REPRESENTING PERFORMANCE AND TRADE-OFFS WITH MARCEL BREUER'S VASSAR RESIDENCE HALL

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ABSTRACT: Donald Schon coined the notion of wicked problems that are too complex to be broken down into their component parts prior to offering solutions. He noted that wicked problems faced by large organizations and social structures have increased in light of technical advancements, and have been challenged by expertise in which knowledge is distributed among disparate individuals and institutions (Schon, 1987)

Architects utilize intuition and creative leaps fostering a notion of architect as genius, and a model in which architects provide leadership and orchestrate specialist consultants. Owner initiated pressures on budget and schedule, increased systems performance expectations has challenged this model while internationally recognized firms have come to rely on collaborations with engineering firms such as ARUP to provide sophisticated integrated designs. A gulf has formed between firms that can forge, afford, and manage these relationships, and those that cannot.

In the face of performance goals warranted by environmental and social needs, can architects as a group achieve emergent designs without relying on collaborations with elite engineering consultancies? If so, how can intuition be complemented increasing efficacy and performance? Opportunities for optimal solar and daylighting performance increase when performance factors are considered and buildings correspondingly shaped early in the design process but architects have limited time to validate design decisions before committing to actions.

Considering the importance of knowledge, a paucity of studies exist that validate how form has impacted the performance of modern architecture. More importantly, existing studies fail to acknowledge relationships and tradeoffs between different factors where value is added in design. This paper utilizes results from a study of a Marcel Breuer design for a college residential hall where tradeoffs between solar performance and composition are considered. The analysis expands on methods of analyzing seminal buildings that have been traditionally available, but do not provide sufficient perspective on building performance.

KEYWORDS: Performance, Knowledge, Representation, Analysis

INTRODUCTION

Building technology advances over the last couple of centuries have fostered faster growth of non-architect building design specialists including engineers and manufacturers who provide design-assist. Architects are challenged by demand for complex buildings and higher performance since verification of performance requires significant effort and cost. Evaluation of design outcomes is complicated by varied site conditions, programs, available technologies, and aesthetic traditions that warrant being considered. Many design outcomes such as views elude quantification and are intertwined with other actions.

In order to integrate design objectives with form, architects must identify design problems prior to, and after proposing solutions which require evaluation. Architects can gain assistance of non-architects with analyzing problems and forming solutions, but they have to recognize the importance of, and be able to integrate supplemental perspectives. Incorporating outside expertise early in the design process typically lies outside of budget expectations, and works against the highly personal nature of building design which is speculative and places a significand demand on intuition because building problems can't be exhaustively researched prior to action.

Intuitive problem identification by architects is complimented by rigorous analysis late in the design process when engineering systems design is solidified and performance benchmarks are verified. However, objective verification is typically implemented when it is too late to realistically integrate performance objectives into building form. For example, opportunity for optimal solar and daylighting performance increases when performance factors are considered, and buildings correspondingly shaped early in the design process. Digital tool are available to facilitate performance analysis, but the efficacy of these tools is limited by the knowledge available to frame problems and evaluate output.

This paper focuses on methods architects use to make decisions during the design process in light of the complex nature of the design process and limits on time, labor, and knowledge. Inherent in the process is consideration of alternate solutions requiring a weighing of the implications of particular solutions which ultimately lead to compromises as different proposals address underlying problems with different degrees of effectiveness. A dormitory designed by Marcel Breuer that includes ornamental shading projections is studied using digital representation technologies not available in 1950 when the building was designed to better understand the implications of design decisions. Central is the weighing of information normally processed intuitively, by integrating data and images in a manner that would be too tedious to factor in Breuer's time.

1.0 BACKGROUND

The subject building (Fig. 1) was featured in *Solar Control & Shading Devices* by Aladar and Victor Olgyay which was published in 1957, an era when energy was scarce and mechanical cooling had yet to be expected new institutional buildings. The Olgyays' overtly featured the energy impacts of shading devices but subtlety made the argument for the ornamental benefit of shading devices which would help justify their cost. (Olgyay & Olgyay, 1957) In this light, positive energy benefits of shading devices and their additional cost of are rationalized.

