Transparency in Architecture: A Literature Review

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Abstract

Transparency in architecture demonstrates a long relationship between glass and architecture. Most cities today leave us a uniform impression caused by the predominance of an almost ubiquitous use of transparency on the facades of the buildings. This paper presents an overview of the different uses of transparency concept by architects in building across different architectural periods, from its first concrete realization such as the Gothic Basilica of Saint-Denis to the architecture of the second half of the 20th century. The transparency viewed in this paper as a strongly seductive and persuasive attribute to different architects' generations. This study reveals that the natural light and exterior views are among the concepts that led architects to use transparency. It was also found that Transparency in modern architecture is associated with the search of glass transparency, to perceive several spatial positions at the same time. Transparency is also related with use of initial curtain walls on skeleton buildings and new conception of space, spatial depth and creation of continuous space by tools of architecture. At the end of 20-tieth century the term transparency is connected with high performance glazed structures.

Keywords: *Transparency, architecture, glass facades, natural lighting, view outside, curtain wall.*

1. Introduction

With the aid of a touch of light, transparency enables the vision of what lies ahead of what is behind, the exterior of what is within. Architecture has attached great significance to the notions of transparency, which have been employed in various senses. The polysemy of the term indeed refers to significant identifications; transparency resides between matter and society, public and private, architecture and democracy... Without total transparency in the relationships that bind us to one another or to things, there could be no social, economic, or even political life today.In the domain that concerns us, namely architecture, transparency is now associated with a specific material and its technical and performative evolution.

The concern for transparency emerged in the late 19th century. Jules Henrivaux, a chemical engineer and inventor of "wire mesh glass," published an article titled "A Glass House" in the *Revue des deux mondes* [1]. In this article, he described how glass and iron would be the sole materials of future houses: *" The walls, we propose, shall be constructed with an iron framework at the corners, onto which glass panels will be vertically placed, forming a double layer on the interior. Within this space, during the winter, warm air shall circulate, while during the summer, compressed air will flow, and upon expansion, it will cool the walls. The roofs shall consist of meshed glass, and naturally, the interior walls, staircases, and more shall be made of glass. [...] Everywhere, the facilitation of air, light, easy cleaning, and the visibility of wall impurities: these are the conditions that the use of glass allows us to realize, distinctly establishing the role that this remarkable material can and must play in our modern world*". [1]

Architects, spanning various epochs in the history of architecture, have gradually laboured to abstract and dematerialize the very essence of architecture. This evolution has led, as exemplified by figures like Philip Johnson and many others, to the creation of entirely transparent residences [2].

In a similar vein, Walter Benjamin designates architectural transparency as a symbol of a new world:

"*The primal form of every dwelling is not a house but an enclosure of life. This enclosure bears the imprint of its occupant. In the most extreme case, the apartment becomes an enclosure. The 19th century sought habitation more than any other did. It viewed the apartment as a case for humanity [...]. The 20th century, with its penchant for porosity, transparency, abundant light, and open air, has brought an end to the old way of dwelling."*[3].

These novel ideas are intertwined with the potential for greater visibility of the external environment. Thus, the window has evolved from the traditional vertical window to the horizontal window and eventually transformed into the building envelope itself (*Figure 1*) [4]. Transparency allowed the design of a light and open appearance for the building whilst providing a view out for the user [5, 6]. On another hand, it creates an illusory beauty due to natural light additionally to lightweightness and openness to outside [7].

Figure 1. View from the Living Room of the Johnson House

For contemporary architects, the question no longer revolves around the necessity or relevance of transparency; their predecessors have thoroughly examined and established its enduring nature. Instead, their focus lies in exploring the myriad ways to implement transparency [8].

2. Emergence of the transparency concept

Throughout history and until the end of the 18th century, humans have consistently been intertwined with nature when constructing their shelters [9]. Architectural designs have relied on the materials provided by the natural environment, resulting in structures primarily composed of wood, stone, or earth. Natural light has always held a significant role throughout the evolution of architecture [10]. The relationship between the interior and exterior of a construction was constrained by solid walls with small openings. These openings represented vulnerabilities to wind, weather, and external hazards. The pre-industrial human had distinct requirements, obligations, and needs compared to today's society. They spent a significant portion of their time outdoors, and natural light was crucial for work, much of which took place outside. Domestic activities indoors were straightforward and did not demand abundant lighting [11].

