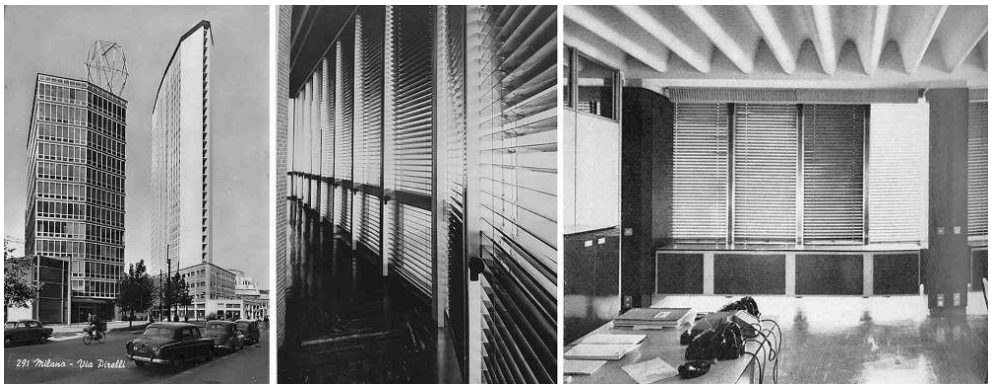


Palazzo Galbani, in Milan (Italy). **LEFT**: Advertisement of the Angelo Bombelli company that realised the curtain wall published in *L'Architettura. Cronache e storia*, n. 75, 1962. **CENTRE**: cover of the issue n. 135 of 1963 of the journal *Vitrum* published by CISAV Italian Information Centre for the Study and application of glass in construction and interior design. **RIGHT**: view of the building in 2020.

30 A prismatic and asymmetrical plan shape, tapering towards the ends of the building; reflects the diagram of the movements of people inside the different floors, which are more intense in the central part, at the arrival of the lifts, and minimum at the ends. The top floor is the president's floor and hosts a wind-screened patio.

31 The structural solution adopted by Nervi - who with his own company, Nervi and Bartoli of Rome, also realizes all the works in reinforced concrete - is that of a skeleton composed of a few pillars on which to support special corrugated prefabricated floor slabs, with undulated beams, working as a self-supporting structure. In this way, the structural dimensions are reduced to a minimum, guaranteeing, on the one hand, the maximum distribution flexibility necessary for office buildings, and on the other hand, the thin folds of the floors - made with prefabricated V-shaped elements [fig. 8], left exposed on the intrados of the floors themselves - make up a scenographic wave visible also from the outside of the building through the glass plates of the building envelope, constituting an important factor in the figurative consistency of the block[14].

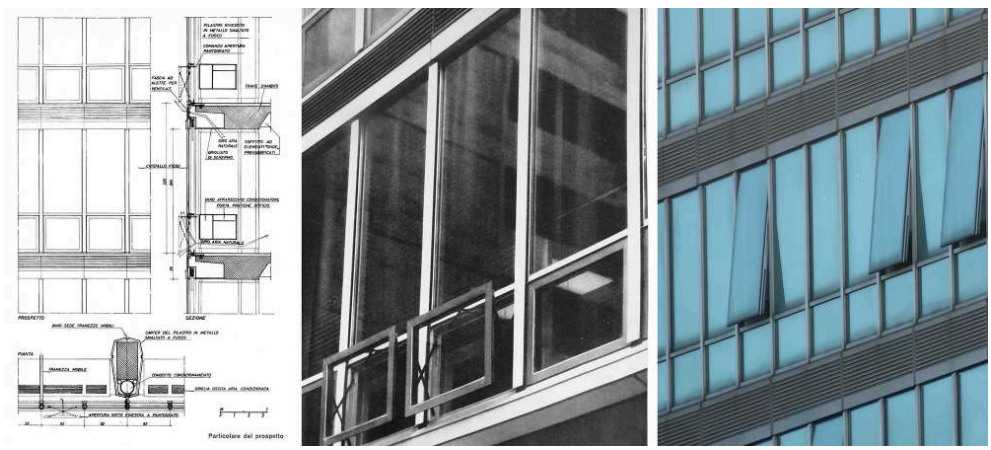
Figure 8



Palazzo Galbani in Milan (Italy). **LEFT**: view with the nearby Grattacielo Pirelli. **CENTER**: "Parsol" glazed wall of the service wing with Venetian blinds solar shadings. **RIGHT**: interior space of an office with a view of the corrugated floor slabs designed by Nervi (source *L'Architettura. Cronache e storia*, n. 75, 1962).