When the Olgyays' study was published in 1950's, the positive and negative impacts of light and views on building performance could be considered, but the energy impacts of artificial illumination could not accurately be framed in conjunction with shading devices and views, and are seldom recorded as prime drives of architectural form in institutional buildings. Prior to the development of analytical software, designers and evaluators had to perform arduous calculations to estimate heat gain and loss in a building, and even the most advanced techniques such as those advanced by the Olgyays' were crude compared to modern standards.

Part of the difficulty of linking daylighting performance to energy use includes tools available for complex calculations; another is reconciling science based outcomes with visual instruments, traditionally employed by architects. Until recently, most solar analysis was performed crudely, incorporating basic inputs such as solar path diagrams, climate data, and drawings. Use of shading diagrams for prototypical or specific site related conditions are more reliable than a similar analysis performed intuitively without the benefits of diagrams, but ultimately the output of daylighting, and more specifically energy analysis, is numerical.

Arduous analysis early in the design process, when it is most effective, has historically been difficult and expensive. Now digital simulations allow for observation of changes in basic daylighting performance and energy performance early in the design process permitting time to shape a building when it is least costly. Even with current digital tools, however evaluating images as well as data is challenged by a multitude of factors including diffusion of factors across different modes of representations. As a result, a designer has to mentally integrate the different forms of feedback. Although designers ultimately utilize intuition and personal judgment, objective feedback bolsters existing capabilities as opposed to displacing them altogether. Analysis tools do not make decisions for designers, nor do they capture nuanced design considerations that experienced designers can process.

2.0 ROLE OF INTUITION IN DESIGN

Proposing appropriate solutions in light of vague problems is one of the mysterious talents that architects develop and hone throughout a career. The process by which architects pose solutions is personal and can include inspiration from sources external to the stated problem. Speculative solutions that are ill suited to relevant problems are risky in a practice environment in which architects have to act quickly and address many complicated issues including code, budget and material constraints. Early process solutions lack detail reflecting considerations not easily extracted due to their lack of representation, requiring verbal or written supplement to satisfy lay individuals or skeptics. More realistic and detailed representations of a design come later after larger decisions have been committed to.

Fundamental early phase representations of proposals are not easy to evaluate testing the intuition of the designer although parameters can be checked against standards including codes. Because of the fundamental nature of early phase output, architects traditionally have critiqued work at this stage themselves with some input from clients to check solutions against their expectations. More objective informed feedback of design proposals has historically come at the later stages of the design process from engineers after the engineers have contributed enough information to the design to facilitate verification through calculations or more recently digital analysis. This analysis is particularly important to verify compliance with codes and performance benchmarks.

Reliance on intuition allows architects to cut through complex problems by honing in on problems they can identify readily and offering solutions unencumbered by incomplete knowledge of underlying problems. Although intuition is personal, it is highly dependent on a sufficient knowledge base to be effective. Without sufficient knowledge, an architect cannot recognize and isolate important problems that need to be addressed. Architects also gain knowledge about issues related to specific problems they are engaged with through a combination of analysis and reflection of represented solutions. (Lawson & Dorst, 2009) Project specific knowledge helps guide future design moves, and is bolstered by ability to contextualize knowledge.

According to Nobel Prize winning psychologist Daniel Kahneman, there are downsides to intuitive analysis that rest with two mindsets that drive human thinking. The two modes which are intuitive and analytical, do not operated simultaneously. The intuitive mind which functions quickly, operates without consciousness, and cannot perform computations. The analytical works much slower and requires more energy, is more objective, and less susceptible to deceiving itself. (Kahneman, 2016) The difficulty of reconciling intuitive and analytical thinking supports the notion that architects limit use of statistics because it cramps intuition. Kahneman advocates finding ways to make it easier to performing analytical functions while not dismissing the importance of intuition, a challenge central to architects ability to better understand and address complex problems.

