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Reflective Façades: Revisiting a Neglected Trait of Modernism in Contemporary Architecture with New Implications and Significance

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Abstract: Reflection and transparency are two valuable properties associated with the use of glass as an architectural material. While proponents of modernism favored transparency over reflection, whether in its physical or conceptual implications, to justify the designs of façades of Modernist buildings and in architectural criticism, contemporary architects are revisiting the neglected trait of ‘reflection’. Taking advantage of the technological advances in glass and other materials that have taken reflection to new limits, they are able to design reflective façades, providing new implications and significance. This paper aims to fill the theoretical gap that arises from the different conceptual ideas of using reflective façades. It will also explore the implications intended by architects to be perceived by viewers, thereby facilitating the future use of these façades in a way that satisfies architects and attracts beholders. The research methodology employed thematic analysis of various experiences of the use of reflective façades in different buildings with diverse functions and locations. The vocabulary used by architects and their intended implications were analyzed, coded, and categorized under three main themes: ‘Aesthetics of Disappearance’, ‘Games of Optical Illusions’, and ‘Mystery and Arousing Curiosity’.

Keywords: reflective façades; transparency; invisible architecture; optical illusion; mirrored façades



Citation: Elmoghazy, Z.A.A.E.; Afify, H.M.N. Reflective Façades: Revisiting a Neglected Trait of Modernism in Contemporary Architecture with New Implications and Significance.

Buildings **2023**, *13*, 2740. <https://doi.org/10.3390/buildings13112740>

Academic Editor: Davide Settembre-Blundo

Received: 10 August 2023

Revised: 28 September 2023

Accepted: 20 October 2023

Published: 30 October 2023



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1. Introduction

Materials have always been a critical and crucial element in directing architectural ideas and practice. The continuous innovation in the field of materials has changed how architecture is perceived and how concepts are generated and accepted. New materials have been influential in creating many innovative styles and shifts in architectural thinking, starting with concrete, steel, and glass, and continuing to nanomaterials, fiberglass, and self-healing concrete, which is used in shaping the parametric designs annotating contemporary architecture [1]. Materials are becoming stronger, smarter, self-sustaining, more elegant, and eco-friendly. They are also becoming more dynamic and possess changeable properties to meet users’ needs.

Glass, with all its qualities, captured both theoretical and practical interest, dominating twentieth-century architecture with its physical and conceptual interpretations. The new material arose at the end of the 19th century and amazed both architects and users with the richness of its design possibilities, innovative potential, and aesthetic outcomes [2]. Glass has two main physical properties, transparency and reflectivity. When used in the outer skin of a building, both traits have effects on architectural implications and messages to viewers, adding to the conceptual values of the building’s façade. The façade is an important part of a building, as it is the means of communication between the building itself and the public, and is the first encounter between the user and the building. Alzahrani asserted that the

most significant and immediate approach to forming an opinion about a building is through its exterior look [3]. Lee and Ostwald added that façades have attractiveness that is both visual and psychological [4]. Jürgehak clarified that the exterior and interior, as well as the public and private, are split by façades, ‘a functional skin, the representational element, and a boundary protecting the inner and negotiating with the outer world’ [5]. The materials used in façades are major components in their design and have a strong impact on and key role in delivering the messages intended by the architects for the viewers.

Although reflection and transparency exist together when glass façades are utilized, transparency was more popular in conceptualization and explanations by both architects and critics, especially during the modern architecture era [6]. Currently, reflective façades are intentionally being revisited by architects. These architects are reintroducing reflective materials in the concepts of their buildings and designs, taking advantage of the availability of cutting-edge materials that facilitate their use on large surfaces; they are satisfied with the contemporary and futuristic look these materials give the beholders.

2. Literature Review

2.1. Transparency: The Beginning of the Journey

Modern architecture had an intense effect on architectural theory and practice as it established different theories and provisions, some of which were paradoxical or controversial; it impacted architecture from the late 19th century to this new millennium. One of those contradictory ideologies was the prohibition of ornaments while promoting and hailing transparency by allowing it to become a new type of architectural expression, creating a new form of aesthetic sensibility, and opening unlimited possibilities for visual perception. As stated in the Encyclopedia of 20th Century Architecture, the transparency of the new architecture suggested a revolutionary, classless society based on freedom and flexibility [7], as it became the honest, natural ornamentation that compensated for the artistic, forbidden ornaments. According to Rowe and Slutzky, transparency was the subject of much critical analysis, which described its literal and phenomenal or perceptual and conceptual meanings. They stated that transparency provided multiple complex implications and concepts other than its physical properties of displaying clearly what was behind it, permitting the inside to be observed from the outside, and vice versa, or being able to see what was in a space while physically being in another space adjacent to it [8].

Glass, the symbol of industrialization in modern architecture, was essential to the materialization of these ideologies as it acted as a neutral presence, or as Alexander D’Hooghe phrased it, its ‘presence would be studied as a kind of absence; whose form would have no expression’ [9]. Although there are two physical properties of glass, namely, transparency and reflection, transparency was the characteristic studied and targeted more by architects and critics. Transparency in glass allowed for the overlapping and penetration of spaces. It enabled spaces, which previously could not be seen together, to be viewed at the same time. It permitted ‘simultaneity’, which means seeing various aspects of an object at the same time without moving, and it reflected time as the fourth dimension in architecture [10]. Gudkova and Gudkov added that it contributed to the idea of ‘freedom’ that prevailed in modern architecture by freeing the boundaries between the inside and the outside, adding extra space to interiors, and communicating with the exterior [11]. Mies Van Der Rohe declared the rise of abstraction in his façades by using flat sheets of glass in his pavilion, houses, and skyscrapers, producing skin-and-bones architecture with crystal façades connecting the indoors with the surroundings. He favored transparency over reflection in his glass façades, expressing his reservations concerning the huge amount of light that is reflected by glass mirrors and its effect on the urban context [12]. Apostolou stated that transparency ‘...creates multiple readings of spatial relationships and their connections. It allows flexibility in the organization of the composition.’ [13]. Mies Van Der Rohe and other Modernist architects are to be thanked for advancing the material of glass by emphasizing its transparency qualities. Balik asserted that transparency was ‘read as an ephemeral and temporal artwork’ as its quality and degree changes throughout the day and according to

environmental conditions and passersby positions [14]. Glass continued to liberate the user from his enclosure by promoting transparency to connect with the outside context.

