TU Delft

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Glass and the Presence of Nature

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Despite having become a ubiquitous material, the nature of glass continues to cause lively scientific discussion. The science is in contrast to the use of glass in the building industry and world of architecture, where, typically, only transparency is considered and any manipulation of the glass is deployed to improve the glass' performance as a cladding material. Through the discussion of a selection of JCDA's work, this paper will explore the potential for glass in architecture to be considered in a manner that includes its many undeveloped properties and its powerful potential for revealing the presence of nature in the expanding urban public realm.

Keywords: Glass, Nature, Phenomenon, Phenomena, Light, Material, Public Realm, Urban, Linear Lap, Curtain Wall, Volumetric

1. Introduction

It is interesting to note the relationship between the development of science and the exploration and manipulation of glass' properties and optics. Humans have been exploiting glass properties for over 2000 years through the development of obsidian tools, glass beads and vessels. One only has to think of the development of the lens and its use in the earliest telescopes in the late 16th Century to accept the deep connection between glass and the modern world's expanded view of our planet and universe. My own interest in this history is in the fact that glass has been both an aesthetic tool manipulating materiality and light, and a scientific tool expanding the exploration of the universe through the observation of light. In each case glass is closely related to the observation of nature as it is revealed through light. In essence glass has the capacity to reveal the information possessed by light, and this information is deeply connected to nature. Today, I think we can agree that attentiveness to nature is essential to our humanity.

1.1. Material/Immaterial

Though we think of glass mostly as a material, it can better be described as a state in which a material finds itself. Glass describes amorphous solids and resins in their glassy state (such as acrylic) as well as soda-lime glass, borosilicate glass or even sugar glass. Although scientists such as physicists studying granular materials or biologists studying polymer science are far better qualified to describe what 'glass' is, it is interesting to note that glass science is still in the process of describing and debating glass' very nature. Beyond the problems defining glass scientifically, I am interested in the simultaneity that glass possesses. It is a dense material with the ability to appear weightless and its mass is literally transparent, but once we understand the full range of optical properties found in glass - transparency, reflection, refraction and diffraction – it

becomes evident that glass has the potential to capture and represent many levels of light information simultaneously, and that this information can also be deployed across the depth of the glass. The projects I survey below, consistent with the overarching concerns of JCDA's practice, have in common an exploration of volumetric light. Because it straddles materiality and immateriality, glass has often been our material of choice due to its ability to expand and reveal itself within an interstitial space, a phenomenon I describe as volumetric light.

2. Beyond Transparency

2.1. Films

My origin as an artist working with glass and film is the foundation on which my practice has built its exploration of light in the public realm, both through public art works and architecture. In the 1970s I was producing film installations which transposed nature into the gallery. For example, Migration, 1975 [figure 1] involved fixing six 16mm synched cameras to a scaffold to simultaneously film segments over 18m of a tributary of the Puget Sound in Washington State, thereby capturing the passage of migrating salmon. The film installation in the gallery essentially switched the cameras with synched projectors thereby transposing the salmon's migratory behavior, at 100% scale, into the gallery. The cameras and projectors are an elaborate device reflecting nature into a purely human environment. However the use of cameras, film and projection bring the viewer's attention to the nature of light itself. The mysterious phenomenon of migrating salmon merges with the mysterious phenomenon of light in reflection and refraction. The light's interaction with the water allows for the simultaneous experience of information about the salmon, the body of water, the surface of the water and the sky. My work since then has sought to establish that sense of volumetric light, integrating it into the urban environment. Within this depth it is possible to capture and reveal the phenomenal information possessed by light. Glass, like water is a powerful medium to interact with light and due to its ubiquitous use, glass has the potential to give dense urban environments a deeper connection with nature.