2.1. Balancing Intuition and Information

Although architects cannot discard intuition completely and rely on machines or algorithms to address complex design problems, they can utilize computation to complement capabilities they already possess. One of the preconditions of including alternative methods of evaluating design during the design process is developing data that does not require an exceptional expenditure of energy to process. Similarly, part of the process of making this possible is increasing the reservoir of available perspectives on building performance through study of accessible forms of precedent. Historically this study has been static and limited in perspectives provided through traditional media such as plans, sections, elevations, and perspectives.

When evaluation of architecture involves environmental conditions, particularly solar, shading studies of elevations, sections, and plans are challenged by the changes that motion throughout the day and seasons renders on building performance. Most often when shading diagrams are developed, they are limited to key elevations where shading strategies are under consideration. This contributes to a problem of perspective across time. It also contributes to a problem of perspective of the actual impact of the sun toward heat gain, how insulation factors into performance, and how internal heat loads complement thermal gains.

Efforts to develop media that demonstrate effects of heat gain and loss in buildings has resulted in limited success. More often than not these diagrams involve superimposing heat flow arrows over building section drawings. Heat flow diagrams and shaded elevation and sections do not relate to local climate conditions that play a significant part in the effectiveness of passive and active building design strategies. Recently progress has been graphically grounding the building in a specific location/context by placing an aerial plan of the building under a sky dome with sun paths for the different seasons. Example includes site diagrams in *Learning from Modernism*, which included a shadow cast by the building. (Bone, 2014)

Limits to graphic feedback exist without numerical feedback and narrative. Numerical feedback is particularly pertinent to energy performance as measures for performance can be found in quantities of energy utilized and available light. Statistics can be compared to benchmarks or used as project specific reference points for changes in building performance difficult to capture with traditional graphics. Significant meaning can be derived from analyzing data and statistics, but data as a design tools has been largely limited, with the exception of dimensional criteria provided by clients or code.

The appeal of data has been tempered by the relative ease of reacting to drawings and models as opposed to numbers during the design process. When the final result is assessed visually, the value of data, no matter how significant is diminished. Visualizing data is particularly challenging because deriving meaning of the data is less suggestive of future design moves than review of design speculations. Ultimately data is not what is presented to clients as a final product. Architects also perceive as data constricting, preventing creativity, and inserting impersonal judgement. However, by using data for comparatively as opposed to against benchmarks, knowledge gained can contribute to creativity, optimization, and justification.

Figure 1: East façade of the Ferry Co-op Residence Hall. Source: (Author 2016)

3.0. THE BUILDING

The Ferry Cooperative is a residence hall (Fig. 1) which opened in 1951 at Vassar College in Poughkeepsie, a small city abutting the Hudson River approximately 80 miles north of New York City. Breuer adopted the concept of a bar elevated over a perpendicular bar from a design intended for a nurse's home at Long Beach Hospital, located on Long Island, which was never realized. (1) The 146 foot long elevated bar contains residence rooms flanking a double-loaded corridor with communal baths located near the center and a central stair connecting a lower mass perpendicular to the bar, housing communal space including a kitchen. The open area under the elevated bar that is not enclosed is not programed. The upper bar points due north and south resulting in bedroom windows oriented to the east and west.

Relief from the flat brick surfaces of the building is provided by a ribbon of window and wood laminated panels that run along the upper level, and a segmented corrugated metal canopy above the ribbon at the roof line. The canopy (Fig. 2) is the architectural point of interest for this study since it was featured in *Solar Control and Shading Devices*, and is an expressive element equating to ornament in older buildings. The lower level storefront window is set back on the south exposure and not on the south exposure demonstrating that Breuer was actively working to acknowledge the effects of the sun.