In Postmodern architecture, this emphasis on the relationship between the inside and outside of a building was not prominent, as the style and form of mass gained greater importance in design concepts. Later, Norman Foster and others adopted the high-tech style, using vast amounts of glass to cover entire walls in their buildings and revealing daily life in them. Connections between the passersby and the occupants of the buildings were established, creating a new state of continuity, clearance, and an invitation to remotely share the experience. Conceptually, the glass curtain wall had two integrated functions of the same importance. The passersby sharing the experience of what is inside the building was as important as the inside user connecting to the surrounding context. The Willis Faber and Dumas Headquarters designed by Norman Foster (1975) came with a twisted feature taken from transparency. Dark smoked-glass curtain walls were used with curved corners and recessed building structures, creating continuity of the glass façades and a new experience of reflection [15]. The building acted as a temporal mirror of the surrounding context in the morning and revealed the inner activities at night through the transparency of its glass façades (Figure 1). Whether the reflection was intended by the architect or not, it established a new and different design statement in architecture.



Figure 1. Willis Faber and Dumas Headquarters, 1970–1975, Norman Foster, England. Source: <https://www.flickr.com/photos/martinrp/405687745>, accessed on 19 October 2023.

Reflection seemed like a new output of glass that withdrew some of the main characteristics of transparency. Not only did it stop the connection between the outside and the inside from the outsiders' position, but it also completed the scenery of the existing context and concealed what was supposed to be unveiled. At that moment, the building's glass façade gave a message negating what was expected from it through a slight alteration in the material used.

Hans Hollein, another key figure in Postmodern architecture, tried to free himself and his Haas House from imposing historical references on the building, a typical characteristic of Postmodern architecture [16]. Instead, he used a mirrored glass façade to reflect the context of historical churches and traditional buildings (Figure 2), thus enhancing the connection between the building and its surroundings. He purposely used the reflection characteristic of glass as an architectural concept in designing his building.

In deconstructive architecture, metallic claddings were a prominent feature that enhanced the iconic characteristics of buildings. Despite this, reflectivity was not considered a main design concept feature. In the Guggenheim Museum in Bilbao (1997) and The Walt Disney Concert Hall in California (2003), designed by the star architect Frank Gehry, metal cladding panels, and the curves of the façade, brought dynamic colors to the buildings by reflecting their ambient conditions, and thus changing how they looked from day to night [17]. However, the panels were not completely reflective and were not intended for reflection, either in their materials or concepts.



Figure 2. Reflections on the Haas House, Hans Hollein, Vienna, Austria, 1990, Source: https://commons.wikimedia.org/wiki/File:Hass-Haus_%2834756764442%29.jpg, accessed on 19 October 2023.

2.2. Implication of Glass from Transparency to Reflection

Many architectural texts have discussed the relationship between the intentions of architects in using transparency in their designs and the outcomes that are perceived by the people. Transparency is linked to openness, purity, spatial continuity, seeing what is behind, and layering of both hidden and visible elements, whether literally or symbolically. Many classifications were set to types of transparency or their outcome products. The most seminal was by Rowe and Slutzky (1956), who defined transparency as phenomenal and literal, as the physical quality of a substance. Shimmel stated that their papers were ‘...influential in shifting the interpretation of transparency’ [18]. Another classification was performed by Adrian Lo, who divided transparency into perceptual and conceptual [19]. Herzog in his ‘Treacherous Transparencies’ analyzed transparency as conveyed in architecture and art, trying to understand the intentions and goals that motivated its use by architects and artists [20]. Brzezicki explored conceptual transparency in depth and declared that some transparent architectures were not intended to be transparent. He saw that supplementary effects made to glass such as printing, fritting, and tinting through glazing technology took transparency down a more obscure path [21].

In contemporary architecture, the development of glass materials, technology, and installation techniques has pushed the boundaries of transparency. New versions of glass address its two major defects, loss of privacy and massive heat stress. Voronkova emphasized the significance of making the right decision about the glass used for glass façades; she stated that the decision should be made at the building design stage [22] to optimize thermal efficiency, control ventilation, offer noise insulation, and enhance visual comfort. Glass type, size, scale, color, and design have become crucial elements in the aesthetic success of buildings. Smart glass has dominated architectural glass designs, allowing the user full control to choose the degree of opaqueness he desires according to his mood or needs. Brzezicki discussed new ideas such as inviting the observer to the ‘game of guessing’ by using translucent glass [21]. This is achieved by preventing the whole picture from reaching the viewer, allowing his own interpretation and speculations, and replacing the clarity and openness of transparent glass.

In parallel, using intentional pure reflection in the architectural façades of buildings began to appear as a new conceptual phenomenon in architectural design. Although reflection is one of the outputs of glass, similar to transparency, it has different implications, especially when it is intended by the architect. Previously, both effects of glass coexisted side by side: transparency was intentional, and reflection was the collateral effect. Now, transparency fades, and pure reflection stands out. Transparency and reflection could be viewed as two contradictory, but complementary, traits. Transparent glass can mirror the surroundings while allowing a viewer to see through it, but glass mirrors only reflect

their surroundings and do not reveal what is behind them. In glass, opacity decreases to zero for transparency and increases to reach its maximum for reflection. Distorted superimposed views of an interior can be seen depending on the position of the viewer and according to the physical characteristics of the glass façade. The same occurs with mirrored façades, but the views are of the surroundings, and the virtual images are created depending on the degree of reflectivity of the glass. Transparency shows with honesty, but reflection hides with illusion. Transparency implies lightness, revelation, and mobility, but reflection suggests heaviness, obscurity, and steadiness. Both have dynamic effects, as they show or reflect the motion behind or in front of the glass, giving a sense of continuity and blurring the borders between the interior and the exterior. Transparent glass façades target the interior users, connecting the interior space and the surroundings, or sharing the experience inside with the passersby. On the other hand, mirrored façades aim to blend the building's mass with its surroundings for the passerby's interactive experience.

