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GREENING GREENPOINT:

INVESTIGATING TECHNOLOGY AND ENVIRONMENT-BASED DESIGN

A Thesis Presented

By

ADAM CASTELLI

Submitted to the Graduate School of the University of
Massachusetts Amherst in partial fulfillment of the
requirements for the degree of

MASTER OF ARCHITECTURE

May 2014

Department of Art, Architecture, and Art History
Architecture + Design Program

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ACKNOWLEDGEMENTS

I would like to thank Kathleen Lugosch and Ajla Aksamija, my thesis advisors, for aiding me with their knowledge and support throughout the project. I would also like to express my appreciation for the insight of numerous project reviewers, as well as for the continued support of my family, friends, teachers, and fellow students.

ABSTRACT

GREENING GREENPOINT: INVESTIGATING TECHNOLOGY AND ENVIRONMENT-BASED DESIGN

MAY 2014

ADAM CASTELLI, B.S. VILLANOVA UNIVERSITY

M.ARCH UNIVERSITY OF MASSACHUSETTS AMHERST

This thesis investigates architectural design with a focus on technology and parametric, or computational, design strategies in relation to environmental simulation and sustainability. While numerous studies of new digital and parametric design technologies have been undertaken, few discuss their potential application or synergy with sustainable or environmentally focused design. However, there is increasing interest in bridging the perceived gap between these areas of focus in architectural design, as will be discussed in a section on recent symposia related to performance and design technologies. The research project seeks to apply insight gained from these studies to a design project to be located in the Greenpoint neighborhood of Brooklyn, New York.

The project type is a library and research center which would serve as a knowledge base and community hub for the study and discussion of environmental protection, sustainability, and conservation. As a hybrid archive, learning center, forum, and repository of information, it would aim to serve as a catalyst for the ongoing attempts to remediate the environmental conditions of nearby Newtown Creek and adjacent land, which has been subjected to severe environmental degradation as a result of a century and half of industrial activities related to oil refining and storage. The eastern portion of Greenpoint along Newtown Creek has been designated a superfund site as a result of millions of gallons of oil spillage occurring over an uncertain length of time, much of which remains below ground today. Additionally, the

surrounding water bodies have been polluted from the discharge of excess wastewater due to overflow of the city's combined sewer system during large storms. Thus the community and city face numerous environmental challenges and would be well served by a facility which would provide a research base and meeting place.

The project also engages with an additional set of conditions related to the site. Recent zoning changes have been approved which will convert the formerly industrial East River waterfront to a dense residential zone. While the zoning aims to establish a public space along the waterfront, it will also likely result in residential towers vastly out of scale and context with adjacent neighborhood, which includes an important historic district, and a diverse population. The project seeks to place instead, at the tip of the peninsula which was once named for its greenness, a public space dedicated to its restoration.

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CHAPTER I

INTRODUCTION

1.1 Intent

This thesis investigates architectural design with a focus on technology and parametric,

or computational, design strategies in relation to environmental simulation and sustainability.

Over the course of the previous two decades it may be said that the two most notable areas of

innovative architectural design have been the usage of emerging digital technologies and a

renewed interest in creating better performing buildings in relation to the environment. While

numerous studies of new digital and parametric design technologies have been undertaken, and

substantially more have engaged with topics related to sustainability, environmental design, and

building performance, few discuss in depth the potential synergies or overlaps between the

revolutions taking place in these two areas of design investigation. However, there is increasing

interest in bridging the perceived gap between these areas of focus in architectural design, as

will be discussed in a section on recent symposia related to performance and design

technologies. It is clear that numerous designers interested in the innovative use of new

software tools are seeking to shed the perceived image of being mere formalists infatuated with

the abilities of the computer to allow for more complex designs. At the same time, there is a

great interest among "green" designers to apply the latest technological advances to their

projects with the intention of improving energy and resource efficiency. Over the previous

decades, there has been an increased use of environmental simulation tools within architectural

design offices. This trend is likely to only increase in the near future. The emphasis placed on

integrated design teams capable of synthesizing the knowledge of multiple disciplinary

practitioners for the purpose of developing better informed designs earlier in the design process

also points towards the increasing relevance for architects to understand systems principles and how the simulation tools may be used to reach project goals.

The research project seeks to apply insight gained from these studies to a library design project to be located in the Greenpoint neighborhood of Brooklyn, New York. The library was chosen as building type for a number of reasons. As a building type, it has experienced tremendous change in its goals, mission, form, and approach to the environment. Technology has obviously played an important role in this transformation. With the invention and subsequent rise of the internet and related information technologies, the proper future role of the library, whether public or academic, has been endlessly speculated upon and debated in recent years. The intention of this research project is not to attempt a prediction of an unprecedented future library model. It seems clear that the library has not disappeared or decreased in relevance in the current "information age" but in many ways the situation may be viewed from a contrary perspective. There has been increasing recognition of the need for a public "place" which can serve the multiple and varied needs of users. The library can be seen as one of the few remaining publicly accessible spaces designed to accommodate the public's specific needs. The rise of technologies which have in some ways removed the necessity of extensive book shelving has also given rise to the recognition that the space freed up from storage can be better utilized with extensive common spaces, which allow for comfortable reading spaces and act as social interaction or group study zones. The topic of building performance is also not unrelated to these trends, but is an integral consideration. Of particular importance is the usage of daylighting for reading spaces, common zones, and other areas, and how this relates to building orientation, massing, and envelope strategies, as well as in relation to thermal transfer through the building envelope. The consideration of such aspects of design, for which computation and simulation tools may be particularly suitable, is a key design

consideration in many recent libraries, as will be discussed in a segment on the sustainable features of recent libraries, as well as within the text segment on selected library case studies.

The design project, as a library and research center, is intended to serve as a knowledge base and community hub for the study and discussion of environmental protection, sustainability, and conservation. As a hybrid archive, learning center, forum, and repository of information, it would aim to serve as a catalyst for the ongoing attempts to remediate the environmental conditions of nearby Newtown Creek and adjacent land, which has been subjected to severe environmental degradation as a result of a century and half of industrial activities related to oil refining and storage. The eastern portion of Greenpoint along Newtown Creek has been designated a Superfund site as a result of millions of gallons of oil spillage occurring over an uncertain length of time, much of which remains below ground today. While remediation efforts have been ongoing since the discovery of the spill a number of decades ago, it is clear that improvements to the remediation systems and/or additional systems will be necessary if the site is to be cleaned up within a reasonable time frame. Additionally, the surrounding water bodies have been polluted from the discharge of excess wastewater due to overflow of the city's combined sewer system during large storm events. Thus the community and city face numerous environmental challenges and would be well served by a facility which would provide a research base and discussion forum. In fact, the importance of community organizations and local activist groups has been instrumental in facilitating the positive changes which have increased remediation efforts in recent years.

The project also engages with an additional set of conditions related to the site. Recent zoning changes have been approved which will convert the formerly industrial East River waterfront to a dense residential zone. While the zoning aims to establish a public space along the waterfront, it will also likely result in residential towers vastly out of scale and context with

adjacent neighborhood, which includes an important historic district, and a diverse population. The project takes as an assumption that a large-scale development of some kind will inevitably be constructed on this prime stretch of real estate along the East River waterfront. It is not my intention, by any means, to condone such developments, but to use it as a design scenario for the project, specifically in terms of the environmental context of the surrounding site. Were a community-focused center of the sort proposed actually built prior to the approval of such developments, it might very well serve also as a base for community groups opposed to these projects. In any event, the project offers an alternative to the private land grab of the valuable waterfront. It seeks to place instead, at the tip of the peninsula which was once named for its greenness, a public space dedicated to its restoration.

1.2 Objectives and Goals

In terms of overall research, the primary goal is to gain knowledge and insight into the usage of digital software tools, primarily in relation to how parametric and computational tools may be utilized in conjunction with environmental simulation tools. This research takes the form of studies in existing literature, as well as applied research in the usage of such tools. It is intended to apply the knowledge gained from these studies to the design project component of the thesis. Of particular interest in relation to these tools is in the simulation and study of daylighting strategies to the building's interior spaces, as well as the evaluation of related solar heat gain to the building. Simulation tools and optimization strategies might be utilized to inform the overall building orientation, massing, and glazing strategies, but also envelope components such as shading devices, light shelves, and/or roof light monitors or skylights. A key consideration is the evaluation of potential performance strategies in relation to the programmatic considerations specific to library design. As such the research extends to a study

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of multiple aspects of contemporary library design, from programming to orientation and building form to innovative features in recent library projects. In this regard, literature on contemporary library design is investigated, as well as case studies of varying scale and program. These considerations will not be reviewed in isolation of the specifics of project site. Of particular interest are climatic and microclimatic conditions of the site, and opportunities for visual engagement both to and from key interior spaces. To gain a deeper understanding of the site and its context, an investigation into the industrial history, present environmental conditions, demographics, and other information pertaining to Greenpoint is presented. It is a further objective of the project that digital design tools not be used such that they dictate the form or features of the project, but that they be used as aids in supporting the design objectives of the project, whether performance or environment-based goals, or related to programmatic, aesthetic, or site considerations.

CHAPTER 2

PARAMETRIC, COMPUTATIONAL, AND ENVIRONMENT-BASED DESIGN

2.1 Review of Existing Literature – Theories of Parametric and Environmental Design

2.1.1 Parametric Patterns

In the article "Parametric Patterns" for Architectural Design, Patrik Schumacher of Zaha Hadid Architects explores the topic of patterning as it applies to architectural surface articulation in the context of parametric design strategies.[1] The functional range of patterns is as broad as the lineage of their usage is deep. Among the purposes which Schumacher identifies as within the scope of their application are "decorative enhancement, feature accentuation, camouflaging, totemic identification, semiotic differentiation, or any combination of these."

Traditional terminological usage refers to such features as "ornament" or "decoration." Schumacher opposes the modernist dichotomy which sees a clean split between the decorative and the functional. In contrast, "decoration" in classical architectural theory, such as that espoused by Jacques-Francois Blondel, operated as one of the three essential and complimentary tasks fundamental to successful architecture, along with "spatial distribution" and "construction." Likewise Karl Friedrich Schinkel utilizes the same tri-partite division in his 1802 treatise. He employs the term "purposefulness" to describe the importance of each of these three "principal perspectives."

Schumacher proposes that with changes such as the advent of outsourcing of construction related tasks to the disciplines of engineering, we might replace the triad with the terms "organization" and "articulation." While "organization" refers to the "spatialisation of the social order via objective distances/connections between domains, "articulation" is related to the "subjective comprehension of the spatialised social order." Articulation is of aesthetic

importance in the engagement of the user with the built environment. It offers an "orientation" through a kind of legibility of the "social order." Schumacher believes the fields of vision which various articulation strategies can establish might "guide the eye to recognize abstract

configurations and the focal moments or key distinctions within them." Patterns, in their articulatory role, may emphasize formal characteristics or distinguish among functions.
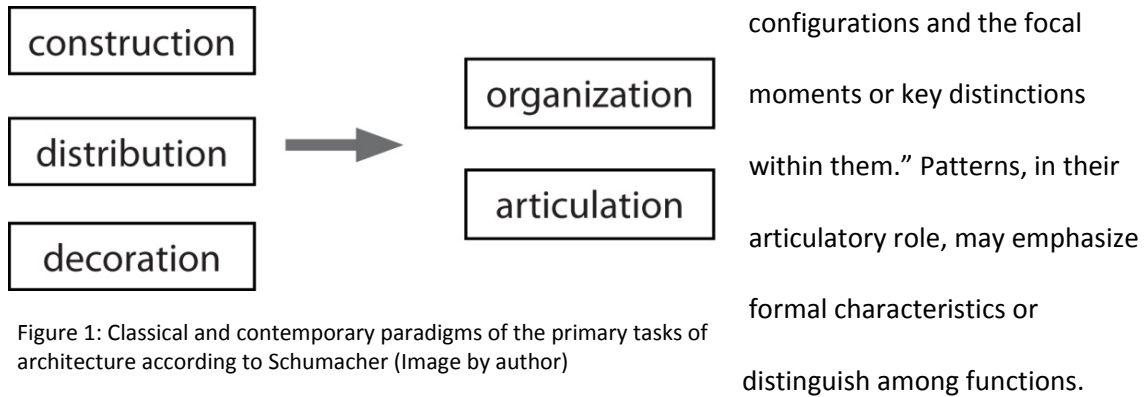
Figure 1: Classical and contemporary paradigms of the primary tasks of architecture according to Schumacher (Image by author)

Terms such as "expression" and "character" have been used throughout the history of architectural theory to describe the purpose of "decoration." Schumacher mentions that Germain Boffrand, for example, considered proclamation of purpose essential to proper architectural expression. Schumacher also references the fact that patterns can "convey atmospheric values." He suggests that an unconscious "information processing" occurs for individuals entering or passing through an architectural space. This idea has an affinity with Grant Hildebrand's conception of "complex order." Sensory information communicated by an environment is continually processed and ordered as its features are distinguished.

In the late nineteenth and early twentieth century, a reevaluation of "ornament" occurred with the influence of architects such as Adolph Loos. The impact of his "Ornament and Crime" continues to reverberate through architectural culture.[2] For Loos, the absence of traditional ornamentation signified a mark of cultural progress and distinction from earlier "primitive" cultures. "Ornament" is likened to the tattoos which he claims indicate criminality and degeneracy. No distinctions are made throughout the writing between such varied phenomena as Papuan facial treatment, decorated gingerbread cookies, and bathroom graffiti.

There is no consideration of cultural specificity, tradition, signification, or formal syntax. Any kind of surface articulation is considered superfluous and a form of "backwardness." Aside from his prejudiced constructions of cultural hierarchy, he ultimately bases his argument primarily on economic grounds. Labor is "wasted" on elaborate designs which cost more and take more time to produce.

In connection to industrialization the emphasis on simple architectural elements which reflected their material composition and methods of production was an important and relevant change in the history of modern architecture, though this change should not be confused with a need to strip architecture of aesthetic or expressive possibilities. For even the "International Style," which emphasized the crisp white wall and valorized the "functional" was indeed a "style." Its aim might ideally be said to been a synthesis of the aesthetic and functional which would coincide with the technological opportunities provided by industrialization. More recent technological changes allowing for mass customization, however, have rendered largely outdated the opposition between buildings which express their character as rational assemblies of mass produced parts versus individually unique and expressive buildings.

Schumacher distinguishes between earlier Post-modernist usages of pattern, which was primarily used as a device to reference historical motifs, with more recent attempts at a more systematic engagement with patterning. Minimalist currents, while ultimately deriving from the aesthetics of the International Style, have not entirely ignored the effects of patterning as might be assumed. The pattern has been subsumed into surface textures in the recent work of architects such as Herzog and de Mueron. These patterns, however, are utilized in a simple repetitive mode, whose effect is produced in tandem with the qualities of the surface material rather than through digitally generated variations.

The formal strategies in the work of early Deconstructionist architects often focused on complex surfaces, but did not engage with the possibilities of patterning. Beginning in the late 90's, efforts began to utilize software to generate panel elements for complex surfaces, but these efforts aimed primarily at the ability to actualize a predetermined surface geometry. Today, the primary interest in digital technology, as far as patterning is concerned, lies in its potential as a generative tool with the ability to establish systems exhibiting continuous and complex localized variations.

Such "differentiation" should, according to Schumacher, "serve as a medium of articulation" in the sense that it correlate with "the geometric or functional aspects of the space the surface constructs." Datasets may be utilized to establish correlations such that, for example, structural members might correspond to stress distribution or panel apertures correspond to environmental conditions. Differentiation might also correspond to programmatic or circulatory patterns. Datasets need not be used exclusively, and multiple influencing features may be adapted to generate the differentiation of facades. Schumacher notes the potential for surface relief which can allow for surfaces "sensitive to both changing light conditions and changing view angles." In this way articulations may engage with phenomenological experience through choreography with the changing positions of viewers as they move through a space.

The articulation of surfaces, for Schumacher, seems to be partly justified through a referral to social organization, though one could argue for its architectural relevance independent from this aspect, for example at an environmentally performative level. He states that articulation is necessary to provide "orientation," and then goes on to describe orientation as providing, among other things, indications of "the conduct that is appropriate within a space." This "behavioral priming" aspect of his conception of the role of articulation seems to stray from the potentially more liberating postulation that "what things look like matters."

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Schumacher points out correctly that connotation-loaded terms such as "ornamentation" and "decoration" do not "carry the full intent and emphasis of what the agenda of articulation involves today." In any event, an engagement with patterning today can provide for new architectural opportunities in connection to "function," "the purposive," and experiential qualities in general. A full reevaluation of such considerations would involve sorting out the biases underlying the rhetoric often employed by both proselytizers of the digital and their opponents.

Criticisms of Schumacher's ideas are ample, and often justified, though his persona as a practitioner and academician is likely so wrapped up in the politics of the wider discourse that it may be difficult to extricate critical response to the actual theoretical content from this context.[3] Perhaps the most significant and valid criticism of Schumacher's position relates to his insistence that "Parametricism" should be viewed (with a capital P) as a "style." Farshid Moussavi, in a piece for Architectural Review, rightly questions this approach.[4] Some of the problems with movements are that they tend toward orthodoxies, often limit experimentation and development, and may prevent unique responses to particular cultural, site, and environmental conditions. Schumacher has stated, not particularly convincingly, that he is "trying to revitalize the concept of style as a concept that allows architecture to project its contemporary innovations into society at large."[5]

Moussavi emphasizes the importance of engaging with social and environmental parameters in responding to the complex challenges which architecture must face. Her claim that Schumacher's position "dispenses with the hindrances of external parameters" seems to contradict what is stated in the Patterns article, as Schumacher states that "arbitrary play" should ultimately be rejected, though he does leave open room for experimentation to further development. Moussavi's own architectural projects hardly live up to the ideals of synergy

between environment and appearance which she sets up in the Architectural Review

commentary, as she has pursued ample experimentation with establishing purely visual effects

in her own work, such as at Ravensbourne, with its investigation of an aperiodically tiled facade.

Actual, large-scale built projects which employ strategies of parametric design that

incorporate environmental data in relation to patterned surface elements are still relatively

rare, given the somewhat larger amount of discourse surrounding the topic. More prevalent

seem to be projects which employ parametric design to develop surface components which also

may function as shading devices or have other functions, but whose patterning or paneling is

not derived from the environmental data itself.

An example of a non-completed design cited by Schumacher in the above discussed

article is Zaha Hadid's Civil Courts of Justice project for Madrid. He describes the adaptation of

the façade components as modulated according to sunlight exposure, with shading elements

projecting in correspondence with these levels. Reiser and Umemoto's O-14 tower project's

structural shell has modulations which correspond to multiple data-driven parameters, namely

"structural requirements, views, sun exposure, and luminosity."[6]

Jean Nouvel's Institut du Monde Arabe in Paris completed in 1987 presaged current

interests in environmentally reactive devices as it attempted a real-time input parameter to

control arrays of complex mechanical screens of changing geometrical patterns.[7] Future Cities

Lab and others today are investigating experimental approaches to utilizing sensory inputs for

structures and surface assemblages which interact with environmental data, often utilizing

patterns or repetitive elements.[8]

2.1.2 Morpho-ecological Approaches

It may be posited that the "performance" of a building, from an ecological perspective, should be considered as inseparable from its "form." Rather than an approach which seeks to recall nature through the usage of elements which simply visually suggest it, a building might participate in an engagement with the environment in which its form is connected to its ability to accomplish the goals related to its purposes. These purposes include function, from the perspectives of program as well as environmental, but also aesthetic, the aesthetic experience of form ideally engaged with the wider environment or the functional representation of one or more of its conditions.

In an article for Architectural Design entitled "Inclusive Performance: Efficiency versus Effectiveness," Michael Hensel and Achim Menges describe their own understanding of what a "morpho-ecological" approach might entail.[9] They consider the possibility for architecturally "heterogeneous space" whose form is integrated with environmental factors as well as material properties and capacities, spatial conditions, and assembly requirements. "Enhanced context-sensitivity" might be said to characterize this approach to form generation. This approach is similar to that of biomimicry in the sense that it seeks to engage with particular environmental conditions of a given site by calibrating the building systems towards these ends. As it is for Janine Benyus, efficiency is not the sole goal, and a synergy between aesthetics and function are sought. Where the paths diverge perhaps is on the origin of the particular design strategy, which biomimicry seeks in specific examples in the natural world, such as deriving from the biological functioning of a plant species, while a more general morpho-ecological approach is not particularly tied to this notion and may generate responsive forms through computational analyses of environmental conditions. This points to the other primary difference, which is an

interest, for researchers such as Menges, in integrating the formal possibilities of computational and parametric design with environmental response.

2.1.3 Digital and Environmental Design: Dichotomies and Potential Synergies

Susannah Hagan, in her study of the subject of digital technologies in relation to environmental design, identifies the multiplicity of uses to which computers have been utilized in contemporary architectural design. From their representational role in traditional CAD applications to environmental simulations, expanded manufacturing capabilities and exploratory geometries, the usage of software is seen, however, to be characterized by its "immaterial" aspect.[10]

Hagan proceeds from this perspective to understand the perceived current divide between "digital" and "environmental" areas of focus in architecture as typical of the western tendency to split the world into binary oppositions. More specifically, she suggests that this dichotomy may be seen in relation to the "mind-body" duality which has dominated western thought since Descartes and is traceable to the philosophical speculations of Plato. The age-old opposition between the idea and the thing may then be updated as the conflict between the virtual and the material.[11]

In contrast to oppositional thinking, we might look to traditions and thinkers who have proposed instead a conception of interdependencies. Hagan notes that non-western traditions such as Buddhism and Confucianism sought to establish frameworks which recognized relationships of complementarity rather than privileged exclusivity. Within western philosophy, she suggests we might look to Leibniz, whose conception of "Monism" sought to establish the notion of a continuum on which perceived oppositions ceased to have meaning and the "material" was integrated with the "spiritual." This notion has been revitalized with the

Deleuzean conception of the "fold." She states that Lefebvre too sought to think in terms of interdependence rather than opposition, presaging notions of contemporary ideas of "networks" in his analyses of capitalism. Hagan suggests that architects must question and rethink the assumed oppositions between notions of nature and culture, materiality and transcendence, mind and body.[12]

Another question which leads into discussions of an environmental-digital architecture is the role of the avant-garde in contemporary architecture. She notes the social engagement of avant-garde movements early in the century, whose utopianism eventually gave way to recognitions of the failures of modernist idealism. Manfredo Tafuri, for example, understood the avant-garde movements as supporting an adaptation of capitalism rather than truly advancing socially-oriented goals. The Marxist philosopher Theodor Adorno, too, presented a bleak view of the "culture industry," though he understood avant-gardism as potentially offering a means of resistance to commodification.[13] The various strains of the post-modern movement responded to this situation primarily by a disavowal of socially-oriented architectural ideals, with the sustainability movement, however, more recently picking up the ball.

Hagan sees the potential, however, for the "either/or" attitude (autonomous art or active agency) to give way to a "both/and" approach in which artistic and social goals might once more be aligned in support of a greater good. In looking towards "alternatives to what exists" both environmentally and digitally-based practices have sought a resistance to the status quo, in relation to the social and formal, respectively. Hagen recognizes the potential for a convergence in these "free spaces" to form an engaged avant-garde which might be said to be "in-the-world" rather than distanced from it.[14]

She highlights the range of directions with which digital tools have been employed and how they are variously understood within practice. She notes that procedural innovations within

practice have been largely influenced by changes in in CAD/CAM technologies to the extent that

these allow for changes in how building components may be produced, assembled, and at what

cost. In the academic realm, innovation with digital design has focused on generative design

strategies, most notably at the Architectural Association Digital Research Laboratory (AADRL).

