An Integrated Daylighting Design Process
Mary Guzowski, Professor, School of Architecture, University of Minnesota

ABSTRACT
This paper explores the daylighting design strategies, methods, and tools used by Brad Cloepfil of Allied Works Architecture at the Clyfford Still Museum in Denver, Colorado. The author interviewed Brad Cloepfil and Chelsea Grassinger of Allied Works and Christopher Rush of Arup New York to assess design intentions, strategies, processes, and the diverse daylighting design methods and tools used to integrate the poetic and practical dimensions of daylighting design. The case study reveals the diverse processes and methods used by the design team to work back and forth between exploratory methods such as drawing, diagramming and physical study models; performance based analysis and calculations; and spatial and atmospheric renderings and visualizations. Design processes, methods and tools that integrate qualitative and quantitative design issues are key to the successful realization of daylighting in architectural design.

INTRODUCTION
Daylighting design is complex, multi-faceted, and oftentimes messy and unpredictable. As Louis Kahn explained: “A great building, in my opinion, must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable (Twombly, 2003).” On the one hand, light is tangible, predictable, and quantifiable. The apparent movement of the sun can be precisely determined and luminous attributes can be analyzed using standardized metrics such as lux, candelas per square meter, and spatial daylight autonomy. Yet, the experience of natural light is often ephemeral and immeasurable, as Juhani Pallasmaa explains: “... the character of space calls for our entire embodied and existential sense, and it is perceived in a diffuse, peripheral and unconscious manner rather than through precise, focused and conscious observation (Pallasmaa, 2014).” There is a necessary element of intuition and experimentation required to discover the unanticipated and emergent qualities of natural light as it interacts in time with changing site forces and sky conditions, architectural form, and material properties.

The design processes for the Clyfford Still Museum in Denver Colorado by Allied Works Architecture are particularly illustrative of the diverse methods and tools used to explore, develop, and refine daylighting. In describing the museum as a “chapel to Clyfford Still,” architect Brad Cloepfil’s intentions were to effectively display and protect the artwork and to create a contemplative experience. Natural light was at the heart of the project. The author interviewed Brad Cloepfil and Chelsea Grassinger of Allied Works and Christopher Rush of Arup, which revealed the varied daylighting methods and tools that were used to achieve a delicate balance between the poetic intentions, practical goals, and the immeasurable and the measurable dimensions of daylight.

Immeasurable dimensions of daylighting design
At the site scale, early qualitative studies included charcoal and pastel sketches, diagrams, paper spatial models, wood and plaster massing models, and material experiments (Figures 1 and 2). Cloepfil explained: “I did this really early sketch; in fact it was one of my first sketches...
where I wanted light to penetrate deep into building. That’s what created those shafts and [to go] metaphorically deeper into Clyfford Still’s life (Cloepfil, 2015).” Grassinger elaborated: “Sketching is usually the first act. It’s a fluid and intuitive way of putting thoughts into visual form. Elemental insights are conveyed utilizing the physical and conceptual models. The more iterative, quick and messy models are seeking order, volumetric space, or various qualities of daylight. In parallel we are trying to find more tangible and literal ways to express the building experience (Grassinger, 2018).”

Cloepfil desired an experience that contrasted with the neighboring Denver Art Museum extension by Daniel Liebskind. To help accomplish this, a large plaster model was built to explore the connection to the earth, the play of light and shadow, and the experiential journey: “With Liebskind as such an expressed object, I wanted to de-objectify the Still. This is why we built the huge plaster model… You would walk through the dappled light of trees… And the thing would sort of dissolve in the patterns of light (Cloepfil, 2015).” Video and photographs of the plaster model revealed the qualities of space, as Grassinger explained: “We created a movie walking through this sequence… and still shots of the galleries. Achieving what we captured in the model images became our goal. We kept going back to those. This is what we were trying to design and build (Grassinger, 2018).” Grassinger clarified that early qualitative sketches and physical model studies were essential in exploring massing, spatial organization, materials, and luminous qualities: “Early tools provide a more poetic and elemental way to convey what we’re seeking and communicating to the client.”

Figure 1: Charcoal rendering in plan (left) pastel rendered section (center) and spatial studies (right). Source: Allied Works

Figure 2: Examples of wood concept models (top) and plaster studies (bottom). Source: Allied Works
At the gallery scale, Cloepfil and the team explored a variety of daylight strategies using qualitative renderings, drawings, and small physical models (Figure 3). Interior renderings using Rhino, Grasshopper, and Maxwell Render explored strategies and atmospheres in the gallery, as Cloepfil explains: “We did this one rendering using Maxwell lighting software that has that quality [of water]. I said if we could just get that sense of it, almost not being an obvious pattern, but a kind of ripple of light (Cloepfil, 2015).” At one point, Cloepfil did a sketch and asked the team how to create “light-emitting concrete?” “I wanted the light to come through and off the concrete and I wanted the ceiling to be perforated in some way. I wanted it to be like the concrete was emitting light through the ceiling. We tried it with the structural engineers and with the daylighting and it worked.” The appearance of a heavy concrete ceiling screen was transformed in density and weight through the ovoid openings and detailing to create a water-like quality of light. As though immersed in an underwater world with a dappled play of light on the surface, the direct sunlight is transformed and diffused by the translucent glazing, 7-foot (2.1 meter) lightwell, sectional details, and perforated concrete surface of the light-emitting ceiling.