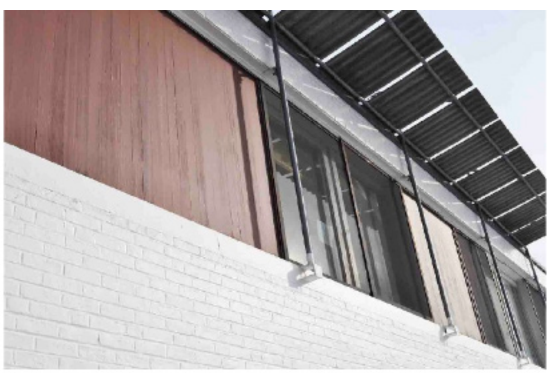

Figure 2: Awning detail. Source: (Author 2016)

The Ferry Co-op is significant as the first modern building on Vassar's campus and the fact that Marcel Breuer is one of the most accomplished and celebrated architects of the period tracing his history to the Bauhaus in Germany. Additional virtues of the building are its compactness and economy of material. Although it can be grouped with other buildings of the era reflecting a utilitarian aesthetic, the Ferry Co-op demonstrates, primarily with its ornament that modern buildings can reflect order, elegance and defy monotony.

4.0 DIGITAL MODELLING

A digital model (Fig. 3) of the building was created to serve as a basis for energy and daylighting analysis, as well analytical drawings. Fundamental building characteristics were modeled in Revit based on a survey of available construction documents produced by Breuer's office and a field visit made to verify exterior conditions which confirmed that the current building was consistent with original documents. Energy and daylighting analysis was performed in Safaira, a computer program that allows for rapid adjustments of building assembly properties providing opportunities to change material parameters and limiting model changes to building forms. As a result of the analysis process, material properties including insulation were specified in the analysis engine and not derived from the model. This also allowed for modeling to consider contemporary material standards and original material properties to be applied to the same model geometries. Fine details such as pipe rail used to stabilize the shading devices were omitted from the model.

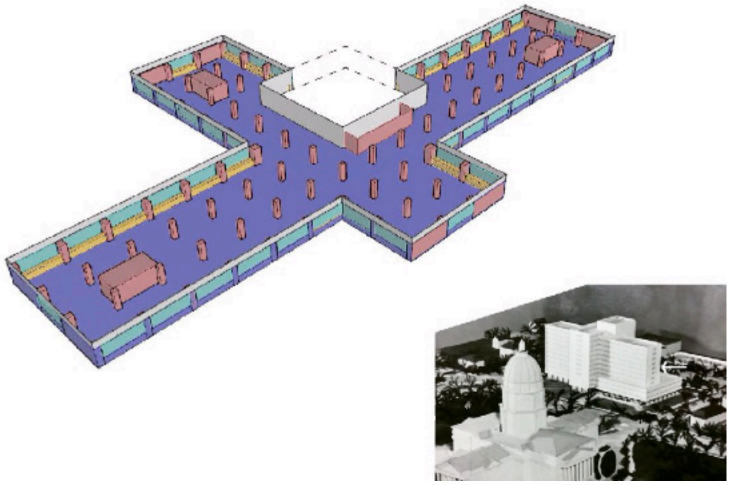

Figure 3: Revit Model. Source: (Author 2016)

4.1. Existing conditions vs. No shades
An initial analysis was performed to determine effectiveness of shading devices by comparing results run for the existing building with results with the shading devices removed. The primary purpose of the exercise was to determine how effective the shading devices are by measuring the difference between results. It was expected that the annual energy intensity of the building without shading devices would be greater without shading devices than with, but the feedback pointed to the shading devices having an adverse effect with respect to energy consumption with energy use being 0.17 percent higher with the shades vs. without. (Table 1) The first step confirmed that intuition can be misleading and that the original designers would not have had a fair chance of confirming the impact of shading devices with tools available around 1950.