In the Merriam-Webster dictionary, 'reflection' is defined as the return of light or sound waves from a surface or giving back the image by a reflecting surface. Architects developed their practice when designing contemporary buildings: first, using simple glass or smoked-glass walls with a natural reflective effect and, later, using claddings with the intention of developing reflectivity as part of the façade's conceptual design. Reflected glass, back-painted glass, metal sheets or panels, polished stainless steel or polished aluminum or composite, high-gloss paint, and reflective ceramic panels are all options that give a reflective effect to the building through the façade cladding material [23]. These materials could be polished, perforated, and/or textured to change their level of reflectivity and the degree of picture purity. All materials used for an intended reflection effect must have a glossy feature: as Fleming et al. affirm '...specular reflections lead to complex image' and variation occurs due to the change in form of the surface or the amount of light falling on it [24]. Anderson added that the images reflected by surfaces could be visually perceived as superimposed on each other, blurred, or even distorted, depending on the geometry of the reflecting surface [25] or/and the position of the viewer.

Aesthetically, mirrors in façades change boundaries, stand out, and make a statement. They attract passersby and turn buildings into icons in the urban context, contributing to place-making. A sculpture with a reflective surface standing in Millennium Park in Chicago has marked the neighborhood. Its form and effect were inspired by a liquid mercury drop, and its shiny exterior reflects the people, the activity, the skyline, and the greenery surrounding it. This sculpture invites people to interact with its mirror skin, seeing themselves from different angles and capturing a moment with their images reflected along with the surrounding context, with some deformations in the proportions due to the oval-like shape of the form (Figure 3).

On the other hand, Sen and Khazanovich asserted that reflective façades can raise urban air temperatures by deflecting sunlight onto nearby objects and pedestrians; this also increases cooling energy demands [26]. According to Ishak et al., reflective façades indirectly contribute to the problem of urban heat islands by reducing outdoor thermal comfort, producing undesired glare, and creating a rise in global warming [27]. Mehaoued and Lartigue concurred with this, stating that employing reflecting façades in hot areas has a significant thermal influence on raising the temperature of the atmosphere and the energy required for cooling [28]. Consequently, even though reflecting façades might lessen heat transmission within the building and aid in lowering inside temperatures, their negative environmental effects still exist. Fortunately, numerous technical approaches [29,30] have recently been developed to address these problems including adding reflective coating films and new sources of reflective materials.



Figure 3. Different reflected views, The Cloud Gate, Anish Kapoor, Chicago, IL, USA, 2006, source: <https://www.flickr.com/photos/warriorwoman531/5551208249>, accessed on 19 October 2023.

3. Aim and Methodology

3.1. Aim of the Study

During the twentieth century, glass and its transparency were a main focus of many theoretical and critical architectural essays. The topics to be discussed, appraised, or rejected by critics centered on the meanings of what appeared from behind the glass façades. On the other hand, reflection received less attention. It was the already-there subsidiary trait that accompanied transparency, without any real intention by the architect to frame it as a unique feature that deserved its own share of critical analysis. More recently, however, this has changed: reflection has become a target intended by the architect to convey certain implications to the viewers and bestow character on a building. Reflection has turned into a symbolic tool that gives more value to the architecture of the building, rather than just a cladding technique. This paper aims to fill this theoretical gap by exploring the intentions of architects when using reflective façades in their buildings, and the conceptual and aesthetical implications they intend to be perceived by viewers.

3.2. Methodology of Research

To achieve this aim, over thirty different buildings with reflective façades were considered. These buildings were then filtered according to specific criteria to identify a total of ten for use as explanatory and representative models in this paper. The criteria included variations in location, context, function, mass volume and form, and architect. Construction of all ten buildings was completed during the last decade, so none was under construction or a paper project. The most important criterion was the intentional use of a reflective façade as a conceptual design idea and not as an outcome of using a reflective cladding material. Towers and skyscrapers were not included in the study because these do not meet the criteria for using intended reflecting façades; nor do they directly affect the context or contact with people because of their height.

The researchers adopted the thematic analysis approach; this is a method for ‘identifying and analyzing patterns in qualitative data’ [31]. Texts written about the selected buildings, whether by their architects or critics, were the source of the qualitative data. The data were analyzed, and the main keywords were extracted, reviewed, coded, and categorized in an inductive framework that interprets the features and implications of using reflective façades in architecture.

Table 1 outlines the chosen buildings and their architects’ explanations. Keywords were extracted from the architects’ statements and then coded under major ‘umbrella’ themes; this enabled us to answer the question of why architects used reflective façades in their buildings.

Table 1. Thematic analysis of buildings with reflective façades, by researchers.