![Figure 3: Examples of physical models (left), sections (center), and Maxwell renderings (right). Source: Allied Works](image)

Physical models and large scale mock-ups at ½” and 1” to the foot were constructed to study the galleries, ceiling, and wall detailing (Figure 4). Grassinger explained the integral role of models: “In our process we are committed to physical making to test the material quality and as a way of ensuring it is really conveying what we are pursuing. There are so many types of physical models that can help find insight into the design and the spatial and material experience that we can’t do with a [computer] screen or piece of paper (Grassinger, 2018).” Mock-ups allowed the design team to view the serendipitous interactions between the changing moods and character of light.
and real material attributes in ways that are oftentimes surprising and unpredictable: the shifting ambiance as a cloud passes over the sun, the visual warmth of morning light, or color of light reflected between surfaces.

![Image](image_url)

**Figure 4**: Example physical model studies: Interior plaster model (top); exterior plaster model (bottom); Source: Allied Works

**Measurable dimensions of daylighting design**

The intentions for the daylit galleries were to celebrate the changing character of natural light, create the desired atmospheric qualities, and obtain an appropriately uniform distribution of light and illuminance levels on the gallery walls. In addition to creating a sublime mood, the galleries needed to meet practical conservation requirements, as Grassinger clarified: “There was an experiential pursuit for the project but we were also working with tools that were much more precise to be sure what we were doing was working on the technical side (Grassinger, 2018).” Collaborations with Brian Stacy and Christopher Rush, daylighting engineers at Arup, helped the team meet the highest qualitative and quantitative standards for lighting performance.

The team used iterative physical and computer models and full-scale partial room mock-ups to refine and verify that the design was successful at meeting conservation goals (Figures 5-7). These included meeting a daylight exposure of less than 65,000 footcandle-hours per year (65 Kfc-h) while achieving a consistent 20 footcandle (215.2 lux) illuminance on the gallery walls at
a five foot (1.5 meter) height (Figures 5 and 6). The desired daylighting was achieved through a combination of diffuse toplighting, vertically screened and filtered sidelighting, borrowed indirect light from adjacent galleries, and supplemental electric lighting.

Figure 5: Examples of daylight analyses using Radiance software: daylight (left) electric (right). Source: Arup

Figure 6: Physical daylight model of gallery: exterior model (left) and interior (right). Source: Arup and Allied Works

Longtime collaborations with trusted engineers from Arup were essential in balancing poetic and practical intentions. Cloepfil emphasized that data is not an end in itself: “You have to trust your eye. [Arup] will give us the data and light ranges . . . and then I always push back. We might need more light or find ways of controlling and diffusing it. It’s a back and forth all the time between the data and what you want the experience to be. That’s why it’s nice working with Arup, they have worked on so many museums. We can talk about different museums and the quality of light and they know the light levels (Cloepfil, 2015).”

Cloepfil further emphasizes the importance of visual perception: “There are certain things your eye does that you have to take into account. That’s where the data really doesn’t work; because you look at the data and you have this range of light across the wall, but yet it’s not perceived. Here is this data, now what do we want to do with it? They understand that data is not an end, just a base to work from; it gives you a reference that you desperately need, but it’s not an end.”
Conclusions

The case study reveals three essential ingredients of an integrated approach to the daylighting design process:

1. **Use diverse methods and tools**: Qualitative and quantitative design methods and tools are essential throughout the design process and should be considered in early and later phases of design.
2. **Balance computational analyses with experiential models or renderings**: Atmospheric renderings or physical models complement the performance analyses and enrich the decision-making process.
3. **Employ physical mock-ups**: Hands-on construction of physical models and mock-ups at varied scales and levels of detail are invaluable in understanding the experiential dimensions of daylight and the realization of design intentions through the construction process.

By integrating diverse processes and tools, the design team engaged the technical and sensory potential of daylight as a dynamic building material. Working back and forth between both the qualitative and quantitative methods, tools, and data facilitated the translation of design intentions into built form, as Cloepfil explained: “Something magic happened there. There is design intention and then there is experiential phenomena. The experience is so much richer than we had even hoped… I have worked with the same daylight engineers for ten years at Arup. We have a language between us that is about the quest, the qualities that we’re looking for. The attempts are both from an analytical point of view that they [Arup] do and the leaps we have to make beyond analytics to try to find the quality (Cloepfil, 2015).” Grassinger clarified: “On the one hand you have charcoal sketches and concept models of rough wood core. On the other side are really technical and precise tools; 3D modeling and daylight testing using Rhino and Grasshopper with many iterations… All of the tools are fundamental in achieving what we did. Each serving a unique part of the process and search. Never would we do a project without utilizing each of these tools (Grassinger, 2018).” The Clyfford Still Museum reveals that the processes of discovery, experimentation, and serendipity are equally as important as is a rigorous analytical approach to the art and science of daylighting design.
ACKNOWLEDGEMENTS

The author gratefully acknowledges the contributions of Brad Cloepfil and Chelsea Grassinger of Allied Works Architects and Christopher Rush of Arup for their time and graphic materials.

REFERENCES