32 The anodized aluminium curtain wall façades were realized by the Bombelli company of Milan. From a technological point of view, one of the most interesting aspects was the natural ventilation (all the interiors were also conditioned), which is obtained with the simultaneous opening of the glass (pantograph mounted) of the lower part of each window and of the small ventilation openings located in the upper part, invisible from the outside because they are shielded by the string course made of aluminium louvers with a radiator-like screen. The choice of this pantograph opening system was dictated by the desire to keep the pure glass volume of the façades intact even when the elements were open, without altering the building's linearity [fig. 9].

Figure 9



Palazzo Galbani in Milan (Italy), architects Eugenio and Ermenegildo Soncini, Giuseppe Pestalozza, Pier Luigi Nervi (1956-1959). **LEFT**: original curtain wall with athermal "Parsol" glass panel and pantograph window opening system that does not alter the linearity of the building. Drawing from *Vitrum*, n. 135, 1963. **CENTRE**: original curtain wall. Photograph from *Vitrum*, n. 135, 1963. **RIGHT**: detail of the new window opening system, July 2021.

33 At the time of the construction, the relatively recent innovations in glass manufacturing were adopted for the curtain wall and a blue-green "Parsol" athermic

glass was chosen: these toughened heat-absorbing plates were produced by Saint-Gobain in the Italian factory of Pisa, consisting in a special body-tinted glass, which was coloured throughout its mass by the addition of metal oxides, that provided a colourful appearance together with the reduction of light, solar and thermal transmission, consequently achieving a more efficient energy balance by the reduction of solar gains.

34 The colour chosen for the anodizing of the aluminium stringcourses, of the pantograph openings frames and of the Venetian blinds (a bluish tone called "gunmetal", in chromatic contrast with that of the "Parsol" crystal) made the Venetian blinds almost invisible from the outside, whether raised or lowered. In this way, the external image of the building was unchangeable, in its play of reflections, avoiding the disorder that would have been generated by the different position of the Venetian blinds, if they had been visible, so as to guarantee the aesthetic invariability of the building envelope surfaces[15]. Finally, an accentuated relief of the silver hue surfaces of the aluminium was obtained, enhancing with the anodizing, the play of shadows of the aluminium profiles constituting the curtain wall.

35 The building, located in via Fabio Filzi, in the Milan business center, right in front of the Pirelli Skyscraper (another extraordinary example of the collaboration between architects - Gio Ponti's studio - and engineers - again Pier Luigi Nervi together with Arturo Danusso), is currently used according to the original functions of the office building and restaurant in the side wing. Over the years, some retrofitting interventions have been carried out which included the disposal of the original natural ventilation system with pantograph opening of the windows, while the largest portions of the windows, originally fixed, were made openable with a top-hung outward opening type [fig. 10]. Despite these changes, the original partition of the curtain wall and the materials have been preserved while maintaining the overall perception of the façade almost unchanged.

Figure 10

Façade of Palazzo Galbani in Milan (Italy) overlooking via Filzi, architects Eugenio and Ermenegildo Soncini, Giuseppe Pestalozza, Pier Luigi Nervi (1956-1959). **LEFT**: elevation from *Vitrum*, no. 135, 1963. **CENTRE**: original curtain wall, photo from *Vitrum*, no. 135, 1963. **RIGHT**: current state of conservation of the curtain wall, July 2021.

RAI headquarters skyscraper in Turin

36 The RAI (Italian Radio and Television) headquarters skyscraper in Turin [fig. 11], was built between 1962 and 1968 as part of a general infrastructure strengthening program

of the national public broadcasting company to host plants, administrative headquarters, central and regional offices.

Figure 11

Comparative views of the RAI headquarters skyscraper from Piazza XVIII Dicembre (Turin, Italy). **LEFT**: construction of the site, just before 1968, photo kept in the archives of the Politecnico di Torino. **CENTRE**: in the 1960s, photo kept at the Politecnico di Torino, "Roberto Gabetti" library archives (Morelli collection). **RIGHT**: in 2020.