Hagan describes the team-based research methods of the AADRL, which she considers as

offering an alternative to the artist-architect paradigm, though she critiques it as well,

suggesting that with a focus on the formal aspects of design a potentially "signature"-oriented

model is still maintained. She also indicates that AADRL has often not realized the potential for

generative design because she considers the "ends" of projects to be often subordinated to the

means, or design process. She notes that parameters as system constraints within the project

might be considered as arbitrary rather than oriented towards environmental or production

constraints.[15]

2.1.4 Experimental Research in Academia

Michael Hensel and Achim Menges have pursued research at the intersection of digital

and environmental design through the exploration of generative design strategies related to

environmental performance. Both Hensel and Menges received their degrees from the

Architectural Association before teaching at that institution. Currently, Hensel is Professor of

Architecture at the Oslo School of Architecture and Design in Oslo, Norway and Menges is the

founding director of the Institute for Computational Design at the University of Stuttgart. In a

2008 essay, the collaborators defined a "Morpho-Ecological" approach as one which looks

beyond efficiency towards an integrative practice with the goal of establishing heterogeneous

architectural spaces which benefit from a synergy of formal, material, environmental, and

spatial factors.[16] It entails an "enhanced context-sensitivity" in which the performative aspects

of building systems are calibrated to the environmental context in which they are embedded. The aim is not optimization per se, but to utilize technology to realize a greater effectiveness in design, which must satisfy conditions related to a multitude of parameters and design considerations. Rather than using new computational and computer-aided manufacturing capabilities to repeat already well-established design procedures, architects might utilize these technologies to investigate innovative approaches to form-generation which link material and form to contextual conditions through the consideration of performative effects.

The potential suggested by Menges and Hensel is for an alternative design approach in which complexity and performance are integrated with considerations of material processes. Analysis tools allow for the evaluation of such behavioral aspects as thermodynamics, structure, light conditions, and acoustics which may become generative drivers of a project design. Through an understanding and utilization of system forces and influences, a designer might realize a more holistic design approach in relation to the interaction of space, form, and microclimatic conditions established in a particular design.

The concept of "material systems" is employed by the researchers in their investigations involving the characteristics, geometrical behavior, and manufacturing and assembly requirements of potential construction materials. Ideally these properties are brought into the computational model in order to examine the complex interrelations which might provide for a generative solution that takes advantage of these integral properties. "System-intrinsic characteristics and constraints" such as these may define relevant parameters which inform a computationally-based design approach.

Menges and Hensel view analysis throughout design processes as essential in evaluating the "effectiveness" of design performance. The interaction of "stimuli and response" establish the relationships which define the system as a whole, thus making evaluations of this sort

potentially valuable as part of a generative design process. The authors note that the interfacing

with analysis tools should be viewed as worthwhile because they allow for a productive

recognition of patterns and behavior that might be instrumentalized within a design, not for

being able to reproduce environmental or material conditions exactly in order to reproduce the

real-world complexity of these conditions, a complexity which inevitably cannot be captured by

current analysis methods. For example computational fluid dynamics (CFD) cannot provide full

insight into actual thermodynamic conditions which computational models cannot handle

though it is often valuable for the insight which it does provide.

The concept of "effectiveness" is offered by the authors in counterpoint to notions of

"efficiency" or "building correctly" which do not take into consideration the full range of criteria

for an integrated design method. Nor would such notions allow for a revitalized approach to

research which seeks to investigate the potential opportunities offered by generative design

approaches based on performance. "Effectiveness" might be defined by the ability to produce

"emergent effects" based on quantitative analyses and qualitative evaluation. The generative

process involves not simply an optimization, but requires a level of "creativity, intelligence, and

instrumentality" in the development of particular design solutions sensitive to environmental

conditions.

Although in many ways the research pursuits of Menges and Hensel seems to exemplify

an approach to parametric design advocated by Hagan in her book *Digitalia*, she has maintained

herself at a distance, considering them to be "not fully versed with environmental design."

Whether this is true or not, there seems to be, in fact, much overlap in the "performative"

notions discussed by Hensel and the pursuit of a digital architecture driven by environmental

parameters suggested by Hagan in *Digitalia*. Conflicts seem to arise for Hagan over terminology

such as "mopho-genetic" which she perhaps conflates with notions of bio-morphism or

experimental extravagance in general, and therefore architectural forms which are assumed "unbuildable." While this characterization may not be entirely inaccurate in reference to some of the research projects, Hagan seems to possibly end up faltering on her own premise for greater interaction between digital and environmental research currents which avoids the pitfalls of binary oppositions. She partitions off generative design into two distinct categories, the "process-driven," which she considers to be necessarily unbuildable, and the "product-driven," which is buildable. In theory, there seems to be little reason why a "process-driven approach" should necessarily end in an unrealizable product. Arguably a more focused critique of projects such as those of Menges and Hensel would lie in their potential inadaptability to broad scale application to solve the immediate big problems of environmental design at low costs. Then again, this weakness of experimental work is also perhaps a strength as new areas of investigation are undertaken which explore unorthodox approaches to the familiar problems.

If there is a continuum between hard and soft approaches to efficiency in environmental-generative design, Hagan's position is more on the hard side, but fundamentally the direction of digital design suggested by Hagan in *Digitalia* specifically seems to be more closely aligned with AA efforts than work being done elsewhere in the academic realm. One of the projects which she highlights as exemplary is the "Groningen Project" by John and Julia Frazer of the AA. The other project which features prominently in this publication is Future System's ZED London Case study project. For this project, dating from the mid-'90's, the primary determinant of the building's form was the ability to deflect wind into the central aperture where wind turbine would be located. The form was molded with the aim of maximizing wind speed and therefore energy production. The skin was also designed to be smooth enough to reduce air turbulence and prevent high pressure zones from developing. Other examples of work which Hagan positively cites in relation to their usage of parametric design strategies are

works by ecoLogicStudio, such as their design for Marco Polo Airport in Venice, with its undulating shade roof, and their Cirie Public Library design, whose interior responds to varying daylight levels.

In general, though, Hagan's own approach is rather one of "environmental pragmatism" which her Research into Environment + Design (R_E_D) has pursued in projects such as their Ergohome prefabricated dwelling unit, and their Social Housing project in Sao Paulo, Brazil. One of her group's projects which has utilized parametric design is their Pattern Books Competition projects, which investigated "how parametric design can enable users to generate low carbon buildings with a prefabricated kit of parts and a set of rules for putting them together that maintains structural and environmental standards while at the same time giving the users a high degree of flexibility."[17]

2.1.5 Performance as a Framework

In 2012, Hensel edited a collection of essays, *Design Innovation for the Built Environment: Research by Design and the Renovation of Practice*, which explores the topic of architectural research with an emphasis on digital technologies and the interfacing of design with the larger environment and site context.

In this essay, Hensel highlights some of the difficulties involved in establishing an adequate framework for architectural research and describes the potential opportunity for a research approach based upon the notion of "transdisciplinarity."[18] He suggests that this notion might aid in the effort to establish a framework for what he terms "performance-oriented" architectural research efforts.

Contributing to the current discourse on performativity in architecture are both those related to "systems theory" approaches and to notions of "instrumentality" stemming from a

variety of disciplines. Hensel notes that the development of performance theories in the

humanities and social sciences which arose in the mid-century focused on the development of a

"dramaturgical paradigm" to explain human behavior. For example, the philosopher John

Langshaw Austin considered speech acts as having a related performative role, since speech

may be said to constitute an affective and transformative potential. In other words, human

behavior came to be understood as exemplifying performance characteristics as people "stage"

their appearance within a social context. In science and economics, theories related to

performance shifted focus from questions of representation and knowledge to those related to

the social and material dimensions of these disciplines.

Such expanded areas of investigation resonate with the notion of a transdisciplinary

practice, one in which there is an acknowledgement of the potentially transformative effects

which a dialogue between different areas of study may affect. A 1967 issue of *Progressive

Architecture* dedicated to the subject of "Performance Design" focused on the usage of

mathematical modeling and scientific methods towards environmental ends, but avoided less

quantifiable criteria and more active human agency within the design process. Susannah Hagan

has suggested that despite interest in the application of systems processes in the 60's, the trend

collapsed due to the failure of linear analyses to handle the non-linear behavior of urban

systems.[19] In other words, systems-oriented architecture can avoid neither the human agency of

the designer, nor the uncertainty and inherent variability of the systems within which

architecture is embedded. In the discussions surrounding system-based approaches derived

from the thought of Christopher Alexander, among others, centered at the University of

Cambridge in the 60's, debate surrounded the idea the of an objectification of the design

process.[20] Such discussions remained largely conjectural since theories concerning the potential

application of technologies were far in advance of actual technological capabilities themselves.

More recent publications discussing this topic such as that by Kolarevic and Malkawi have highlighted the continued divide between "hard" and "soft" approaches to systems performance and called for the need for more integrative design practices. In his own formulation of the performance paradigm, Hensel identifies four main interrelated areas of investigation: the human subject, the environment, the spatial, and material.

He suggests that architectural practice should be rethought from a perspective of what he terms "auxiliarity," by which he seems to mean that buildings should be considered not as independent from external concerns, but participating in a larger set of conditions. The Khaju Bridge in Iran, built in the mid-17th century exemplifies what Hensel terms "first-degree auxiliarity." It is a construction which functions in multiple ways with respect to the environment. Functioning as a bridge and a weir, its spatial organization is calibrated to provide for a cooling of the air. The water with which it is in contact acts as a heat sink, while its arcades manage the microclimate by facilitating air movement through its lower spaces. These provisions allowed for the structure to provide civic social spaces for the city. "Second-degree auxiliarity" is a supplemental design intervention which adds to an already existing built context rather than modifying the urban fabric. Hensel considers his AA Membrane Canopy installation, designed in collaboration with the engineering firm Buro Happold, as a second-degree auxiliarity installation.

Mashrabīyas, wooden Islamic lattice screens, may be considered as resolving the opposition of form and function, since the forms of these devices are calibrated to affect a modulation of environmental conditions suitable to occupant comfort. Their integrated functionality is seen as exemplifying a desegregation of form and function which may be considered a key task for performative architectures. Incidentally, the inspiration and reinterpretation of the traditional mashrabīya plays a key role for high rise building project

which will be discussed below as case study in the application of new façade technology. The usage of mashrabīyas suggests the importance of responding to boundary conditions for environmental performance. Hensel cites, for example, David Leatherbarrow's examination of a "breathing wall" system of louvers, which, although physically passive, are active in the sense that they work to establish a condition as a response to an environmental context. Hensel elaborates on his theorizations of building performance in his recent book *Performance-oriented Architecture*.

2.1.6 Digital Workflows in Recent Practice

Aside from the more experimental work outside of the mainstream, on the one hand, and the purely technically-driven use of simulation and analysis often late in the design process in industry, it is clear that environmental considerations are increasingly considered in earlier stages of design, often in more creative or fundamental ways, through their incorporation into new digital workflow processes. These developments in technology and method offer the possibility to allow architects a greater ability to investigate, research and apply their findings, in relation to environmental simulation among other tools, and to incorporate these in the architectural design of their projects. This counters a prevailing mode in industry where an architect may rely exclusively on a subconsultant to analyze a building's forms and features only after they have already been formulated and largely decided upon. In sum, design and analysis are beginning to converge, such that the architect can make more informed decisions throughout the design process.

Scott Marble documents some of the most recent ways in which digital tools are being used and incorporated into the design process in his recent book on digital workflows, which

incorporates essays from a number of innovative practitioners which describe how these

innovations are affecting design processes today.

Ben van Berkel, for example, describes the evolving usage of digital tools and models at

UNStudio, where the usage of a "mother model" continually in development and linked to the

work of all of a given project's consultants aids in a design process where the model geometry is

adaptable but tightly controlled and managed. The firm's Raffles City project how the firm is

using parametric modeling to study and incorporate data driven design solutions, in this case for

the façade system, for which geometric and optimization studies were undertaken on the basis

of variations in such parameters as glazing and shading device size and geometry.

A common theme from a number of commentators in the book is the usage of

parametric modeling to allow for an incorporation of fabrication constraints and geometric or

material tolerances into a project's digital models. For example, at Buro Happold, parametric

modeling workflows may be utilized to ensure the satisfaction of geometric constrains while still

allowing a flexible framework within which to easily explore variations in design options. This

point is illustrated in the example of the Crystal Bridges Museum of American Art project, for

which the engineering firm provided consulting services for Safdie Architects. The firm

developed a custom piece of software for the project entitled "Master Builder" which would

provide the ability to regenerate geometry associated with connection details for the building's

glulam roof structure, such that changes in the overall roof geometry could be quickly

accommodated. Key output parameters could be easily obtained, such as the length and angles

of connector components so that these could be obtained and sent to the fabricator for

production.

The above example highlights how a number of progressive firms are increasingly

capable of developing their own software applications, often on the basis of challenges related

to specific projects and their unique needs. At Morphosis, custom tools developed for specific applications within a given project are even encouraged to be "thrown away" such that each script or software tool is specifically tailored to the particular project challenge at hand. Firms are also increasingly developing workflows which seek to avoid the limitations of working within the predefined frameworks established within commercially available software packages. Since firms are utilizing multiple software tools on any given project, and consultants are likely to be using still different software, the issue of interoperability has become a key challenge and point of focus for a number of firms, who may employ programmers to develop custom tools to help bridge the gaps between software applications often on a task-specific basis.

For this reason, increasing the designer's facility with custom software and cross-platform information exchange and integration forms a key part of the curriculum at Stevens Institute of Technology's Product Architecture Lab (PAL). The program seeks to integrate the study of engineering and architectural design through the exposure of students to technical digital practices and design strategies. Founder and director John Nastasi has characterized the architect's broadening approach in digital design as one which he refers to "the fluid desktop," by which he suggest the pairing of parametric modeling with engineering analysis into a more integrated design process. For example, students at PAL in collaboration with designers at SOM have studied the application of data to form-finding techniques, such as for the Ali Al-Sabah Military Academy, for which variations on a façade system were iteratively tested for their effect on solar heat gain and interior lighting conditions.

Overall, the observations on the current application of software technologies and in-house programming capabilities highlighted in Marble's book undoubtedly point towards an increasingly sophisticated usage of these tools within practice, though it is also clear that there

are also inevitably challenges to their wider adoption within the industry at large as well as questions as to the architect's proper role within this shifting landscape.

In relation to sustainable design, for example, parametric software has been used to aid in the design of several recent high-profile sustainable building projects, not, it should be highlighted, for formal or aesthetic aims, but to aid in the development of the best performing design option. This is due to the ability of parametric design processes to allow designers the ability to explore a wide range of design options quickly and easily. For example, Buro Happold and Gensler used Grasshopper as part of their workflow on the recently constructed PNC Tower in Pittsburgh, specifically to iterate through a number of different design variables in translating from architectural design ideas into models for various building analysis software platforms. It was also utilized for the design of what has been called "the greenest commercial building in the world," the Bullitt Center in Seattle, by designers at Miller Hull Partnership. For this project, the parametric software was used to evaluate a large number of options regarding the building's iconic solar panel array over the roof, with variables including solar panel location, orientation, tilt, and panel type. In combination with use of analysis tools such as Ecotect, this allowed the design team to quickly determine the associated energy potential and costs of many options. Such examples suggest that architectural design teams are making use of these tools in inventive ways for day to day tasks, but also often in such ways as to aid in exploring substantially larger arrays of design options, integrating better with analysis consultants, and gaining greater insight into building performance earlier in the design process in-house.

2.2 Case Study in Practice

 2.2.1 ICHQ Towers

The Al Bahar Investment Council New Headquarters (ICHQ Towers) in Abu Dhabi

designed by the global architectural firm Aedas is a set of twin 25-story, 145 meter tall, office

towers which are the result of a cross-pollination of research interests in sustainable design,

computation and advanced modeling. These three aspects of the project are the active areas of

investigation for Aedas London's Research and Development group. The R&D group aims at

utilizing parametric-based computation and simulation to "help quantify, visualize and

manipulate spatial, environmental, and financial factors of a design." This establishes the basis

of coordinated efforts to investigate such aspects of the built environment as energy usage,

building occupancy patterns, and the life-cycle impacts of early design decisions.

The ICHQ Towers, completed in June 2012, were designed with both the cultural and environmental conditions of the project site in mind. In the Middle East, where designers throughout history have had to contend with often extreme environmental conditions, strategies employing such features as solar screens, shaded courtyards, and natural ventilation were often

Figure 2: Aedas, ICHQ Towers, Abu Dhabi, UAE, 2012, View of north-facing elevations (Retrieved 3/8/13 from http://www.archdaily.com/270592/)

used. The design for this project builds on this tradition while incorporating new technologies to

meet the needs of a modern building. The immediate context of the site is a flat area of terrain

surrounded by fields and low rise buildings with a highway to the north.

The most prominent and significant feature of the design is its distinctive shading screen

system which kinetically responds and adapts to changing solar exposure conditions and varying

incidence angles throughout the year. In designing its tiled, parametrically-designed façade components, design architect Abdulmajid Karanouh was inspired by regional vernacular architectural patterns found in traditional Mashrabiya, windows which utilize a latticework of wood which simultaneously provide protection from the sun and privacy while allowing for air movement to cool interior spaces.

The ICHQ facade elements "unfold" based on the exposure of particular façade regions to direct sunlight. The skin wraps around the perimeter of the building envelop except on the north side which does not receive direct sunlight. These origami-inspired units are "tensile fabric structures" which allow for the dynamic control of lighting conditions, glare reduction, reduced solar heat gain and cooling loads, as well as allowing for views across the city.

Figure 3: Aedas, ICHQ Towers, Abu Dhabi, UAE, 2012, Illustration of kinetic action of façade components (Retrieved 3/8/13 from http://www.archdaily.com/270592/)

The frames of these units are a combination of aluminum and steel element with the shade itself consisting of fiberglass with a Teflon coating. The components, which weigh approximately 600 kilos each, required rigorous mechanical and environmental testing in order to ensure that they will function properly for the life of the building with as little maintenance as possible. The screen
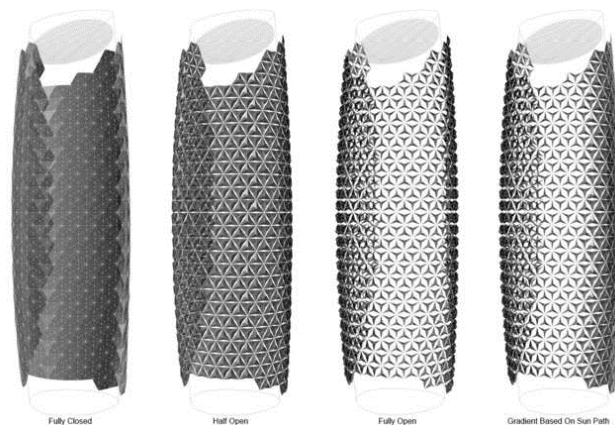
Figure 4: Aedas, ICHQ Towers, Abu Dhabi, UAE, 2012, Dynamic states of parametrically-controlled façade (Retrieved 3/8/13 from http://www.ribablogs.com/?p=5796)

operates as a curtain wall system positioned at a two-meter offset from the building glazing. The system can be manually overridden in the occurrence of dust storms or other storm events.

The design offers an alternative approach in contrast to that of typical mid- and high-rise office buildings throughout the Middle East, where the predominant strategy to dealing with glare and solar heat gain seems to be choosing glazing which is tinted to the extent that it allows only 10 to 15 percent daylight transmission.[21] This means that occupants must rely almost entirely on artificial lighting, placing a heavy burden on electrical usage and consequently the energy consumption of the building due to air-conditioning systems. In contrast, the Al Bahar towers' screen system allows for an estimated 50 percent reduction in solar gain while maintaining natural light filtration into interior spaces with light transmission of the windows at 40%. While the "umbrellas" are opened, they effectively provide 80% shading while still allowing for views through the material of the units. As a result of its innovative approach to sustainability, distinct aesthetic, and sensitivity to urban and cultural context, the building received the 2012 Tall Building Innovation Award given by the Council of Tall Buildings and Urban Habitat.

One of the significant aspects of this "intelligent skin" strategy is not simply that it is dynamic, but also that the building's form is shaped by local environmental conditions. As such it offers both performance and a representational aspect which is tied to the particular environmental conditions of its site in relation to its geometry. In this sense, it accomplishes an integration of formal and sustainable design strategies while meeting programmatic goals. It is seemingly situated within a current oriented towards a more thoughtful design approach to the environment, energy consumption, site and cultural context than that exemplified by many of the ill-considered pseudo-post-modernist type buildings which have proliferated in Abu Dhabi and elsewhere.

Figure 5: Aedas, ICHQ Towers, Abu Dhabi, UAE, 2012, In-place testing of facade components (Retrieved 3/8/13 from http://www.archiscene.net/wp-content/gallery/archiscene/al-bahar-aedas04.jpg)

The building has achieved a LEED Silver rating and demonstrated significant reductions in cooling loads and consequently low carbon released into the atmosphere and associated contribution to global warming. Aside from the activated façade, sustainable features of the design include rooftop mounted photovoltaic cells on the south-facing roofs, which provide approximately 5% of the building's total required energy, as well as optimized wall-to-floor area rations. The energy required to power the façade sunshade system could be provided this photovoltaic system. However, it is uncertain whether the PV panels have actually been utilized due to issues with the amount of maintenance required to keep the panels free of sand and dust.

Aedas group has utilized the "Tall Building Model," a "parametric platform" the group developed which provides interactive feedback on how design changes affect construction cost and life cycle costs, as well as operational and embodied carbon associated with particular design iterations. The firm's Computational Design Research group (CDR) utilizes algorithmic logic to inform design processes based on how varying morphologies affect sustainability and user comfort. Efforts of the Aedas R&D have also extended to broader issues in the sustainability of urban design in their development of the Digital Masterplanning simulation framework which emphases issues related to access in order to inform planning decisions related to urban spatial configurations, taking into consideration, for example, travel times and modes of transport associated with varying schemes of zoning and density.

While the Al Bahar towers offer a creative approach to establishing an iconic, energy –

efficient building, the cost of the project, at a total of $245 million for the total complex is a

significant issue with such mechanically-dynamic designs. The operational savings of the system

are uncertain, but it is unlikely that these savings could come close to recouping the costs

necessary to research, test, construct, and maintain the system elements. The economic

incentive would come instead from the ability of the owner to attract tenants and lease its

spaces at a higher cost. A more "low tech-high tech," or non-mechanically driven solution might

have been developed to provide similar levels of efficiency at a lower cost while still providing a

level of iconicity consistent with the aims of the investment corporation.

Another potential issue is the possibility for mechanical failures and high maintenance

costs. It seems that in this case the design team and client have, in fact, tested the system

extensively, but the trade-off is the large price tag which such extensive testing requires. Of

course, there is also no guarantee that the system will continue to operate as expected in the

future, making such investments a gamble. This is an issue with new technologies generally and

designers need to weight the potential risks and benefits from pursuing the use of untested

technologies. In relation to dynamic facades in particular, the example of the failure of Jean

Nouvel's Institut du Monde Arabe to operate as designed suggests the risks which such

approaches take.

Examples of non-dynamic, parametrically-driven design solutions to similar

programmatic and site/climate conditions include the (not completed) Khalifa and Al Faisaliah

buildings also designed by Aedas. The Khalifa building design responds to solar irradiation by

varying the size and number of glazed openings as well as depth of a veiling louver system

depending on the orientation of each face of the facade. The Al Faisaliah design utilizes shading

fins whose orientation transitions based on solar direction. These projects are highlighted not

because they are necessarily ideal solutions to sustainability goals without their own challenges, but to examine the relationships of form to function and environmental conditions which they explore.

The issue of cultural adaptation is always a tricky situation. Can, for example, patterns inspired by Middle Eastern traditions be applied to a high-rise office building without appearing insensitive to the contexts in which they originated? At the same time, the importation of the non-descript western office towers into the Middle East is also problematic. The designers of the Al Bahar towers, to some extent, seem to have avoided either extreme by focusing on the origami motif and adapting it to the climatic situation. Programmatically, though, the project offers little variation from the norm of such office projects, which suggests perhaps that there was a missed opportunity for a greater engagement with regional cultures, social issues, and site conditions at a programmatic level. The situation in a place like Abu Dhabi, one of the wealthiest cities in the world, composed primarily of expatriates, and characterized by recent explosive economic and construction growth, complicates attempts at simple resolutions of these complex issues.

An additional concern, in relation to the sustainability goals of the Al Bahar towers, is the contribution to embodied energy due to the supporting structure of the shades which should be taken into consideration in reviewing life cycle environmental costs of the design. Other types of responsive technologies are being developed which might offer greater efficiencies and less physical structure. For example, the Adaptive Building Initiative is developing products with movable graphic patterns which can be controlled to alter light transmittance, solar gain, views, and privacy. ETFE technology is also being utilized to offer variable levels of light transmittance and reduced heat gain. It is also uncertain how well the shade system actually meets the lighting requirements of the office spaces. While it allows

for a greater amount of natural lighting compared to the typical design solutions for office

buildings in the region, other shading devices and configurations could likely have allowed for

greater levels of light transmittance while similarly reducing heat gain and glare.

