The Modern Movement heritage: proto-bioclimatic solutions and building elements

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THE MODERN MOVEMENT HERITAGE: PROTO-BIOCLIMATIC SOLUTIONS AND BUILDING ELEMENTS

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ABSTRACT

Before the publication of the book *Design with climate: a bioclimatic approach to architectural regionalism* (1963), which established its author, V. Olgyay, as an international figure in the bioclimatic design, several works of the Modern Movement (hereafter MoMo) had already revealed a variety of passive thermal solutions/elements.

Le Corbusier's *brise-soleil* has spread throughout the world the concern of merging *arté* and *teknê* in the design of shading elements increasingly adaptable to control changes in light radiation, since the 1920s. Natural ventilation building solutions are integral parts of the iconic architectures designed by F.L. Wright masterfully revealing some paradigms of climatic sustainability into the material heritage of the MoMo. Forward-thinking Italian architects have started testing an impressive combination of new thermo-insulation autarkic materials (e.g. Eraclit, Populit, Faesite) to design performative climate-responsive building envelopes also suitable for colonial buildings.

By considering the 'anatomy' of the building, our study focuses on the identification, analysis, and categorisation of proto-bioclimatic building solutions conceived by the architects of the MoMo to achieve both the clime adaptability of building elements and adaptation of the International Style to diverse climatic conditions.

Our critical survey goes beyond a single discipline as it is the result of an integrated process of interpretation of the history of architecture, building design and construction history. This process has assumed a reductionist paradigm to highlight those systems seeking to reduce the negative impact of the building through its passive thermal efficiency.

Looking under the lens of thermal sustainability the building solutions of the MoMo legacy, our study aims to foster further progress in improving the resilience to climate change in design practices devoted to both: the conservation of the MoMo architecture and renovation of the 20th-century building stock.

KEYWORDS: Modern movement heritage; proto-bioclimatic; solar shading solutions; sustainable heritage; passive thermal control.

1. INTRODUCTION: WHY THE MODERN MOVEMENT AND THE BIOCLIMATIC ?[2]

It may seem odd to associate the heritage of the Modern Movement (hereafter MoMo) with the bioclimatic, when its most famous strand, the International Style still is synonymous with a lack of concern for the energy performance of buildings. The ideal of the International Style was perceived as the possibility of 'creating every building in every place' regardless of the climatic conditions of the site. This ideal has been applied on a large scale since the second half of the 20th century when it was possible to heat and cool buildings with mechanical systems thanks to the low-cost fossil fuels energy.

Concerning building techniques, the poetics of the MoMo had led to the construction of architectures that had progressively disrupted the traditional building organised on a massive shell that, thanks to its thermal inertia, could behave as a conservative structure of its environmental conditions. The response to the environmental factors of discomfort in new buildings was found mainly through the use of mechanised systems, increasingly energy-intensive based on fossil fuels. However, since the first MoMo, there were trends and studies – even by the best-known authors, including Le Corbusier – which showed interest in climatic and site factors in architectural design.

Among the projects characterised by 'architectural regionalism' – defined in 1958 by Sigfried Giedion as designing with religious respect for the habits of life and climate [1] – there are several works of the protagonists of the MoMo who conceived what in this essay we call proto-bioclimatic solutions. By this term we mean those technological solutions that through passive devices, such as solar shadings, integrated into the structure or applied, contribute to increasing the thermal-hygrometric comfort of the building acting together with the openings of the façades. Le Corbusier was the creator of the "*mur neutralisant*" (based on a double glass with hot or cold air circulating between the two shells) which he applied in the Cité de Refuge (Paris, 1933). However, the wrong orientation of the glassed façade to the Southwest created severe problems of overheating in summer, which the Master solved by adding a *brise-soleil*. This example shows that the correct understanding of bioclimatic principles in architectural design demanded further insights at those time.

The Hungarian twin brothers Olgyay – who emigrated to America after the Second World War – laid the scientific foundations of bioclimatic in their 1957 *Solar Control and Shading Devices* [2], and subsequently in 1963, in the more comprehensive manual *Design with Climate: A Bioclimatic Approach to Architectural Regionalism* [3]. However, in the golden age of the uncontrolled economic growth of the 1960s, the studies of the Olgyays remained little known. Though, at the same time in the 1960s and 1970s, several events changed the knowledge of the environment and human society.