37 The project by Aldo Morbelli (1903-1963) and Domenico Morelli (1900-1998), with Domenico Bagliani, Vittorio Defabiani, and Fabrizio De Miranda (1926-2015)for the structures, is innovative in many aspects thanks to the choice of a steel structure, functional to the needs of construction time and cost[16]. The main volume, the "skyscraper", is over 70 mt tall with 18 floors above ground, and overlooks piazza XVIII Dicembre from a backward position, while the integration with the historical urban plan is resolved through the presence on via Cernaia of a volume with dimensions proportionate to the context, respecting the composition of the surrounding buildings but with modern characteristics. The architects decided to create a complex volumetric configuration that clearly denoted the new technical and functional requirements (with the materials and architecture) and at the same time «maintained the architectural lines within the limits of maximum simplicity and traditional compositions, in order to disturb as little as possible the valuable architectures still preserved in the surrounding environment»[17]. The building envelope, divided into modules with a structural skeleton, is mainly characterized by a curtain wall system in aluminium and double glazing [fig. 12]. The grinatal, a special alloy of aluminium and silicon, which takes on a particular purple-gray colour, has also been used to cover the beams towards the façade, and in other internal parts[18].

Figure 12

Advertisement of the Alsco Malugani company that realised the RAI skyscraper curtain wall published in *L'Architettura. Cronache e storia*, no. 158, 1968 (**LEFT**). Original view of the curtain wall (**CENTRE**, Source Politecnico di Torino, "Roberto Gabetti" library archives (Morelli collection, photo Riccardo Moncalvo). Current state of conservation in 2020 (**RIGHT**).

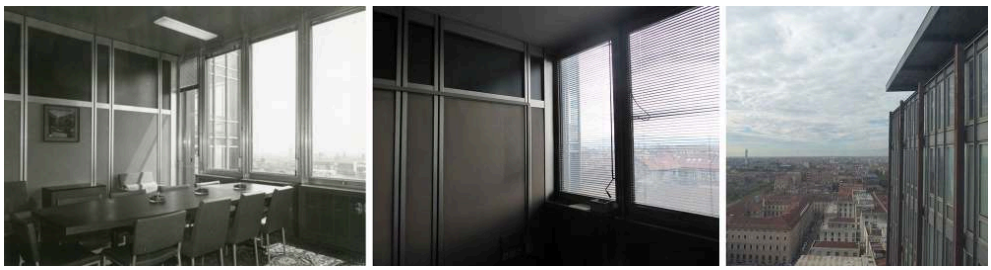
38 The curtain wall was custom designed in collaboration with the Alsco Malugani company, using prefabricated elements within a complex project. After numerous executive versions and tests on prototypes[19], the façade provides a homogeneous architectural language, with the openings in the different parts of the building bringing rhythm and modularity. The use of natural anodized aluminium and glass fulfilled not only the need for linearity and lightness, but also that of low-cost maintenance, enhancing the intrinsic qualities of durability of the materials[20]. The building required complex and delicate systems, which at the time of construction, were among the most modern ones in Italy, like the air conditioning system, while the Venetian blinds and the numerous lamps made it possible to create the best lighting conditions at any time of the day [fig. 13].

39 The RAI headquarters building, still preserved in its original configuration, has been closed and unused since 2014, partially due to the presence of asbestos in some internal components (as well as in the sealants of window-frames). In 2021 the building was sold to a real estate company and in 2022 the asbestos removal operations should start. The future rehabilitation project, which will probably transform the building into a residence and luxury hotel, should inevitably consider the adaptation to new functions and energy-environmental requirements, requiring interventions on the building envelope.

40 Given its role within the Italian architectural heritage, the building has been selected and included in the national census of relevant architectures from the second half of the 20th century by the Italian Ministry of Culture[21] but, since the building is less than 70 years old, it cannot be protected according to the Italian national law. The RAI skyscraper, classified as a "recent building" in the urban plan PRGC[22], can be subject to building renovation[23], an intervention that would entail the need to satisfy numerous minimum performance requirements for the entire building system and the individual components subject to modifications[24]. For example, according to the Ministerial Decree DM 26-06-2015, the portions of the façade subject to renovation should reach, after the intervention, a thermal transmittance U, considered inclusive of thermal bridges, lower than 1.9 W/m^{2}K, from 1 July 2015 and 1.4 W/m^{2}K from 1 January 2021.

41 Energy retrofitting imposes choices on the building envelope for which it is possible to identify different scenarios according to the levels of intervention. Certainly, an intervention that would guarantee safety (in particular regarding the removal of asbestos), and the eventual reuse, but also the preservation of the building envelope, fully respecting the compositional characteristics of the complex, would be desirable.