Its abbot Suger (1081-1151), that the first concrete realization of a transparent space takes place in ceremonial and religious buildings, such as the Gothic Basilica of Saint-Denis *(Figure 2),* erects it. The large glass window becomes a filter between God and men [12].

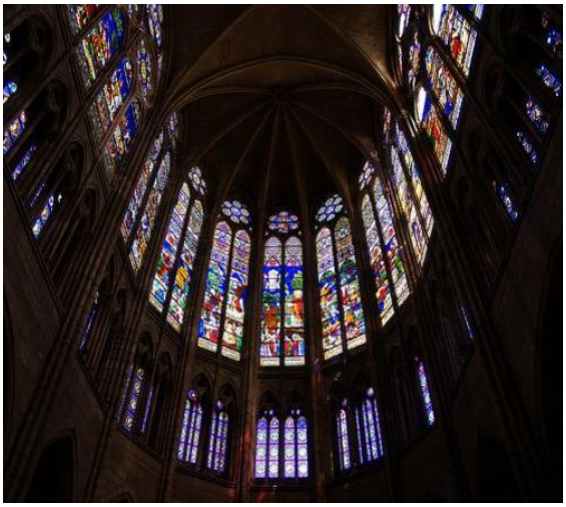

Figure 2. The Gothic Basilica of Saint-Denis ,erected by its abbot Suger (1081-1151)

3. Transparency in History: A Contribution to the Relationship between Interior and Exterior

3.1. The industrial revolution and new techniques and materials

Starting from the Renaissance, the window presents *(Figure 3)*, on one hand, its utility as a means of lighting, ventilation, insulation, etc. On the other hand, it is conceived as a thing through which one can look. The window is an architectural arrangement that serves as a useful and hygienic device, connected to the needs of the body. It is also an "optical" apparatus, a kind of magnifying glass, or like glasses, which provides an opening to the world.

Figure 3. Window of a palace in Florence.

The 19th century, marked by the industrial revolution, introduced new construction methods through the emergence of novel materials such as iron, glass, and steel [13]. Advancements in glass manufacturing techniques made significant strides. The fusion of iron and glass directed designers toward innovative solutions in public buildings such as greenhouses, markets, arcades, department stores, galleries, and railway stations.

In a pioneering move in 1829, architect Pierre François Léonard Fontaine conceived the idea of combining glass and cast iron to construct a barrel-vaulted roof covering the Galerie d'Orléans of the Palais Royal [14] (*Figure 4)*. This roofing defied rain while allowing light to filter through, imparting a sense of freedom and space. Taking it further in 1832-33, Rohaut de Fleury constructed greenhouses for the Jardin du Roi (Garden of Plants) in Paris, genuine glasshouses comprised of an iron framework and glass panels.

Figure 4. The Orleans Gallery of the Palais Royal, 1833, Architect: Fontaine

The use of glass in significant ironwork became universal. This is evident in cases such as: i) The Palm House in Belfast, Northern Ireland (Figure 5a), built in 1839 by Richard Turner, ii) The Grand Greenhouse in Lyon, constructed between 1877 and 1882 by the architect Vedrine (Figure 5b) and iii) the historic greenhouse in Frankfurt (Figure 5c), built in 1871 by the architect Heinrich Siesmayer [15].

Figure 5. a: The Belfast Palm House (Northern Ireland); b: The Historic Greenhouse of Frankfurt; c: The Grand Greenhouse of Lyon.

However, the first iconic building that combined the virtues of glass and iron structure was the Crystal Palace designed by Joseph Paxton, built in London in 1851 for the Universal Exhibition [16] (Figure 6). With its length of 563m and width of 124m, and its glass covering spanning over 84,000 m², it exudes an airy elegance, lightness, and transparency. The Crystal Palace is closely associated with the concept of a greenhouse, providing a vast, open space that blurs the boundaries between interior and exterior. As the first industrial prefabricated building in history, the Crystal Palace becomes the archetype of its era. Lothar Bucher, who attended the inauguration of the Crystal Palace, summarized the sensation experienced by visitors, emphasizing the impression of unreality and infinite space where everything becomes ethereal [17].

Figure 5. The Crystal Palace, Joseph Paxton, London, 1851.