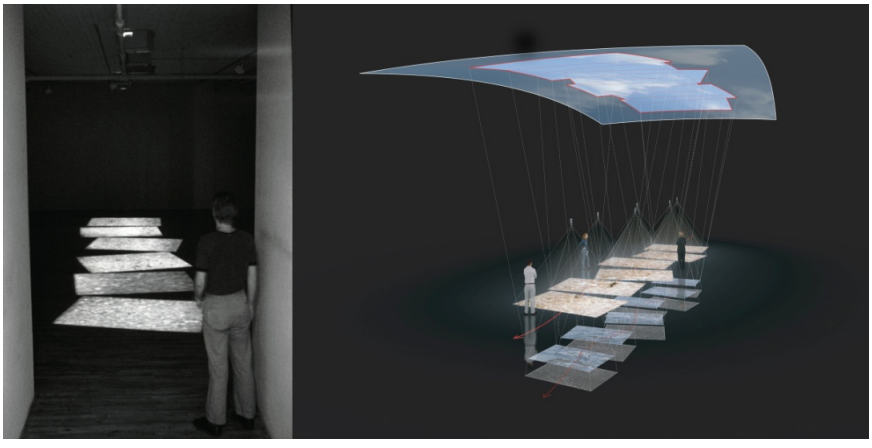


Figure 1a, b: "Migration" film installation created in 1978; rendering deconstructing the installation's operations.

3. Glass as an Optical Device

The projects outlined in this section are more intimately scaled and focus on the interstices between personal space, public space and nature. They can be directly related to the Films. The films' elaborate process to transpose nature into the controlled space of the gallery, involved scaffolds, 16mm cameras, film editing, synching and projectors. In the following projects the transposition is achieved by the creation of an assembly that is able to synthesize nature through its very design. Instead of organizing light within the fixed medium of film, glass becomes the essential medium that fluidly captures light and reveals the dense information that connects us directly to nature.

3.1. Retracting Screen

This private residence, designed by Richard Meier and Partners, included a gallery space for the display of the client's extensive collection of modern art objects. The dining room was conceived as a flexible space adjoining this that could act as a buffet area in the event of a reception in the gallery. It was suggested by the architect that JCDA propose a design for a glass screen between the two spaces. To achieve the desired flexible use of the space, the screen was to be lowered into the floor at the push of a button. [figure 2]

Figure 2: view from the gallery of the “Retracting Screen” as it descends into the floor.

The concept for the screen grew from the variety of light conditions in the spaces surrounding the screen. The bright lighting on the art objects in the gallery [figure 3a], the subtle light of a private environment [figure 3b], and the daylight playing in different ways on either side of the screen led to the idea of a mutable and dynamically responsive surface.

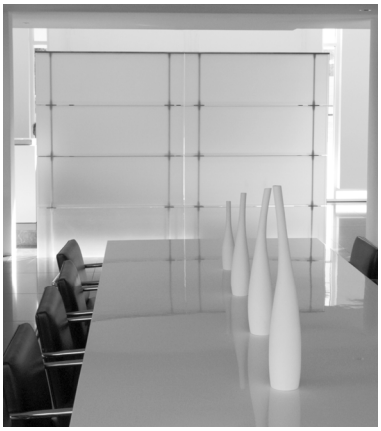
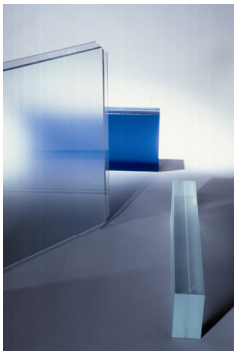


Figure 3a, b: View from the gallery (a) and from the dining room (b).

The screen was seen not only as a space divider but also as a conveyor of reflected and transmitted images. A simple observation in the studio [figure 4a, 4b] of the superimposition of glass with a subtle colorless reflective coating, and acid-etched glass, grew into the concept of a screen made of two separate layers of glass. One surface is entirely about absorption and scattering of light with no potential for reflection while the opposing surface has a heightened degree of reflectivity through the use of a coating typically used on glass for displays and lenses. The tension between the crisp, subtle reflection in the coated glass, and the outline of objects beyond the screen blurred by the acid etched glass, became the subject of a careful exploration of the integration of material, structure and light. The acid etched glass sheet faces the dining area to catch the low lighting and the coated glass would face the gallery to reflect the illuminated objects in the gallery.