Ludwig von Bertalanffy general systems theory (1956) of and later research works by philosophers and scientists, such as Edgard Morin or Edward Lorenz, have laid the foundations for studying and understanding complex systems that questioned the worldview based on the laws of Newtonian linearity. The space race and the conquest of the Moon and the first vision of the Earth from space favoured the birth of global ecological consciousness. The publication in 1971 of the MIT study, funded by Aurelio Peccei and the Club of Rome *Limits to Growth*, and the 1973 oil crisis showed the physical limits to the exploitation of environmental resources for the first time. These events triggered a decisive interest in controlling energy in buildings and gave relevance to the studies of the Olgyays for the first time. As a demonstration of the fact that at the beginning of the 1960s the time was ripe to start a design experiment consistent with the bioclimatic principles of passive energy, in England Emslie Morgan – an almost unknown architect – built the new secondary provincial school of St. George in Wallasey (1961). As mentioned by R. Banham in *Architecture of the Well-Tempered Environment* (1st ed. 1969) [4], Morgan built a massive structure coupled with a solar wall adaptable to the seasons and completed the system with adjustable windows for natural ventilation. Just like the studies of the Olgyays, it took several years for this project to be appreciated and at least two decades for the application of bioclimatic principles with passive energy to be understood by design culture.

Our research addresses the issue of energy sustainability through the lens of architecture and construction history, focusing on the MoMo heritage and legacy. We propose a classification of external solar shading devices as a result of an integrated process of interpretation of the history of architecture, building design and construction history. The aim is revaluing passive thermal solutions of the MoMo to foster further progress in sustainable-design practices devoted to both: the conservation of the MoMo architecture and renovation of the 20th-century existing building stock facing to the hazards of climate change.

2. DESIGN AND CLIMATE BEFORE "DESIGN WITH CLIMATE" [1]

Bioclimatic architecture reached its first systematic scientific formulation in 1963 with the book by Victor Olgyay *Design with Climate* [3]. This foundational text is the result of a series of scientific studies on climate and architecture that, according to Barber [5], Aladar and Victor Olgyay – who were also modernist architects – have possibly started at the end of 1934 in the United States of America. By the definition of an integrated system of architectural principles based on calculation and application methods, the Olgyays pushed forward the modernist vision of architecture as a science. Though many issues addressed in the book – such as the solar-air orientation, wind and architecture, thermal effects of materials – had previously been explored in a disjointed way within several contexts of the early MoMo in the Old continent.

2.1. Acting with the forces of nature: earth, water, air and sun

Earth, water and air were among the pedagogical concerns of the legendary Bauhaus school as shows, for example, the graphic scheme of P. Klee published in his *Bauhausbücher Pädagogisches Skizzenbuch* (1925, vol. 2, fig. 53). (Figure: 1) The Sun and its radiation appear recurrently in Le Corbusier's published sketches to exemplify his architectural and urban theories and projects [6]. Environmental concerns took part in formulating the Master's thought about the conception of Modern, and they become explicit in the texts of the 1942 book *La Maison de l'Homme* by F. de Pierrefeu and le Corbusier. (Figure: 2) It is also noteworthy that, already in 1934, Le Corbusier built for the Mason de weekend (La Celle-St-Cloud, Paris) one of the first green roof solutions on a reinforced concrete structure. In this work, he also exposed a variety of natural-traditional local materials to minimise the environmental visual impact of the building deliberately. (Figure: 3)

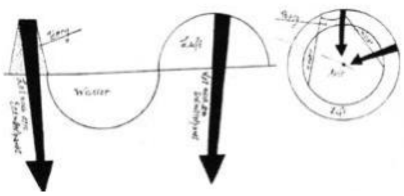

Figure 1: Paul Klee's sketch "*Erde, Wasser und Luft*" (1925)

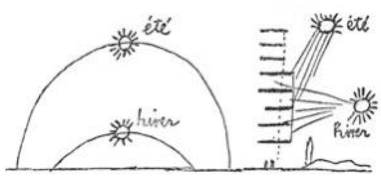

Figure 2: Le Corbusier's sketch. (*La Maison de L'Homme*, 1942)

Figure 3: Le Corbusier, Maison de weekend, 1934. Fond. Le Corbusier.