Discussing transparent buildings in Paris, Walter Benjamin observes, *"Glass architecture acts as a social equalizer within itself, where the rules are equal for all. Glass will now have less the purpose of allowing external light to penetrate, and more the aim of attenuating its individuating effect and creating a space of pure equality"* [3].

Indeed, galleries and passages experienced a golden age in the 19th century, particularly in Paris, France. The most famous among them are the Vivienne Gallery, built in Paris in 1832, and the Pommeraye Passage in Nantes in 1843. In Italy, the most renowned gallery is the Galleria Vittorio Emanuele II in Milan [18].

These passages are also places of consumption (shops, cafes, and restaurants), meeting points, and shelters for people from bad weather. These spaces are covered by a glass roof that provides areas bathed in light through zenithal lighting, giving them a distinctive illumination. The glass roof is the visually most significant element of the gallery; it encloses the space, providing physical and moral security to the walker.

Walter Benjamin describes them as follows: "*These passages, a recent invention of industrial luxury, are corridors with glass ceilings and marble entablatures, running through entire blocks of buildings whose owners have come together for this kind of speculation. On both sides of the passage, which receives its light from above, line up the most elegant shops, so that such a passage is a city, a miniature world where the shopper can find everything they need. When sudden showers break out, these passages become the refuge of all the surprised strollers, offering them a secure, albeit limited, promenade, from which the shopkeepers also profit*" [3].

3.2. The Chicago School (approximately between 1885 and 1905)

In October 1871, a violent fire destroyed almost the entire city of Chicago. It was only after this fire that the city expanded and was rebuilt in the area known as the Loop. A business centre, consisting of offices, department stores, hotels, and facilities, was established. This reconstruction provided architects with an opportunity to experiment with new construction systems that needed to be implemented. The protagonists of this city's reconstruction came to be known as the Chicago School. Among these prominent figures was William Le Baron Jenney, who influenced architects like Daniel Burnham, Root, William Holabird, Martin Roche, and Luis Sullivan [19]. These architects bestowed upon the city of Chicago an architecture of coherent simplicity, conceived in accordance with functional requirements and materials. The development of Chicago would be marked by two major

factors: the distinctive layout of the Loop, Chicago's commercial center, and the evolution of the steel-framed skyscraper.

This steel skeleton structure *(Figure 6)*, developed by William Le Baron Jenney achieves a triple purpose: i) reducing the self-weight of the building, ii) minimizing the spatial impact of structural elements, and iii) generously opening up the building's facades. Additionally, there is the foundation system proposed by F. Baumann, which allows for supporting concentrated loads. Furthermore, the invention of the elevator by Elisha Grave Otis, who first installed it in the E.V. Haughwout Building in 1857, provided the true impetus for tall constructions. The challenge of access to upper floors had thus been resolved.

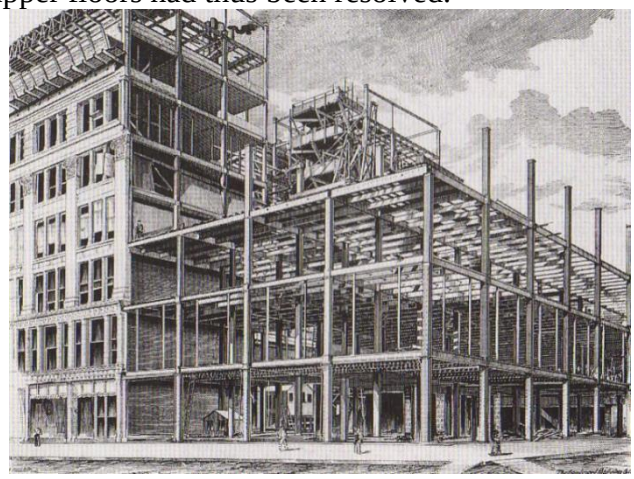

Figure 6. Construction Site View, Faire Store, William Le Baron Jenney, 1891.

In 1884, William Le Baron Jenney constructed the Home Insurance Building *(Figure 7)*, considered the first skyscraper, standing at a height of 10 stories. The windows were larger than what was possible in a masonry building. The windows were wide and horizontal, known as "Chicago windows." With the second Leiter Building and the Fair Building in 1889, William Le Baron Jenney further manifested his concept in construction: a steel post-and-beam structure in which he eliminated load-bearing walls. The facades were no longer load bearing and were reduced to lightweight screens. This skeleton framework allowed for increased height without the concern of excessive load on the lower levels and enabled the creation of almost continuous openings along the walls to illuminate deep building cores.