Figure Number	Title of Building, Architect, Location, and Year of Construction	Explanation	Main Themes
1-Figure 4.	Mirrorcube Tree Hotel, Tham and Videgård Arkitekter, Sweden, 2010	<p>The Tree Hotel is a $4 \times 4 \times 4$ m cabin fixed on a tree trunk, covered by highly reflective glass to ‘merge with the surroundings’ and conceal the cabin among treetops, creating a ‘camouflaged’ space [32] as shown in (Figure 4).</p> <p>Transparent ultraviolet color, only visible to birds, is laminated onto the glass panes to stop birds from crashing into it [33]. This simple structure in the form of a mirror cube is an example of ‘disappearing architecture’ as it merges with the surroundings.</p>	<div>Disappearing architecture</div> <div>Merge with the surroundings</div> <div>Camouflage</div>
2-Figure 5.	The Museum of Contemporary Art, Farashid Moussavi Architecture, USA, 2011	<p>According to the architect’s description, the museum is a six-sided structure with mirror stainless-steel skin that ‘reflects the surroundings’ as shown in (Figure 5). The building ‘alters its look’ according to the viewer’s location and angle of light [34]. He continued by saying that ‘multiple perspectives’ of the museum are possible thanks to the building’s ‘geometry, form, and reflective/absorptive surfaces.’ The facets communicate with the surroundings, and the face, including the entrance, is covered in transparent glass to connect with the public plaza in front of it. The other facets have patterned stainless steel, creating a variety of ‘illusionary’ blurred pictures. The inclined six facets constantly give multiple perceptions to the viewers as if it is in a ‘continuous dialogue with the passersby’ [34].</p>	<div>Reflects the surroundings.</div> <div>Illusion</div> <div>Multiple perceptions</div> <div>Dynamic appearance</div> <div>Continuous dialogue with the passersby</div>
3-Figure 6.	Cairns Botanic Gardens Visitors Centre, Charles Wright Architects, Australia, 2011	<p>The city council wanted a building that would ‘blend seamlessly into the surroundings’ [35]. This meant having it as invisible architecture. The Cairns Botanic Garden Visitors Center was the output (Figure 6). ‘We proposed a design which literally reflects the gardens as camouflage for the building,’ explained the architect [36]. He described it as having a ‘visual effect’ [35]. The architect used expressions such as ‘blending seamlessly’, which means (merging with the surrounding), and he said that the building has a ‘visual effect’, meaning that it will give an (illusion) effect. The exteriors are covered with shiny panels, each reflecting the images at a different angle, activating the ‘pedestrian promenade’ and linking the gardens with the art center inside [35].</p>	<div>Illusion</div> <div>Visual effect</div> <div>Camouflage</div>

Table 1. Cont.

Figure Number	Title of Building, Architect, Location, and Year of Construction	Explanation	Main Themes
4-Figure 7.	House, WZ/Bernd Zimmermann Architects, Germany, 2013	To renovate a house without changing its proportions, the architect chose to cover it all with reflective stainless-steel panels to ‘reflect the surroundings’, wanting the house to ‘dematerialize’ [37]. The panels are textured to ‘distort reality’ in their reflections and to provide an ‘ever-changing display’ of the weather and the surroundings with little ‘illusion’ (Figure 7). The intended dematerialization of the building means the building’s ‘disappearance’ and thus its adaptation to blend with whatever context surrounds it.	<div>Dematerializes</div> <div>Reflects the surroundings.</div> <div>Dynamic appearance</div> <div>Distorts reality</div>
5-Figure 8.	Mirrors Cafe in Gifu, Japan, Hisanori Ban, 2014	An L-shape café with ninety-degree angled façades ‘reflecting the surrounding’ trees as well as the smaller tree it embraces (Figure 8). This form of reflection, intentionally made by the architect, creates the ‘illusion’ of increasing the number of trees surrounding the café, creating a forest [38]. The game in fixing the mirrors perpendicular to each other is that the real and ‘reflected scenery can be seen simultaneously’.	<div>Catching simultaneous views.</div> <div>Illusion</div> <div>Reflects the surroundings.</div>
6-Figure 9.	Château de Renteilly-Frac Ile-De. Exhibition, Bona-Lemercier, France, 2014	Trying to restore the Château De Renteilly-Frac Ile-de after losing its historical and location values, the architect chose to cover the façades with mirror-polished stainless steel that ‘reflects the greenery’ in the context to ‘add mystery and charm’ to the old pale building while maintaining its relationship with the surroundings [39,40]. The building stands as a crystal in its landscape with its multi-facets and different angles of reflection providing ‘different perceptions’ of the surroundings, emphasizing the value of the building as a palace (Figure 9).	<div>Reflect and enhance the surroundings.</div> <div>Different perceptions</div> <div>Add mystery and charm.</div>
7-Figure 10.	New BNL headquarters, Atelier(s) Alfonso Femia, Italy, 2017	The building reflects the ‘dynamic character’ of the nearby trains, relating it to the context as a ‘reflection of reality’ [39]. Using the layered paneled mirrored façade, as shown in (Figure 10), the building develops ‘a dialogue with the surroundings’, giving a perception that is ‘dynamic’ and different meter after meter. It is ‘Dynamic, reflective and fading’, as if the building is ‘moving’ with the train [40].	<div>Dynamic</div> <div>Almost moving</div> <div>Develop a dialogue with the surrounding.</div>

Table 1. Cont.

Figure Number	Title of Building, Architect, Location, and Year of Construction	Explanation	Main Themes
8-Figure 11.	Maraya Concert Hall, Giò Forma and Black Engineering Studio, Al-Ula, KSA, 2019	<p>The word ‘Maraya’ is the Arabic word for ‘Mirrors’ (Figure 11). A huge, simple mirror cube designed specifically for the location, it is an example of ‘object architecture’ as stated by the architect [41].</p> <p>The building emphasizes the surroundings instead of competing with them. It is intended to be ‘invisible’, developing a ‘Land–Art architecture’, coining a new term that refers to the art of creating architecture that inspires its aesthetics from the land it stands on [42]. The building creates a ‘mirage-like impression’, as if in a dialogue with the adjacent rocky desert. The designer concluded that the mirrored façades render the building ‘more mysterious than obvious’ [42]. The cladding is a new, corrosion-resistant material, designed specifically for the project [43].</p>	<div>Invisible architecture</div> <div>Mysterious architecture</div> <div>Dialogue with the surroundings</div> <div>Mirage-like impression</div>
9-Figure 12.	Cube Berlin Smart Office Building, 3XN, Germany, 2020	<p>This sculptural, iconic building generates ‘moments of interaction with the city’ (Figure 12). Passersby are fascinated by the cube; they take pleasure in seeing their pictures in the glass mirrors. The designers intended to ‘animate’ the whole location and engage the square in a ‘dialogue’ with the surrounding landmarks of Berlin [44].</p> <p>Each side of the six faces of the building provides a changing perception of the surroundings, resulting in a ‘dynamic façade’ with a unique view from every angle [45].</p> <p>Due to the use of solar coatings on the outer layer of the double-glazed façade and a variety of technical solutions, such as energy capture from heat, the Cube Berlin’s façades are extremely energy efficient, enabling Cube Berlin to function as a highly energy-efficient glazed building [45].</p>	<div>Interaction/ dialogue with the city/ context.</div> <div>Dynamic facades</div> <div>Animate the location.</div>
10-Figure 13.	Depot Boijmans Van Beuningen Museum, MVRDV, Holland, 2021	<p>The depot in Rotterdam’s Museum Park offers its museum visitors a novel kind of experience (Figure 13). Its glass façade is divided into 1664 mirrored panels and reflects everything in its immediate surroundings, including people, the landscape, and the vibrant skyline. The reflection creates a ‘strong relationship with the surroundings’, making the museum ‘completely integrated’ into it [46].</p> <p>The mirrored-façade structure will ensure ‘visual merging into the surroundings’. The depot is a ‘vibrant work of art’, as it has a distinct appearance every day according to the weather, animating the location it is in [47].</p>	<div>Integration in the surroundings</div> <div>Blend with the surroundings</div> <div>Animate the location</div> <div>Vibrant work of art</div>