In the 1920s and 1930s, an astonishing number of new bio-based building materials entered the market, including thermal-acoustic insulation materials made out, for example, of the processing of the wood industry waste – such as Eraclit, Populit, Faesite or Masonite, and Frigorite (from the cork industry). Trade journals, architecture magazines and technical manuals – in Italy those by Griffini (*Dizionario dei nuovi materiali per l'edilizia*, 1934; *Elementi costruttivi nell'edilizia,* 1943) – widely advertised and described the performances and suitable applications of these materials, thus favouring their use in line with the functionalist paradigm of the MoMo. The autarky policies of Italy's fascist government fostered the experimentation of the new thermal-insulation materials that spread in Italian rationalist architecture as well as in projects for the African colonies. As noticed by Ascione [7], these materials are hidden into the building envelope, sometimes multi-layered, offering different performances according to the heliothermic orientation of each building front. The heliothermic orientation of buildings gained ground in many architectural manuals, and calculation methods found applications in the “global Modernities” soon. For example, the use of the solar diagram by Mattioni’s method is well illustrated in the plates published by Diotallevi and Marescotti [12]. Together with the solar orientation of buildings, the concern about solar thermal control is the one that most features the face of the material heritage of the MoMo through the external solar shading solutions and devices designed according to different climatic regions.

3. PASSIVE THERMAL CONTROL: CLASSIFICATION OF EXTERNAL SOLAR SHADING SOLUTIONS[1]

We have identified and analysed a vast repertoire of external solar shading systems and devices, gathered by over 250 works designed by the architects of the MoMo between the 1920s and 1950s, to provide a classification. We based our sorting on the relationship between the building ‘anatomy’ and the shading solutions, and we defined the followings three macro-typologies:

1. **Self-bearing**: with detached structure from the building envelope, thus enabling ventilation too;
2. **Structural**: resulting from external extensions of the horizontal/vertical structural elements of the building, including those of the roofing;
3. **Supported**: variously fixed to the structure or envelope of the building.

These macro-typologies do can also coexist in the same building and often act combined with several solutions for natural ventilation.

For each macro-typology, while taking in consideration the Olgyays brothers’ taxonomy based on the shading masks – horizontal, vertical, “egg crate”, and fixed/mobile – published in their pioneering 1957 book [2], we set a different classification as shown in the graphic scheme below. (Figure: 4)

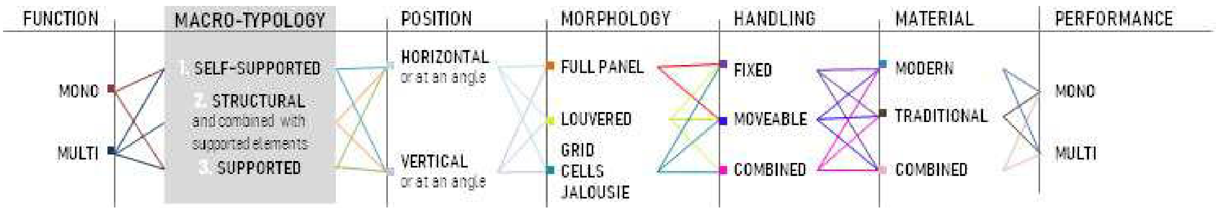

Figure 4: Classification scheme of external solar shading systems (by. C. Franchini).

Primarily motivated to address the issues of healthy living, hygiene and well-being, the international Masters of the MoMo conceived proto-bioclimatic solutions for passive thermal control. They succeeded in offering both the climate adaptability of building elements and the adaptation of the International Style to diverse climatic regions, including the tropical and subtropical zones, by combining *arté* and *teknê*.

In the next two paragraphs, according to our classification, we will initially provide a summary of some examples that show the functional combination of different solutions and their synergy with natural ventilation considering the meeting of various needs and the "paradigms" that have guided the MoMo. To follow, we will present the case study of E.1027 as an epitome of the adaptation of the Riviera traditional louvred shutters (vertical solar shading) to modernism.

3.1. Proto-bioclimatic heritage: from hygienism to humanism

When in the first decades of the 20th century Europe was ravaged by tuberculosis and other diseases, Functionalism and Rationalism embraced the hygienist cause. Sunlight, ventilation, “fresh air”, and exposure to the outdoors became the significant factors of a healthier life in the *existence-minimum* houses as well as in schools and buildings for care.