In 1889, William Holabird and Martin Roche constructed the Tacoma Building with 12 stories. In 1891, they completed the Monadnock Building with 16 stories. The Brooks Building, the latter of which is considered a masterpiece of simplicity, takes on a unique and distinctive appearance with a metal structure. Shaped like a slice, the Brooks Building appears as an individual and isolated element. It features a remarkably open facade that directly reflects the skeleton structure. The "Chicago window" is incorporated, consisting of an operable bay at the center.

Figure 7. Home Insurance Building, Chicago, 1884, William Le Baron Jenney.

In 1895, Daniel H. Burnham and John W. Root constructed the Reliance Building *(Figure 8)*. It is considered the most beautiful skyscraper in Chicago and features a remarkably advanced structure for its time. The skeleton structure relieved the exterior walls from bearing the load. The building is almost entirely covered in glass, with the wide frames contributing to the open character of the facade. No building of the era succeeded better in achieving this goal than the 'Reliance Building'.

Figure 8. Reliance Building, Chicago, 1895, Burnham.

Between 1899-1904, Louis Sullivan constructed the Carson, Pirie & Scott Store. The building is notable for its metal structure, which allowed for an increased window area, enabling more natural daylight to enter the interior. The "Chicago windows" *(Figure 9)*, stretched horizontally and evenly spaced, are created with slender metal frames and seamlessly integrate into the steel framework.

Figure 8. The Chicago Window.

3.3. The modern architecture:

The modern period in architecture was undoubtedly a grand stage for remarkable and innovative achievements on multiple levels: technical, formal, and social. The ideas of modern architects aligned with a new conception of space. This space, which was enclosed and constrained in the past, was shattered, and breaking down those barriers became one of the central goals of modern architects. Moreover, the advent of new materials such as reinforced concrete, steel, and glass allowed these new ideas to be expressed architecturally. By dismantling enclosed spaces, architecture became transparent. The concept of transparent architecture inspired the German writer Paul Scheerbart, who published his manifesto "Glass Architecture" in 1914 [20], envisioning how the new human would inhabit houses entirely made of glass—bright, clean, and pure—where matter would become mere light: "*We most often live in enclosed spaces, which form the environment where our civilization takes root and develops. To a certain extent, our civilization is a product of our architecture; if we wish to elevate its level, we must, willingly or unwillingly, transform our architecture. And this will only be possible if we ensure that the rooms in which we live no longer have this closed character."* [21].

In the same year, Bruno Taut presented his Glass House at the Werkstattbund exhibition in Cologne. Since then, transparency has continued to manifest itself through the architecture of prominent figures of the modern period such as Walter Gropius, Ludwig Mies van der Rohe, Giuseppe Terragni, Le Corbusier, and many other architects of this era.

Peter Behrens, considered one of the pioneers of industrial design and the founder of industrial aesthetics, designed the Factory Assembly Hall for AEG's turbine plant in Berlin in 1908-1909 *(Figure 9)* the building features a metal structure with large glass facades. These expansive transparent surfaces constitute the majority of the building's envelope, emphasizing a significant presence of void space in contrast to solid elements. The design establishes a clear permeability between the interior and exterior, blurring the boundaries between the inside and outside spaces.

Figure 9. AEG Turbine Factory, 1908-1909, Berlin, designed by Peter Behrens.

A few years later, between 1910 and 1914, Walter Gropius, who had previously worked with Peter Behrens, collaborated with Eduard Werner and Adolf Meyer to design the Fagus Factory in Alfeld, Germany *(Figure 10)*. The building bears resemblance to Behrens' AEG Factory with a more open architectural aesthetic. It features a metal structure and fully glazed facades. Vertical glass panes project outwards continuously along the entire height of the facade, emphasizing the transparency of the glass. The glass walls no longer serve a load-bearing function but act solely as protection against weather elements. Gropius highlights his commitment to new techniques and the utilization of light in his design. The Fagus Factory was one of the very first buildings with curtain-wall facades, highlighting the innovative use of glass in architecture.

Figure 10. The German Pavilion, 1929, designed by Ludwig Mies van der Rohe.