The early glass studies [figure 4a, b, c] explored the possible choices of laminated glass that could exploit the variable light conditions of the space and the capacity to embody the entire space even as that space would be divided and obscured by the screen. By exploring the relationship between the glass surfaces, the body of the glass and the use of interlayers and coatings on each plane of laminated glass we established the powerful expression of volumetric light where the depth of the complete assembly could simultaneously capture and reveal light information from throughout the space [figure 6]. Essential to achieving this apparently simple juxtaposition of reflectivity and diffusion was the minimal structure beyond that of the glass itself. The laminated panels are on either side of central stainless steel rods [figure 5a, b, c] which keep the glass in position and compress it to a steel beam at the assembly's base and head for structural stability. The entire tensile structure rises up and down by a simple mechanized counterweight system. This integration of the screen's structure into the body of the glass itself adds a further sense of the device's capacity to sublimate its materiality and become a floating volume of light. The Retracting Screen, features an unusual combination of processes and materials. The level of optical subtlety, exacting structural demands and challenging installation was possible since JCDA could control every stage of the process, from design and engineering to installation.



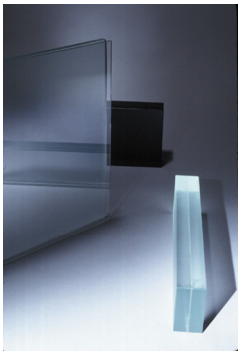


Figure 2: view from the gallery of the “Retracting Screen” as it descends into the floor.

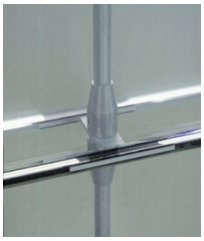


Figure 5a, b, c: details showing the center rods, glass connections, laminated panels and base beam.

Figure 6: view of the Retracting Screen from the gallery at night.

3.2. Periscope Window

The primary conceptual premise of the Periscope Window is to create a new paradigm for a 'window' by expanding the idea of how a 'view' could be represented. Here the glass is more closely associated with a window in that it is also a weather barrier separating the inside from the outside. However, the Periscope Window is still very much an optical device transforming your experience of that intersection between interior space and exterior space. The lenses are an obvious connection to film projection, but here the lenses' operation is broadened to go beyond re-presenting an optical image of a view. Through the use of lenses and diffused glass the 'view' of the outside is captured and layered within the depth of the assembly. As a device, the Periscope Window's simplicity belies its ability to assemble multiple visual fragments from various exterior vantage points into a synthesis of a window view. Depending on the conditions, you may see [figure 7] a blank surface, fragmentary projections, shadows, direct transmissions or any of these in combination. There is the powerful

cumulative effect of information abstracted from the outside world and experienced over the passage of time.