Driven by hygienism, the team of architects BBPR designed an ingenious **self-bearing vertical solar** shading to shade the glassed Southern façade of the Health Centre of the Summer Day Camp for Children (Legnano, Milan, 1937-38). The Milanese team built a vertical self-bearing wooden structure that is multi-functional, as it serves as porch-solarium, and multi-performance, as it provides for shading and allows ventilation of the double-height interior space of the dining hall behind it. (Figure: 5) This “double façade” for passive thermal control makes it possible the heating in winter and cooling in summer required in the temperate climate zone. The Olgyays presented it in 1957, but it was already identified in 1943 as an excellent solution by Irenio Diotallevi and Franco Marescotti, who published the technical drawings in *Particolari costruttivi di architettura* in *Casabella-Costruzioni* n. 186, pl. XLIX [8]. Ingenious and inexpensive, it still a unique case of its kind and need to be preserved and restored together with the entire building that is in state of decay.

Outstanding examples of **self-bearing horizontal** shadings systems originated from the Argentinean Structuralism by the late 1940s. The paradigm of ‘scientific aesthetic’ drove the researches of Amancio Williams and Horacio Caminos on thin concrete-shells for spectacular umbrellas protecting infrastructural buildings underneath. Even though astonishing projects such as the three Hospitals in Corrientes Province (Williams and Giulio Pizzetti, 1948-52. Figure: 6) or the Community Center of the University City of Tucúman (Caminos, 1953) remained on paper their use as multi-functional and multi-performance shading structures inspired many other modernist architects active in Humid Subtropical climate zones, thus becoming representatives of a climatic-regional MoMo. This “Regionalism” assumes the proper meaning given by V. Olgyay in his 1963 book, while different is the sense within other modernist strands such as those of the Sarasota School in Florida.

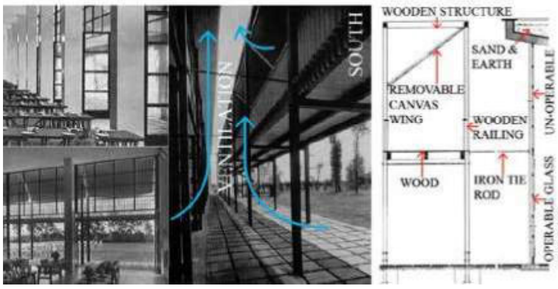

Figure 5: BBPR, Porch-solarium, Health Centre of the Summer Day Camp for Children, Legnano, 1937-38.

Figure 6: A. Williams, Hospital in Corriente Province, 1943-52 (Archive Amancio William).

By the early 1950s, architects of the Sarasota School, such as Paul Rudolph, changed the traditional front porch of Florida’s home into large self-bearing ventilated structures. These structures, acting with several solutions for interior cross-ventilation, provided a passive cooling of the houses making saving energy possible. Hence, by associating the architectural language of the International Style with the traditional dwelling design of the region, they gave rise to a Modern proto-bioclimatic “regionalism” typical of the tropical modernism. The Hiss Residence or “Umbrella House” (Lido Shores, Sarasota, 1953-54) is an epitome of this strand of modernism. (Figure: 7)

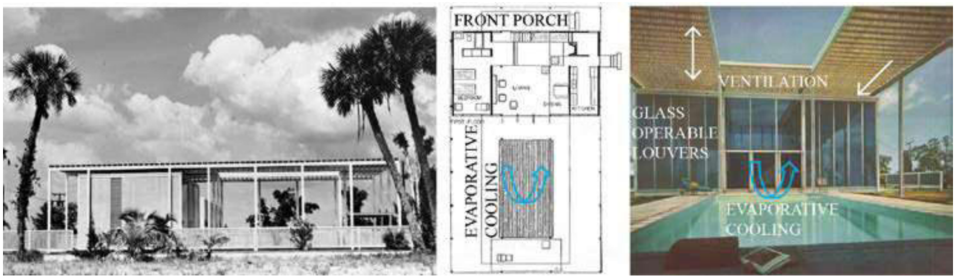

Figure 7: P. Rudolph, Hiss Residence or “Umbrella House”, Lido Shores, 1953-54. (Paul Rudolph Foundation and *House & Home*, p.103 [13])

In the early 1950s, mechanical conditioning systems were spreading in homes in the U.S. In July 1954, the article *Hot-wether houses* in the magazine *House & Home* celebrated the Hixon house for its design solutions of natural ventilation cooling, thus limiting the use of air conditioning.