Later in 1946-1950, Mies van der Rohe designed the Farnsworth House *(Figure 11)* in Plano, Illinois, United States. Mies creates an infinite spatial experience using what he calls "almost nothing." The Farnsworth House is one of the most rational applications of purist glass architecture and one of the purest examples of an open plan. The exterior walls consist of vast glass panels that ensure the continuity of the interior space towards the outside. The unique treatment of the building's corners further enhances the idea of freedom and openness.

During the same period, Philip Johnson, in collaboration with Richard Foster, designed his Glass House in 1949 in New Canaan, Connecticut, United States. Often compared to Mies van der Rohe's Farnsworth House, which features floating plans, the Johnson House is a box

anchored to the ground. Unlike the Farnsworth House, Philip Johnson does not provide a terrace, but the lawn offers a beautiful outdoor space.

The house is mainly characterized by the extensive use of glass, from floor to ceiling, concrete for both the floor and roof slabs, and steel for structural elements. The design allows the house to be open to nature, surrounded by greenery and trees. It represents an architectural shelter blending the interior and exterior, simultaneously independent yet interwoven with the natural elements.

Figure 11. Farnsworth House, Plano, Illinois, United States, 1946-1950, Mies van der Rohe.

Le Corbusier, on the other hand, focused on openings and the possibilities of views towards the exterior. He famously stated, "Windows can run from one end of the facade to the other" [22]. He proposed smooth and extensively open flat facades *(Figure 12)* to adhere to the principles of illumination and transparency. Inside, Le Corbusier introduced frames for views *(Figure 13)*. He envisioned the house as a device for capturing views, where living in it was akin to inhabiting a camera, with windows serving as lenses. The space would not be composed of walls but of images, "walls of light."

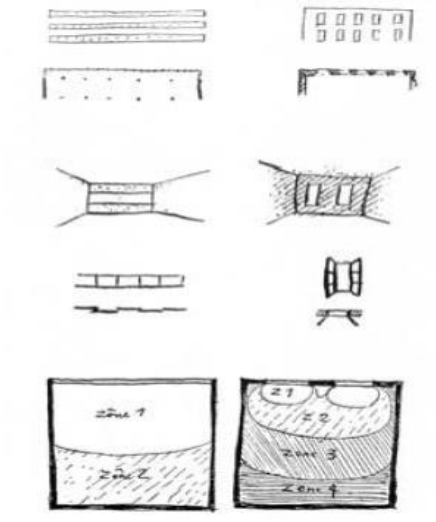

Figure 12. Schematic drawing of the longitudinal window in Le Corbusier's architecture.

Figure 13. Villa Savoye, Poissy, 1931, designed by Le Corbusier.

During the period 1930-1933, Le Corbusier completed the Salvation Army Shelter City located on Cantagrel Street in Paris *(Figure 14a)*. The building's facade, spanning a thousand square meters, is entirely made of glass. Due to delays, cost overruns, and technical issues, the structure was ultimately finished with a single-glazed fixed facade on the south side, lacking air conditioning. Ducts in the hallways, dormitories, and individual resident rooms were intended to provide ventilation and heating. The absence of any cooling system during the summer and the inability to open the fixed windows led to the failure of this approach.

In 1952, the building underwent a complete renovation *(Figure 14b)*, and the original facade was replaced with operable windows set behind parapets, all covered by a sunshade. This sunshade subsequently became one of Le Corbusier's favored architectural elements. It was also employed in other projects, such as the Ministry of National Education building in Rio de Janeiro, Brazil, in 1936, and the Cité Radieuse in Marseille in 1952.