2.3 Overview of Applicable Software Tools and Design Studies

2.3.1 DIVA Overview

DIVA, a recently introduced plug-in for Rhinoceros modeling software, was originally

developed at Harvard's Graduate School of Design and is currently distributed by Solemma LLC,

which issues licenses for professional use.

It allows users to perform daylighting and

energy analysis evaluations. Among the

tools which the software makes available

are radiation mapping, realistic rendering,

daylighting, glare analysis, evaluation of
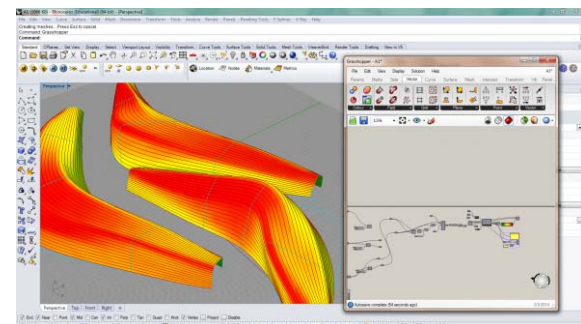
Figure 7: Solar Irradiation analysis of massing forms with DIVA add-on for Grasshopper (Image by author)

LEED daylighting compliance, and single thermal zone energy and load calculations. What

distinguishes DIVA from typical environmental simulation tools is that it can be utilized within

the parametric interface of Grasshopper. Thus, it allows for real-time simulation feedback

allowing the designer to observe how design changes affect environmental performance. DIVA

utilizes the Radiance simulation engine for its

daylighting analyses.

In the example at left, a design is

evaluated for interior lighting conditions by

running a daylight factor analysis. The
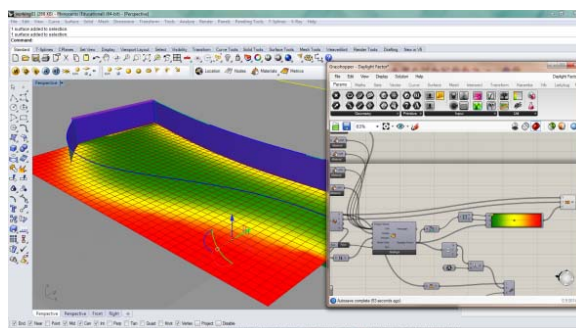
Figure 6: Daylight Factor analysis with DIVA add-on for Grasshopper (Image by author)

gradient representation allows for a quick

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visualization of environmental or lighting conditions. The data output is quantitative, allowing for specific values of, for example, daylight factors or irradiation values, thus allowing the designer to utilize that data in further algorithms to further develop or alter a form or set of architectural components.
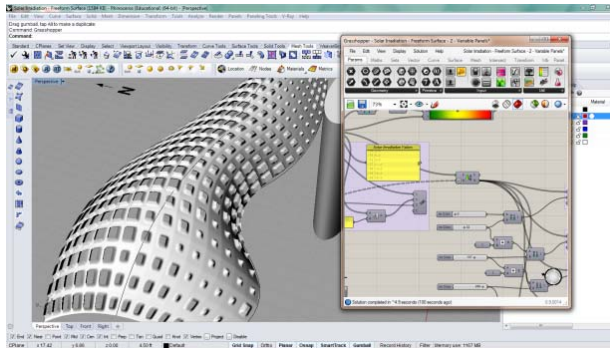
Figure 8: Component distribution based on irradiation analysis output (Image by author)

In the example at left, the output of an irradiation analysis over a summer period drives the distribution of pre-defined panels. Being that the results are dynamically updated, a change to the overall geometry of the form will alter the distribution of the panels as the orientation of the surface at their location changes. The logic in this case is to have smaller panels where most irradiation occurs in order to reduce heat gain.

Rather than pre-defining the geometry of a component, one might also attempt to optimize it. In this example, an idea for a projecting window frame which functions as a shading device is optimized to maximize heat gain in winter and minimizing it in summer. After the initial definition of the relationships between elements, a simple optimization can be done. This is done by first defining the parameters which can be varied while the computer tests out variations, then initializing the first analysis which will then run repeatedly, and finally starting the optimizer, in this case the Galapagos component in Grasshopper.
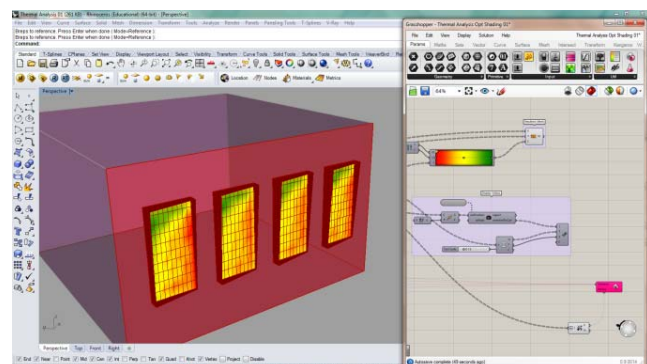
Figure 9: Optimization of projecting window frame for heat gain in winter and shading in summer (Image by author)

It is important to note that the "optimizer" will simply try to either maximize or minimize a given output value that you assign to it. Thus the user needs set up the particulars of the logic which drives the solution. In other words, the computer just does what the user tells it to. It is not aware of the goals the user is trying to accomplish. There likely needs to be some creativity on the part of the designer to define the relationships which drive the final solution.

2.3.2 Studies Utilizing DIVA

2.3.2.1 Study 01

In this example, a self-shading wall is created based on the distribution of solar irradiation on the facade, the aim being to shade façade apertures whose sizes would be proportionally reduced where greater heat gain would occur on a non-shaded surface during the summer.

A given surface, in this case double-curved, is divided into subdivisions which will determine the number of panels which will make up the façade. These panels are then themselves each subdivided into a grid of points which will be used as nodes for the solar analysis. Increasing the number of nodes will increase the accuracy of calculation determining the amount of irradiation on each area of the façade. An irradiation analysis is run through
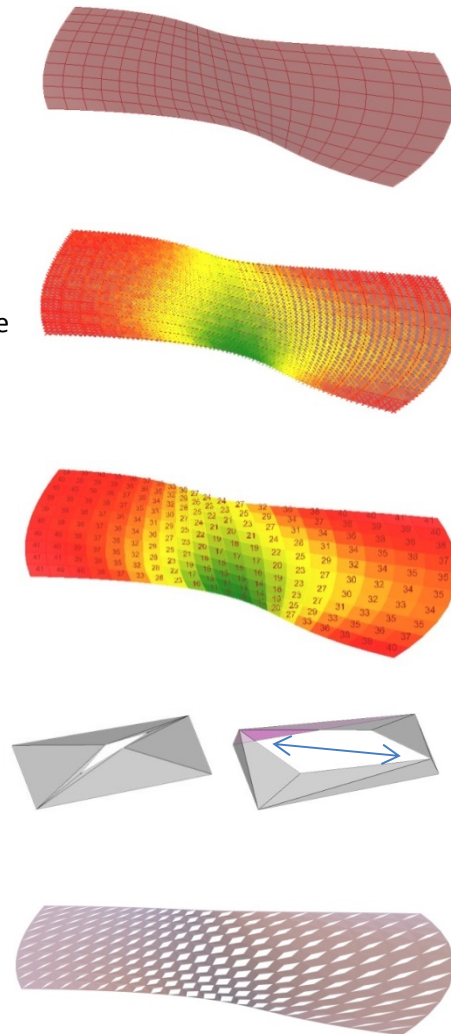
Figure 10: Illustration of Study 1 (Image by author)

Radiance via the GH DIVA Daylight Analysis component to obtain the data values for each point. This is visualized with colors based on the data applied to the input points. Since ultimately it is easier to work with a single value for each panel whose geometry we would like to define, the values for the set of points on each subdivision can be averaged to obtain the average amount of radiation reaching that portion of the façade. This can be visualized through an application of the subsequent gradient map applied to the subdivisions themselves.

The next step is to develop a parametrically variable base panel which can be built-up from sets of the nodal points on the surface grid. Here the panel aperture is adjustable by referencing a t-parameter point along a curve which defines the diagonal direction of the unit. Once the reference points of the base unit are replaced with corner points of the cells of the surface grid, the data set of values from the solar analysis can be remapped and applied to each panel at the corresponding location on the surface.

2.3.2.2 Study 02

In this example, diagonal fin shading devices are created whose forms are derived from solar irradiation data, the aim being to provide more shading at locations on the façade where greater heat gain would occur on a non-shaded surface during the summer.

Starting with a given, pre-determined double-curved surface, it is subdivided into sub-surfaces. The corner and center points of these subdivisions serve as the nodes for an irradiation analysis. In this case, irradiation values for a typical summer week are determined and the
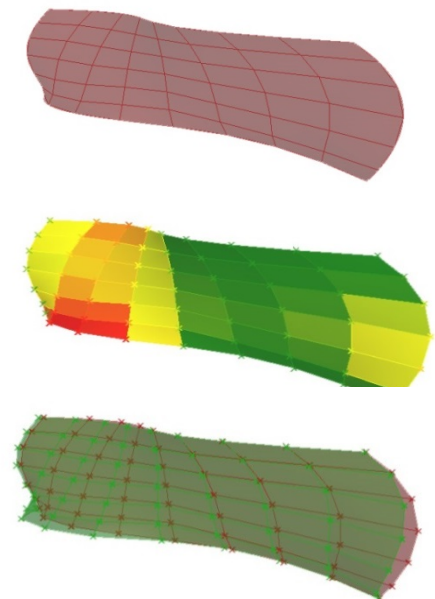
Figure 11: Illustration of Study 2 – part 1 (Image by author)

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results are visualized with a gradient map of the
surface and nodes, the colors indicating the
relative amounts of heat gain on each area of the
surface.

The irradiation data at the sub-division
corner-point nodes is used to determine offset
values for the points. The raw data must be "re-
mapped" (or scaled-down) to an appropriate
domain of values. In this case, the corner points are
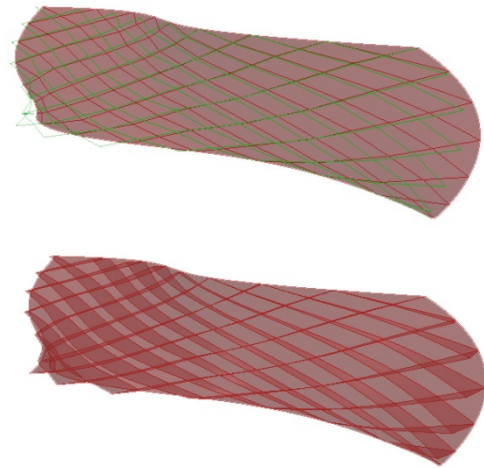
Figure 12: Illustration of Study 2 – part 2 (Image by author)

moved along an axis rather than normal to the surface. These points are used to generate a new

surface by creating interpolated curves between them which are then lofted to create the

surface. The generated surface is then sub-divided in the same manner as the initial surface.

Subdivision points on the two surfaces are then used to create the fin geometry. Here,

opposite corner points are used to create curves which are then lofted to generate diagonal

surfaces. Alternatively, variable vertical or horizontal fins could be generated with a similar

method. Here fins on both diagonals are shown, a configuration which might allow for structural

stability of the shade screen. Alternatively fins might be utilized in a single direction.

Parametrically, this design could be adjusted in terms of the number of fins through culling or

adjusting the number of subdivisions in the U and V directions (which would change the angle of

the fins as well as their number) and the re-mapping of the values which determine the

generated surface and consequently the depths of the fins. By analyzing the results of varying

design iterations, by either manually adjusting variables or through an automated optimization

routine, variations with the best thermal and daylighting performance could be determined.

Results will vary based on initial surface input, orientation, and site location.

Assuming that the glazed wall being shaded by the fins would be geometrically rationalized by triangulation given the double-curvature of the façade, an offset surface is subdivided into triangular panels. Center points of the panels may be used as nodes for subsequent solar irradiation analyses. For greater accuracy, each panel might be subdivided to create a grid of analysis nodes for each panel. An initial analysis shows the effects of radiation on the non-shaded panels. Rather than creating a color gradient based on relative values, it is useful to base it on an absolute scale so that the outcomes of multiple subsequent analyses might be more easily compared to each other visually.

10,473 kWh/wk

3,895 kWh/wk

6,140 kWh/wk

4,204 kWh/wk

Adding a version of the diagonal fins to the analysis, after establishing their reflectance properties, immediately shows their beneficial effect on reducing the heat gain on the glazed façade. It can be seen, however, that improvements might be made or greater

Figure 13: Illustration of Study 2 – part 3 (Image by author)

efficiencies of material usage established through a change in the shading geometry. Analyses with a large number of shading elements increase analysis time substantially, meaning that care

should be taken when developing a method for automating an optimization routine in such cases.

By multiplying the analysis output at each node, given in kWh/m^2, by the corresponding area of each panel and then adding the results, the total irradiation gain on the façade for the analysis period can be determined and compared to parametric variations of the system. Adjusting parameters to obtain different analysis results, the effects might be observed, for example, of eliminating the second diagonal fins, adjusting the fin spacing, or the extent of the fin depth scaling.

Going a step further, the effects of the shading fins on the interior lighting conditions can be investigated. The first task would be to define the materials of all the surfaces which would have an effect on interior lighting conditions. The reflectance properties of the surfaces will determine how much indirect light reaches the analysis surface. The analysis surface might be defined as a plane bound by the building envelope at a height of a typical work surface. For simulation purposes, the surface may be divided into sub-surface whose center-points can be used as analysis nodes. As for irradiation analyses, it is important in daylight simulations for analysis vectors at the nodes to be oriented correctly, in this case "facing up."

In this example, a non-shaded glazed façade is used on the north side, non-glazed east and west facades, and a version of the previously described

7.88 DF AVG
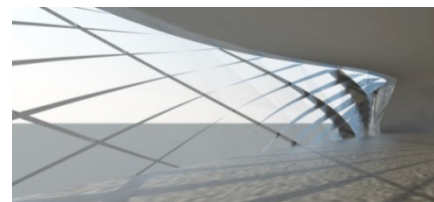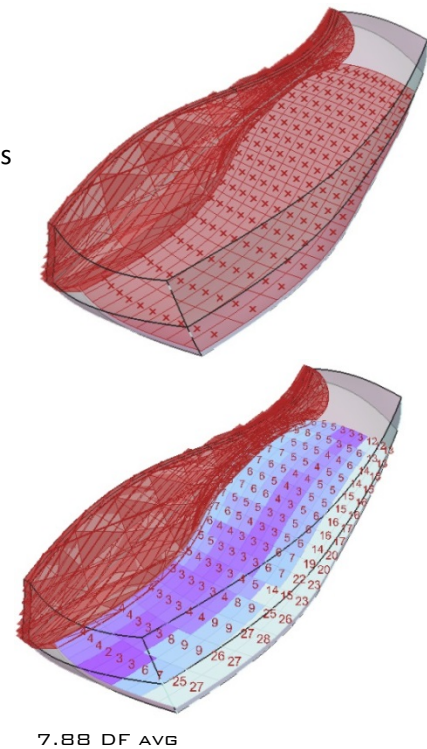
Figure 14: Illustration of Study 2 – part 4 (Image by author)

shading fins is used on the south side. On the bottom floor of this two-level building mass, an analysis grid is set up at three and half feet above the floor. A daylight factor analysis is run to determine the daylight factor at each of the analysis grid point locations. An automated procedure might be set up to test out variations on the shading system and observing the effect on average daylight factors of the interior.

2.3.2.3 Study 03

In this example the gradient resulting from the solar analysis is used to drive the geometry of façade and shading panels, but this information is overlaid with additional levels of variation. Firstly singular data values are obtained for each of the panels.

Independently of the value distributions a pattern can be applied to the surface subdivisions. In this case the pattern is based on the repetition of a random sequence. This will be used to determine the orientation of the shading system elements.

An additional layer of complexity can be added by creating further subsets of the subdivisions. These subsets are here used to determine the orientations of the triangularized panels which rationalize the double-curved subdivisions. In other words, it determines whether the subdivision will be split from the lower left to upper right or the lower right to the upper left. The original
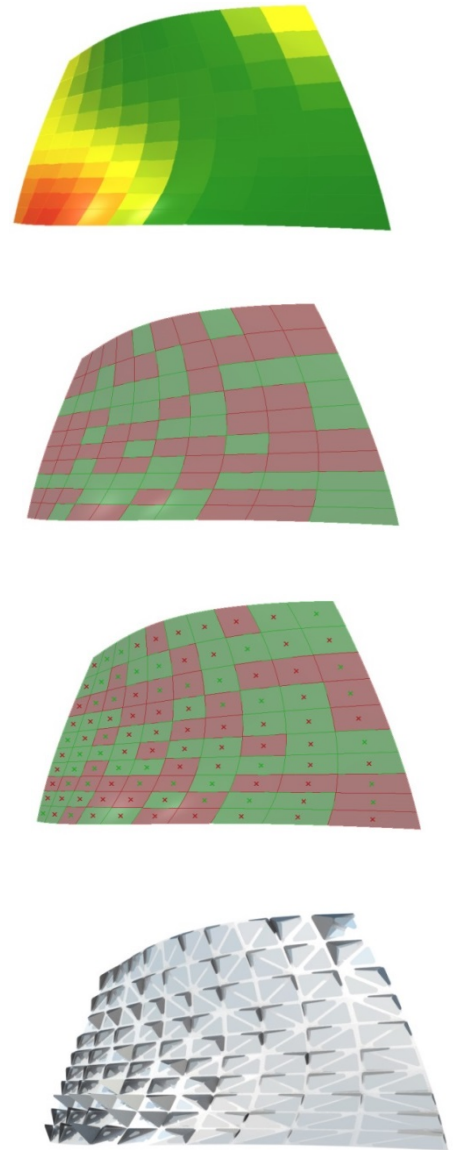
Figure 15: Illustration of Study 3 (Image by author)

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solar data can still influence the variations. Here the triangular glazing areas are scaled

according the gradient as well as the depths and angles of the shading elements. This example

shows how multiple variations can be applied while maintaining a geometric distribution which

is derived from the initial dataset.

2.3.2.4 Study 04

The idea for this exercise was to computationally test out iterations on a design for a

louvered glazed façade. While it is a rule of thumb that building facades facing south should

utilize horizontal louvers and those on the east or west vertical louvers, it perhaps less intuitive

what the orientation of shading devices should be when the façade is at some angle between

east-west and north-south in plan. The louver system is set up parametrically at a constant

distance apart and constant depth. The program is then set to rotate the fins at 40 iterations

between 0 and 180 degrees, held perpendicular to the wall plane, and the total irradiation

values for both typical summer and winter periods calculated with DIVA are recorded, as well as

the average daylight factor for the front half of a floor at mid-height of the glazed wall. These

values are then plotted to visually determine what might be the best option.
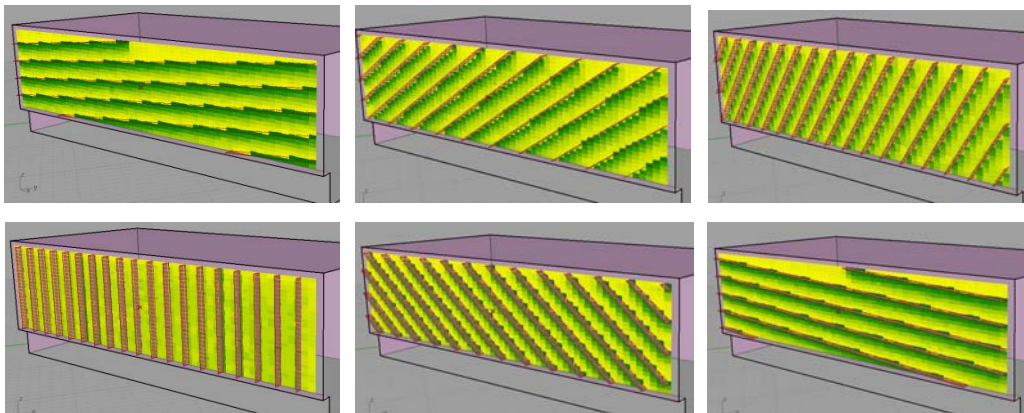
Figure 16: Illustration of Study 4 (Images by author)

The results for this particular set-up and building position, which was oriented its long dimension at 34.5 degrees off axis with east-west, showed the better fin orientations as being between about 130 and 160 degrees counterclockwise from horizontal, both for minimizing summer gain and maximizing winter gain. The average daylight factor was about one percent lower for this orientation in the half of the floor plate behind the glazing. Additional tests might be run to determine what might be the preferred spacing, depth, or axial rotation of the shading fins.
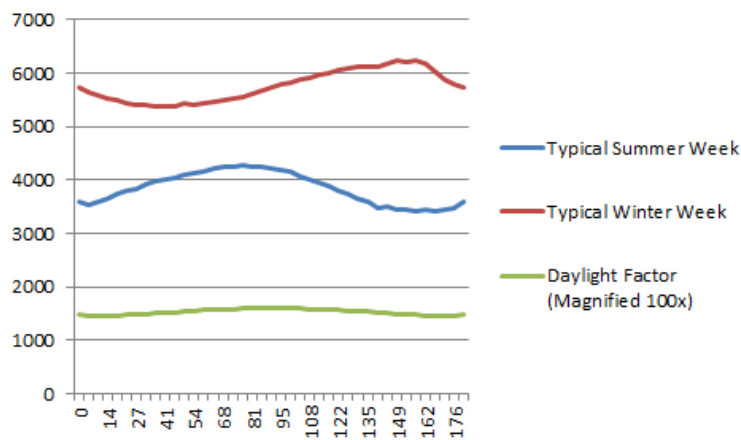
Figure 17: Study 4 – Graph of results showing avg irradiation for typical weeks in summer and winter for each orientation (Image by author)

The graph shows amount of irradiation (in a typical summer week) on the fin-shaded façade on the vertical axis (kWh), and façade-plane rotation angle counterclockwise from horizontal.

2.3.2.5 Study 05

In this exercise, a building's orientation will be computationally tested. Given a particular building geometry which is predetermined, it might be desired to determine what the effects of orientation would have on the total amount of irradiation on the building's facades. Given a rotational parameter, the building can be analyzed incrementally and the data recorded at each step. The results for this test are plotted below, showing that the difference in irradiation for a typical summer week could vary in this case by approximately 4,000 kWh (or about 25%) from the best to worst orientation.
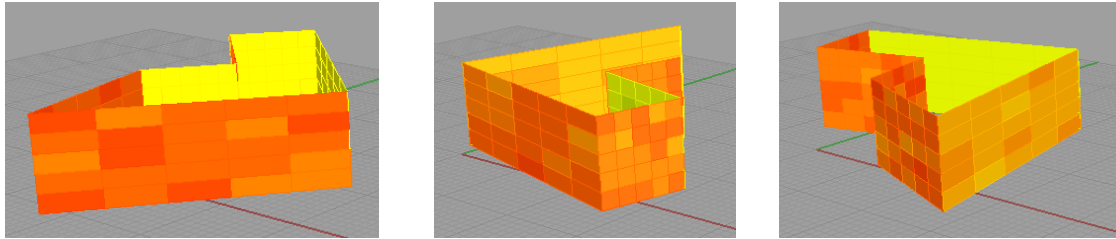
Figure 18: Illustration of Study 5 (Image by author)
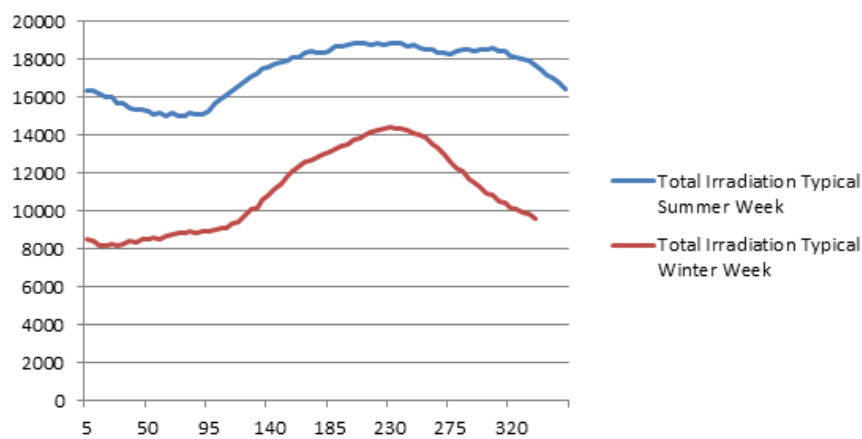
Figure 19: Study 5 – Graph of results showing avg irradiation during summer and winter for each iteration of building orientation (Image by author)

2.3.3 GECO Overview

GECO is an add-on for Grasshopper developed by [uto], a design research and development consultancy based in Innsbruck, Austria. Their intention in creating this tool was provide a link between the iterative modeling possibilities of parametric software and environmental analysis capabilities. Specifically, the tool provides a connection to the Autodesk's Ecotect software, so that project geometry does not have to be remodeled within separate software environments. Instead, geometry can be quickly exported, analyzed and retrieved within the parametric design platform, where it can provide visual feedback and allow

for iterative development of a design. An example of a project in which the software was utilized is the 1234 building in Beirut, designed by Built by Associative Data, for which GECO was used to evaluate daylight autonomy in the building's office spaces. The following examples, which are based on exercises from a workshop given by the developers, illustrate how some of the GECO tools function within the Grasshopper/Rhino and Ecotect interfaces.