Figure 13



Original view of the interior space of an office (**LEFT**, Source Politecnico di Torino, "Roberto Gabetti" library archives (Morelli collection, photo Riccardo Moncalvo). State of conservation in 2020, original curtain wall and Venetian blinds as shading system are still preserved (**CENTER** and **RIGHT**).

42 The conservation of the original building envelope, however, would probably prove to be incompatible with the performance levels required by the current energy-saving and efficiency regulations, unless the new requirements are met by a new internal "envelope". In this case, the external alterations could be minimal.

43 Even within the complex, and sometimes unclear legislation on energy retrofitting (which allows preserving the building envelope even without responding effectively to environmental issues), finding such solutions may not, however, be the best option ethically but also economically, given the high maintenance and management costs required to maintain adequate levels of internal comfort. The considerable investment necessary for the rehabilitation and retrofitting would probably lead to explore solutions aimed at limiting intervention costs and management costs.

44 Another possible scenario would be the project of a new building envelope to replace the existing one which could respond to the environmental requirements of the current legislation, and would also be fully compliant with the architectural language of the existing one. While this is not an impossible scenario, it requires in-depth levels of knowledge of the existing building, recognition of the codes and values of the architectural project and building technology, and a careful approach to the respect of the original architecture. Perhaps other intermediate ways between the outlined scenarios could be viable but always with particular attention and in-depth analysis during the phases of knowledge and project and, above all, with the recognition of the value of the building.

45 The intervention of replacement of the envelope, regardless of the existing architecture and its context, almost as a new building, denying the original architectural features of historical and cultural values, is absolutely to be avoided.

Conclusions

46 Le Corbusier's 1947 letter highlights all the functional limits that make energy retrofitting necessary on many of the metal-framed glazed façades of modern architecture. Many significant buildings, but not constrained or so emblematic as to justify their integral conservation only for their value as a cultural testimony, risk deep transformations while they guarantee their existence through continuous use and functional adaptation[25].

47 It is necessary to recognize the impossibility of establishing universal rules for the compatible rehabilitation of these buildings. In current practice, very different design attitudes are recognized, ranging from mere operations of addition-subtraction-modification of building organisms in a functional way, to purposes that do not contemplate conservation, to critical reinterpretations of the original projects which, while modifying the building, leave the building original 'modern' settings visible. Emblematic, for the first case, is the intervention on the *Palazzo a* Vela of Turin by Annibale (1870-1968) and Giorgio Rigotti (1905-2000) with Franco Levi (1914-2009) and Nicolas Esquillan (1902-1989) for the structures, realised (on the model of the reinforced concrete thin shell designed in 1958 by Esquillan for the CNIT building in Paris) for the Expo of 1961 celebrating the 100th anniversary of the Italian Unification, radically transformed and altered for the XX Olympic Winter Games of 2006, with the total elimination of its original doors and windows frames for the use of the reinforced concrete shell as a functional element with a completely new architectural composition [fig. 14].

48 Siptel and Serenissima are another type: the interventions on the façades are expressly aimed at improving the performance of the building envelope, but the results are very different.

Figure 14

Palazzo a Vela in Turin (Italy): original image of the building during the Italia '61 Expo (left, source *Vitrum*, n. 128, 1961); the building after the removal of the window frames (https://www.atlanteditorino.it/PalaVela) and after the re-use intervention for the XX Winter Olympic Games (Gae Aulenti, 2006, photo by Aree Protette Po Torinese, http://www.parcopopiemontese.it/pun-dettaglio.php?id=1076 [link valid in February 2023]). An emblematic example of how architectural icons of a city and of an age are now hopelessly compromised.

49 It is interesting to note that although the intervention on the Campari headquarters is a complete replacement of the building envelope - unlike the one on the Sip headquarters which instead retains some of the original parts - the result remains more consistent with the main compositional lines of the designers, reinterpreting them with greater attention and sensitivity. Although the final result is different and does not give up contemporary virtuosity, such as the irregular positioning of the new

opaque portions on Via Turati, in the new Serenissima the original setting is better recognized than the intervention of the Sip headquarters.

50 From the case studies presented and from the many transformations in progress on the modern heritage not protected by law [fig. 15], it emerges that the adaptation of the façades is probably inevitable, for energy, comfort, and safety issues, but the technical solutions to find a compromise that does not completely distort the original work or in any case make the "modern" approach readable is possible if the designers and all the decision-makers set this cultural issue as an objective, aside from the energy retrofit. Many buildings such as the Rai skyscraper will soon be subject to intervention, with the hope that a culture of rehabilitation and adaptive reuse project will be able of enhancing them and not simply using them, or part of them, for mere functional purposes[26].