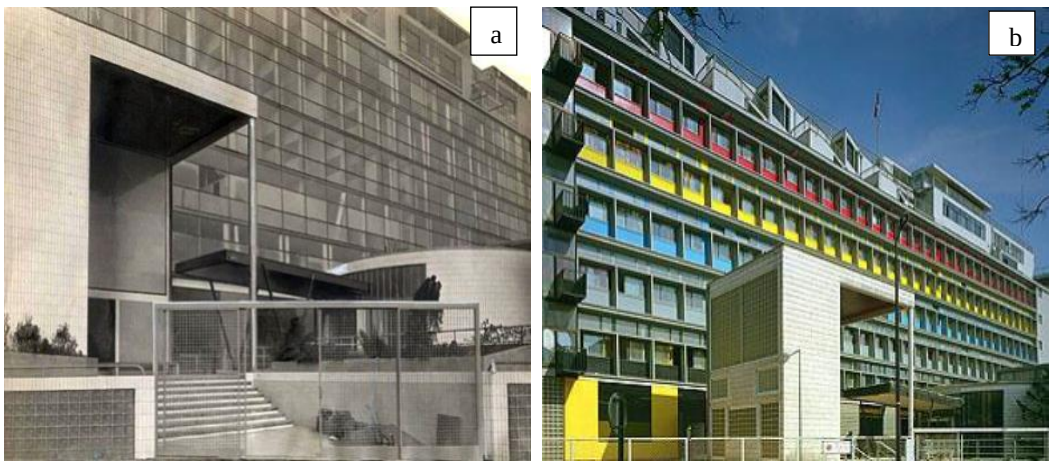

Figure 14. Salvation Army Shelter City, 1933, Paris, designed by Le Corbusier. a: The building's façade; b: facade renovation.

In 1932, Giuseppe Terragni completed the Casa Del Fascio (the House of Glass, currently serving as the local customs headquarters) in the historical center of Como, Italy *(Figure 15)*. In this design, the architect aimed to capture the architectural expression that could embody fascism (the regime of his time in Italy), which he associated with transparency. The building takes the form of a large parallelepiped with a central atrium. The 33.20-meter-long facade is

twice its height. Transparency is manifested in various parts of the building both inside and outside: through large glass openings framed by a post-and-beam structure.

Figure 15. Casa Del Fascio, 1936, Como, Italy, designed by Giuseppe Terragni.

3.4. Architecture of the Second Half of the 20th Century

After World War II, cities needed to be rebuilt and populations needed to be relocated. Le Corbusier introduced the concept of the "machine for living." New cities emerged in developing countries, such as Brasilia, which was entirely constructed starting from 1957 [23]. In Chicago, Mies van der Rohe constructed buildings based on the principle of exposed steel framework.

This period witnessed the emergence of various movements, such as organic architecture, characterized by lively, ethereal, and organic forms sculpted in concrete (such as the Solomon R. Guggenheim Museum in New York, designed in 1956 by architect Frank Lloyd Wright). In the 1960s, other architects turned to contemporary technology as a source of imagery, forms, and structures. This gave rise to the "high-tech" movement, which emphasized the idea of a building as a work of technical art. Technological expression within architectural works became highly prominent, as seen in architects like Norman Foster, a prominent figure in the high-tech movement. The same can be said for Renzo Piano and Richard Rogers, who designed the Georges Pompidou National Centre of Art and Culture, built between 1971 and 1977 in Paris.

During the 1980s, architects turned towards an architecture that aimed to evoke a sense of the provisional and the improvised. The deconstructivist movement emerged, featuring slanted walls, inclined ceilings, and skewed windows, creating buildings that appeared to have experienced seismic disruptions. Notable architects in this movement include Frank Gehry, Bernard Tschumi, Daniel Libeskind, and Zaha Hadid.

In 1950-56, Mies van der Rohe designed the Crown Hall *(Figure 16)* at the Illinois Institute of Technology in Chicago. It was intended to house the schools of architecture, urban planning, and design. The building consists of a single uninterrupted space measuring (36.6 x 67 m) with a height of (5.5 m), covered by a striking structure. The facades are made up of large glass panels, offering a completely open configuration, similar to the approach used in the Farnsworth House. During the same period, from 1954 to 1958, Mies van der Rohe and Philip Johnson designed the Seagram Building in New York. This 39-story office tower is constructed with bronze and smoked glass. In this case, glass wasn't used for its transparency effect, but rather as a material that reflected light like a mirror and prevented the gaze from penetrating the interior space. Prioritizing interior lighting and the visual effect of the building and its luminous reflections were key aspects of the design.

Figure 16. Crown Hall, Illinois Institute of Technology, Chicago, 1956, Designed by Mies van der Rohe.

In 1968, James Stirling created the History Faculty at Cambridge University in London. In this building *(Figure 17),* Stirling employed various construction materials, such as steel, concrete, brick, and glass. The interior layout features a reading room for 300 readers (covering approximately 1400 square meters of shelving), occupying nearly half of the total area, along with rooms for professors, seminars, and communal spaces.