With exhaustive analysis, the architect might have been able to anticipate points of excessive heat gain, but would not have been able to anticipate the heating potential of the sun as well, the impacts of the sun in the transitional seasons, and the effects of lighting. Poor performance of the shading device pointed to the northern location of the building which is heating dependent, has a very small cooling season, and is overcast for much of the heating season. Horizontal shades on the east and west sides of the building block sun that is desirable at the peak of spring and fall when the sun is still high enough to be impacted by horizontal projections on these elevations but heating is needed. Also, the horizontal projections have a continual negative impact on daylighting driving up electrical use. The initial feedback of poor sunshade performance opened up two paths for improving the performance of the building. One path involved changes in the shading devices and the other changing the aperture size.

4.2. Increased Glazing
Windows were added to the upper level east and west facades in different edits to the model to test if additional sunlight would reduce the energy intensity of the building. Tests for additional glazing did not result in improved energy performance with energy use increasing by 5.62 percent when opaque panels were replaced with glazing. (Table 1) Additional widows did result in increased daylighting autonomy to a factor of slightly over 2. The primary factor attributed to the reduced energy performance with additional glazing is that additional glazing on the east and west facades could not offset thermal loss in this climate. The primary benefit of additional glazing would be psychological which were benefits lying outside of factors considered for this study with the exception of the visual impacts of building form.

Shading adjustments were tested, including removing horizontal shading devices from one side of the building and adding vertical shading devices to the edges of the windows slightly interrupting the ribbon effect. Models with horizontal shading on the east, and west side only, showed distinct results, pointing to the heating effect of the sun during the transition seasons. Horizontal shading on the east side did not contribute to improved performance but the shading on the west did. Visual results of this feedback were factored into final recommendation for improvements in the building design. With the horizontal shading device on the east of the building proving a liability, vertical shading devices were tested on both the east and west sides of the top building mass. Deep vertical louvers also contributed to negative energy performance and were shortened until an 8 inch projection from the face of the building provided positive energy results. (Table 1)

Table 1: Table of energy use for different design scenarios. Source: (Author 2017)

Model	EUI [annual] Contemporary insul. standards	Existing insul.
Existing condition	716,865	952,795
No shading	715,745	951,204
Existing added glazing	749,023	1,006,307
Vertical shading east and west	715,382	950,525
Horiz. shading west, vert. east	716,347	951,871

5.0 REPRESENTING DAYLIGHTING

Interest in the potentials of the sun to illuminate building interiors has increased with focus of the downsides of over reliance on artificial lighting, which includes heat-gain across the seasons. The shortest dimension across early modern buildings such as the Ferry Co-op Residence Hall were narrower than buildings built after central cooling systems became typical eliminating the need for operable windows and cross ventilation. These planning ramifications, features of a building that would support natural ventilation and their operational benefits are difficult to recognize with typical architectural representations. The clearest way to represent the impact of daylighting for a building is to utilize a metrics such as *Daylight Autonomy*.

Although performance metrics are gaining currency with architects, their fundamental numerical nature makes them difficult to reconcile with traditional graphics. As a result visualizations have become an important complement to the statistics allowing the mathematical representation of building factors to be understood against plan and section drawings. Most of these representations involve gradients applied over building plans or sections. The Ferry Co-op Revit model was used to generate a gradient plan in Sefaira for existing and modified schemes. Graphic and numerical output did not register notable changes in daylighting with the exception for the schemes in which additional glazing was added resulting increased energy use.

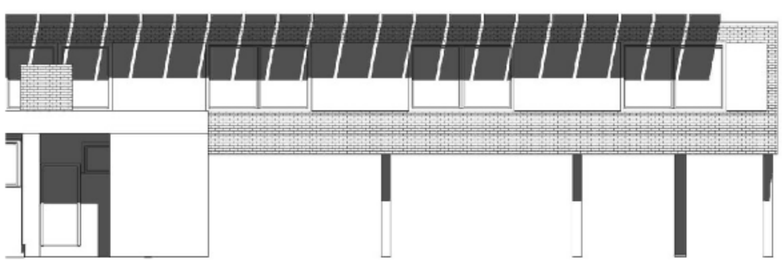

Figure 4: Detail elevation from east with vertical shading at 11:30 am summer solstice. Source: (Author 2016)