A typical workflow which uses GECO, begins with establishing a link to Ecotect. The program can be opened with a component which accomplishes this task. Project geometry can be taken from Rhino or Grasshopper (as a mesh), which is then exported to Ecotect via a GECO component. In this case, an elliptical dome mesh is used. An analysis can then be done utilizing Ecotect's analysis functions, with the parameters and execution of the analysis are specified from within the parametric definition. A component for an analysis of incident solar radiation, "EcoSolCalc," is used in this example. It should be noted that the analysis grid for the solar radiation will be based on the divisions of the mesh geometry, so that each face will have a single analysis point and value. Also fed into analysis components are the appropriate weather
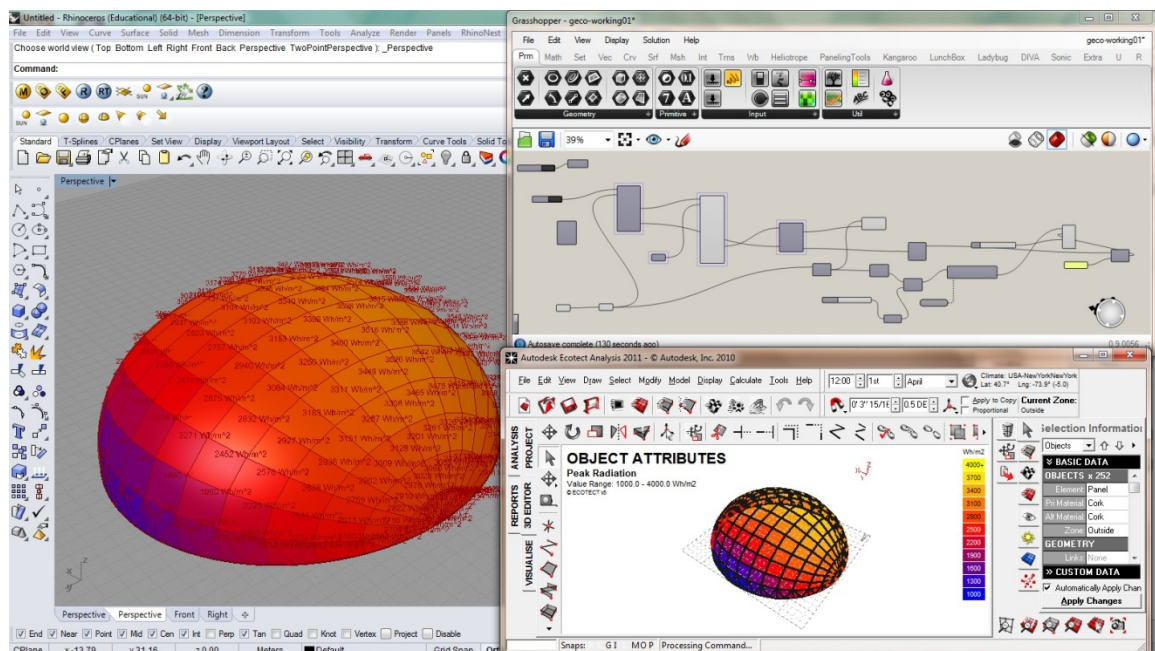
Figure 20: Example of basic insolation analysis using GECO and Ecotect (Image by author)

file and analysis parameters, such as the specific time period to be investigated. The results are then imported back into Grasshopper with an additional component, "EcoObjectRequest," at which point they may be visually displayed or otherwise used as feedback to inform changes to a design. A gradient can be easily applied to the object to help visualize results, and the specific analysis value results for each particular location can be shown correspondingly on the geometry.
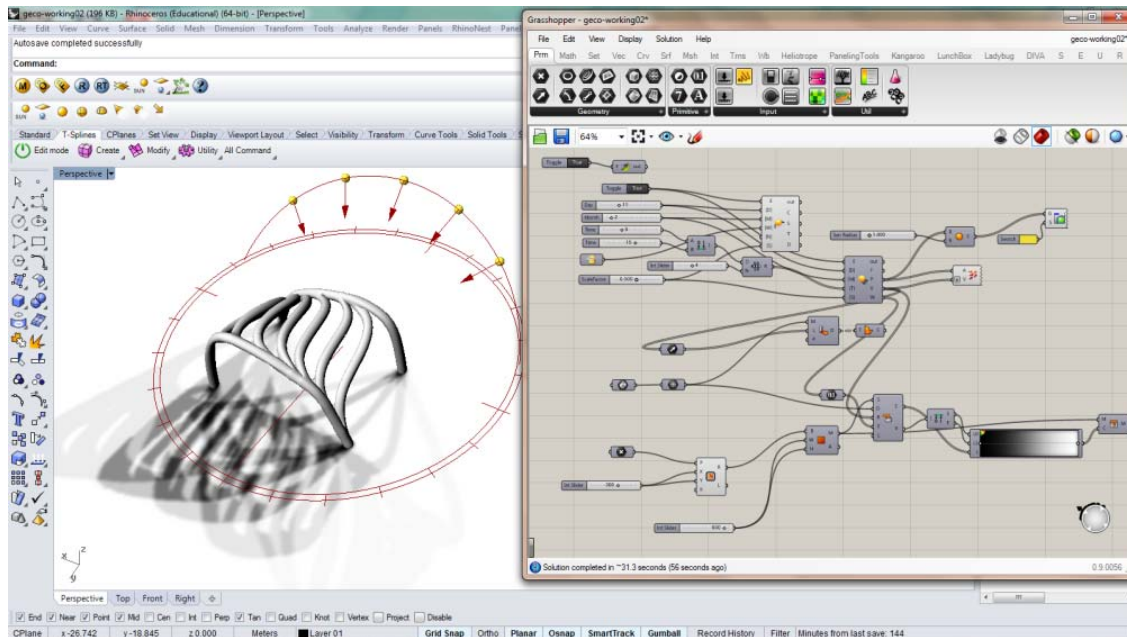
Figure 21: Example of a shadow exposure study using GECO (Image by author)

GECO can also be utilized to perform shadow studies. The sun-path for a specific location and date is first retrieved from Ecotect, and then a specific time of day input for the shadow to be generated. To create an exposure study, which indicates how areas of a project may be blocked from sunlight over the course of a specified time period, a range of values would be input for the hours and/or days to be studied. To better visualize results, the diffuse solar radiation values over the course of the period may be utilized to determine gradation values for the shadows visualization.

GECO is useful for the use of daylighting analysis as well. In this example, a building

volume with four glazed walls is used as the input geometry which is exported to Ecotect. Each

of the geometric elements should be assigned a material for greater accuracy of results. A

component, "EcoFitGrid," is used to define the analysis grid parameters, such as degree of

precision, number of grid subdivisions, plane height, etc. Once the grid and objects for export

are defined, the lighting analysis component, "EcoLightCal," can be utilized. In addition to a two-

dimensional slice, a 3d volume can also be analyzed. For visualization of results, the grid used for

analysis must then be imported back into Grasshopper with an additional component. This type

of workflow of exporting and importing multiple times within a definition can be non-intuitive,

but overall works more smoothly and quickly than might be expected and offers advantages

over remodeling geometry from scratch within the Ecotect modeling environment. Also

somewhat unintuitive is the way in which the components are strung together. Often they are
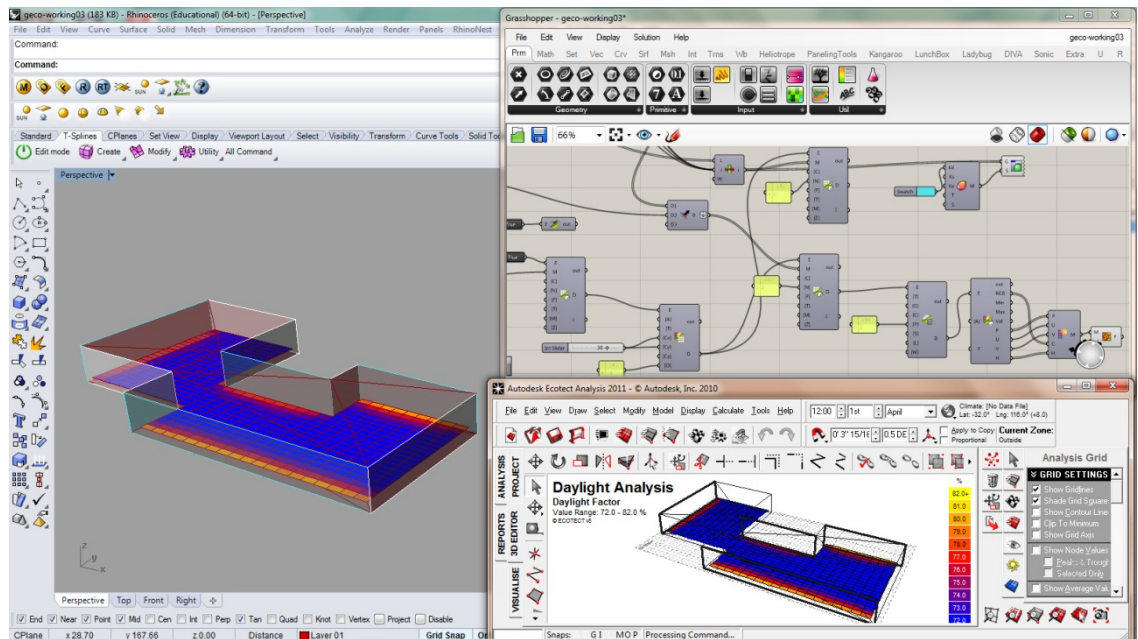
Figure 22: Example of a daylight analysis using GECO (Image by author)

connected only so that when the function of one component is executed, those of the following components are also executed, rather than there necessarily being a deeper algorithmic link between them as might be assumed.

With reference to the analysis type being used, it should be noted that Ecotect, and therefore GECO, uses what is known as the Building Research Establishment (BRE) Split –Flux method for calculating daylight factors. While this method can be useful for determining results, it is generally considered to be not as accurate as the ray-traced computer simulation methods such as that used in RADIANCE, which is utilized in DIVA, and was originally developed for use in more simplified manual calculation procedures. Ecotect, however, can also provide output data which can then be used within the RADIANCE program, but this is a separate task and not incorporated within a GECO workflow.

The following exercise shows how insolation analysis data may be incorporated directly into a design for façade panel system. The intention in this example is to use the average hourly
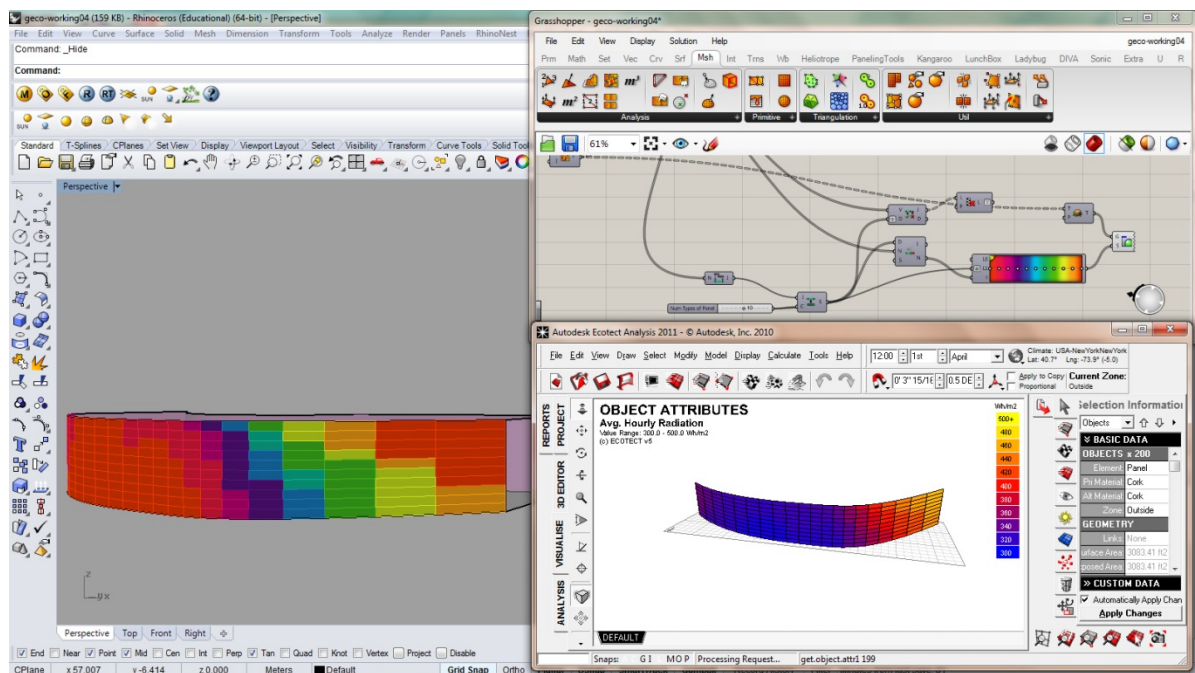
Figure 23: Example of using insolation data from GECO to determine panel type distribution (Image by author)

data to determine subsets of the panels so that each type could be designed for the particular

amount of solar radiation to that zone of the façade. The first step might be to model the base

surface geometry of the façade, and subdivide it into areas for the panels. For GECO these

would then be converted to meshes and used as input for the mesh export component which

sends this geometric information to Ecotect where it can then be analyzed using the insolation

calculation component. The resulting data must then be reimported back into Grasshopper

using the object request component. In order to sort the panels according to analysis values (for

which there is no GECO component) some work with data trees is necessary, but essentially the

panels can be put onto separate lists, which can be visualized using a color preview applied to

the geometry as shown. These areas on these separate lists could then be used as the base

geometry for each of the desired panel types.

Aside from panel type distribution, the data might be used to determine relative values

of panel geometry. For this example, given a double curved façade, with some areas more prone

to heat gain than others, average irradiation values might be used to scale aperture sizes, with
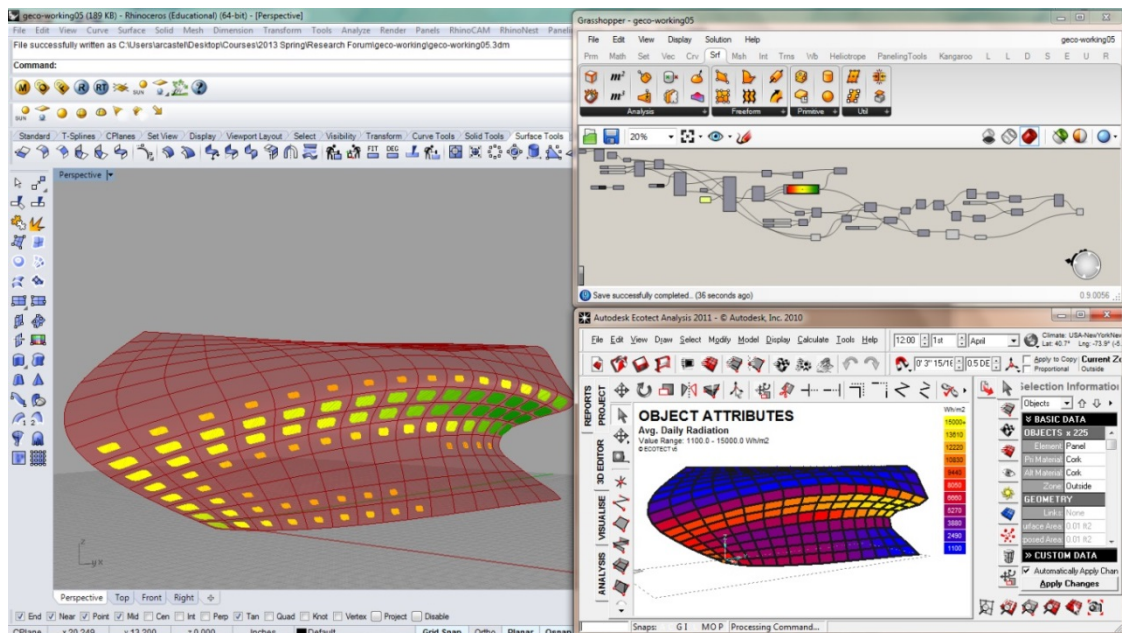
Figure 24: Example of using insolation data from GECO to scale apertures (Image by author)

areas of smallest irradiation having the largest windows. Such a strategy might be most appropriate in a particularly hot climate. A threshold is also set in this example whereby the areas receiving the greatest irradiation have a solid panel. In GECO specifically, the procedure is much the same as previously, but that rather than dividing the panels into subsets, the data is remapped to an appropriate range and applied as scaling factors to the aperture geometry of the corresponding panel locations.

2.3.4 Ladybug Overview

Ladybug is an add-on for Grasshopper which allows for access to weather data, basic radiation analyses, and includes other tools which allow for tasks such as creating shadow
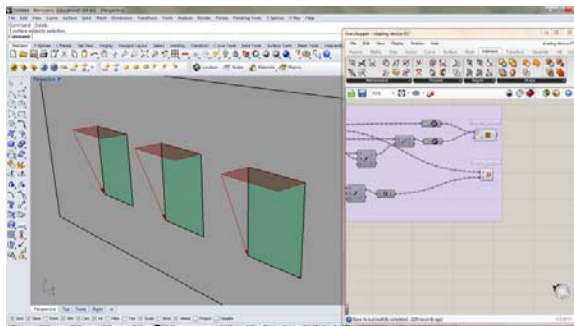
Figure 25: Example of using solar vectors to determine depth of shading devices (Image by author)

studies. The add-on is free, open source material using the Python programming language, and was created by Mostapha Sadeghipour Roudsari, a graduate of the Environmental Building Design program at University of Pennsylvania who recently joined Thornton Tomasetti's Advanced Computational Modeling Group.

A useful feature in Ladybug is the sunpath tool, which easily allows for solar vectors to be obtained based on the project location set. The vectors might be used, for example, to determine the depth of simple shading devices over windows.
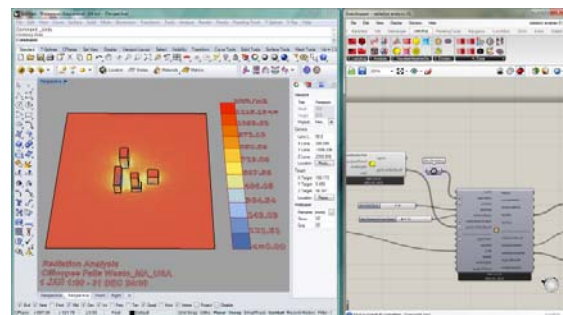
Figure 26: Example of daylight hours analysis using Ladybug (Image by author)

The components also allow for shadow studies, as well as daylight hours analyses once the sunpath for the project location is set up. The results of the daylight hours analysis can be visualized by color gradient.

As with DIVA, Ladybug can be used to do irradiation studies. In this exercise, the summer and winter values on a curved wall surface were obtained, and the difference visualized on a third copy of the surface. This strategy could, for example, provide some
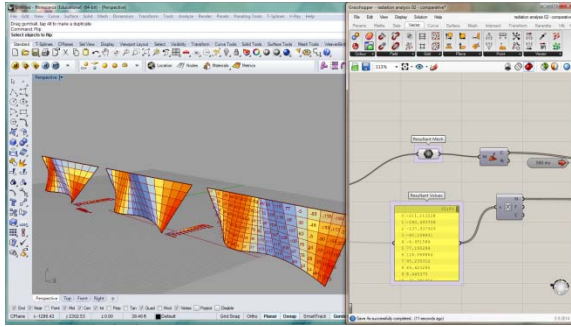
Figure 27: Study of solar irradiation on double-curved surface (Image by author)

indication of better or worse locations for glazing if it were desired to have solar heat gain in the winter while minimizing it in the summer.

A computational method to attempt an optimization of form for shading devices might also tried, for example using Grasshopper's Galapagos solver to maximize or minimize a desired analysis result's value. Using this solver can be problematic or overly time-consuming, however, if too many variables are being tested.
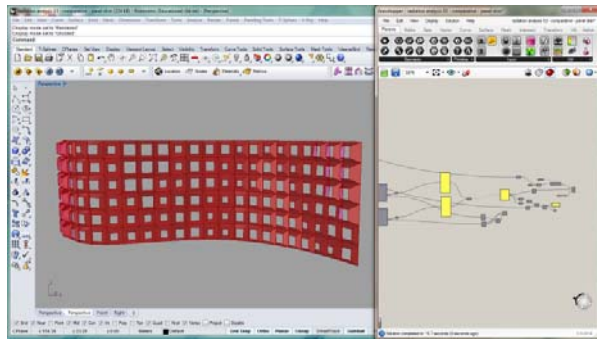
Figure 28: Study utilizing optimization routine and solar irradiation data for façade panel system (Image by author)

The above described studies demonstrate only a few of the tools and possible strategies for utilizing them during the design process which the Ladybug add-on makes available to users.

Another open-source Grasshopper add-on developed by Roudsari, recently released in 2014 and called Honeybee, allows for more advanced solar analyses than Ladybug, utilizing Radiance as a simulation engine, thus allowing a ray-tracing method rather than the weather file

data-based approaches used with Ladybug. Additional features in Honeybee include the ability

to generate custom Radiance materials with the add-on's Grasshopper components, as well as

the ability to generate and visualize various types of sky domes to be used in analysis. The use of

Daysim with Honeybee allows for annual-based daylight analyses. Not yet available in the

current release, but planned for future development in Honeybee, is the ability to perform

thermal analyses utilizing EnergyPlus.

[1] Schumacher, Patrik (2009). "Parametric Patterns." AD: Architectural Design. Vol. 79 No. 6.

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[3] Colletti, Marjan (2011). "Turbulances Ahead." <http://marjan-colletti.blogspot.com/2000/09/turbulences-ahead-book-review.html> accessed 1 Mar 13

[4] Moussavi, Farshid (2011). "Viewpoint." *Architectural Review*. October 2011

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[6] <http://www.reiser-umemoto.com/> accessed 1 Mar 13

[7] Jodidio, Philip (2012). *Jean Nouvel*. Cologne: Taschen.

[8] < http://www.future-cities-lab.net/> accessed 1 Mar 13

[9] Hensel, Michael & Menges, Achim (2008). "Efficiency Versus Effectiveness: Towards a Morpho-Ecological Approach for Design." *Architectural Design*. Vol.78 no.2

[10] Hagan, Susannah (2008). *Digitalia: Architecture and the Digital, the Environmental, and the Avant-Garde*. p1-7

[11] Ibid. p8-12

[12] Ibid. p10-18

[13] Ibid. p30-36

[14] Ibid. p36-38

[15] Ibid. p39-50

[16] Hensel, Michael & Menges, Achim (2008). "Efficiency versus Effectiveness: Towards a Morpho-Ecological Approach for Design." *Architectural Design*. Vol.78 no.2

[17] <http://www.theredgroup.org/architecture/pattern-books-competition/>

[18] Hensel, Michael (2012). "Performance-oriented design as a framework for renovating architectural practice and innovating research by design." *Design Innovation for the Built Environment: Research by Design and the Renovation of Practice*. New York: Routledge.