A large glazed roof covers the building with a steel framework extending over the reading room, supporting two glass walls. An upper portion of these walls incorporates movable awnings that facilitate the ventilation of the space situated between the two glass layers (this space, reaching up to 4 meters in height, contains walkways for maintaining the lighting installation and air extraction machinery). A second inner layer of frosted glass provides shadowless illumination onto the reading tables. The chimney-like shape created by the sloping glass roof aids in the expulsion of hot air through fans positioned at the highest point. During hot weather, three separate extraction machines expedite this process.

Figure 17. Cambridge History Faculty, London, 1968, James Stirling.

In 1968, Kevin Roche and John Dinkeloo designed the Ford Foundation Building in New York *(Figure 18),* covering an area of 3000 square meters on the ground and rising 80 meters high. The building's "C"-shaped floor plan was strategically conceived to provide an extensive view of the exterior surroundings. The most significant innovation of this edifice is

the vast glazed garden that spans the entire height of the southeastern section of the building. This garden courtyard was established by enveloping the open spaces within the "C" shape with a transparent zenithal glass roof, resulting in the creation of a central atrium. Each office is endowed with a sliding door that opens onto the park, fostering a sense of well-being. The atrium is enclosed on only two and a half of its sides, with a substantial transparent wall closing off the remaining one and a half sides, corresponding to the southern façade and a portion of the eastern side. This design feature facilitates significant and constant direct sunlight exposure to this landscaped area.

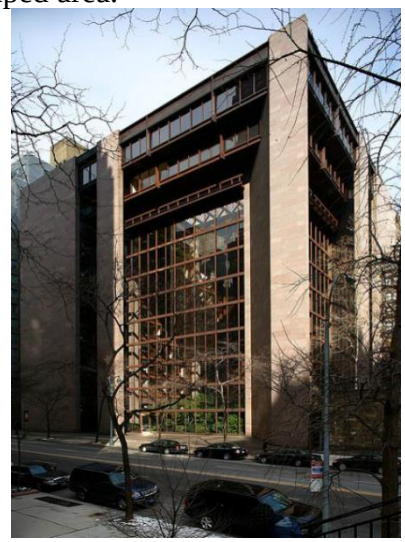

Figure 18. The Ford Foundation, New York, 1968, Kevin Roche.

In a similar vein, the Debis Tower *(Figure 19)* was realized between 1993-1979, an office building designed by Renzo Piano in Berlin, Germany. This building comprises around twenty floors. From the exterior, however, it does not appear as a single structure, but rather as a composition of distinct volumes with varying heights and facade treatments (curtain wall, terracotta element lattice, and adjustable glass fins).

The eastern, southern, and western facades, where direct solar gains are most significant, feature a double-skin system consisting of an outer screen equipped with adjustable glass fins. At the center, there is a 10-meter wide by 28-meter high and 62-meter-long atrium, designed to illuminate the offices that overlook this central space.

Figure 19. Debis Tower and its central atrium, 1997, Berlin, Germany, Renzo Piano.

Dominique Perrault, in 1990, designed the Berlier industrial hotel in Paris, aiming to "present a new architectural image for the industry." *(Figure 20).* The facades of the Berlier industrial hotel are uniformly composed of a transparent curtain wall from top to bottom, equipped with slightly tinted double-glazing. This transparent building allows the glass to reveal cables, various technical pipes, as well as industrial activities taking place inside. Inside, a system of metal sunshades is implemented, above and below which pass the ducts for heating and air conditioning. The sunshades consist of horizontal 0.4-meter-wide strips made of perforated galvanized sheet metal, spaced at intervals of 0.3 meters.

Figure 20. Industrial Hotel, 1990, Paris, Dominique Perrault.

In 1979, Thomas Herzog designed a house in Regensburg, driven by the need to conserve energy due to the oil crisis of the 1970s. Architects began to contemplate energy-efficient construction methods. Sustainable development became the guiding principle for a few architects, including Thomas Herzog, who was a pioneer of low-energy architecture in Germany. The house in Regensburg is entirely constructed from wood, single-story, and features a triangular shape with a greenhouse and a long single-pitched roof that extends down to the ground, designed to harness solar energy.