As regards the second macro-type, the **structural solar shading** notable examples are many and various, including those designed by the Masters.

By the first decade of the 20th century, Frank Lloyd Wright had already started to define an architectural concept for the humid continental Midwest climate based on the "cantilever principle", the second principle of his legendary "organic architecture". In the Prairie Houses at first – whose the Frederick C. Robie Residence (Chicago, 1906) is an archetype – and later in the Usonian houses, the cantilevered roofing acts as horizontal solar shading. In the Affleck Residence (Bloomfield Hills, 1940), Wright demonstrates total control and appreciation of microclimatic effects. For this Usonian House, he designed an original solution for evaporative cooling that acts with the solar shading of the upper porch allowing for up-draft air movement and cross-ventilation. (Figure: 8) Wright turned the Affleck Residence into a prototype for low-cost single-family homes accessible for everybody, thus making American "Dream Home" come thermally sustainable.

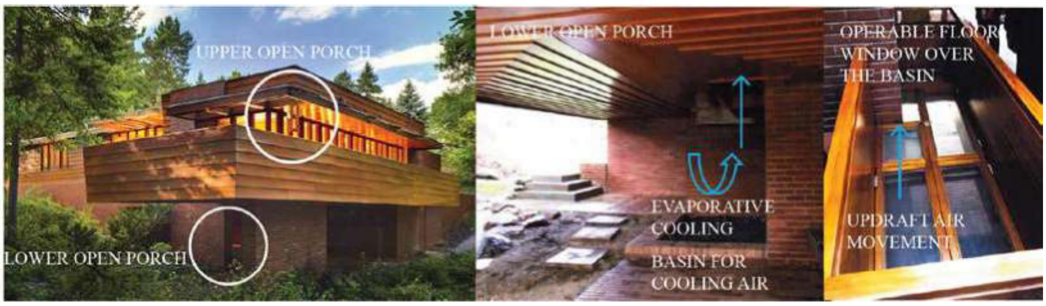

Figure 8: F.L. Wright, Affleck Residence, Bloomfield Hills, 1940.

Wright's cantilever principle inspired others leading modern American architects, including Richard J. Neutra, whose cantilevered reinforced concrete flat roofs shading the glazed walls underneath mark his humanist poetic. In his Californian works, the structural solar shading defines patios, verandas and arcades playing a multi-functional role. It is in extreme climatic conditions, with the famous Kaufmann Desert House (1946, Palm Spring) that Neutra fully reached the expressive and bioclimatic performance potentials of the solar shading, alternating and associating roof overhangs with innovative mobile vertical aluminium sun louvers [9].

In the book *Architecture of Social Concern for Regions of Mild Climate* (1948, São Paulo, Brazil: Gerth Todtmann), Neutra suggests using passive climate design to improve social conditions with minimal financial and infrastructural expenditure. The book is the result of the prototypes and methods developed for the construction of schools and hospitals in Puerto Rico (1943) mainly based on induced ventilation, to better adapt to the regional climate.

The most popular structural solar shading is the *brise-soleil* developed by Le Corbusier to export his lesson in hot climates, from the French colonies in Africa to India passing from Argentina. In the first project for Villa Baizeau a Carthage (Tunisia, 1928. Figure: 9) and, twentieth years later, for Villa Shodhan at Ahmedabad (India, 1951), the Swiss-French master used the *Dom-ino* structure as solar shading. And for his projects in Algiers such as Maison locative Ponsik (1933. Figure: 10) and the skyscraper Cité des Affaires (1938) he designed his famous grid of rectangular cells *brise-soleil*, that later appeared in many works including, in Argentina the Maison Curutchet (project 1948-49) built at La Plata by A. Williams (1949-55. Figure: 11), in the Indian Palais des Filateurs (Ahmedabad, 1951) and the Haute Cour of Chandigarh, 1952 (Figure: 12). In the latter, Le Corbusier combined the *brise-soleil* of the façade with the colossal concrete shell of the covering that acts as self-bearing solar-shading and the water mirror in front of this masterpiece acts as a gigantic evaporative cooling basin.