Figure 4. Shows the Mirrorcube in its context day view, Mirrorcube Tree Hotel, Tham and Videgård Arkitekter, Sweden, 2010. Source: <https://www.flickr.com/photos/detlefschobert/8947381762/>, accessed on 10 April 2023.



Figure 5. Multifaceted reflections on the six faces of the façades. The Museum of Contemporary Art, Farashid Moussavi Architecture USA, 2011. Source: By Erik Drost—Flickr: MOCA Cleveland, CC BY 2.0 https://en.wikipedia.org/wiki/Museum_of_Contemporary_Art_Cleveland#/media/File:MOCA_Cleveland.jpg, accessed on 10 April 2023.

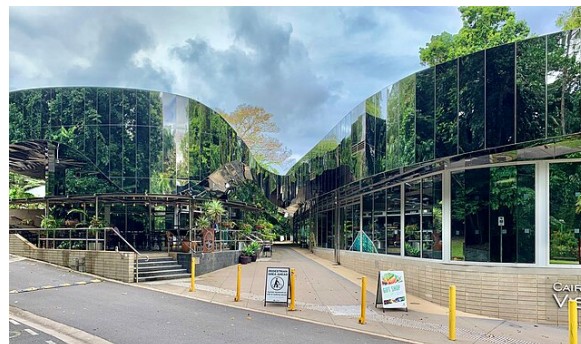


Figure 6. The mirror cladding panels dismiss the continuous views of the surrounding gardens, and the building's form stands out to be seen with different views from different angles. Cairns Botanic Gardens Visitors Centre, Charles Wright Architects, Australia, 2011. Source: Cairns_Botanic_Gardens_Visitor_Centre,_Queensland,_2020,_02.jpg (3967 × 2346) ([wikimedia.org](https://commons.wikimedia.org/wiki/File:Cairns_Botanic_Gardens_Visitor_Centre,_Queensland,_2020,_02.jpg)), accessed on 22 April 2023.



Figure 7. Textured stainless steel reflects a blurred picture of the surroundings that dynamically change according to position and time. House WZ/Bernd Zimmermann Architects, Germany, 2013. Source: Photography by Valentin Wormbs. <https://www.archdaily.com/496803/house-wz-bernd-zimmermann-architekten/534ca246c07a80f3510001ab-house-wz-bernd-zimmermann-architekten-photo>, accessed on 22 April 2023.



Figure 8. Polished stainless steel reflects the surroundings with glass windows showing the real exterior. Source: <https://www.ribenbang.com/1038252/>, accessed on 22 April 2023.



Figure 9. The cladding significantly enhances the surrounding environment. Source: <https://www.flickr.com/photos/129231073@N06/35524175562>, accessed on 20 April 2023.



Figure 10. The horizontality of the panels gives the impression of a moving building. Source: https://en.wikipedia.org/wiki/Banca_Nazionale_del_Lavoro#/media/File:Sede_BNL_Roma.jpg, accessed on 19 October 2023.



Figure 11. Maraya Concert Hall reflects the context and extends the horizon of the site. Source: https://ar.m.wikipedia.org/wiki/%D9%85%D9%84%D9%81:Al_Ula_9.jpg, accessed on 19 October 2023.

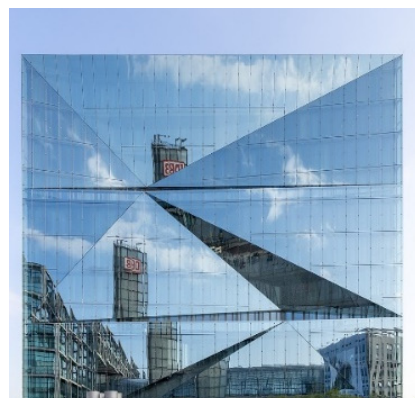


Figure 12. Different reflections from different angles and perspectives, Source: https://commons.wikimedia.org/wiki/File:Cube_berlin_%28Europacity%29_-msu-2021-3789-.jpg, accessed on 22 April 2023.



Figure 13. Dynamic façade for the Depot Boijmans Van Beuningen Museum, reflecting distorted images that change according to the surrounding environment. Source: https://commons.wikimedia.org/wiki/File:Rotterdam_depot_boijmans.jpg, accessed on 22 April 2023.

Table 1 above shows many themes that induced the architects' concepts when designing their buildings. The use of reflective façades was decided from the first stage of concept development and any other design decisions were taken accordingly to reinforce the main targeted concept. Evocation by the site or context and an unwillingness to perturb it, whether by hiding the building, by blending with the context, or by interacting with it, triggered the first spark in the idea of using reflective façades. Regardless of whether it is a mega structure or a small building, using a reflective façade works as a catalyst for social experiences between the building, passersby, and the context, animating the urban environment and contributing to the place-making of the site in which the building stands.