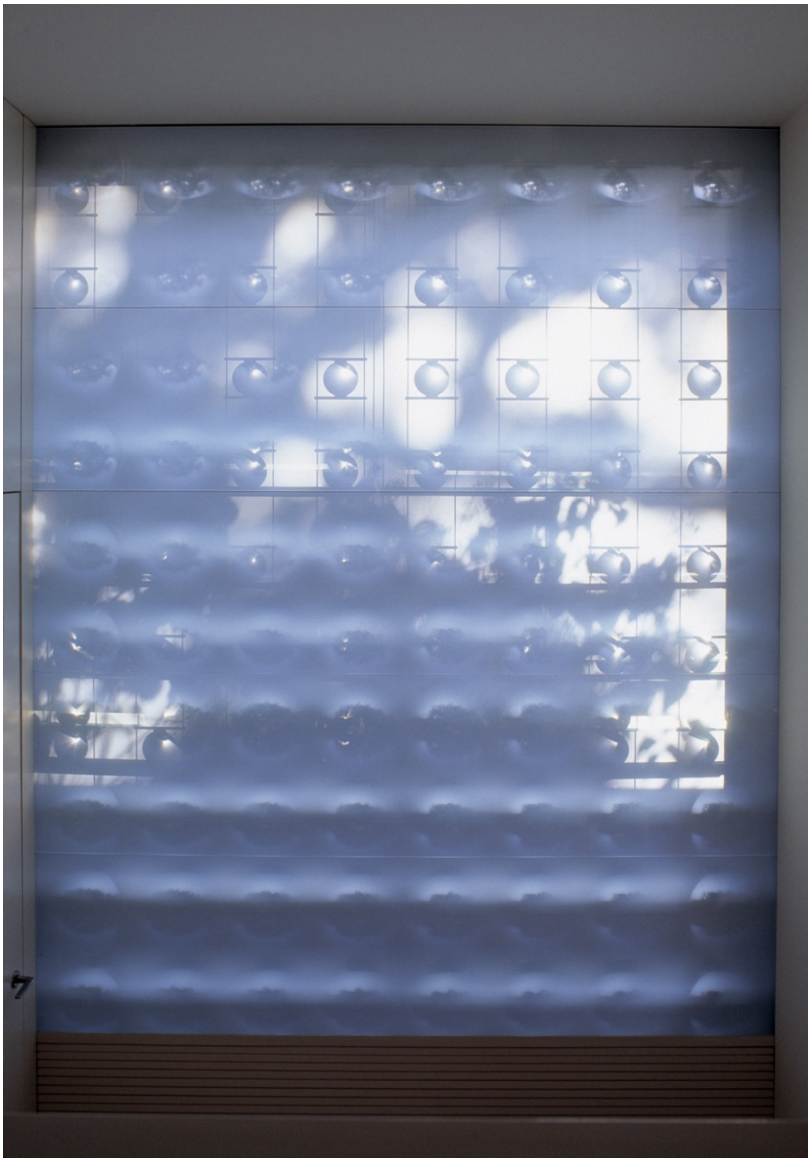


Figure 7: The Periscope Window seen presenting many types of projections, direct transmissions, cast shadows and diffusion.

Before the choice of lens and level of diffusion or the design of the assembly could be determined JCDA systematically calculated the diurnal and seasonal interaction of light within the site. In essence the idea of the 'view' was redefined as the experience of light and its innate information about the passage of diurnal and seasonal time. Located in the stairway of a residence in Minneapolis, the window redirects views from the exterior

onto a diffused glass screen through the use of mirrors and optical lenses. The window aperture faces the property line and a fence [figure 8] at eye level, with views of a tree and the sky above and beyond. Our goal was to emphasize and multiply views of the tree and sky while eliminating any direct views of the fence and neighboring house. The concept for the window is to synthesize a 'view' and re-present it as pure light rich with information. A window often establishes our relationship to the horizon but in this instance, the window is presenting a "view" and information from a different vantage point, expanding the understanding of the exterior environment. This is accomplished in a depth of 12" through the use of 80 glass lenses and 14 angled mirrors [figure 8, 9] suspended on tension rods behind specially treated laminated glass panels which act as the projection screen. Over the course of the day the device captures views collected from a high angle of the surrounding environment, activating the interior surface of the Periscope Window with constantly changing images, light, and shadow. To bring the high angle view of the sky and treetops down into the window plane, mirrors are utilized as a periscope. The optical lenses read the image off the mirror and optically resolve the sky/tree image on the interior lite's diffused glass.

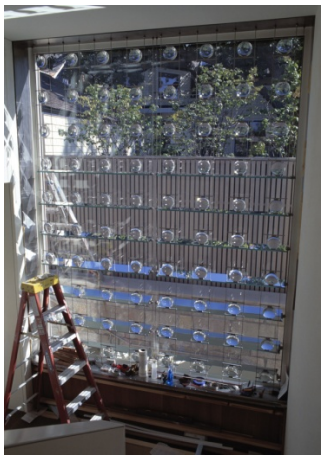


Figure 8: view of the window during installation.

Figure 9: the completed window seen from outside.

3.3. Structural Glass Prisms

The Structural Glass Prisms window was created for the Christian Theological Seminary's chapel. Despite being over twenty years old, this project is still deeply relevant to our practice and encapsulates the potential for glass to operate beyond its transparency. In this case the idea was to have the structure fully integrated into the glass, such that the standard 'view' visible through the window [figure 11] is simultaneously projected as prismatic light onto the walls and floor of the chapel.