Figure: 9 Figure: 10 Figure: 11 Figure: 12

Le Corbusier (Le Corbusier Foundation)

Supported solar shading offers an impressive variety of solutions from the fixed balustrade/railing-sun shadings, that spread globally in the modern terraces, to the operable louvres covering entire façades of Oscar Niemeyer's architectural legacy. The concept of adaptability pervades the Modern kinetic façades since Oscar Niemeyer's first significant project; the Day nursery Obra do Berço (Rio de Janeiro, 1937-40. Figure: 13). Through the combination of adjustable oversized louvres, smaller-scaled louvres, and voids, the Brazilian master offered a low-cost thermal comfort and richly layered external solutions for highly functional and dynamic façades. He oriented and shaped the louvres always according to the sun orientation of each façade and the ventilation flows. In several works such as the Ministry of Education and Health in (Rio de Janeiro, 1937-40. Figure: 14) – designed with Lucio Costa and Le Corbusier – or in the Boavista Bank (Rio de Janeiro, 1937-46. Figure: 15), the Brazilian Master painted the adjustable louvres in different hues of white and blue so as to reflect or absorb light and thermal radiation. He also took into account the need for privacy to place and design the louvres as it is evident in the case of the Boavista Bank. He used for the same building the *combogós* – like other protagonists of the Brazilian MoMo did [10] – in combination with adjustable louvres façades as occurred the Building for the Emprezas Gráficas o Cruzeiro (Rio de Janeiro, 1949. Figure: 17). Concerning the possibilities offered by the solar shading devices, in 1939 Niemeyer published an article in the *Revista Municipal de Engenharia* [11] where he wrote:

O sistema proposto nos garante ainda as seguintes possibilidades:
a) - o desvio será feito conforme a época do ano, para um lado ou para outro o que permitirá sempre mínimo de inclinação.
b) - durante as horas não insoladas (6 horas da manhã às 2 da tarde) ou nos dias sombrios teremos a vista inteiramente livre, bastando para isto conservar as placas normais à fachada;
c) - nos dias frios ou chuvosos poderemos evitar as rajadas de SO com uma pequena retificação;
d) - a luz interior poderá ser graduada a vontade em função do dia e das exigências do trabalho.

Figure: 13 Figure: 14 Figure: 16 Figure: 17

Oscar Niemeyer, Rio do Janeiro (Oscar Niemeyer Foundation)

The designers of the MoMo were able to upgrade of traditional local shutters or ventilated screens to create Modern and more performing solutions for supported solar shading devices in the humid subtropical as well as in warm temperate climates. In several cases, these solutions originated from a humanist approach to modernism, as epitomised by the E.1027.

3.2. Traditional elements for Modern solutions: the sensitive prosthetic approach of the E.1027

Already in the 1920s a pioneering masterful interpretation of the traditional louvred shutters of the Italian-French Riviera was designed for the E.1027 *Maison en bord de mer* (Roquebrune-Cap-Martin, 1926-29). A masterpiece of the MoMo, the E.1027 is the first architectural work by Eileen Gray: an exceptional designer, eclipsed by history for decades, and later internationally recognised as a pioneer of "non-heroic" modernism [12]. (Figure: 18). She chose a parcel of land on the Cap-Martin that had no car access to building a vacation home with minimal luxuries, but maximal comfort. The relationship of the building to its site anthologises the principles of Modern architecture. Its rotation in the direction of the terraces of the ground allows for a more favourable solar orientation, meanwhile preserving the terraced skyline typical of this coastal landscape. Taking advantages from the slope of the hill, the most significant space – the open-space living room – is raised on *pilotis* to create both a covered area for the outdoor kitchen and the ventilation below the floor.

In collaboration with the young client and co-designer, architect Jean Badovici, Gray designed the "*fenêtre-paravent*" (screen-window). This shading and ventilation device alternates fixed louvres shutters with a horizontally pivoting part operable to the outside and simple fixed louvres shutters, both sliding on multiple rails, moved away from the building envelope by a frame, closed or open on the sides as needed. This dynamic shading device, which was patented, is both original in shape and performing as, like the window, it can be operable in several different ways to better adapt to the climatic conditions. As stated by the architects, they considered the problem of shutters as crucial and often neglected. In the special issue devoted to the E-1027 of the avant-garde magazine *L'Architecture Vivante* (1929), directed by Badovici, they wrote: "A window without shutters is an eye without bows. Moreover, all the combinations commonly in use obtain the same result: insufficient aeration when the shutters are closed. Our solution is large and open to the outdoor air while blocking excess of light" [13].