Figure 15

Palazzo di Fuoco in Milan (Italy), architects Giulio Minoletti and Giuseppe Chiodi, 1962. Original views of the building with aluminium frame curtain wall with "Thermopane" insulating glass, electrically operated Venetian blinds, and a particular coloured night lighting system (left, source *L'Architettura. Cronache e storia*, n. 96, 1963). Recent replacement of the façade, project render and photo of the construction site in 2021 (right, source GBPA Architects, https://palazzodifuoco.it/ [link valid in February 2023]).

NOTES

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7. They have an 8mm external sheet covered with a magnetocromic layer, a 16 mm air gap of dehumidified air, a 12 mm internal safety sheet consisting of two layers of clear glass joined over the entire surface with a PVB film. At the time of the project, the windows and doors complied with the then current requirements for thermal insulation (Legislative Decree 192/2005) with an overall thermal transmittance of less than 2.8 W/m^2K, however shortly after the regional regulations (Excerpt Plan of the Piedmont Region) and municipal (Energy Annex of the City of Turin) brought the limit value to 2.2 W/m^2K.

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ABSTRACTS

Metal framed glazed façades and curtain walls can be considered one of the most important innovations of modern architecture but are certainly a critical point in the conservation of modern heritage. Next to the most important modern architecture masterpieces, which are under special conservation and safeguard regulations, are a lot of minor and less known architectures that are part of the diffuse modern heritage and risk to be compromised in refurbishment interventions. In most cases, modern metal framed glazed façades systems do not meet the current energy requirements, and it is difficult to preserve them in their original features, finding a compromise between conservation and energy and ecological transition.
This contribution presents a critical overview of the problems relating to the conservation of metal framed glazed façades built in the second half of the twentieth century. Requirements and standards established by energy and environmental international protocols and Italian regulations are critically analysed. Through the description of case studies, different attitudes of intervention are presented and discussed: from conservation to total replacement, with a radical change of modern building envelope original features. The mere verification of the minimum performances required by the current regulations inevitably leads to the substitution of original curtain walls. Therefore - looking beyond but respecting the regulations - architects in charge of refurbishment interventions can find innovative envelope technologies and function distribution solutions to preserve curtain walls, limiting the intervention to the strictly needed.

Bien que les façades vitrées à structure métallique et les murs-rideaux vitrés à structure métallique puissent être considérés comme l'une des plus importantes innovations de l'architecture contemporaine, leur préservation en tant que patrimoine du XXe siècle s'avère parfois problématique. À côté des chefs-d'œuvre architecturaux du XXe siècle les plus importants, protégés par des réglementations spéciales de conservation et de sauvegarde, de nombreuses architectures mineures et moins connues appartiennent au patrimoine contemporain. Elles courent un grand risque d'être altérées par des interventions de rénovation. Dans la plupart des cas, les dispositifs de façades vitrées à structure métallique modernes ne répondent pas aux exigences énergétiques actuelles, et il est difficile de les conserver avec leurs caractéristiques d'origine, ce qui nécessite de trouver un compromis entre la préservation et la transition énergétique et écologique.
Cet article présente le bilan critique des problèmes liés à la préservation des façades vitrées à structure métallique construites dans la deuxième moitié du XXe siècle. Les exigences et les normes établies par les protocoles internationaux en matière d'énergie et d'environnement et les réglementations italiennes sont analysées de façon critique. À travers des études de cas, plusieurs approches en matière d'intervention sont présentées et examinées. Celles-ci vont de la conservation au remplacement intégral, qui entraîne une modification radicale des

caractéristiques d'origine de l'enveloppe du bâtiment contemporain. Vouloir atteindre les performances minimales requises par les réglementations actuelles en matière d'énergie conduit souvent à la substitution des murs-rideaux d'origine. Par conséquent, les architectes chargés des interventions de rénovation, respectant les réglementations tout en cherchant à les dépasser, doivent trouver des technologies d'enveloppe et des solutions innovantes pour la distribution des fonctions afin de conserver les murs-rideaux, limitant l'intervention à ce qui est strictement nécessaire.

INDEX

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Mots-clés: enveloppe du bâtiment, architecture du xxe siècle, mur rideau, rénovation énergétique du bâtiment, rénovation de l'architecture moderne, Italie, Turin, Milan

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