An example to illustrate the potential of having an architecture that respects its surroundings and enhances it is the Maraya Concert Hall in Saudi Arabia (Figure 11). The building's site is located near Alhegra, which is a UNESCO World Heritage-listed location and an archaeological attraction in the country. This site created a number of challenges for the architects as they did not want to compete with it. They concluded that 'Nothing visible should be built here, so if we really have to, it should be a silent mirror cube' [48]. The location, therefore, inspired the use of reflective façades, and the silence needed in the building inspired the pure cube form of the building (Figure 14).

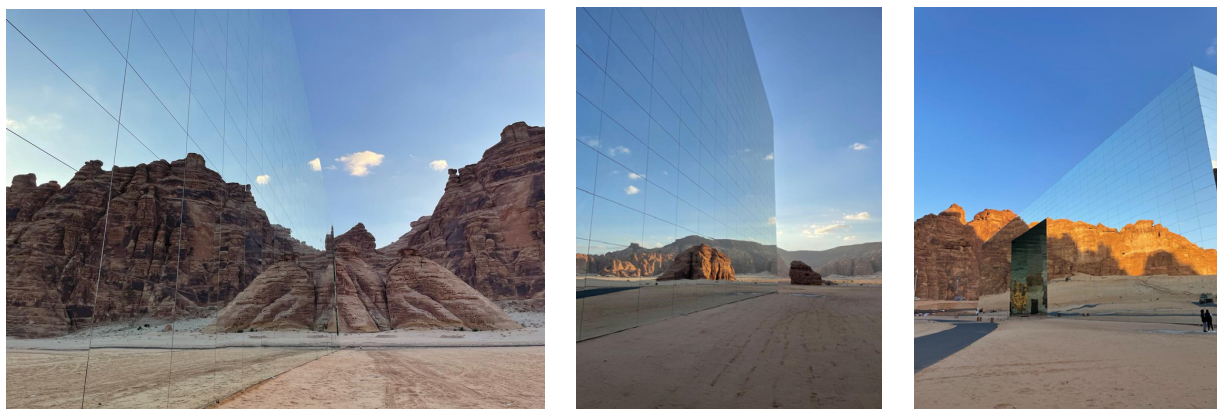


Figure 14. Different views show different reflections and illusions blending the building with the surroundings, Maraya, AlOula, Saudi Arabia. Source: Researchers.

Maraya won the 2020 Popular Choice Award for the Architizer A+ Awards after receiving the most public votes in its category: the structure shows the advances in the glass industry in solving how mirror and glass materials adapt to the harsh environment of the desert, hot weather, sand winds, and expected glare effects. For this reason, a specific

type of glass made from copper was developed and coated with a special substance that can resist heat and sand corrosion [48].

4. Results

Using reflective façades has evolved into a design strategy carrying various implications and significances, as shown in the previous examples of buildings with reflective façades. Architects use them as a central concept in their designs and, accordingly, different messages and impressions are transmitted to the beholders.

In general, reflective façades create a futuristic perception of their building, with minimal or abstract features, as the façades are settled with their reflective effect without interrupting it with any kind of ornamentation or artistic details. Conceptually, architecture with reflective façades can be categorized as either invisible or visible architecture (Figure 15). It is a core design decision that an architect makes at the beginning of his design journey and, accordingly, supports it with all the other choices. Architects try to hide their buildings, to avoid competing with nature or to integrate with the surroundings. In this case, architects use the vocabulary of pure simple forms with plain reflective surfaces covering them. The masses are mostly rectilinear to avoid distorting the reflected scene and to exhibit it as clearly as possible, as shown in Figures 4 and 11. Other architects want to reflect the surroundings and interact with them without hiding their buildings. In this case, their vocabulary is to use reflective panels with different angles and textures, as well as complex building masses and forms, which are considered more suitable for emphasizing the mass of the building under its reflecting skin, as shown in Figures 10, 12 and 13.

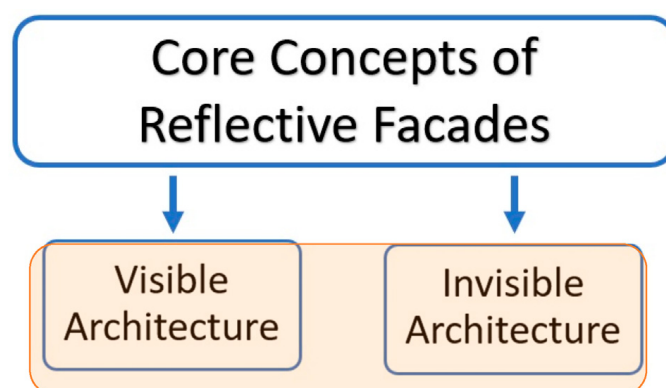


Figure 15. Architects’ core concepts of reflective façades. Source: Researcher.

Many approaches have been employed in attempts to comprehend the significance, both literal and symbolic, of employing reflecting façades. The implications extracted in this paper do not claim to be valid for all cases and are limited to the cases themselves; however, they work as an exploratory study, providing insights into what architects intend when they use reflective façades in their building design. The main literal motive for using mirrors as the outer skin of any building is to reflect the surroundings, but this is accompanied by various meaningful intentions. These intentions differ according to the context, the function of the building, and the building’s design. The architectural concept interferes significantly when these intentions are being formulated; consequently, the concept employs different languages and tools to transmit the implications that are intended to be perceived by the viewers. The form, orientation, glass type, and even the distance and height from which the building is perceived, have an impact on the perception it gives to the public. In the previous examples, the keywords extracted from the main intentions and perceptions of the architects were categorized under the three major themes of ‘Aesthetics of Disappearance’, ‘Games of Optical Illusions’, and ‘Mystery and Arousing Curiosity’. The implications could be radiated alone or collectively from the same building; this is shown in (Figure 16).