[19] Hagan, Susannah (2008). *Digitalia: Architecture and the Digital, the Environmental, and the Avant-Garde*. p6-7

[20] Ibid. 51-61

[21] <http://aedas.com/Al%20Bahar%20Towers> accessed 7 Mar 2013

CHAPTER 3

CONTEMPORARY LIBRARY DESIGN

3.1 Overview of Contemporary Library Design

As Ken Worpole writes in his recent book on contemporary library architecture, the design of public and academic libraries have generated increased interest in recent years.[1] This is perhaps against expectation, as the emergence of new media and means of communication have challenged the prior dominance of the book as a primary source of information. Libraries have emerged, however, which "are as much about creating places where people meet, read, discuss and explore ideas, as they are about the collection and administration of books in an ordered form."[2] This marks one of the significant changes that characterize the innovative trends occurring in contemporary library design. "Libraries," writes Philip Jodidio, "faced with the challenge of the Internet, but also the realization that interesting contemporary architecture can serve the purpose of keeping contact with the present, have evolved dramatically…"[3]

While many cities, in the post-Bilbao period, have seen large-scale downtown libraries which seek to revitalize an urban area with signature design, as discussed in Shannon Mattern's recent study on the subject, many have, despite perhaps inflated budgets, provided much needed public space which positively contributes to the civic life of the city. The most famous and largely successful example of the new centralized library is undoubtedly the Seattle Central Library designed by Rem Koolhaas and his firm OMA, which will be discussed further as a case study. More recently, the Library of Birmingham in the UK is similarly high-profile and projects a similar number of visitors per day. More small-scale and modest local or city branch libraries have also emerged as, in many cases, an area where architectural design has contributed to the social and cultural life of the area.

While some conservative critics are resistant to the idea of incorporating social spaces and expanded programs into the library, fearing that internet cafes, coffee bars, and informal reading areas are deviations from the traditional mission of libraries, the trend towards a wider variety of programming being embraced within their purview has generally gained wide acceptance. This can be observed on a number of fronts. In academic settings, libraries have been used to increase both quality of education and quality of life more generally. For example, at the Aberdeen University Library in Scotland, by the firm Schmidt Hammer Lassen, the library has been envisioned as a beacon of learning, but also as a meeting place and cultural center for both students and the wider public. Part of the success of these developments may be the service they provide as what sociologist Ray Oldenburg termed a "third place," that is to say one which is not devoted to two primary types of human space, those of the home dwelling and of the workplace. Libraries remain one of the few public spaces open to everyone and providing resources free from individual costs. As books become more widely accessible by means of e-readers and online services, this public space component becomes an even more important aspect of library design.

It is interesting to note, in relation to possible future directions for library programming, a schema suggested by a UK study called the "Academic Libraries of the Future Project."[4] While the three possible scenarios it envisions are specifically concerned with academic libraries, the schema may well provide some insight into public libraries as well. These scenarios are termed the "Beehive," the "Wild West," and the "Walled Garden." The "Wild West" type library would be based on a consumer-oriented model, where the library would be funded from a mix of sources both public and private, and users would essentially "get what they want" within a kind of market-driven approach to services. In contrast, the "Beehive" type is state funded, less market-driven, but seeking primarily to provide the informational resources necessary for the

training of a skilled workforce, with efficiency of material circulation being a key goal, as well as the provision for educational spaces and computer access. The third type is that of the "Walled Garden," perhaps less open in terms of large public spaces, but providing a type of "sanctuary" for quiet, intellectual studies, disinterested in mass appeal but allowing for individual needs. Of course, libraries need not fall exclusively into any such category, each of which with its own advantages and disadvantages, but the variations in these scenarios suggest some of the tensions and possible directions in future library design.

The programmatic changes and focus on the needs of contemporary users has also signaled shift in the architectural design of libraries, over the course of the previous century, particularly with notable changes over the previous two decades. In contrast to the typology of the traditional library, which may be generalized as being characterized by an often Neo-Classical form, with imposing main steps and hall spaces, walls lined with bookshelves tall enough to require ladders to access books, institutional furniture, and an overall hierarchical organization, modern library architecture can be characterized by a contrasting set of features. More free-form compositions were implemented, with more welcoming, pedestrian-scaled entrances, open plans, rows of user-scaled shelves, atria often proving daylight into the interior, more casual communal and reading spaces, and generally a wider variety of types of interior spaces. Older attitudes towards collections have also changed in the modern period. Where an older library may have held a canonical stock of books curated by librarians as custodians of knowledge, modern libraries typically provide a range of material, much of which popular entertainment material rather than of educational interest, and librarians are more like disinterested navigational aids. However, as Matthew Battles points out in his history of the library, such debates between high and low culture, and the role of librarians, have been points of contention at numerous times in the centuries-long history of the library.[5]

More recent shifts in library design have occurred which break with many of the earlier

characteristics of modern library architecture. Many modernist libraries, with their deep floor

plates, relied primarily on artificial light, an energy inefficient aspect of their design which also

contributed to users' sense of disconnect from the exterior environment. Contemporary

libraries, by contrast, often strive for a greater connection to exterior spaces and increasingly

have utilized natural lighting as will be discussed in the following segment on sustainable design

strategies in contemporary libraries. Well-designed contemporary libraries, says Shannon

Mattern, "are newly transparent, legible, accessible, responsive to context. They facilitate new

patterns of interaction with media and new patterns of library service. In the process, they make

possible new roles for the library patron and the librarian."[6]

In addition to the "living room" type of more socially oriented communal spaces, the

programming of recent library projects has, of course, been influenced by the importance of the

computer as both workstation and information portal. Computer access zones provide Internet

access to community members unable to pay for personal service. These may also provide

access to digital content as well provide information necessary for finding books and other

content within the library. "The library," according to Manuela Roth, "has become transformed

from a quiet introverted building into an information provider for the promotion of

communication. It has become an important social interface where users contact each other,

exchange information and work together."[7]

An important characteristic of many new libraries is the manner in which it engages with

the street. A prevalent strategy is to place an attractive reading commons adjacent to glazed

street façade. This serves the dual purpose of allowing passersby an advertisement for the

welcoming space within and providing interior occupants with a visual and spatial connection to

the exterior context of the neighborhood. The visual connection from the exterior to the activity

to be found within is a feature not only of smaller scale branch libraries, but is also a

development for recent large-scale academic and public central libraries. For example, it is

notable about OMA's Seattle Central Library, particularly at night, that the interior organization

and sense of the life within can be observed from the exterior. In contrast, the San Antonio

Library, designed by Legorreta and Legorreta, is apparently widely unliked because of the lack of

engagement between interior spaces with the street front.

In addition to such open and varied reading and work spaces as found in the new library

commons, group study spaces are an additional feature to be found in new many libraries, as

well as community meeting and presentation rooms. It is worth noting that while computers as

individual workstations have been prevalent in libraries for the past couple of decades, the more

collective usage of computer technologies is only beginning to emerge in recent years. Most

notable in this regard is the use of such technologies at NCSU's Hunt Library, which is discussed

as a case study. Other technological changes such the availability of Wi-Fi and the ability to rent

e-books have become common place. A more recent trend is the inclusion of maker spaces

within the library program, such as at the Detroit Public Library, where patrons can have access

to 3d printers or laser cutters.

A number of European libraries have explored new models for the usage of technology

and related services within the library environment. For example, music and video editing

spaces might be made available, staff may be available for teaching how to use software, or

specific spaces may be made available for "mobile workers," as at the Helsinki City Library. Such

experimentation with the library model points toward a building type in transition, one

increasingly flexible and capable of accommodating novel and emerging programmatic elements

into its mission. Libraries which resist meeting user's changing needs risk becoming irrelevant or

underutilized. For example, at the Nashville Library, the building's primary reading room is rarely

used because the institution has maintained a policy of not permitting patrons to use their

laptops within the space. This is not to say that the traditional uses of libraries are no longer a

primary concern, but that libraries must be able to evolve to meet user's changing needs and

expectations within the twenty-first century context.

3.2 Sustainable Design Considerations and Strategies

Contemporary libraries, like many other building types, are being impacted by the

recent interest in creating more sustainable and better performing buildings. The resulting

changes in the approach to architectural design have a number of consequences specific to

library design which should be considered. In addition to the need for buildings to consume less

natural resources, contribute a smaller carbon footprint, and provide better and healthier

indoor environments, it is also worth noting that libraries, as places of community and learning,

are particularly suited to educating the public about these concerns and the potential means of

solving some of these problems. This may be through "visible" measures which the building

employs to improve building performance, educational exhibits about building features and

environmental concerns more generally, and also by providing spaces for guest speakers, special

events or symposia, and community meetings concerned with these topics. Additionally,

specialized collections can provide a valuable resource for individuals and organizations, while

careful design of common and group collaborative spaces can potentially allow for a "place"

which acts as both knowledge base, focused social interaction zone, and collective activity

center. These are some of the programmatic and social features of libraries which may positively

engage with sustainability and environmental issues, and offer opportunities for a more

widespread impact in relation to these areas.

To return to the topic of building performance, specifically as it pertains to new library design, perhaps the most significant aspect to consider regards the use of natural lighting. This is particularly important for libraries for a number of reasons. In comparison to typical office buildings which can use approximately 30 percent of its energy consumption on artificial lighting, public libraries may have as much as 45 percent of its energy load from lighting.[8] Over the previous decades a substantial shift in the approach to daylighting has affected and been affected by changing library programs and their organization. Generally speaking this is a move away from deep plans which require extensive artificial lighting. There is instead now often greater emphasis on narrower floor plans with glazing strategically allowing for daylighting of large open common spaces. These sources of side-lighting are often multiple stories in height and often placed on the north side of the building, as can be seen in a number of the case studies. This strategy minimizes both the potential for glare and direct solar radiation at the location of the glazing. In cases where common spaces and reading areas are located along the eastern or western sides of the building, vertical shading fins may be employed to reduce unwanted solar gain and decrease glare potential. This strategy was effectively employed to great visual effect, for example, at Snohetta's Hunt Library. Along south facing glazed areas, horizontal shading devices may be used, such that they block solar heat gain during summer while allowing for some passive heat gain in winter. Libraries are also increasingly utilizing courtyard schemes to bring natural light into the interior while providing a sheltered exterior space for reading. For example, this strategy was used at the two recent branch libraries in Boston, Machado and Silvetti's Allston Branch Library and William Rawn Associate's Mattapan Branch Library. Larger scale buildings may employ an atrium type layout where daylight at be brought down from roof level through to the lower floors. Recent examples of this type of

organization are two recent large-scale libraries in the UK, the Mecanoo's Birmingham Library and Hammer Schmidt Lassen's University of Aberdeen Library in Scotland.

In relation to cooling and heating loads, should be mentioned that, although the relative extent of each is obviously dependent on local climate and other factors, libraries often are more cooling dominated than some other building types for the reason that they may contain a large number of heat-generating devices such as computers, as well as large numbers of people which also generate a significant amount of heat. Additionally, the lighting requirements for libraries which are greater than for numerous other building types, means that artificial lighting can also be a significant source of heat in the interior. This was particularly the case for older projects which relied more extensively on artificial lighting than most new building projects. The recent emergence of LED fixtures and there substitution for the incandescent bulbs changes this phenomenon however. LEDs have multiple benefits over traditional artificial lighting sources. In addition to consuming less energy, they also emit substantially less heat, which translates to a reduction in cooling loads, and given that they last for a much a longer period of time, they are also materially, more efficient. For these reasons, LEDs are being increasingly utilized in new libraries and will undoubtedly become more prevalent in the future.

The shift from the deep plan, artificially lit interior to narrower and more strategically oriented buildings is also a result of changing attitudes towards the reliance upon large mechanical systems for cooling. In addition to increasing insulation values in order downsize systems, passive ventilation strategies are increasingly being employed for library design. This is not without its challenges since sensitive collection storage or IT equipment may require more controlled conditioning. However, innovative and more efficient approaches to heating, cooling and ventilation are being increasing used in new library projects, for example at the South Jamaica Branch Library discussed as a case study. An example of a project using natural

ventilation is Bennetts Associates' Brighton Public Library, which utilizes large ventilating

chimneys positioned over the main space. Libraries may also be designed with multiple zones,

with appropriate areas designed form natural ventilation and areas with more stringent

requirement using mechanical ventilation as needed. Libraries typically require about 4 air

changes per hour, so heat-recovery systems are a beneficial feature to reduce energy use while

ensuring adequate ventilation when mechanical ventilation is used.

These are some of the most significant considerations for contemporary library design in

relation to sustainability and building performance. Additional discussion on environmental

strategies is discussed in examination of the selected case studies.

3.3 Selected Case Studies

3.3.1 Case Study: Seattle Central Library

The Seattle Central Library by Office for Metropolitan Architecture (OMA) and LMN

Architects, and completed in 2004, is likely one of the most notable and prominent of large-

scale libraries completed in the recent
decades. The needs of the Seattle
Library system which led to the
competition are clear. Many libraries
were outdated or in poor condition and
lacking necessary storage capacity. The
decision to build a large central library
rather than make improvements to local
libraries was not without opponents,
but eventually the proposition was

Figure 29: OMA & LMN, Seattle Central Library, Seattle, WA,
2004 (Retrieved 10/21/13 from
http://www.archdaily.com/11651/seattle-central-library-
oma-lmn/)

favored and there was a strong desire to create a world-class facility which would also aid in revitalizing the downtown area. The architects were selected after a competition, whose finalists also included Steven Holl, Cesar Pelli, Foster and Partners, and regional firm Zimmer Gunsul Frasca (ZGF).

OMA's stated ambition for the project was "to redefine the library as an institution no longer exclusively dedicated to the book, but rather as an information store where all potent forms of media – new and old – are presented equally and legibly."[9] As media technologies evolve and the sources of information change, there has been debate over the future role of the book. OMA's response was essentially to allow for the cohabitation of these multiple formats, recognizing the importance of roles that each play in the current era. Early critics feared that book storage was being undervalued in the distribution of programmatic elements, but the building in fact would expand capacity to house 780,000 books, and with enough extra space in the bookshelves to accommodate almost 1.5 million. The overall floor area of the building amounts to 363,000 sqf, with an additional 49,000 sqf of parking underground. The project, whose cost amounted to $165.9 million, attracted more than 8,000 visitors a day during its first year, which is more than double the attendance of the previous building.

Figure 30: Diagram of "stable" program elements in Seattle Central Library (Retrieved 9/17/13 from http://www.archdaily.com/11651/seattle-central-library-oma-lmn/)

While the building's form is iconic and visually engaging, it is also the product of a rigorous examination of the program elements and a conceptual approach to the relationships between them: "Our first operation was to 'comb' and consolidate the library's apparently ungovernable proliferation of program and media. By combining like with like, we identified a set of programmatic

clusters – five of stability, four of instability."[10] The "stable" platforms were architectonically

articulated as closed rectilinear volumes, stacked vertically but shifted in plan and separated by

the open spaces of the "unstable" platforms. Specifically, the "stable" category includes, from

bottom to top, parking, staff areas, meeting space, the book spiral, and the "hq," or

administration space, at the top. In essence, these are the building areas dedicated to well-

defined specific functions, and each is defined with its own color scheme. In contrast the

"unstable" spaces are envisioned as spaces where social interactions take place. The different

emphases placed on these zones are highlighted in the architects' labels of the Mixing Chamber,

Living Room, Reading Room, and Kids. They are likened to "trading-floors where librarians

inform and stimulate, where the interface between different platforms is organized – spaces for

work, interaction and play."[11] Aside from the metaphor of instability, the shifting volumes also

produce some compelling spaces in the "unstable" zones, and also facilitated the ability to

orient different levels of the building towards varying view directions. The result is building

which avoids any formal correlation with

existing library typologies, but which is relates

to a research-based design concept focused on

functional, organizational, and spatial

considerations. The architects aimed to combat

a traditional library organization based on a

repetitive array of floor plates, each floor

Figure 31: The Living Room of the Seattle Central
Library (Retrieved 9/17/13 from
http://www.archdaily.com/11651/seattle-central-
library-oma-lmn/)

discrete and separate from the others though

often containing the same functions.

From Fifth Avenue, to the east of the building, visitors enter the Living Room, a dramatic

atrium space lit from the perimeter's angled diagrid walls. A series of casual social and reading

spaces line one side of the floor plan. A series of shelving units housing fiction books are

irregularly placed throughout the floor plan, these seemingly attracted or directed towards one

of the casual spaces, which has been demarcated with a photo-imprinted flooring depicting a

close-up shots of grass and leaves. Also on this level are a Teen Center, library gift shop,

information desk, and coffee cart.
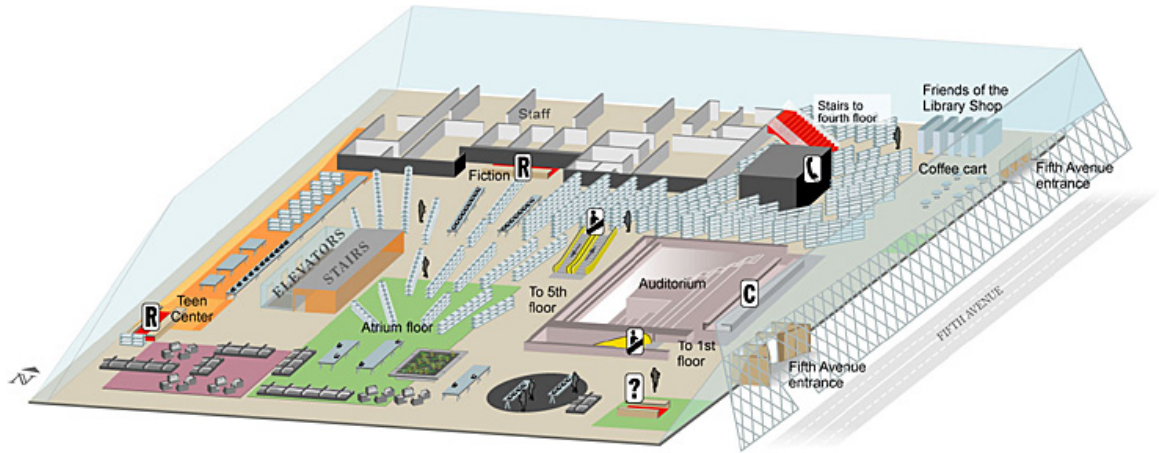
Figure 32: The Living Room of the Seattle Central Library (Retrieved 9/17/13 from
http://seattletimes.com/news/local/library/architecture/livingroom.html)

The Mixing Chamber is envisioned a hub where librarians can be efficiently sought out

to provide information to users. The intent was for library users to not have to wander around

seeking out help finding material or information. The floor is split between a user area and staff

area. Public-access computer desks are ordered in rows along one side, adjacent to reference
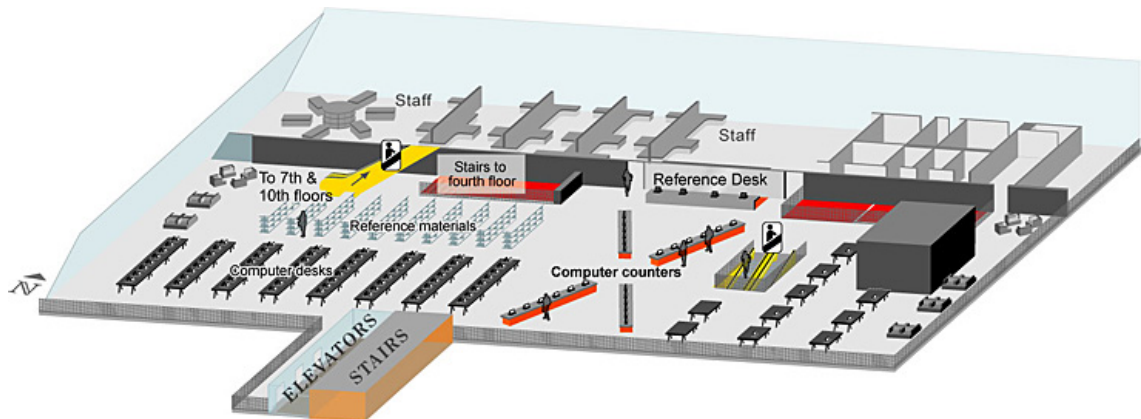
Figure 33: Illustration of the Mixing Chamber of Seattle Central Library (Retrieved 9/17/13 from
http://seattletimes.com/news/local/library/architecture/livingroom.html)

material. A reference desk is located near the escalator from below, and an x-shaped cluster of computer counters of information look-up.

The main book collection is innovatively arranged along a spiraling ramp which occupies the upper floors of the building. As the visitor walks along this path, he/she follows along a continuous organization of the Dewey
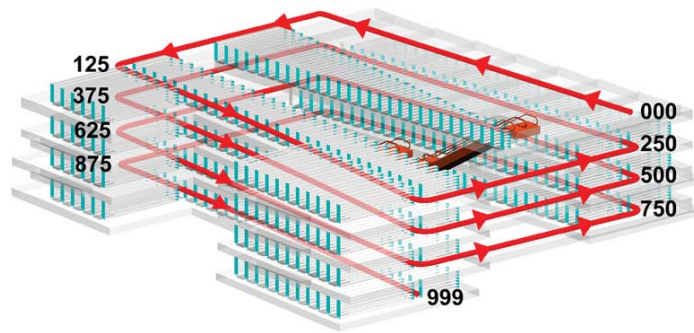
Figure 34: Diagram of Book Spiral of Seattle Central Library (Retrieved 9/17/13 from http://www.archdaily.com/11651/seattle-central-library-oma-lmn/)

Decimal System, from 000 at the top to 999 at the bottom. Adjacent to the spiral are staff spaces and an atrium. The book spiral culminates in an informal reading room at the tenth level, where light filters in from a sloping plane of glass and steel. Ancillary spaces include a music practice room and a performance arts workspace.
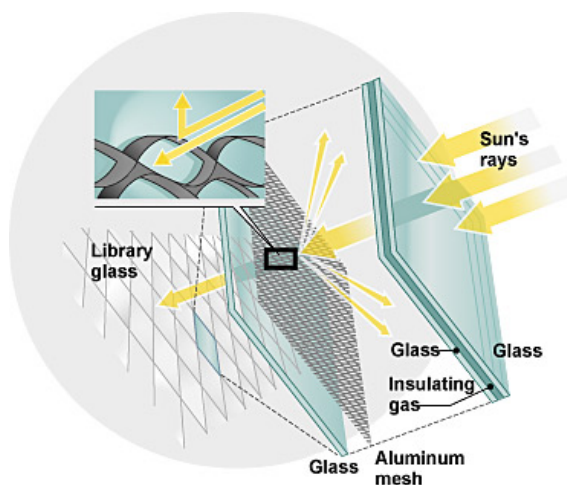
Figure 35: Illustration of glazing system of Seattle Central Library (Retrieved 9/17/13 from http://seattletimes.com/news/local/library/graphics/windows.html)

In relation to environmental performance, it is worth noting that the building was awarded a LEED Silver rating from the USGBC. LEED points were gained for an energy reduction of 40%, and 20% water usage reduction. It might be suspected that extensive glazing would result in poor energy performance, but approximately half of the glazing area is triple-paned, and aluminum metal mesh is used between their

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layers to reduce heat, as well as glare. Ample daylight is also provided by the glazing in the large

social spaces. However, it should be noted that an extensive amount of material went into the

building's construction, including over 18,000 cubic yards of concrete, enough to cover a

football field in ten feet of concrete, and over 4,600 tons of steel, about 20 times the weight of

the steel which makes up the Statue of Liberty.[12] While incorporating a number of features to

improve environmental performance, the projects most notable contribution to contemporary

library design is undoubtedly its approach to program and how it relates user's needs as well as

the overall building's form and individual spaces. Structurally, the building features a diamond

grid exoskeleton said to be designed such as to reduce the effects of lateral loadings from

earthquakes or high winds. While the building is noteworthy from a number of perspectives,

most noteworthy is its approach to program organization which has been discussed previously

and has been particularly influential in library design over the previous decade.

3.3.2 James B. Hunt Library

The James B. Hunt Library is a recently completed academic library on the campus of

North Carolina State University, designed by Oslo-based Snohetta with local firm Clark Nexsen (formerly PBC+L) as executive architect. The approximately 221,000 square foot building is among the first high-profile buildings on a recently developed research

Figure 36: Snohetta, James B. Hunt Library, North Carolina State University, 2013, View of Exterior (Retrieved 10/8/13 from http://www.snoarc.no/#/projects/544/false/education/)

area of the university known as Centennial Campus, to which Snohetta has also contributed

further development of the master plan for the area to the north of the building. To the south

are Lake Raleigh and its natural surroundings to which the building responds through strategic

views.