The design of each shielding element is integrated with that of the opening system of its window (three different types) and takes into account the orientation and the handling combination of both. For example, the north-northeast oriented living room window has a thin metal hinged window frame completely foldable as a room divider, so that the view of the landscape can be left completely clear and the flow of light and air can be controlled at will. The shutters frame protrude from the edge of the façade not only to accommodate the folded window protecting it but also to offer the maximal ventilation. The "screen-windows" belong to the same design research of Gray's furnishing like the "*coiffeuse-paravent*" (vanity table-screen), "*bar-dégagement*" (bar-alcove). They result from the same design process that has driven Gray's legendary pieces of furniture of the house that are ingeniously shiftable, slidable, foldable, adaptable, transformable. Gray pursued the conviction that "An object must be given the form best suited to the spontaneous gesture or the instinctive reflex that accompanies its use" [13].

To shield the main terrace (south) from the sun, horizontal and vertical white canvases – as easily removable as a bimini-top – give to the façade a nautical appearance. The system is multi-functional as the terrace of the large room can extend outside when the glazed is folded back against the pillars. And it is also multi-performance: "A removable canvas serves as the balustrade; in the winter months it may be removed to warm the legs in the heat of the sun. The canvas awning is made in four independent pieces and can resist even the Mistral wind" [13].

The upgrade of the shutters of the Riviera is not a solitary element of the local tradition. As the preliminary study for restoration works revealed [13], the original plastering was made out of lime mortar and the finishing coats tinted with lime wash, whether chosen by the architects or imposed by the local contractors, this finishing materials offered a practical solution for both thermal insulation and protection to humidity. In *L'Architecture Vivante*, the accurate caption of the technical detail of the terrace-roof demonstrates, once more, the concern of achieving effective insulation, waterproof and weather resistant. The published dual "scheme of circulation and sunlight" shows independent paths through living spaces based on the rhythm of the sun. Natural ventilation, particularly cross-ventilation, and solar control feature the entire building design and leads its spatial, morphological and aesthetic characteristics. Giedion in his article "*L'architecture contemporaine dans les pays méridionaux: Midi de la France, Tunise, Amerique du Sud*" (*Cahier d'Art*, 1931) infers that E. Gray established a new response tailored to the Mediterranean climate.

Figure 18: Eileen Gray, Jean Badovici, E.1027, Roquebrune-Cap-Martin, 1926-29.

In this seaside house on Cap Martin, both the principles of Le Corbusier and those of the De Stijl coexist in a personal humanist view of the Modern. While remaining functional, this masterpiece of Modern architecture transcends the "*machine à habiter*" formula to embody a sort of "prosthetic" view of the dwelling space: an "organic unity" that can change as both an adaptive reaction to external conditions and intimate emotions of an individual human being. Gray states "Formulas are worth nothing; life is everything. And life is the mind and the heart simultaneously. […] One must build for human beings, so that man may rediscover in architectural construction the joy of feeling himself, of being in a whole that extends and completes him" [13].

4. CONCLUSIONS[2]

From our research, it seems clear that the interest in climatic and environmental factors has characterised studies and projects of significant strands of the MoMo since its inception. The reasons come only in part from the reforming hygienism of which the architecture of the MoMo was the 'spokesman' - as it is in common opinion - and they are ascribable to several others causes explained in this essay through some selected cases among the many we classified in our repertoire.

The need for well-lit, ventilated, and healthy interiors led the designers to consider natural factors such as solar radiation, wind and humidity carefully in the joint conceptual and technical design process. Notably, in the architectural production closest to the local building practices, some technological and formal solutions were adopted to improve the comfort, such as solar shading systems, anticipating what now we call bioclimatic design. On the other hand, it is clear that the conceptual principles at the base of the new architecture, which involved the rejection of the massive shell, the emptying and transparency of the structure of the building, caused problems of a thermal, lighting and acoustic nature that had to be solved. From these needs, today called performances, originated the search for technological solutions formally consistent to be applied to buildings, despite the lack of awareness of the need to reduce the energy consumption of buildings, which would arise only after the 1970s.

