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The Relationships between Users and Daylighting Design in the 20th Century Architectural Practice

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Abstract: Architecture is considered a crossing field between arts and sciences that is supported by multiple, various and complex issues. Considering that architecture is a man's creation for men, this research explores human factors in architecture. It specifically focuses on the relationships between users and natural lights (both sunlight and daylight) within houses and public buildings designed during the 20th century modernist era by renowned architects. The investigative approach relies mainly on a literature review as well as in site observations and some interviews for the case studies in France. Six contemporary architects' work composed the study corpus. The results highlight first that i) users did not perceive natural light as architects intended it, ii) users' sensations could not replace the essential requirements contributing to satisfaction with a comfortable daylit space, and iii) after the disappearance of the sensation first effect, dissatisfaction occurred and often generated transformations disfiguring the striking effects previously designed by the architects.

Keywords: Daylighting; Users; Perception; Behaviour; 20th century Architecture

1. Introduction

Lighting an architectural space is an essential act enabling users to carry activities. Generally, a given standardized light level could satisfy this need. But, in terms of suitability, the issue becomes more complex and may lead to a distress followed by a deep transformation of the architectural space. This complexity along with the variety of the related parameters have generated substantive interest in daylighting across various scientific fields, such as psychology, ergonomics, architecture, energy, economics etc. For instance, the user has become the center of interest of several research studies on daylighting. These investigations relied on the user's self-expression of the perceived daylighting inside his living spaces [1,2]. In order to investigate such issues, this research work attempts, first, to explore the relationships between the users and daylighting in the context of the architectural production as a know-how professional field. A critical review is undertaken for six among the 20th century's most famous modern architects known for their architectural design that strongly valued natural lighting. The review will focus on the relationships to the user's perception, choices and behavior. The architectural productions under review (houses and public buildings) are principally examined through a literature review. For some of them, in situ observations as well as interviews with the current buildings' managers were undertaken.

2. Gropius and Mies van der Rohe: in search of transparency

As precursors of the modernism in architecture, Walter Gropius and Mies van der Rohe largely used daylight and transparency as their main design concept, including their buildings in the United States. For Gropius, access to light and air reduces the needs of habitable space [3]. He rejected the idea of the window as a hole in a wall and advocated the curtain wall. The Fagus Factory built between 1911 and 1913 in Alfeld was the first building he designed with 65% glazed wall (Figure 1). The clear design intent was to allow very large amounts of daylight without glaring effects on the occupants. Presently, the offices use heavy curtains for glare control concealing the transparency so appreciated by the architects. However, this is not the sole project that encountered such issues. In fact, the Törten Housing Project built in Dessau in 1926-28, displays similar issues due to the poor orientation of the buildings [5].

On the other hand, Mies van der Rohe used the window wall indistinguishably between offices and houses. Moreover, Mies designed his buildings as a whole and did not differentiate between the functions of the various areas according to their requirements in terms of daylighting. Mies was convinced that the emotion felt by the users of glazed spaces is generated from the multiple and combined reflections of natural light rather than the light-shadow contrast used in classical buildings. Critics do not share the same opinion and criticized his buildings from the daylight and sunlight perspective. For instance, one of the most prominent architectural historians, Paolo Portoghesi, cited the uncontrolled and uncontrollable luminosity of the Mies' famous Lake Shore Drive Apartments in Chicago (Figure 2) [3].

Dr. Farnsworth's House is an entirely transparent glass box that causes various thermal and luminous comfort problems. The occupants' recourse to curtains during the summer season [5, 7], sacrificed transparency, so glorified by the Modernist movement. Expressing the idealist formalism of Mies van der Rohe, the New National Gallery in Berlin experienced issues due to excessive daylighting. The temporary exposition hall is located at the luminous and totally transparent ground floor. This wide space endures a visual discomfort caused by the excessive reflection and glare as well as a problem of color rendition because of unsuccessful combination of natural and artificial lighting [8].



Figure 1, An inside view of the largely transparent office of Gropius' Fagus Factory showing the use of curtains [4].

Figure 2. The transparency of Mies van der Rohe's Lakeshore Drive apartments' facades is greatly reduced because of the occupants' use of the external solar protections [6].