Among notable features of the building is the use of a five-story automated, robotic

book storage and retrieval system, known as bookBot, which allows storage for the collection's

two-million books within an area perhaps 1/9th the size of that of conventional shelving spaces.

Users can browse through the book collection on virtual shelves within a software interface

called Virtual Browse. The machine scans and sorts the books, transporting them, before storage

in over 18,000 bins. Users can request books for retrieval from anywhere with Internet access,

such as from their laptops or mobile devices. About 40,000 books remain on traditional open

shelving for quick access, particularly new and frequently used books. Aside from the bookBot,

other innovative approaches to media include a Teaching and Visualization Lab, a Creativity

Studio, and a Makerspace, with 3D printers, a 3D scanner, and a laser cutter. These kinds of

spaces aid in the university's goal for the library to put technology in the fore, and make the

most advanced tools widely available for the campus community, removing barriers to accessibility. The design also seeks to become a heart of student activity, interaction, and collaboration. A formal design concept centered on the idea of "threading," derived from the history of textile manufacture in the region. This formal strategy can be seen in the

Figure 37: Snohetta, James B. Hunt Jr. Library, North Carolina State University, 2013, Automated book retrieval system (Retrieved 10/8/13 from http://www.dezeen.com/2013/04/03/james-b-hunt-jr-library-by-snohetta/)

experience of the exterior skin with its overall texture and layers of shading fins, and in the

overall building design as it relates to its surrounding landscape and context of nearby campus

buildings.

With the storage portion of the building significantly downsized as a result of the spatial

efficiency of the automated book storage system, more space was made available for other

programmatic elements, which include almost a hundred study rooms, two large learning

commons, and auditorium space. The lowest level of the building, which is at grade on the west

side and below grade on the east, contains about half of the building's staff areas, in addition to

a large auditorium and a café by the entry. Overall the building is oriented in a north-south

direction, with the multi-story book retrieval system taking up approximately the middle-third of

the western half of the building.

On the second level, visitors enter from the east to a lobby, where a large multipurpose

room for events and meetings can be accessed, and an Emerging Issues Commons is located.

The main library areas are accessed to the left. This level contains extensive common space with

a large reading lounge on the east side which looks out to the adjacent rain garden, as well as a

quiet reading area at the south end which
is surrounded by group study rooms. The
group study rooms generally contain a
table to accommodate a number of
students and are provided with
whiteboards and wall-mounted wide
screens for presentation purposes. Also
on this floor are an "Immersion Theater"
and a technology showcase area. The

Figure 38: Snohetta, James B. Hunt Jr. Library, North Carolina State University, 2013, Reading lounge on second level (Retrieved 10/8/13 from http://www.snoarc.no/#/projects/544/false/education/)

commons on this level are double-level in height, reducing the floor area of the third floor.

The third floor is primarily dedicated to the Nexgen Learning Commons, an area for computer use with printing areas. A number of group study rooms are located at the perimeter to the north and south. Additionally, a Game Lab is located next to the main stairs.

On the large level above are located three other commons spaces, the Learning Commons, Graduate Student Commons, and a Reading Lounge. Along the west side are a number of more specialized areas, the Teaching and Visualization Lab, Creativity Studios, and a Video Seminar Room. Along the central spine, in addition to circulation, are media production and music rooms. Occupying the northern third of the floor level is space for the Institute for Emerging Issues.

The Fifth floor contains primarily staff space and space for university institutions, but also a faculty area, complete with focus rooms and workrooms, the Skyline Reading Room, which looks out to the perimeter green roof, and terrace at the south end which offers views of Lake Raleigh and the downtown skyline in the distance. It should be noted that the client and university desired that there be a wide variety of types of spaces within the building which allow for number of different experiences. For example, over 80 different types of chairs are used throughout the building, in a wide range of colors and textures.

While the building seems successful on many levels, it is unclear how well the bookBot system functions in terms of how long users must wait before obtaining their book, how many

Figure 39: Snohetta, James B. Hunt Jr. Library, North Carolina State University, 2013, Close-up view of building enclosure (Retrieved 10/8/13 from http://www.snoarc.no/#/projects/544/false/education/)

individuals may be queued before a user can obtain their book during peak periods of the school

year, or if the Virtual Bookshelves truly provide for the "serendipitous" encounter of nearby

books which is a common experience with traditional library shelving. It is also unclear how

much the system costs, in terms of design, product, installation, operation, and maintenance, in

comparison to traditional shelving. Likewise, the implications for energy consumption should be

considered, and the reduced amount of space to be heated and cooled weighed against energy

usage of the new system in terms of embodied and operating energy required.

The building achieved a LEED Silver rating due to a number of sustainable design

strategies. Most visible is the exterior aluminum shading system and fritted glazing which help

to minimize heat gain while allowing for natural light and views to the exterior. By placing

program areas most in need of light near the glazed perimeter and those without need of

daylight such as some of the technology labs in the interior, the building has efficiency in

daylight utilization. In most of the common spaces which reach deeper into the interior,

increased daylight is provided by cutting the floor plate above such that increased light from the

glazed facade can reach into the interior. In terms of heating and cooling, chilled beams provide

cooling of interior spaces while heating is provided by radiant panels. Additional green features

include the use of green roofs and rain gardens to aid in improved storm water management.
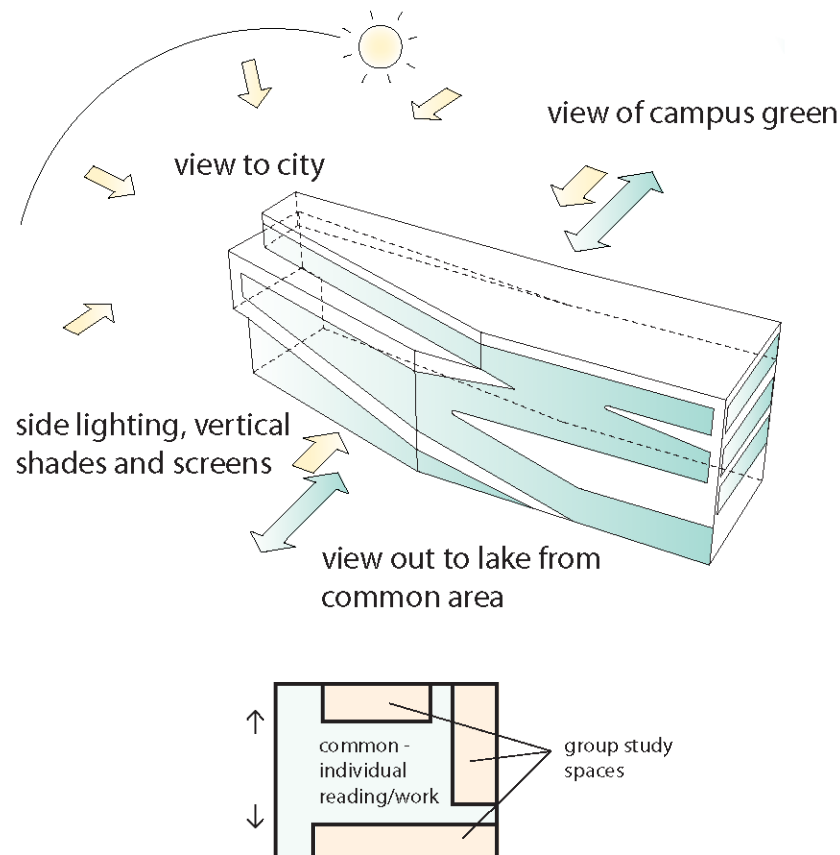
Figure 40: Diagrams of natural lighting, views, and selected program elements for James B. Hunt Library (Images by author)

3.3.3 Selected Recent Branch Libraries in NYC Outer Boroughs

Figure 41: Sen Architects, Kensington Branch Library, Brooklyn, NY, 2012 (Retrieved 10/2/13 from http://senarchitects.com/)

The New Kensington Branch Library in Brooklyn was completed in July 2012, and was designed by Sen Architects, a New York-based architecture firm. The 20,000 square-foot steel-framed building, which cost approximately $12 million, is described by the architects as having a "strong and welcoming Civic presence" within an urban

residential neighborhood.[13] Positioned mid-block within between other low-rise buildings, the

building is rectilinear in form, with the street front side defined by a double-height glazed wall,

displaying the reading area to passersby. This kind of two-way connection between the street-

front and interior casual reading area is a common feature in many recent local library branch

buildings. The façade also utilizes a terracotta rainscreen system. While the form and aesthetics

of the Kensington building are not particularly compelling, it is useful to consider the project in

relation to its programmatic layout and day-lighting strategies. Ample daylight is primarily

brought in through the aforementioned front curtain wall, which is north-facing, and from the

large skylights towards the center of the building, whose light reaches the ground floor through

a large circular opening in the floor above. On the ground floor, immediately below the opening,

are a set of round study tables, positioned between the reading area at the front and the

computer stations to the rear. To the side are book stacks, the lighting for this area being

artificial, suspended diffuse fixtures. Additional stacks are located immediately above on the

sides of the second level, as well as to the rear, where the young adults' books are located. The

below-grade level, receiving no natural lighting, contains a multi-purpose community meeting

room, gallery, and staff room.

The LEED-certified building contains a number of sustainable features which were

designed to reduce energy by 30%. The strategic use of the glazing provides a large amount of

daylight to interior reading and work spaces. As the main side lighting is north-facing, with

reduced potential for glare, while additional light is brought in from the east by offsetting this

side from the adjacent building. The skylight utilizes a computer-controlled louver system which

reduces glare. In addition, ground-source heat pumps reduce the building's energy consumption

and allowing the elimination of cooling equipment from the roof. The project also aims to

achieve a 38% reduction in potable water usage.[14] Storm water run-off was reduced through the

use of permeable paving and drought-resistant plantings. Numerous building components utilize

recycled content, for example the rubber flooring made from used tires.
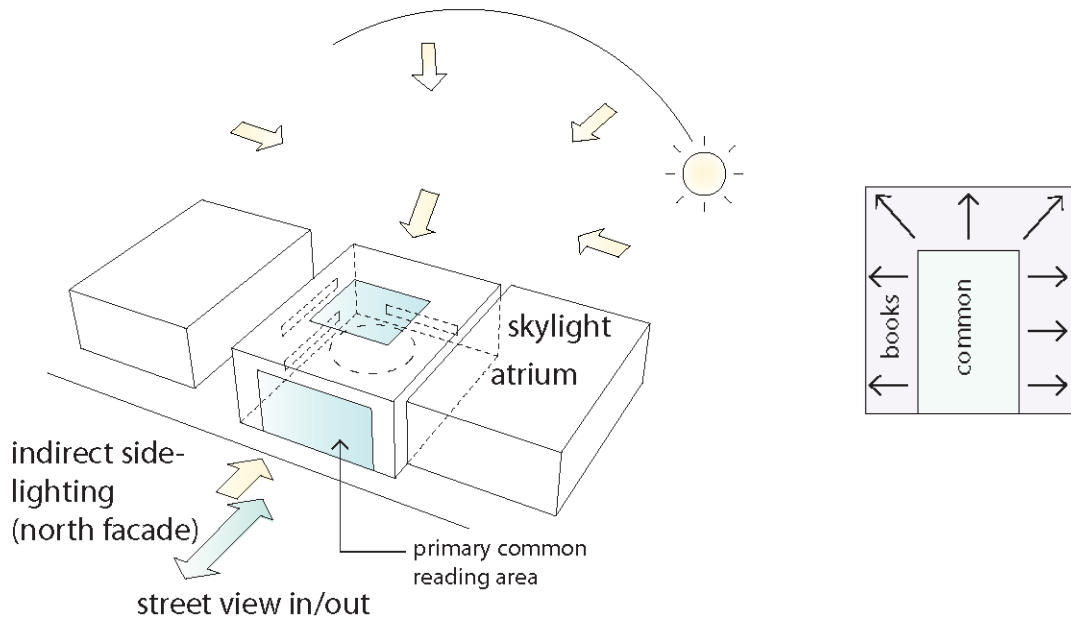
Figure 42: Diagrams of natural lighting, views, and program elements for Kensington Branch Library (Images by author)

In the neighborhood of Glen Oaks, at the eastern end of Queens, a new 18,000 square-

foot branch library was recently completed in 2013, designed by Marble Fairbanks. Located

between a low scale commercial area and a suburban neighborhood, the design responds to zoning constraints by utilizing an extensive amount of space below grade. While much of the programming is below-grade, and the building scaled to fit in with the surrounding context, the architects also

Figure 43: Marble Fairbanks, Glen Oaks Branch Library, Queens,, NY, 2013 (Retrieved 10/2/13 from http://www.american-architects.com/en/projects/42336_Glen_Oaks_Branch_Library)

intended for the building to be beacon for the neighborhood, employing a channel glass system

which provides a luminous glow in the evening. While formally different from the Kensington

Library, the designers expressed a similar desire to "engage the community by exposing much of

the interior to the street" with an extensive clear-glazed wall.[15] This glazed front wall on the

north façade exposes the entry lobby on ground floor and the children's area on the second

floor, providing views "into and out of" this space.[16] As in the previously described project, the

front wall provides one of the primary sources of daylight to the interior space. Here, however, a

full, building-height atrium with extensive top-lighting is not provided, but additional daylight is

brought into the interior through the translucent channel glass of the side elevations, in addition

to other clear-glazed side lighting. The primarily non-glazed east and south facades utilize a fiber

cement board paneling. Formally, the building massing could be described as two snaking,

interpenetrating volumes, with the primary volume defined by the channel glass side-wall and

Figure 44: Marble Fairbanks, Glen Oaks Branch Library, Queens,, NY, 2013, Perspective section (Retrieved 10/2/13 from http://www.american-architects.com/en/projects/42336_Glen_Oaks_Branch_Library)

main front glazing, and the other a clear-glazed, single floor volume which looks out to the side exterior plaza. The landscape architecture, designed by Scape/Landscape Architecture, provides a linear public plaza and exterior reading space. Planters were eliminated which would have impeded

views to and from the interior. Programmatically, the design shifts the majority of the book

stacks below grade, and utilizes the ground floor level primarily for casual reading, study tables,

computer usage, and circulation services. The casual reading space on this floor is located at the

rear, on the south side, adjacent to the glazed perimeter which looks out to an enclosed

courtyard. This permeability between inside and outside seems an effective strategy, though at

the south façade, glare and direct solar radiation to the seating area could potentially be

uncomfortable at certain times or seasons. The second floor contains an auditorium on the

south side, a children's area at the north, and additional computers and reading space in-

between.
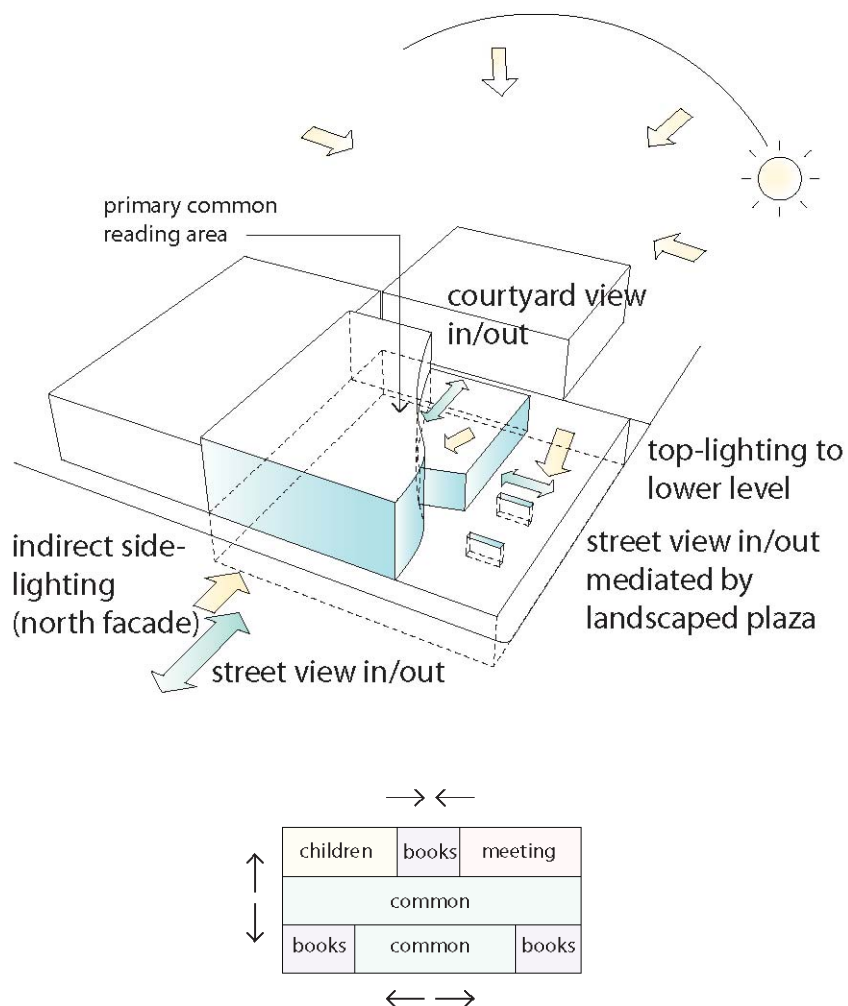
Figure 45: Diagrams of natural lighting, views, and program elements for Glen Oaks Branch Library
(Images by author)

As at Kensington, each of the primary library floors contains reading spaces and computer stations in addition to the other programming. The Glen Oaks Library is also LEED-certified and utilizes a number of energy-efficient features. Daylight reaches approximately 75% of the library's spaces, reducing the need for artificial lighting. The channel glass is insulated, providing reduced heat loss while still allowing additional light into the interior. Radiant heating and cooling may provide a 30% reduction in energy-use, while water use is reduced by an estimated 20% through low-flow fixtures and metered faucets. The project also redeveloped a former brownfield site, while construction waste and demolition material from the prior building was sorted and recycled to result in an estimated 75% reduction in landfill material.

The South Jamaica Branch Library in Queens, designed by Elemental Architecture and completed in 1999, is an older example, but notable for its building performance features. The 13,800 square-foot, two-story building utilizes both active and passive strategies to reduce energy usage. The south-facing monitors of the saw-toothed roof introduce indirect light into

Figure 46: Elemental Architecture (formerly Stein Partnership), South Jamaica Branch Library, Queens,, NY, 1999 (Retrieved 10/5/13 from http://www.solaripedia.com/13/313/3566/south_jamaica_library_nyc section.html)

the main library space by bouncing light off light shelves and curved diffusing elements. The design also takes advantage of the thermal stratification of the interior air. Return air ducts are located at both the roof peaks and floor level. In winter, heated air rising to these peaks is collected and redistributed to the interior space, while cooler air from lower in the space is exhausted. In summer, the system is reversed such that warm air at the peaks is expelled while the cooler air is recirculated. The building was selected as one of the AIA's Earth

Day Top Ten awards in 2000. The building is said to have outperformed expectations and

reduced energy costs by over one-third in comparison to typical previous public libraries in the

borough.[17] While solar heat gain is brought in through the monitors, an automatic control

system limits the gain, and light levels, during the summer. While the building achieves more

uniform distribution of daylight than primarily side-lit buildings, the lack of glazing at most of the

building perimeter makes the interior possibly "cave-like" and likely lacking in adequate

connection to the exterior. This is all the more noticeable in comparison to more recent libraries

of note, such as those previously described. The building layout is also unremarkable except that

it conforms to the trend towards a sizable portion of the main floor space dedicated to reading

and study space as opposed to book shelving, which is here positioned in short rows along the

perimeter of the main space.
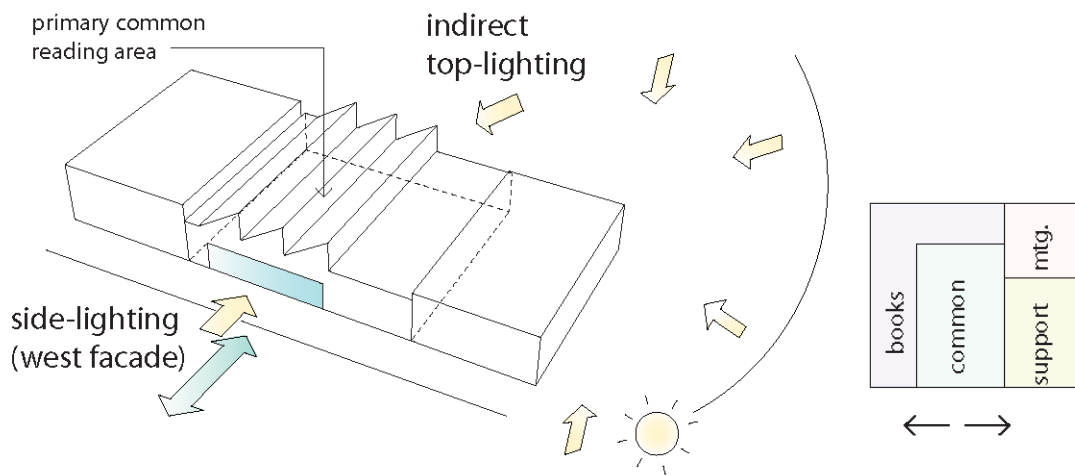
Figure 47: Diagrams of natural lighting, views, and program elements for South Jamaica Branch Library (Images by author)

Steven Holl's proposed design for a new branch library in Hunter's Point, Queens, also provides a useful reference point for this project, particularly because of its geographic location, and similar site context owing to its waterfront location and proximity to new large scale residential

Figure 48: Steven Holl, Hunters Point Community Library, Queens, NY, View of Building Model (Retrieved 10/3/13 from http://www.archdaily.com/108431/queens-library-at-hunters-point-steven-holl-architects)

and mixed-use construction along this waterfront zone. Nearby to the south is the Hunters Point South development project, the first completed part of which recently opened in 2013, a large-scale waterfront park designed by Weiss/Manfredi and Thomas Balsley Associates which extends to two blocks to the south at 50th Avenue. The first residential buildings for phase 1 of the Hunters Point South project recently began construction and will be two affordable housing residential towers, with other buildings to follow. To the north is the large-scale Queens West Development project which has added a number of large residential buildings to the waterfront. To the north of the recently completed park is Gantry Plaza State Park along the waterfront and fronting the future Holl project, which is to be located at Center Boulevard, between 47th Road and 48th Avenue. It will be Holl's first large scale public project in the city, and is currently in the construction document phase, the construction potentially to be completed in 2015. The library will be approximately 21,000 square feet and will contain, in addition to the book stacks, reading areas, a gallery, and a meeting/conference space for community usage and local events.