The 32 foot high glass blades are stabilized with horizontal panels of dichroic glass, creating an all glass structure. Two reflected and two transmitted images are projected from each horizontal glass section, creating reflection and transmission patterns of remarkable complexity that change over the course of the day [figure 10]. The colors change as natural light moves into the room from the southeast before noon to mid-afternoon, tracking a subtle and complicated path through the space. Conceptually, the

window is an optical device that, not unlike a film projector, projects visual information into the room while still maintaining views much as in any conventional window [figure 11]. The images and movement of clouds and birds passing through the sky are directly projected into the space by the upward slanting bars of light. Simultaneously, wind movements of leaves from the adjacent trees are projected into the space by the downward slanting bars of blue light, thus creating a superimposition of landscape and sky. Of critical importance to one's reading of the phenomenon is the appearance and disappearance of the image based on the fluctuations of the sky brightness. The images move from invisible to a muted presence, to moments of crisp, intense legibility, connecting the viewer to the variables of the outside world.

Figure 10: The Structural Glass Prisms provide multiple simultaneous readings of light phenomena.

The simplicity of the Structural Glass Prisms' structure belies the complexity of light phenomena that it generates. Without the actual use of prisms, the grid-like arrangement of the glass and the use of dichroic glass affects light much in the way that a prism would. The reflectivity of glass and its ability to redirect and transmit light is made obvious by the horizontal laminated dichroic glass. As the sun arches west over the course of the day, the reflected and transmitted light create a shifting pattern on the wall and floor of the chapel.

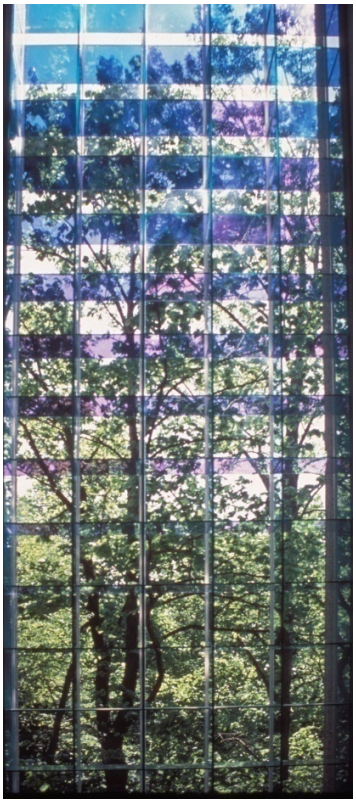


Figure 11: view through the Structural Glass Prisms.

The depth of the building wall defines the depth of the window [figure 12] and each cubic dimension of the grid. This rational geometry is then acted on by the arc of the sun's passage through the sky. The sun's arc is thereby expressed as the dynamic interaction between a natural and artificial geometry. In essence this device is a synthesis of a typical window, simultaneously presenting 'the view' and the phenomena associated with seeing that view.

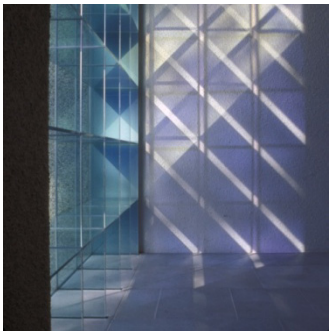


Figure 12: view of the depth of the structural glass wall. This depth matches the depth of the chapel's walls.

4. Light in the Public Realm

The whole technical development of JCDA's practice has been the result of the need for a clear and simple expression of light that supersedes structure. Be it a window or a building, the structure is considered as an integral element of the volumetric light we seek to reveal. By understanding the structural properties of glass and by developing working relationships across many professions and areas of expertise, it has been possible to scale up our approach and to design building skins and buildings themselves. The opportunity of working at larger scale has created new opportunities to consider light beyond daylighting within the building. As towers occupy airspace and essentially consume the public resource that is daylight, JCDA has applied its approach to the issue of light in the public realm. The challenge is less technical and more about determining the essence of a place. By working closely with manufacturers and engineers JCDA has successfully harnessed, brought together and refined existing technologies that further the goal of inserting a beautiful experience light in the public realm. This has been done by considering the physical depth of the building skin as also having the capacity to reveal a density of light information. This volumetric light can be harnessed to enrich the sense of light experienced in the surrounding environment.