5.1. Visualizing Shading

Shading studies superimposed on elevations and perspectives has been part of the tradition of architectural representation with use dependent on the particular styles of the period. In the early years of solar design, physical models were also commonly used to simulate natural conditions and gain feedback on design proposals. With the emergence of digital modeling, simulation involving varied solar conditions can occur without building a physical model, permitting economic comparison of design alternative. Computer generated shading studies also benefit from comparison to data incorporating contextual information relating shading strategies to performance implications.

Graphic visualizations also support design that factors in the shading implications from an aesthetic perspective, something for which Breuer is noted. For purposes of this study shading across the major facades were studied to better comprehend the effects of the sun on the building geometry and to evaluate the visual interest of shading. The Revit model was used to generate shading studies for all elevations (north, south, east and west) at the major seasonal high points at three times throughout the day. Visual comparisons of the same elevation across time provided grounded feedback on what the shading devices were doing and the impact of resultant shadows. (Fig. 4)

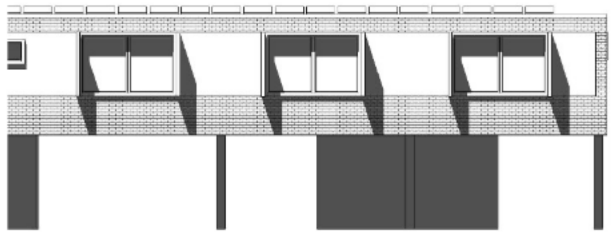

Figure 5: Detail elevation from east with vertical shading at 11:30 am summer solstice. Source: (Author 2016)

6.0 RECONCILING ENERGY AND COMPOSITION

Although the original shading strategy for the Ferry Co-op did not contribute to an overall positive thermal performance, the shading devices provide aesthetic value by providing visual relief to flat facades, and casting shadows on the building façade that are dynamic across the day and year. The latter characteristics that are part of the architect's reservoir of design outcomes are important and are difficult to demonstrate during design. They also require continual observation to appreciate after the building is completed. The impacts of thermal performance and visual impact of the sun on a building façade can both be reconciled by design intuition within limits, without resorting to measured analysis and visual demonstrations that account for time.

Based on modeling alternatives, vertical shading devices (Fig. 5) were found to be a more effective response to solar conditions based on the fundamental building geometry and orientation of the case study building. Like horizontal shades, vertical projections also cast shadows on building facades and are a viable and alternative to horizontal shading with respect to creating visual interest and interrupting the monotony of flat building surfaces. Because horizontal shades are effective on the west face of the building and not on the east, and the west side of the building faces central campus, eliminating the horizontal shades on this face would have a significant impact on the original vision. Adding vertical shading on the east side of the building and eliminating the horizontal would lead to improved energy performance, while contributing to shadows, and not undermine the design on the west face of the upper level. Ultimately, the aesthetic merit of vertical shades is an architectural judgement that cannot currently be rendered through computational analysis or reduced to data.

CONCLUSION

Based on available knowledge and initiative, notable architects in the 1950's implemented design strategies aimed at satisfying compositional objectives with forms intended to mediate the impact of the sun. As this study demonstrates the results of past design efforts did not necessarily lead to performance outcomes which appear to be accomplished. In this case, perception of positive outcomes was reinforced by inclusion in a book featuring solar shading strategies. Rather than uncritically celebrating works by master architects by selectively identifying positive characteristics, and omitting design shortcomings, opportunities to understand fuller implications of design decisions are missed tempering capabilities of sorting through complexity. Considering how form can be improved advances the available knowledge reservoir and efficacy of architects to make decisions independent of engineers.

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ENDNOTES

1 Long Beach Hospital is credited as precedent in the project narrative accompanying drawings for Ferry Co-op as part of the Syracuse University Marcel Breuer digital archives.