3. Frank Lloyd Wright and Alvar Aalto: the importance of context

Although belonging to the same Modernist Movement, but a different design approach, Gropius and Mies, Frank Lloyd Wright and Alvar Aalto took into consideration the natural milieu of the project. Wright's contribution to daylighting design is more qualitative than quantitative because he based his design on his own intuition and did not use system calculations [9]. However, this approach also leads to some daylighting problems inside his buildings. Their interiors are often seen as dark spaces [7]. This character is more accentuated by the cladding materials that are unreflective and dark colored [10]. At Oak Park's Unity Temple, in the suburbs of Chicago, the original artificial lighting has been altered in order to give more clarity inside the building's nave. When more powerful light bulbs were installed, they overheated and melted [11]. Similarly, in the Guggenheim Museum the main ramp was well lit but not the exhibit area. To improve the visual quality of the space, artificial lighting was deemed and was added, after much debate among architects in the exhibit area [8].

In the Johnson Wax Offices and Laboratories in Racine (Wisconsin), Wright used innovative materials and details to emphasize daylighting. A golden, diffuse and shiny light comes down through glass tubes located between the circular capitols of the columns in the offices (Figure 3) [3,13]. This novel material was used for the laboratory but horizontally. This translucent glass allows generous daylight penetration but prevents views to the outside whilst a section of the window area can be opened by the occupants (Figure 4). Daylight is also controlled by the users through mobile mullions [14].



Figure 3. Johnson Wax's office space is provided with zenith daylighting through tubular glass surfaces [12].



Figure 4. Johnson Wax's laboratory spaces, enjoy large surfaces of tubular glazing with possibility of control by the users [14].

Unlike his fellow Modernists, Alvar Aalto operated under a more stringent climatic environment. Therefore, most of his buildings have been translated by a careful consideration for sunlight and daylight [3]. This interest goes beyond intuition and creativity and intentionally borrows from scientific experimental work, particularly that of models simulation [15] as for Aalto, architecture is a combination and integration of various techniques [16]. Contrast and various light gradients are evident characters of his interiors. Sarfati [17] speaks about the interior ambience of Imatra Church by describing the hot interior light welcoming people after having been exposed to the brilliant whiteness of the church walls under the snow outside (Figure 5). Aalto's libraries reveal that he was successful in eliminating any glare or visual discomfort through the use of various design solutions [18,19,5,17,8,20]. However, it is important to indicate that: i) most of his buildings are in overcast sky regions, and ii) they were designed in an era of inexpensive energy consumption [15]. This could explain the nearly quasi-systematic recourse to the artificial lighting as a more than a complementary source to daylight. These artificial lighting apertures were replaced by new and more efficient ones perhaps as a response to the users' request and/or to recent building standards [21].



Figure 5. The contrast between the outside cold natural light and the warm one inside the building was one of the signs used by Aalto in his architecture: example of the church of Imatra [7].

4. Louis Kahn and light:

Kahn gives a singular importance to daylight in his buildings as well in his theories. He rejected the principle of a universal lighting and advocated a singular lighting for specific spaces [3]. But unfortunately, the examination of Kahn's buildings reveals some contradictions with his own theory. In the Philips Exter Academy Library, he located more than six different functions behind a wall with the same openings [22]. In several buildings, the changes made by the users in order to improve lighting conditions and solar admission are evident. Curtains, green and lattice screens were used in this purpose by the users of Rochester Church in New York, Yale Art Gallery in New Haven and the Richards Medical Research Laboratories in Philadelphia [23]. In fact, from a daylighting performance point of view an investigation showed that Kahn designed the window as an architectural event more than a device for lighting a space [23]. The Dacca Assembly Building is almost considered as an illustration of Kahn's daylighting mastery. However, some interiors receive insufficient to inadequate and even glaring daylight [24]. Inside the National Assembly Mosque, the direct sunlight disturb the prayers and require moving from a place to another (Figure 6) [23]. Also, the supposedly space-structuring and orientating clear-dim effects [27] are not performing well because they are not the users' habitual references [26].

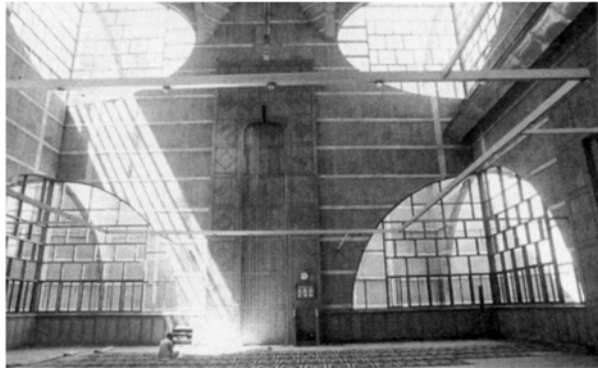


Figure 6. The luminous environment inside the National Assembly Mosque building in Dhaka, Bangladesh [25].