4.1. 7 World Trade Center

With 7 World Trade Center, the curtain wall demanded an intense collaboration between all the parties and the curtain wall manufacturer. JCDA established the organizational principle that the new building must, in a very deep and meaningful way, embody the unique qualities of the light specific to Lower Manhattan. By the team working together from the beginning, the stated goal (to achieve a high performance, economical curtain wall while revealing light within the skin of the façade's depth) could be achieved. The refinements made on the 7 World Trade Center curtain wall have already been absorbed and pushed forward by other architects with the support of the industry. We arrived at our breakthrough design in response to the unique conditions found at the site. In order to capture the local light conditions, we wanted to disrupt the skin of the building and insert light into the interstitial volume that is the curtain wall assembly, thereby revealing an expanded and volumetric sense of light (figure 13).

Figure 13: the 7 World Trade Center curtain wall responding to the sky conditions.

David Childs of SOM has been a very supportive collaborator on many projects and he brought us in to participate on this project early on. At the time there wasn't a complete idea about the tower, but SOM knew that they wanted a solid base, defined by the transformers contained there, and that the base would somehow merge with the tower. They were looking at ideas, for example a slinky, where the metal base would be very dense and get thinner and thinner as it stretched up the building. The broadest influence we brought to the project was to conceive of the overall building as a structure able to luminously respond to its immediate environment. Both the local urban conditions and the particular quality of light downtown would be the organizing principal of the design. From that point on we worked on the principle of a volume of light where the glass curtain wall would act as a reflector and a subtle re-imaging device of its surroundings. When you look at the building you're made more aware of the quality of light happening at that moment.

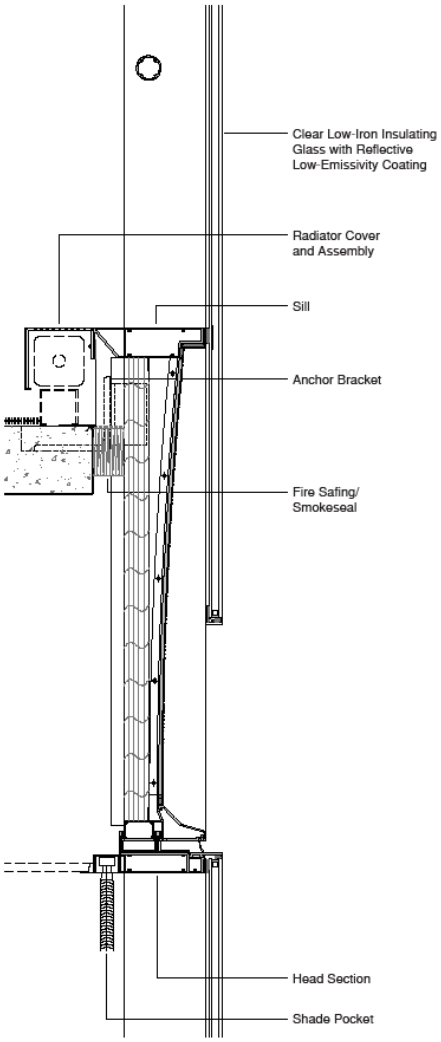


Figure 14: diagram of the 'linear lap' curtain wall assembly.

We did this both with an unconventional curtain wall and a unique skin for the base of the building. Instead of having the curtain wall interrupted at the floor plates, we allowed the glass unit to pass over the floor edge and terminate at the mid-point of the recessed spandrel, thereby defining the floors by revealing a void. Below the resulting floating portion of the 'linear lap' IGU, a reveal [Figure 14, 15] allows light to be inserted behind the curtain wall by means of a formed spandrel section. The spandrel section consists of an inclined blue reflector at the sill that reflects daylight up onto a vertically curved specular metal panel, which in turn projects the light out and down

through the backside of the floating section of the IGU. The result is that the tower's structure is embedded with light and merges with the sky.