The design concept for the building is based on the idea for a building which is "hovering and porous, open to the public park, a luminous form of opportunity for knowledge, standing on its own reflection in the East River."[18] In common with numerous other contemporary library buildings is the expressed desire for the building to act as "beacon" for the community,
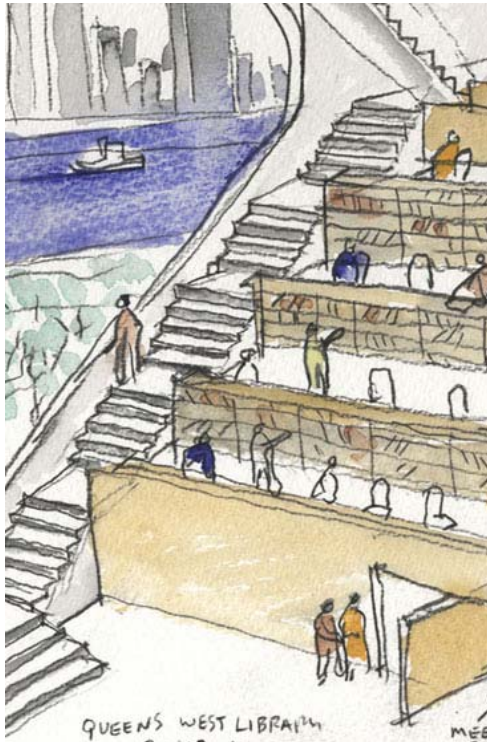
Figure 49: Steven Holl, Hunters Point Community Library, Queens, NY, Sketch of Interior (Retrieved 10/3/13 from http://www.archdaily.com/108431/queens-library-at-hunters-point-steven-holl-architects)

displaying its potential for engagement while allowing users a connection with the exterior context. The porosity of the building form plays out in a series of irregularly shaped and positioned glazed areas in the 80-foot tall façade which allow for extensive views of Manhattan across the East River. Most interesting is the cut which follows the perimeter vertical circulation which is also a series of stepped platforms which will contain reading spaces oriented to the view as well as book cases to rear of each platform. While plans for the building are not yet available, the programmatic distribution is said to "fluid," as "the building section of the new library

is open and flowing, while the plan is compact, allowing for the most energy-efficient design and the greatest amount of public space on the site."[19] Each of the major pores in the building form is said to indicate a particular programmatic zone, such as the teen or children's areas. On the roof, as a culmination to the climb of the perimeter staircase, is planned a reading garden with views across the river. Materially, the building is planned as a concrete structure with an exterior aluminum skin made entirely from recycled content. The interior finish is an exposed concrete surface with fabric-formed texture painted white. In terms of lighting, an extensive

amount of natural lighting will be provided by the large glazed apertures. As these are primarily

on the un-shaded west façade there is a potential for glare in the afternoon. Along the exterior

on the waterfront side is planned a reflecting pool consisting of recycled water and edged with

natural grasses once native to the area.
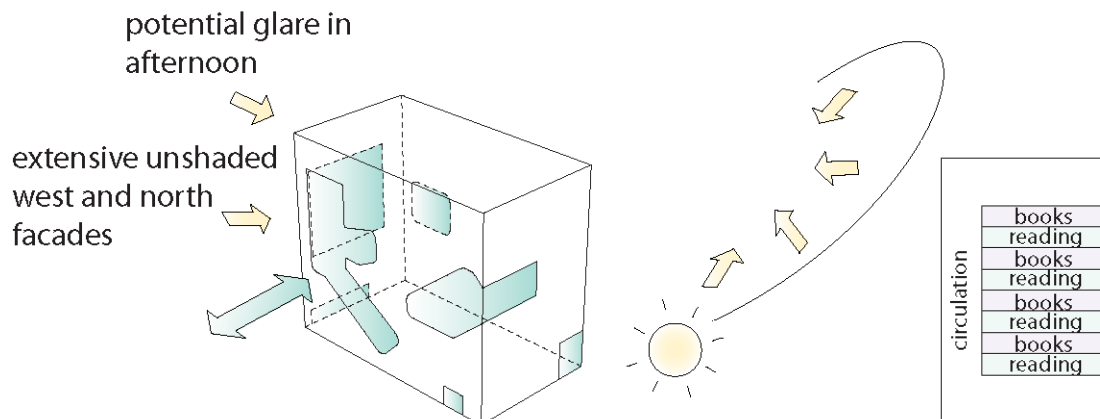
Figure 50: Diagrams of natural lighting, views, and program elements for Hunters Point Branch Library
(Images by author)

The Mariner's Harbor Public Library, located in northwest Staten Island and currently under construction, was designed by the small architectural firm Atelier Pagnamenta Torriani. The main design concept for the 11,000 square-foot, one-story building was to reference

Figure 51: Atelier Pagnamenta Torriani Architects, Mariner's Harbor Branch Library, Staten Island, NY, Rendering (Retrieved 10/24/13 from http://www.atelier-pt.com/frame_nav_projects_news.html)

the area's maritime past with a building which "cracks" open like an oyster shell.

Programmatically, this fissure in the building divides the main book stack area from the

community room and staff offices, and corresponds with the building's main circulation corridor.

It also acts as the primary means of bringing daylight deep into the interior of the building, as its roof is fully glazed and a clerestory is located on the book stack side. The fully-glazed street façade also allows for extensive daylight as well as views to the exterior. Outdoor views will be available to almost all of the occupied interior spaces. Immediately to the left of the entrance and visible to the street is a reading area with study tables surrounded by low-height shelving units. To the right is the community meeting room. The main corridor acts is lined with a series of computer stations, presumably making this an information access zone. Additional computer stations are located towards the rear of the building. While the positioning of the computers along the circulation spine and rear seems logical, this may be a better choice for quick reference access rather than longer term use since these are the more strongly daylit zones of the building, possibly resulting in glare issues, though this is minimized through the use of louvers and low-e glazing. The designers are pursuing LEED Silver certification for the project. While most of the project site is occupied by the building, an outdoor terrace is planned at the rear of the building. Adjacent to the terrace, existing landscape features will be preserved and supplemented with additional landscaping.
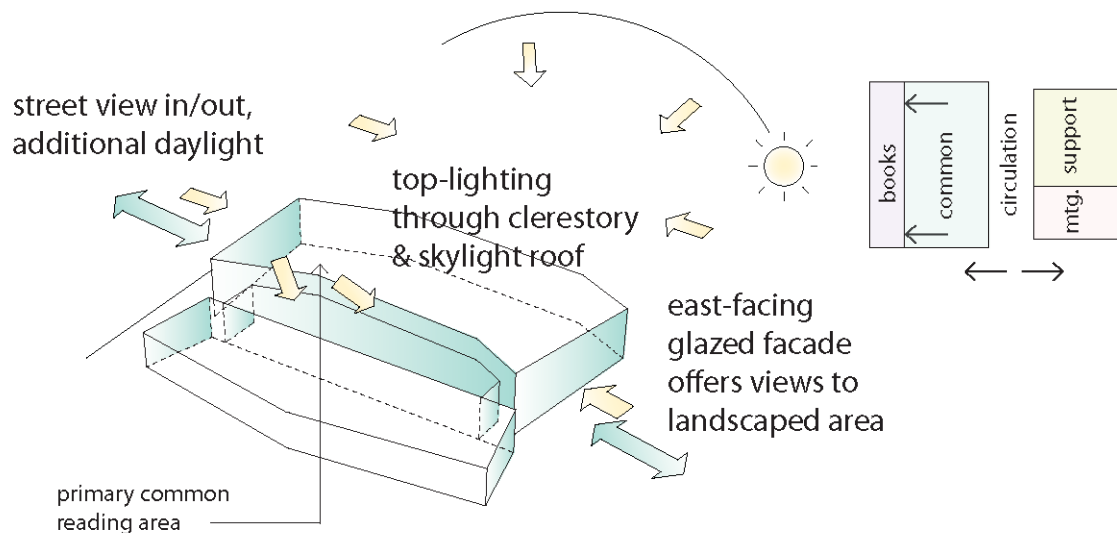
Figure 52: Diagrams of natural lighting, views, and program elements for Mariner's Harbor Branch Library (Images by author)

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[1] Worpole, Ken (2013). Contemporary Library Architecture: A Planning and Design Guide. Abingdon: Routledge.

[2] Worpole, Ken (2013). Contemporary Library Architecture: A Planning and Design Guide. Abingdon: Routledge. P. 1-8

[3] Jodidio, Philip (2010). Public Architecture Now!. Cologne: Taschen. P. 15

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CHAPTER 4

SITE ANALYSIS AND BUILDING PROGRAM

4.1 Site Analysis

4.1.1 Northern Brooklyn Geographical Site Description

The northernmost part of Brooklyn is defined by a peninsula bordered by the East River

to the west and Newtown Creek to the north and east. The Brooklyn-Queens Expressway (BQE),

which runs in a northeast-southeast direction, is the eastern border for Greenpoint, with the

northern edge of McCarren Park defining the southern edge of this neighborhood. To the east of

the BQE and also bordered by Newtown Creek is East Williamsburg. Newtown Creek acts as a

divider between these areas of Brooklyn and Queens to the northeast, specifically the areas of

Queens known as Hunters Point, Sunnyside, and Maspeth. To the east of the creek, a string of

large cemeteries generally serves to further separate Queens from Brooklyn, though with

Ridgewood and areas of Maspeth to the southwest of these cemeteries. South of McCarren Park

is Williamsburg, which extends south to the Brooklyn Navy Yard and Flushing Boulevard, with

the East River and Bushwick Avenue defining the west and east borders of this neighborhood

respectively. The Bushwick neighborhood is located to the southeast of East Williamsburg, with

Ridgewood to the northeast.

4.1.2 History of Greenpoint and the Waterfront

In the 1630's, the Dutch began settling land at the western end of Long Island which had

been inhabited by the Native American people known as the Lenape. The southern area would

become known as Breuckelen, named for a municipality in the province of Utrecht in the

Netherlands. Steven M. Ostrander, writing a history of the county in the late 19th century,

suggests that the term Breukelin effectively had the meaning of "marshland," though indicating more literally "broken land."[1] Relations with the indigenous peoples in the wider area of New Netherland were not always peaceful. Ostrander notes in particular an event in 1643 in which he states that encampments of native refugees who had fled from a conflict with a tribe in the north were mercilessly attacked at night by order of then director of New Amsterdam, Willem Kieft, resulting in the deaths of 120 natives at Pavonia (Hudson County, New Jersey) and Corlear's Hook (a portion of the Lower East Side in Manhattan once occupied by the Lenape).[2] The event incited retaliations and a series of mutual attacks which became known as Kieft's War. After Kieft's dismissal by the Dutch West India Company, the more well-known Peter Stuyvesant became governor in 1647.

The land which included current day Greenpoint was purchased from the Lenape by the Dutch East India Company in 1638.[3] Soon after, a small group of Scandinavians settled there, including one named Dirck Volckersen, erroneously dubbed "Dirck the Norman," whose nickname lives on in the current "Norman Avenue."[4] Felter describes the scene at the time of the ship carpenter's arrival: "Those were the days of smuggling, of rum drinking, of hardy sailors free in the use of their dirks, of gambling, of risk and adventure."[5] Court records indicate that he engaged in street knife fights on a number of occasions. Volckersen acquired ownership of the whole of Greenpoint in 1645 and built his house approximately at the location of the intersection of today's Calyer St. and Franklin St., in the southwest of Greenpoint close to the East River.

Peter Stuyvesant founded the town of Boswyck (including the current areas of

Figure 53: Joost Durie Farmhouse , Greenpoint, built circa 1681 (demolished early twentieth century), from William L. Felter (1919), *Historic Green Point*

Greenpoint, Williamsburg, and Bushwick) in 1660, the name itself meaning "town in the woods."

It was, in fact, a group of fourteen French Huguenot immigrants who had applied to Stuyvesant

to start the community.[6][7] Not much of the early Dutch records from the town of Boswyck have

survived since the town, we are told, "having been swallowed up in the great city [joining with

Brooklyn in 1854], a wise functionary of the City Hall, on assuming charge of its Old Dutch

Records, contemptuously thrust them into his waste-paper sacks and sent them to the paper

mill, by which his perquisites were increased at the rate of four cents per pound."[8] The Dutch

governance at Bushwick, however, would last only four more years since control of the New

Netherland colony would pass to the English in 1664. Greenpoint, located across the river from

New Amsterdam, was part of an area which would be utilized for farming, supplying food and

tobacco which would be shipped down the East River to the main settlement on the south of

Manhattan. Firewood was obtained from the woodland where animals were also grazed. In

addition to their own labor, slave labor was used on these properties until 1827.

Ostrander describes the houses of the Dutch period as initially primitive, but soon

"more solid and permanent, and after the Indian war came comfortable one-story houses,

thatched with straw, and with big stone chimneys."[9] Wood was the primary building material,

brick being available but rarely used due to expense. Ostrander states: "The one-story Dutch

houses generally had an 'overshot' roof, which formed now one and now two piazzas. Very

often a seat was placed at each end of the porch; and when the weather permitted, this

sheltered place was generally occupied by the family and visitors of an evening."[10] Felter

describes the houses as "after the Dutch style, one and a half stories in height, the lower portion

of stone, and the upper usually of wood, with dormer windows and wide overhang. A broad hall

running through the middle of the main floor was lighted in the day time either by the bull's eye

glass insets in the upper part of each door, resembling little port holes, or by opening the upper

portion of the door. Knockers of brass or iron hung on the outside of the door to announce the arrival of a caller, and a great flat stone helped the guest to step over the sill."[11] The fireplace was evidently the central feature of the early houses, sometimes having glazed tiles on the mantle front, but otherwise the interiors would have been very simple and unembellished.[12] The oldest surviving residential structure in Brooklyn as a whole, and dating from the time of the Dutch settlements, is the original part of the Pieter Claesen Wyckoff House located in East Flatbush. The building was constructed around 1652 and later much enlarged in the 18th century. Today the building houses a museum, and a nearby visitor's center designed by NYC-based architecture firm nArchitects is slated for construction as of 2013. The second earliest of surviving residential buildings in Brooklyn is the Jans Martense Schenck House, dating from 1676, which is currently housed within the Brooklyn Museum. Valuable documentation of houses dating from the early eras of farming in Brooklyn was undertaken around the turn of the twentieth century by photographers such as Clinton Irving Jones and Daniel Berry Austin, whose work is part of the photographic collection at the Brooklyn Public Library.

Of other building types in early Brooklyn, the first church was evidently established in Midwout (meaning "middle of the woods" which once separated Breukelen from Boswyck, and in the area of current Flatbush) in 1654, also constructed of wood. Stuyvesant, wanted "to prepare and build in the village of Midwout a house of about sixty or sixty five feet in length, twenty eight feet in width and twelve or fourteen feet high under the crossbeams, with an extension in the rear, where a chamber may be partitioned off for the preacher."[13] In the more immediate area of sparsely-settled Greenpoint, there was neither church nor general store, little in the way of buildings with the exception of the farm houses separated at some distance. For two hundred years little changed in the area, which would remain primarily farmland until the

1850's. Interestingly, Dutch continued to be spoken as the daily language of the area until the nineteenth century when English became the exclusive language taught in schools.[14]

The history of the Greenpoint section of Bushwick during these two centuries is largely that of the five families which came to own the farmlands. Jacob Hay purchased land from Dirck the Norman in 1653 which was then passed to his daughter Maria and her husband, Captain Pieter Praa. By 1719, Praa had possession of the whole of Dirck's land as well as areas of current day Hunter's Point, just across the mouth of the creek. Praa had immigrated to New Amsterdam as a child with his parents who had fled from France for religious reasons to the Netherlands before crossing the Atlantic. It was by passing the land down to his five daughters that the land came to be divided primarily among five farms. Praa's house was located near the current intersection of McGuinness Blvd and Freeman St.[15] The five families which inherited the land were those of Abraham Meserole, Jacob Meserole, Jacob Bennett, Janothan Provoost, and Jacobus Calyer. Each of these surnames, with the exception of Bennett, can be observed as street names in Greenpoint today (Provoost being shortened to Provost).
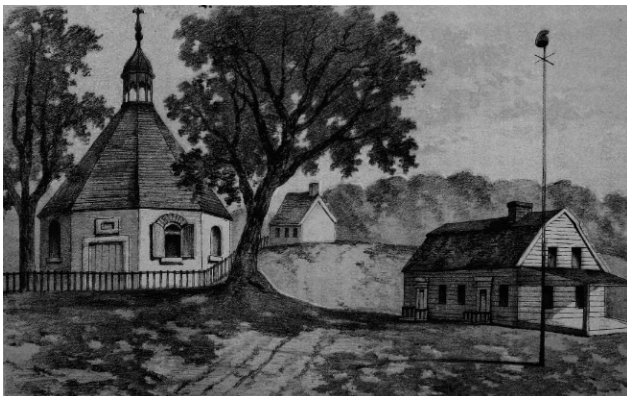
Figure 54: Illustration of the Bushwick Village town plot with octagonal church and town meeting house, from T.W. Field (1868), *Historic and Antiquarian Scenes in Brooklyn and Its Vicinity: with Illustrations of some of its Antiquities*

To the south of these farm properties was the heart of the village, to which the farms were connected by the sole road, which was called Wood Point Road. Thomas W. Field, an author of a book on the history of Brooklyn written in the mid-1800s, described a "Town Plot" where an octagonal church, town meeting house, and school house were located which dated from the late seventeenth to early eighteenth century.[16] Something of the nature of the local justice system is conveyed by Field

who claims "In front of the Bushwick Town House one May morning in 1684, poor John Van

Leyden expiated the offence of an unbridled tongue by being fastened to a stake, with a horse

bridle in his mouth, and a bundle of eight rods tied under his arms, while a label attached to his

breast declared 'John Van Leyden is a writer of lampoons, false accuser, and defamer of

magistrates.'"[17] Nearby was also a graveyard, in addition to a number of residences. The woods

to which the name Boswyck is owed still existed to some extent at the time of beginning of the

revolutionary war, but by its end they had been destroyed. Additionally, a number of the

dwellings were apparently "greatly injured, and deteriorated in value" as a result of a British

encampment being located at the village.[18]

An example of a farmhouse dating
from this time, located in the area of
Flatbush, survives today, moved from its
original location to Prospect Park. The house,
which was owned by the Lefferts family, was
rebuilt just after the Revolutionary War,

Figure 55: Lefferts House, Prospect Park (relocated from Flatbush), circa 1783, renovated 2003

when the earlier house was destroyed. The Lefferts were among the earliest European settlers

in Brooklyn.[19] Whereas many of the early Dutch houses had a double pitched room with shed

dormers and a porch roof at a shallower angle, the later Lefferts House has double-pitched

dormers on a gambrel roofline with the bottom portion curving outward to form the porch

covering. Similar in form is the main portion of the Hendrick Lott House from 1720, which is

located in Marine Park and also survives today. In any case, a common feature of houses from

the Dutch through Revolutionary periods is a porch space "subtracted" out from the main

volume beneath a continuous roof. The extended roof may or may not be supported on

columns, depending on the depth and presence of the porch, and might be on one or both of

the long sides of the house. Some of these houses were in a saltbox form while others were symmetrical in along the longitudinal direction.

Greenpoint remained agriculturally based until around 1840, when ship building activities in the area began to grow. The initial development of the town, in fact, stems directly from these origins. In 1832, the Connecticut-born entrepreneur Neziah Bliss acquired land in Greenpoint. After an initial involvement in setting up a business in Philadelphia to build steamboats, and later expanding his interest into the development of iron resources for the purposes of building steamboat engines and boilers, Bliss moved his enterprises to Manhattan. There, in a business collaboration with the engine designer Eliphalet Nott, the Novelty Iron Works factory was created, which would become known as one of the most well-known producers of boat engines during that era. The undeveloped shore of Greenpoint, across the East River, proved attractive as a shipbuilding area. They obtained a large area of land both through purchasing farmland and through Bliss's marriage to Mary Meserole, a descendent of Pieter Praa. In 1834, Bliss had the land surveyed and mapped into streets. Within a few years, he had constructed a bridge over Bushwick Creek to connect the area with Williamsburg to the south, which had recently seen rapid initial development, and also established a turnpike along what is now Franklyn Street, infrastructure which allowed for the rapid urbanization of the area.[20]

The first among the shipbuilding companies to move from Manhattan to Greenpoint was that of Eckford Webb and George W. Bell, who located their firm at the end of Milton Street. Another prominent firm, which began in shipbuilding and later shifted to manufacturing for the oil industry, was Thomas Fitch Rowland's, which would later become known as the Continental Iron Works.[21] The rise of the shipbuilding industry in Greenpoint roughly coincided with a period of prosperity and financial growth in Manhattan, resulting in the migration of

many shipyards from Manhattan's east side to Greenpoint. Residences on Noble and Milton

Streets were built to house the employees at the shipyards, and many were, in fact, built by the

shipbuilders themselves.[22] Other buildings, such as those on Franklin Street, had commercial

shops on the ground floor with residences above. Many residential buildings dating from this

period through the end of the nineteenth century survive today and are located within the

Green Point Historic District. An overview of the architecture within the historic district will be

discussed in greater detail in a later section.

The 1939 WPA Guide to New

York City notes that "Kent Avenue, now

lined with dilapidated piers and

abandoned buildings, was a center of

shipbuilding after the Civil War. Street

names such as Java and India recall the

once flourishing trade in coffee and

Figure 56: View of residences along Noble Street in Greenpoint Historic District (Photo by author)

spices with remote lands."[23] Beaches along the East River seem to have been particularly suited

as an area for the construction of ships. During the period from 1840 to 1870, approximately

35% of the population here was engaged in the ship building industry.[24] Of the ships assembled

at Greenpoint the most notable is the USS Monitor, the innovative iron-hulled steamship which

was commissioned during the Civil War for the U.S. Navy. Subsequent to merging with the City

of Brooklyn, the population approximately doubled or tripled every 20 years.[25] As the area

developed in the last quarter of the nineteenth century, the dominance of ship building waned

and industries of all kinds flourished, particularly along the waterfront areas. One of the primary

reasons for the decline of shipbuilding was the selling of surplus ships by the government after

the end of the civil war, as well as the rise of iron shipbuilding, which differed from the wood-

based crafts of earlier shipbuilding to which Greenpoint's firms were oriented.[26] By then, however, a variety of other industries had already begun to settle in the area.

Among these industries was that of pottery manufacture. Among the earliest of companies in this industry was that of Charles Cartlidge, which eventually became known as the American Porcelain Manufacturing Co. Another was known as the Union Porcelain Works. Another important industry was glass-making. The most notable of these factories was the Greenpoint Glassworks, which was located on Commercial Street.[27] Amongst the early iron foundries which were established in Greenpoint were those of the Braid Brothers, H.C. Harney and Co., Burr and Houston, and Taylor and Co. These primarily specialized in in machinery castings, but others also created architectural ironwork or constructed steam boilers and gas tanks.[28] Another important industry of the area was that of rope-making, with the American Manufacturing Company and the Chelsea Fibre Mills once having the largest such plants in the world and by the early twentieth century employing more laborers than any other industry in Greenpoint.

Oil refining began in the area during this time and soon Greenpoint became the central location for this activity in New York, which was among the first large markets for crude and refined oil. These were primarily located along Newtown Creek and the East River waterfront. The most famous of the refineries, Astral Oil Works, was located just south of Greenpoint at the north end of Williamsburg, with many of its workers living in Greenpoint.[29] Among the residences built to house the workers was the so-called Astral Apartments. The company's kerosene was apparently "so widely used that it provoked the remark that 'the holy lamps of Tibet are primed with Astral Oil.'"[30] Later, many of the smaller refineries in Greenpoint would come under the same ownership and become part of Standard Oil. Astral's founder was Charles Pratt, who founded Pratt Institute in Brooklyn.

Along with industrial development came large scale immigration. By the turn of the century, many Germans and Austrians had settled in northern Brooklyn. Restaurants, beer halls, and breweries (44 in Bushwick and Williamsburg by 1904) became part of city life. Soon too arrived many Polish immigrants who settled in the Greenpoint area. Lutheran and Catholic churches were also built during this time. The widespread immigration and further urbanization coincided with the years following the opening of the Williamsburg Bridge, which established a connective link with Manhattan.[31]

In the latter half of the twentieth century, manufacturing employment in New York City has been drastically reduced, falling approximately 80 percent since 1947.[32] In Greenpoint, between 1991 and 2002, it was reduced by 60 percent. Surveys have indicated that this is the result of large manufacturers leaving the area due to changes is global trade and economic shifts. While some small-scale manufacturing remains, the local economy has shifted to wholesale and distribution of consumer products and some construction-related uses. As a result, many waterfront areas have become largely underutilized or vacant. In combination with increased demand for housing, and the desire for greater recreational use of the waterfront, efforts to update the area's zoning regulations culminated in the development of a proposal adopted in 2005 which will likely signal significant changes for the area in the near future.

4.1.3 Greenpoint Historic District

The Greenpoint Historic District was designated in 1982.[33] Roughly speaking it is an area generally bound in the west by Franklin Street and to the east by Manhattan Avenue, and extending from Java Street to the north to Calyer Street to the south. A map of the precise boundaries with images of buildings is found in the included illustration. This residential area is noteworthy in connection to the early industrial development of the area, with most of the

original occupants being workers or owners involved with the shipbuilding, and other early industries, of the waterfront. Greenpoint has been particularly fortunate in the survival of these 19th century buildings located within the multi-block area of the historic district. The buildings exhibit architectural styles popular from the mid-nineteenth century to the turn of the twentieth. The earliest of the rowhouses were built in an "Italianate" or "Anglo-Italianate" style. Among the most noteworthy and characteristic of early residences are said to

Figure 57: No. 109 Noble Street in Greenpoint Historic District (Photo by author)

be those at No. 107 and 109 on Noble Street, built shortly after the street opened in 1852. In the 1860's many "French Second Empire" style houses were built, similar to the previous but with a type of mansard roof. In the 1870's, a "Greek Revival" style, such as found at 110-114 Milton Street, became the predominant stylistic choice. Additionally, there are a few buildings of a Romanesque Revival character, such as at 168-172 Franklin Street. Other notable buildings are the Episcopal Church of the Ascension, completed in 1866 in a Gothic Revival style, and St. Anthony of Padua Church, designed in the early 1870's by prominent ecclesiastical architect Patrick C. Keely.