5. Le Corbusier: a singular case

Being the most prolific writer and speaker of all, it seems that no architect did better than Le Corbusier when he evoked the sensations caused by natural light, narrated its plastic qualities and related its benefits to humans. He was also careful towards the occupant's well-being and undertook a survey among various specialists (architects, doctors, physicians and engineers) [28,16]. In order to satisfy users' needs, Le Corbusier referred to his intuitions even if they were purely technical [28]. So, despite his good intentions, his buildings occupants' reactions were chocking and ultimately surprising.

The Frugès Housing District in Pessac, France, is a reference case showing that the universal aesthetics could not be accepted as the Modernists thought. The apartments buildings facades are oriented to the west and east and have subsequently been altered at different stages [29,30]. The windows areas were mainly reduced in response to the sun excessive exposition (Figure 7). Also, the Cite de Refuge and the Swiss Pavillon in Paris saw the addition of brise-soleil devices and venetian stores when Le Corbusier was still alive [5,28].



Figure 7. Views of the facades showing their initial state, the addition of curtain blinds for solar control and then the narrowing of the windows [30].

After its completion, the Couvent de la Tourette experienced thermal comfort issues [31]. In the kitchen, the still most used space until today, we observe that venetian stores were added to the large windows (Figure 8). Even, if they include brise-soleils on their facade, the monks' rooms are equipped with curtains that are changed every year [32]. Also, as previously highlighted by Fontoynt [4], the contrasting levels of luminance and illumination were easily observable to us once in the convent (Figure 9) [32].

The Villa Savoye, converted as a museum today, contains the five points of the modern architecture as defined by Le Corbusier. The curtains used for the strip window were removed in all the visited spaces but are still present in the south-oriented manager's office (Figure 10). In this latter, venetian stores are added to the original curtains in order to solve the overheating and visual problems lived by the manager as she stated it to us [33]. During the Villa Laroche visit, we observed that Le Corbusier used aesthetically interesting, but inefficient daylighting devices. The owner of the Villa observed that his expensive paintings hung on the walls are amply exposed to sunrays and required their protection. Nevertheless, the internal brise-soleil designed by Le Corbusier to protect the paintings was not efficient as it was shown by a model simulation study [4] (Figure 11).



Figure 8. The vertical mullions on the southern façade of the Tourette Convent are ineffective for solar control and users supplant them with venetian blinds [32].



Figure 9. In the Tourette Convent, Le Corbusier used a variety of natural lighting sources in form and position, which has created very contrasted lighting environments [32].



Figure 10. The venetian stores used to protect the windows of the south-oriented manager's office in the Villa Savoye [33].



Figure 11. The internal 'brise-soleil' used inside the exposition-reception room in the Villa Laroche [33].

Among the of Le Corbusier's latest works, the Chapelle de Ronchamp is incontestably the masterpiece where he used the natural light to express beatitude and meditation and all religious feelings he had experienced when he designed it [7]. The luminous environments are very contrasting inside the Chapelle and constitute another original character among those attesting the new design line of Le Corbusier expressed in this religious building. Although the intended sensations emerge when inside, this interior is nonetheless characterized by specialists like Fontoynt [4] as relatively dark. The transition from exterior to interior did not occur without requiring a time for the eyes to adapt [4]. However, it must be mentioned that Le Corbusier has sometimes taken the climatic context into account in his daylighting design. As an example, his buildings in Chandigarh express this approach [35] even if the adopted strategies' efficiency was somewhat negatively assessed, by the critics, in relation to the hot and humid region characteristics [36] as well as revealed by in situ observation [37].

6. Conclusion

In this study, a critical review has been undertaken for the case of buildings known for their daylighting design in order to investigate the relationships between the users and daylighting design. The outcomes bring to light that the users did not perceive daylight as it was previously and instinctively expected by its prominent Modernist architects. Besides, this study reveals that the visual and artistic aspects could not replace the visual comfort related requirements such as allowing solar and glare control as well as avoiding overheating and inner gloomy spaces. Oppositely, it has been shown that when the first sensation and/or impression effect is outdated, dissatisfaction could occur and generate several transformations disfiguring the striking effects previously designed by the architects.

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