It is unfortunate that in the same years in which the Olgyays laid the foundations for bioclimatic architecture, thermal and environmental control in the building started to be entrusted to energy-intensive systems based on the consumption of fossil fuel, then spreading globally. The availability of low-cost energy, the diffusion of plant systems suitable for any building and residential context, together with the affirmation of cost-effective industrialised construction systems based on reinforced concrete, have probably obscured the alternatives and experiments started decades earlier within the

Modern Movement itself. If these alternatives had gained ground, they would have led to more sustainable building and urban models. Today the building sector is still responsible for about a third of climate-changing emissions and global energy consumption. As part of the challenge for energy sustainability, the need to know and investigate the solutions and elements adopted in the built heritage of the recent past seems more relevant than ever. It is essential not only for the proper maintenance and restoration of the MoMo heritage but also for the possible replication of the best performing solutions to huge 20th-century building stock of our cities.

NOTE

Sections 1 and 4 by C. Mele (scientific research responsible); sections 2 and 3 by C. Franchini.

5. BIBLIOGRAPHY

[1] Giedion S. *Architecture, You, and Me. The Diary of a Development.* Cambridge, Massachusetts: Harvard University Press; 1958: 221 p.

[2] Olgyay A, Olgyay V. *Solar Control and Shading Devices*. Princeton, New Jersey: Princeton University Press; 1957: 201 p.

[3] Olgyay V. *Design with climate. Bioclimatic approach to architectural regionalism. Some chapters based on cooperative research with Aladar Olgyay*. Princeton, New Jersey: Princeton University Press; 1963: 190 p.

[4] Banham R. *The Architecture of the Well-Tempered Environment*. London, UK: Architectural Press; 1969: 295 p.

[5] Barber DA. Lessons from *Lessons from Modernism*. In: Bone K, ed. *Lessons from Modernism. Environmental Design Strategies in Architecture 1925–1970.* New York, NY: The Monacelli Press; 2014: pp. 188-195.

[6] Siret D. *Le Corbusier Plans. 1940 - Studies in Sunlight (no place)*. English version. Fondation Le Corbusier. Le Corbusier Plans, DVD N°7, Fondation Le Corbusier, Echelle-1 Codex Images International: 2006. ffhttp://e1-intl.comff. ffhalshs-01249648f (accessed: August 2019)

[7] Ascione P. [Isolanti] *Autori e opere*. In: Cupelloni L, ed., *Materiali del Moderno.* Roma, Italy: Gangemi; 2017: cap. 4, pl. 2-16.

[8] Casciato M, ed. *Diotallevi e Marescotti: Il Problema sociale costruttivo ed economico dell'abitazione*. *Con Particolari costruttivi di architettura*. Roma, Italy: Officina Edizioni; 1984: 95 p. 196 pl.

[9] Fordham C. Richard Neutra and the history of the vertical louvered solar control system. In: Le Brun N, ed., *Construction History: Proceedings of the 6th International Congress on Construction History - 6ICCH*, Brussels, Belgium; Boca Raton: CRC Press; 2018: vol. 1, n.p.

[10] Galvão AB, West Pedrão A. Hiding the sun. The brise-soleil in Brazil. *Do.co.mo.mo. Journal*. 1995; (13): pp. 54-56.

[11] Niemeyer O. A proteção da fachada oeste por "brise soleil". *Revista Municipal de Engenharia*. Rio de Janeiro. 1939; 6 (3): pp. 282-283.

[12] Constant C. E1027: the non-heroic modernism of Eileen Gray. *Journal of the Society of Architectural Historians*. 1994; 53(3): pp. 265-279.

[13] Gray E, Badovici J. E.1027 Maison en bord de mer. *L'Architecture Vivante*. 1929 [special issue]; winter (1st ed). New edition Rougny F, Bonillo J-L, eds. *Eileen Gray, Jean Badovici. E.1027 Maison en Bord de Mer. L'Architecture Vivante*. Marseille, France: Imbernon; 2018 (3rd. ed. with tr.): 135 p.; tr. pp. 100-110.

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