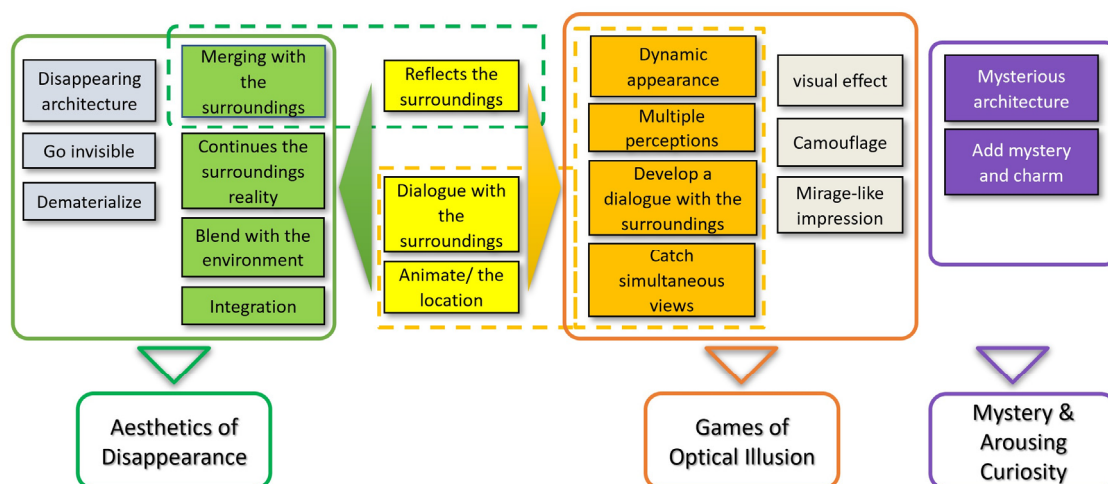


Figure 16. Analysis of keywords used by architects of buildings with reflective façade architecture. Source: Researcher.

4.1. Aesthetics of Disappearance

In these cases, architects create invisible buildings; this tends to dematerialize the structures to reach a sense of purity in the forms and materials, thus allowing them to blend harmoniously with their surroundings. This creates a sense of camouflage for a building to avoid interrupting the beauty of its surroundings, as shown in Figures 4, 6 and 11. The building fits within any context and disappears in favor of highlighting whatever is surrounding it. This invisible architecture blurs the boundaries between the natural and the man-made, maintaining the continuity and fluidity of urban life through its reflection.

4.2. Games of Optical Illusion

One of the main aims of using reflective surfaces on building façades is to invite the viewers to interact with the building, whether closely or from a distance. This interaction could be by watching the reflected views of the city, landscape, buildings, or the viewers themselves. It is similar to capturing a 360 moment with the whole area. The building's mass morphology, the type of technology used in the reflective surface, its color, and its texture all play important roles in the quality and shape of the reflection, as shown in Figures 3, 7, 8, 12 and 13. It might be blurred, distorted, or dramatically transformed, and the angles of reflection and the appearing images differ according to the location of the viewer. The buildings' façades are in continuous change, dynamically narrating the tales surrounding them, documented by time and weather conditions.

4.3. Mystery and Arousing Curiosity

Reflective façades promote the concept of curiosity and suspense by concealing the openings for all architectural spaces and abstracting the form to the level that makes beholders wonder what is inside. Most people will move toward the reflective façade not only to see their reflections but also because they are curious to know what is inside, as shown in Figures 5 and 9. Arrol Gellner states that 'an architectural space that's immediately comprehensible presents little challenge to the mind—it simply is not as interesting as a space that keeps us guessing' [49]. The fewer openings and alterations in the reflective façade, the more curiosity and mystery it surrounds itself with.

This is the main reason that a building with a reflective façade stands out as an iconic building in its context and attracts the minds of passersby before their physical bodies, challenging them to interact intellectually.

Architects, thus, use different languages to express the core concept of visible or invisible architecture to imply either the 'Aesthetics of Disappearance' or 'Play with Illusions', but in both cases, 'Mystery and Curiosity' are present in this reflective façade architecture,

as shown in (Figure 17). These three themes provide the connections needed to correspond with the extrinsic features of beautiful façades [50]. Reflective façades in buildings blend with the surroundings and continue the views, providing contextual connections. They interact with passersby, creating different perceptions according to the changing environmental conditions or daytime. In this way, they create connections with humans, triggering the viewers' minds and attracting their senses, compelling them to question what the reflective façades hide or stand for, thereby generating intellectual connections.

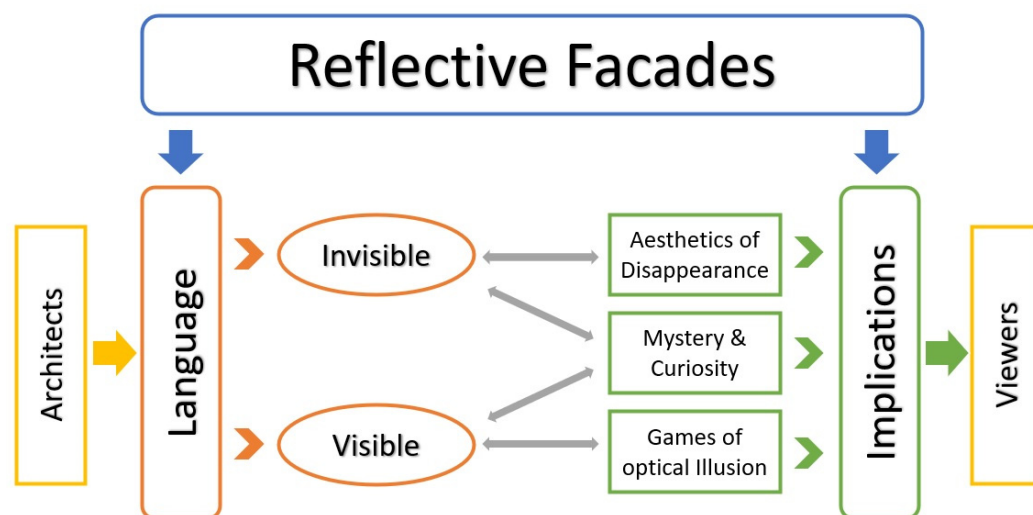


Figure 17. Languages used by architects in reflective architecture, and the intended implications to be perceived by the viewers. Source: Researchers.