In 1993, Norman Foster designed the Fréjus Comprehensive High School in France *(Figure 21),* featuring a concrete structure and a metal roof. The high school encompasses a central longitudinal space for the distribution of various rooms and services. An axial lantern roof with dual North-South exposure illuminates this area, referred to as the «interior street». Classrooms are equipped with large openings on both the interior and exterior facades. Transparency is the guiding principle in this building, evident in the 1000 square meters of glass facades, enhanced by a sunshade system installed on the south facade of the building and along the classrooms, spanning approximately 200 meters in length, with a horizontal projection of 5 meters. These canopy-like elements are positioned at a height of 2.6 meters at their lower edge and are constructed from perforated sheets. The installation of horizontal sunshades on the south side provides effective solar protection. In Fréjus, 1000 square meters of glass facades are thus shielded throughout the year from direct sunlight that could otherwise cause significant discomfort.

In the same year, Norman Foster also completed the Carré d'Art in Nîmes, a Museum of Contemporary Art [24]. It takes the form of a large rectangular glass parallelepiped characterized by perfect lines and, most notably, transparency. Norman Foster's design for the addition to the Reichstag in Berlin, featuring a transparent dome, an observation area, and mirrors, serves as an example of a contemporary building that is sensitive to the potential symbolic significance of transparent glass, associated with honesty.

Figure 21. Fréjus Polyvalent High School, France, 1993, Norman Foster.

The void of the vast atrium in the Hong Kong Bank, designed by the English architect Norman Foster, channels sunlight into the core of the building, while also providing an overall view of the majority of the offices, as if the bank intends to exhibit transparency towards its clients.

In 1995, Shigeru Ban designed the "Curtain Wall" House in Tokyo [25] *(Figure 22)*, a three-story residence with a total area of 110 square meters. The concept of transparency in this house is taken to an extreme level. The facades that fully open on both sides facing the street are enclosed by sheer curtains in summer or glass partitions in winter. The rooms are separated only by minimal partitions. This layout actually aligns with the architect's intention to demonstrate that he has nothing to hide.

Figure 22. Curtain Wall House, 1995, Tokyo, Shigeru Ban, a: without curtains; b: drawn curtains.

Architect Jean Nouvel created the Cartier Foundation in 1994 in Paris *(Figure 23)* [26]. Centre Georges Pompidou., an exhibition space for contemporary art. Its finely woven steel and glass architecture imparts a sense of great lightness. The architect has given paramount importance to transparency and the interplay of volumes and surfaces. Elevators and staircases are located on the exterior. The external circulation layout helps liberate the interior

space, embodying the concepts of flexibility and dynamism associated with the building. A first large eight-meter-high glass partition, like an intangible light-filtering screen, is set along the property boundary and sidewalk, aiming to blur the physical boundaries of the structure. Beyond this initial transparent wall, a second identical fifteen-meter glass facade is visible, housing the main entrance of the building.

Figure 23. The Cartier Foundation, 1991, Paris, France, Jean Nouvel.

A glass cube, of which seven out of fifteen floors are submerged, houses the offices of the Foundation and expansive exhibition halls for Contemporary Art. The open space between the wall and the cube forms a setting for the existing trees on the site, including a century-old cedar tree. Glass is also the chosen material for creating most of the partition walls within the premises and a significant portion of the office furniture.

4. Conclusion

Despite the use of glass since the Middle Ages, such as in the windows of the "Hall of Mirrors" at the Palace of Versailles in 1678, it was not until the late 19th century that the first concrete realization of transparent space in architecture emerged. The combination of iron, glass, and reinforced concrete provides architecture with a more straightforward means of expressing transparency and spatial continuity. The desire to convey transparency has led to the extensive utilization of these two materials.

The need for natural light in large spaces (such as greenhouses, markets, arcades, department stores, galleries, and railway stations) led designers during the period of the industrial revolution to explore transparency. The first iconic building in this regard is the Crystal Palace built in London in 1851 for the Universal Exhibition. This building provided more space and light, symbolizing a breakthrough in architectural design.

Tearing down walls, facilitating the flow of air and light—transparency immediately imparts a sense of lightness, goals pursued by the architects of the Chicago School.

The history of architecture reveals an increasing tendency towards enclosed and confined spaces. One of the tasks undertaken by modern architects was to shatter this closed box in order to articulate and infuse movement into architectural space.

Masters of modern architecture were concerned with introducing time and movement into architecture. To achieve this, they employed various means to transport these concepts into architectural space. Among these, 'transparency' emerged as a key element. Transparency

allowed abundant light to enter and established a distinct relationship between the exterior and the interior.

Thus, this historical overview of transparency in architecture allows us to conclude that natural light and views of the exterior are among the concepts that have led architects to employ transparency.

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