Figure 15: view of the blue reflectors during installation.

Figure 16: the design of the curtain wall allowed for ease of installation. The units are laid out on dollies; an exterior crane lifts each unit out where it is rotated and secured to the building.

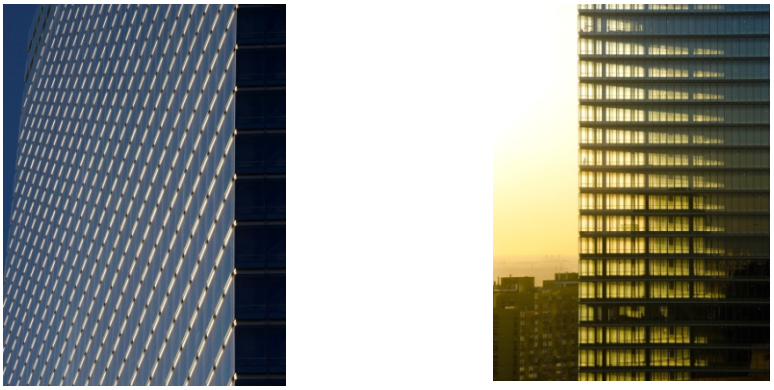


Figure 17a, b: view of the Linear Lap spandrels fully illuminated by daylight and view of the acute edge from the east as the sun sets.

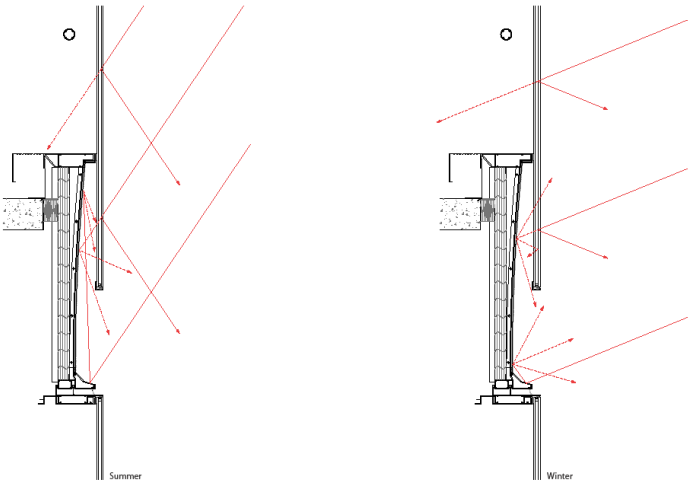


Figure 18: interaction of Linear Lap and summer and winter daylight conditions.

Direct and reflected sun off adjacent buildings and the sky dome brightness [figure 18, 19] creates both subtle and dynamic effects on the building's envelope as one moves through the city and from various points in proximity to the tower. Low-iron glass was selected to create the most transparent envelope possible. The acute vertical edges appear to de-materialize the towers silhouette from certain views making the building edges seemingly disappear into the sky [figure 17b].

Lower Manhattan's geographical and atmospheric conditions produce extraordinary light conditions, yet the narrow streets often deny access to the light both as a practical method of illumination and as an aesthetic experience of the phenomena. 7 World Trade Center reveals this light on its surface and redirects it into the public realm. Our projects strive to make people aware of nature – to reveal nature's presence and refute the assumption that humanity is divorced from nature. Glass is a means to reestablish those connections which are inevitably there but ignored.

5. Conclusion

For JCDA, challenging glass means readdressing why glass is worth using. What is it that makes it so exceptional? There are certain volumetric qualities of light and layers of meaning found in glass that mass production has factored out of the material. What does ‘quality’ in glass really mean? Most people simply believe that transparency is the ultimate goal for glass as a material, but this modernist construct is not adequate to impart the beauty and depth of our environment. The challenge is to give the glass the opportunity to communicate and immerse us in information about nature, even in the densest urban environment. Transparency is only one aspect of this possibility and when transparency is considered along with reflection, refraction, diffraction, diffusion and every other operation by which light can be observed, there is the possibility of transforming the experience of light in the public realm.

Figure 19: view of the 7 World Trade Center tower at dusk.