The indicated themes need the buildings' vocabulary to be incorporated into their masses to deliver the designated messages. Disappearance requires muteness, no exaggerated mass to attract attention or engage sight, and no illusions caused by patterns on cladding materials. On the other hand, using textured or paneled reflective cladding surfaces installed at different angles and/or the building having a complex mass morphology will result in optical illusions that include layers of movement and events, as well as collages of nearby structures and locations, as shown in (Figure 18).

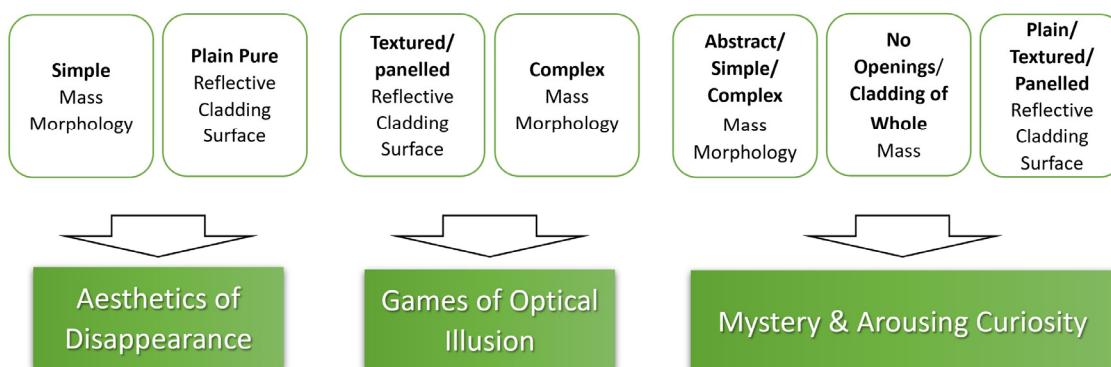


Figure 18. Vocabulary and languages used by architects in their reflective façades to convey their intended perceptions. Source: Researchers.

Addressing the viewers' minds and arousing their curiosity is a generic and representative feature of most buildings with reflective façades. Regardless of the building's mass morphology, the type of reflection panels used, and its assembly or display techniques, the architect hides the building's features and does not display their suggested function or expected design; in addition, the architect surprises the viewer by making him see himself

instead of seeing the building itself. All these unexpected emotions establish a connection that is rich in thought, imagination, and interaction between the building and the viewer.

5. Conclusions

In modern architecture, reflection was abandoned in favor of transparency as the defining feature of glass. Recently, contemporary architects have revisited the ability of reflection to convey certain perceptions as an intentional design decision rather than as the inevitable result of using glass. Each architect employs the type of reflective material that best expresses his intentions to convey certain perceptions to the beholders. Although transparency and reflection are two integrative properties of glass, the messages they convey are at odds with one another. Transparency implies lightness, mobility, and revelation, while reflection promotes heaviness, steadiness, and concealment. Intentionally employing reflection in a building transforms it into an icon, standing out like a shining gem capturing the complete environment on its surfaces. Additionally, it enriches urban life by providing visual attractiveness, and contributes to place-making, acting as an interactive element provoking an immediate response within the beholders.

Reflective façades in buildings have progressed from simply reflecting light or indicating the time of day to becoming a full documentation of their surroundings. Architects use reflective façades conceptually to produce either visible or invisible architecture. Pure, simple, rectilinear geometric masses act as absolute mirrors to reflect the surroundings clearly, while curved and complex façades usually cast distorted reflections of their surroundings, generating more multifaceted, layered, and diverse images. Architects elaborate more on their designs by choosing the type of reflective surfaces, their colors and textures, the angles of the reflective panels, and the technology of their assembly, in addition to the form of the mass of the building itself. These choices, whether individually or collectively, have different implications and impressions on the viewers.

In addition to their complete blending with nature, architects design buildings with reflective façades to impart different implications and messages to the viewers. These implications could be categorized under many themes, among which is appreciating the aesthetics of a building's disappearance. Another theme is experiencing games of optical illusion while watching the reflections of the surroundings in continuous dynamism according to the time of the day, weather, and location of the viewer. Creating a sense of mystery and curiosity is the third theme. The building's openings are concealed behind the reflective surface, which hardly ever indicates the building's purpose. The height of the mirrored-façade building and the angles from which it is perceived contribute to the dialogue between the trio of passersby, the building, and the context. Interacting with the building and context involves having the mirrored façade on the same level as the viewer, or at least having a vast empty area surrounding the building to allow reflection and its interactive perception.

Reflective materials produce high solar reflectance and high thermal emittance, reducing the air temperatures inside the built environment and decreasing its energy use; however, this increases the thermal load on the surroundings. If the use of reflective façades is not supervised, or limitation guidance on their usage and the purpose of their design/concept is not available, they will become a curse that can damage their beauty. Urban contexts will be transformed into heat-emitting mazes or a house of horrors that disturbs more than it attracts or interacts with the users. Specially coated films, together with new technologies in the reflective materials industry, are collaborative attempts to solve these thermal transfer problems.

Reflective façades have much potential that could realize architectural dreams of futuristic designs and visions. Reflective façades are invading new building typologies such as stadiums and even urban settlements, carrying new expressions of interaction, and futurism. The implications concluded in this paper will help architects to develop their ideas and open the doors for more innovation in this field, whether in materials or architectural concepts.

Author Contributions: All authors contributed to the study. The idea and methodology were decided by both authors. H.M.N.A. undertook data collection. Both authors analyzed the available data. Both authors contributed to writing the manuscript. Z.A.A.E.E. undertook the graphics. Both authors contributed to writing the Conclusion and the Discussion. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Conflicts of Interest: The authors declare no conflict of interest.

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