Figure 58: Greenpoint Historic District location (Illustration by author, with aerial photo from Google Earth)

Greenpoint Historic District

Mechanic's and Trader's Bank of Brooklyn (1895)

112-124 Kent St. - View East (1856-68)

St. Anthony of Padua Church (1875)

107 Noble Street (1854)

St. John's Lutheran Church (1897)

139-151 Milton Street (1894)

Green Point Savings Bank (1908)

Figure 59: Illustration of Greenpoint Historic District Boundaries with images of select historic buildings (map illustration by author with aerial from Google Maps; Building images from Historic District Designation Report)

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4.1.4 Recent Projects in Greenpoint

Among new residential projects in Greenpoint, most controversial real estate venture

has likely been that of the Pencil Factory. The Eberhard Faber Pencil Company moved its

headquarters from Manhattan to Greenpoint in 1872, remaining there until the company

moved from this complex of buildings in 1956. Prior to the economic collapse in 2008, plans

were made to use the site for a new condo development. Two of the historic buildings were torn

down and one reused for the new project. In response to losing the two buildings, the city's

Landmark Preservation Commission designated a new historic district in the surrounding area in

order to preserve some of the district's old factory buildings.[34] Architecturally, the new

buildings, designed by Daniel Goldner Architects, are characterized by their facades with planes

of differently colored bricks. At roof level are white-boxed penthouses with large glazed areas at

the façade. Though primarily completed in 2010, the exterior areas at ground floor level of the

building remain in an odd state of incompletion with spray-
fireproofed steel beams still exposed behind the horizontal
ribbon aperture of an enclosing screen wall.

Although Greenpoint has generally not yet seen quite
the large number of new condo developments that
Williamsburg to the south has experienced, there have been a
fair number. At the smaller scale, these include the
undistinguished 10 unit building at 145 McGuinnes Boulevard

Figure 60: Daniel Goldner Architects,
Pencil Factory, 2010 (Photo by author)

and the 6 unit at 48 Box Street. More substantial in scale,

aside from the Pencil Factory, is the 130 rental unit development at 110 Green Street, "The

Viridian," designed by Meltzer/Mandl Architects, a product of pre-2008 building boom

development plans, and the "GeoLofts" project at 149 Huron Street with its not particularly successful Mondrian-like façade. An additional large residential development was spotted under construction at McGuiness Boulevard off Java Street.

The Newtown Creek Water Pollution Control Plant (WPCP), which was completed in 2009, was designed by Polshek Partnership (now called Ennead). It is the largest of New York City's fourteen wastewater treatment plants. It replaces an outdated facility which was especially environmentally unsound. The functioning of the facility will be explained in more detail further on. Architecturally, the new facility is noteworthy for the prominent "digester eggs" which have become something of a landmark, in part through the lighting design efforts of Hervé Descottes of L'Observatoire International. The visitor center was designed by Vito Acconci. Along with the new plant, a "nature walk" was constructed at Newtown Creek in 2007 which was designed by George Trakas. The stretch is a mixture of concrete and plantings, which include native grasses and trees, offers some environmental educational material, but is not particularly accessible.

Greenpoint Manufacturing Design Center is a non-profit industrial developer which has acquired and rehabilitated a number of industrial buildings so that small and medium-sized manufacturing enterprises and artisan tenants can move into such spaces. Among these is the complex at 1155-1205 Manhattan Avenue near the mouth of Newtown Creek. The buildings once housed the Chelsea Fiber Mills, a rope manufacturing company which was begun in 1868. Such projects have aided both historic preservation and urban development. Photovoltaic arrays have also been added to the roofs of a number of these repurposed buildings.

A new pier for the East River Ferry was constructed at India Street in 2011, though a number of planned amenities for the pier have been slow to materialize since then. The views from the pier merit a walk along it even when not taking the ferry. The ferry makes stops along

the Brooklyn waterfront and Hunter's Point before crossing to Manhattan at Midtown and Wall

Street, as well a Governor's Island.

At the end of Kent Street, a small park of 6.6 acres was opened in August of 2012, called

WNYC Transmitter Park. It contains a children's playground as well as a small green area with

benches at the waterfront. Juxtaposed with some of the collapsing infrastructure nearby, it

offers a suggestion of what a revitalized waterfront defined by park space could potentially look

like.

Adjacent to this park, a new pier for recreational purposes was opened in April 2013.

Extending out into the East River, it offers views of the Manhattan skyline across the river and a

clear view at the current poor state of the Greenpoint waterfront. A handful of recreational

fishermen can be seen on this and the nearby East River Ferry Pier. The Parks Department has

stated that fishing can be done on the new pier. However, a discharge point from the Newtown

Creek WPCP adjacent to the Ferry Pier means that its outfall can extend a thousand feet from

the shoreline, according to a posted sign there.

4.1.5 Zoning

In 2005, a comprehensive rezoning proposal affecting the waterfront areas of

Greenpoint and Williamsburg was submitted by the Depart of City Planning and approved by the

City Council. The formerly M3-1 manufacturing zone along the East River was rezoned to R6 and

R8 residential districts. The blocks just to the east of this area were rezoned from a M1-1

manufacturing district (along with a special Franklin Street mixed use district) to primarily MX

M1-2/R6A (and R6B at the Franklyn Street area).[35] The commercial district remained unchanged

in this plan. A multi-block park at the northwest portion of Williamsburg was also incorporated

into the zoning, as well as the provision to incorporate a waterfront esplanade and public

access. Additionally, the zoning proposal included what was termed the Greenpoint-

Williamsburg Inclusionary Housing Program. This essentially allows developments which

incorporate affordable housing to receive bonuses in building floor area, height, or bulk.[36] In

2009, a Greenpoint-Williamsburg "contextual rezoning" plan was approved. This affected the

zoning of the area at the core section of Greenpoint, to the east of the area affected by the 2005

waterfront rezoning area, which remains non-contextually zoned. The goals of this proposal

were to "preserve existing scale of neighborhood by establishing height limits," "create

opportunities for affordable housing through inclusionary zoning at appropriate locations," and

to "better reflect and support existing commercial activity by adjusting commercial districts and

overlays."[37] The R6 zone was essentially sub-zoned into zoning districts that would incorporate

these changes.
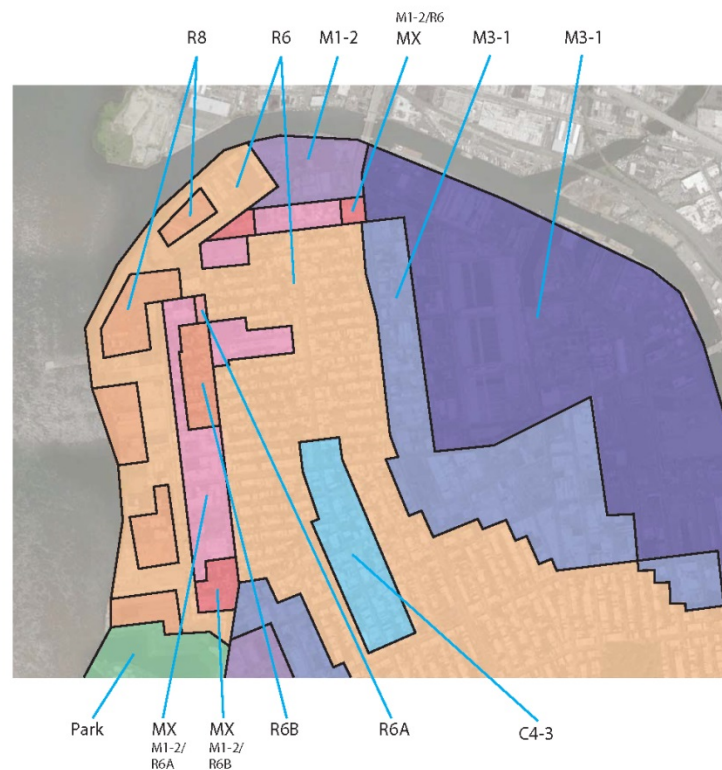
Figure 61: Greenpoint 2005 Waterfront Rezoning (Image overlay by author; Aerial from Google Earth)

The specific lot for the selected project site is located in an R8 zone (with R6 at the water's edge, and a C2-4 overlay at the street side). It has been designated as Parcel 5a in the text amending the 2005 zoning changes. The central portion of this parcel is also shown as including a "Supplemental Public Access Area." This means that if a development does not contain a certain minimum percentage of its lot area for public access to the waterfront (15% in R6 districts; 20% in R8 districts), then it can provide a supplemental access area. These "can be parks, plazas, or sitting areas."[38] Paths which connect the street sidewalks to the shore public walkway are called "upland connections," and are required to be a minimum of 30' wide.

The parcel also contains a "Visual Corridor (within Flexible Location Zone." Visual corridors must provide an unobstructed view to the water, and must be 50 feet wide. Its location within the lot is flexible, as long as it lies within the area designated in the waterfront access plan.[39] Further guidelines for public access areas and visual corridors are found in Section 62-60 of the Zoning Resolution. The public walkway at the shore must be a minimum width of 40 feet wide, and may contain one or more pedestrian paths as well as buffer areas.

Residential zones may contain community facilities, which may belong to either Use Group 3 or 4.Both Use Groups are allowed in all residential districts unless prevented by special regulation. Libraries, museums, and educational facilities such as colleges and universities are included within Use Group 3. Bulk regulations for community facilities in residential districts are found in Article II Chapter 4 of the Zoning Resolution of the City of New York,[40] with additional requirements for waterfront blocks provided in Article VI Chapter 2.[41] These specific requirements are summarized in the appendix table.

Figure 62: Project site photographs (Street level photos by author; Aerial and bird's eye photos from Google Earth and Bing respectively)

4.1.6 Building Code

Construction in Greenpoint is regulated by the 2008 New York City Building Code, with January 1-December 31, 2011 Supplement. In reference to use and occupancy classification, the project would be classified as Assembly Group A-3. Assembly Group A-3 includes museums, lecture halls, exhibition halls, community halls, and other assemblies not classified elsewhere in Group A. If a library is accessory to Group E occupancies, which include academies and schools, then it would belong to Educational Group E. The height and area requirements are summarized in the table in the appendix.

4.1.7 Land Use

The total land area of Brooklyn Community District 1, which includes both Greenpoint and Williamsburg, is 3,043.8 acres, or 4.8 square miles. Within this area, as of 2012, the following statistics were found regarding land use.[42] By percentage of total lot area, residential uses are the largest, with a total of 37.4%, including Mixed Residential and Commercial land use. Within this category, Multi-Family Residential usage predominated at 23.2%, with 1 or 2 Family Residential at 5.3%, and Mixed Residential and Commercial at 8.9%. Also significant is Industrial use at 28.3% of lot area. Within Greenpoint only, this percentage is much greater, with Industrial or Manufacturing uses occupying perhaps something closer to 50%. Vacant Land comprised 4.5%, while Open Space/Recreation comprised only 5%, with the largest such area being McCarren Park.
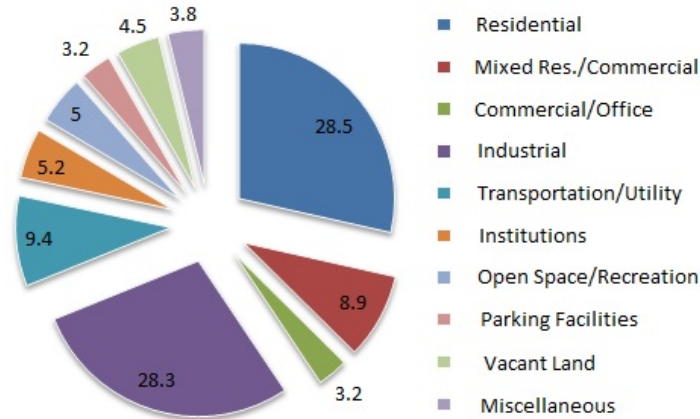
Figure 63: Land use by lot area in Brooklyn Community District 1
(Includes both Greenpoint and Williamsburg) (Image by author)

4.1.8 Population, Demographics, and Housing Characteristics

Brooklyn Community District 1, which comprises both Greenpoint and Williamsburg,

had a population of 173,083 as of 2010, increasing 7.9% over the previous ten years, according

to the Community District Profile.[43] The census districts included in Greenpoint totaled a

population of 34,719. Demographically, within the district as a whole and as of 2010, population

identified as White Nonhispanic comprised 60.8%, Black/African American Nonhispanic 5.2%,

Asian or Pacific Islander 5.1%, Hispanic origin (any race) 27.2%. Between 2000 and 2010,

substantial shifts in demographics occurred with White Nonhispanic population increasing

36.7%, and Hispanic decreasing 22.2%.
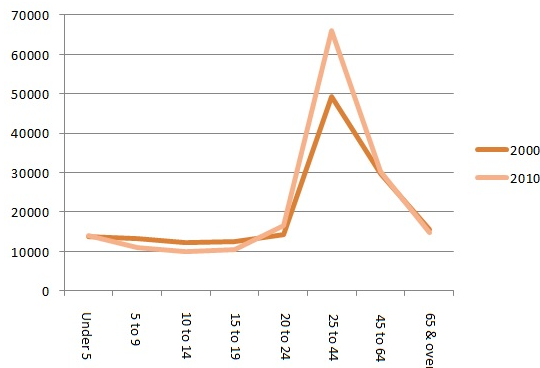
Figure 65: Resident age distribution in Brooklyn Community District 1 (Includes both Greenpoint and Williamsburg) (Image by author)
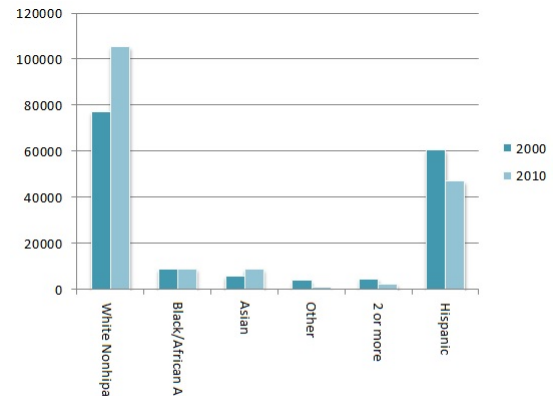
Figure 64: Demographics in Brooklyn Community District 1 (Includes both Greenpoint and Williamsburg) (Image by author)

However, looking at data from the 2010 census tracts within Greenpoint in isolation from those of Williamsburg, it was found that an overall population decline of 8.2% occurred in Greenpoint between the period of 2000 and 2010.[44] Demographically considering these districts, it is found that populations identified as White Nonhispanic comprised 76.9%, Black/African American Nonhispanic 1.2%, Asian 4.9%, two or more races 1.7%, and Hispanic origin (of any race) 14.7%. Changes over the previous decade were not provided for specific census tracts, but it is possible that the shifts have been less substantial than in Williamsburg.

Some statistics for Brooklyn Community District 1 may be worth mentioning in relation to social characteristics of the population. It has been estimated that 31% of the population is foreign born, with 40.9% of immigrants from Europe, 37.1% from Latin America, and 18.3% from Asia.[45] As high as 62.4% of the population was found to speak a language other than English at home, with 26.1% speaking Spanish, 30.5% speaking another Indo-European language, and 4.4% speaking an Asian or Pacific Islander language. The population with Polish ancestry in the whole district amounted to approximately 16,000, which primarily residing in Greenpoint with a population of less than 35,000, would amount to a continued substantial representation in the community.

The following statistics related to housing characteristics apply to the community district as a whole.[46] An estimated 84% of housing units are renter-occupied and 16%-owner occupied. 55.7% of units were built prior to 1939 and 8.1% after 2000. Single-unit structures, attached or detached, comprise 5.8% of units, 2 units 9.1%, 3 to 9 units 48.1%, and 10 or more units 36.9%. The median housing unit value is $658,000, and average rent amounts to $1,069.

4.1.9 Newtown Creek and the Environment

William L. Felter, writing in the early twentieth century notes that Newtown Creek, which was also called Maspeth Kill, once had high banks and led inland to a salt marsh known as Back Meadows, and there were a number of creeks which drained the salt meadows which contained numerous tributaries. He notes that "A traveler in those times gazing at Green Point from a boat on the East River would have noticed many high sandy headlands, remnants of the early glacial period, similar to those still remaining along the north shore of Long Island."[47] The name Green Point apparently derived from the once grass-covered end of the peninsula at the junction of the creek with the East River, but, as noted in the 1939 WPA Guide to New York City, "the grime and smut of industry have long since obliterated the original verdancy."[48]

Newtown Creek has been characterized as one of the polluted sites in the United States and was designated a Superfund site in 2009. It continues to face a number of environmental issues, among which are industrial contaminations from over a hundred and forty years of industrial activity and discharge of excessive flow from the combined sewer system during large storms.

Figure 66: "Digester Eggs," Newtown Creek Wastewater Treatment Plant, plant upgraded 2009

The situation for the latter concern has been improved with the recent construction of the Newtown Creek Wastewater Treatment Plant. In the wastewater treatment process, the wastewater undergoes five processes. After preliminary treatment, 85% to 95% of pollutants are removed in the primary and secondary processes and then the water is

disinfected and discharged into local waterways.[49] Sludge, a byproduct of these processes, is

turned into biosolids, some of which is used as compost and fertilizer. Grit from the settled

solids is eventually taken to landfills.

The preliminary treatment essentially filters the wastewater to remove large pieces of

garbage which have gotten into the system. In primary treatment, the water enters

sedimentation tanks, where heavy solids, known as primary sludge, settle to the bottom of the

tanks and floatable trash rises to the surface, allowing for their removal. In the secondary

treatment, also known as the activated sludge process, the wastewater is aerated, for three to

six hours, in order to facilitate the growth of bacteria and other microorganisms that break

down the organic content of the wastewater and remove many of the remaining pollutants. It is

then given time for the resulting solids to settle before moving on to be disinfected. Chlorine

and sodium hypochlorite are used to disinfect the wastewater and kill the remaining harmful

organisms. Effluent released from the plant is tested for pollutants on a daily basis.

The sludge which was removed in the primary and secondary processes in moved to the

"digesters," which are oxygen-free tanks where the material can be subjected to heat in excess

of 95 degrees Fahrenheit for approximately two to three weeks. The purpose is to stimulate the

growth of anaerobic bacteria which consume the organic content in the sludge. Essentially the

sludge is converted to water, carbon dioxide, methane gas, and a material called "digested

sludge." This sludge is dewatered to produce biosolids "cakes" which can be used for fertilizers,

soil conditioners, or as covering material for landfills. Prior to initiatives beginning in the 1990's

to utilize the material in these ways, sludge had been removed by barges and dumped at sea.

The city has taken initiatives to utilize the methane gas and carbon dioxide to generate heat and

electricity by use of fuel cells at four of the city's water pollution control plants.[50]

The primary environmental problem which the wastewater processing facilities face is from combined sewer overflow, CSO. Raw sewage is not released on a typical basis, but when the sewer system is filled to capacity due to excessive precipitation, excess flow is released into the open waters, bringing with it harmful bacteria, pollutants, trash, and potentially toxic chemicals. A $1.8 billion CSO Abatement Program is currently underway which aims to mitigate CSO by building retention tanks to store system overflow, among other efforts.[51] Efforts to reduce surface runoff through reduced paving areas, permeable paving or green roofs can potentially reduce stress on the system.

Greenpoint has been subjected to an extensive amount of oil spillage due to leakage from the numerous petroleum refineries which once occupied the area along Newtown Creek. It has been estimated that between 17 and 30 million gallons of oil have spilled over the many years of these activities, along with numerous other pollutants.[52] Oil Refinery operations began in Greenpoint in the 1860's, and by 1870 more than 50 such refineries were located along Newtown Creek. In 1892, most of the refineries came under the control of the Standard Oil Trust. Following the breakup of this trust these facilities were owned by the Standard Oil Company of New York, which would eventually become the Mobil Oil Corporation, and later the Exxon/Mobil Corporation. The companies refinery operations in the area continued until the mid-1960's, at which time the properties were sold and became largely occupied by oil storage facilities, some of which would be owned by Amoco Oil (now BP) and Paragon Oil, a subsidiary of Texaco (now Chevron Corporation). Consequently, these companies are now sharing the blame for the oil spills and environmental contamination resulting from these operations.

The signs of oil spillage were first identified in the late 1970's by the U.S. Coast Guard, and a subsequent investigation in 1979 found that at least 52 acres of Greenpoint had been contaminated, with the total estimated petroleum spill volume amounting to 17 million gallons.

Petroleum product recovery operations have been ongoing since then. In the early 90's, efforts were increased with an upgrade of Mobil's product recovery systems. Chevron took over one portion from Mobil in 2005. According to the Environmental Protection Agency (EPA), by 2007 approximately 8.8 million gallons had been recovered from plume areas, and these efforts are on-going.[53]

According to the EPA, four potential health exposure routes commonly considered in relation to petroleum spills are "vapor intrusion from the chemicals found in petroleum," "contaminated drinking water wells that provide a public drinking water source," "ingestion of fish from contaminated waters or food products made from or within the contaminated waters," and "dermal contact from seeps which transport the petroleum to either surface soil or surface waters."[54] Among these, vapor intrusion into residences is considered of the greatest potential in Greenpoint. Groundwater has not been used for drinking since 1947, and the EPA states that drinking water in the area is regularly tested and found to be not impacted. Contact with the creek water is said to be hazardous, though public contact with the water is not typical, and the greater threat in this regard is said to be from discharge from the wastewater processing plant. Fishing in the creek is restricted, though fishermen can often be observed on the piers not far from the mouth of the creek.

The EPA has found of the initial efforts in the early 1980's that the "recovery wells, grout wall, booming and oil collection process did seem to minimize and contain the seeps along the creek," but that "it has done little to remediate the plume of oil."[55] While there are measures to mitigate property-specific areas and a recovery system to prevent large-scale seepage into the creek, such efforts are complicated by the fact that they may inadvertently draw petroleum into unwanted areas or adjacent properties. Beginning in the '90's efforts increased to improve remediation, but these systems have been considered as only marginally effective according to

Riverkeeper, a water quality watchdog organization.[56] In 2004, a lawsuit was undertaken by the

organization against ExxonMobil for contribution to the contamination of Newtown Creek and

Greenpoint, winning a $19 million settlement for an environmental projects fund. This success

was in part due to the efforts of local environmental activists such as Laura Hofmann. Hofmann

was led to take up the environmental cause after witnessing the illnesses of family members

and friends who lived in the area which she believes were likely caused by exposure to

environmental pollution.[57] Such efforts show the importance of community involvement in

taking up the cause of remediating the environmental conditions of the site.

It is worth also mentioning the Newtown Creek Alliance, which is "a community-based

organization dedicated to restoring, revealing, and revitalizing Newtown Creek."[58] It aims to

restore the ecological function of the waterway, educate the public about its history and current

activities, and lead in the process of planning brownfield redevelopments. Efforts have also been

directed towards the creation of a Newtown Creek Brownfield Opportunity Area (BOA), "a

community-based economic development planning process focused on the cleanup and

redevelopment of contaminated sites along Newtown Creek" whose objective is "to create a

21st Century approach to enhancing and reutilizing sites within one of New York City's most

important maritime industrial areas."[59]

combined sewer overflow
(cso) discharge point
[various locations]

newtown creek wastewater
treatment plant

containment booms at former
paragon oil terminal

project
site

cso
locations

future
development
area

wastewater
treatment plant
facilities

newtown creek -
superfund site

approx. current
petroleum plume
area

removing product from recovery
well [various locations]

concrete bulkhead & containment
booms at apollo street creek parcels

ExxonMobil off-site soil vapor
extraction system

Figure 67: Environmental degradation diagram (Map overlay by author; Information and images from
http://nysdecgreenpoint.com (accessed 9/28/13) and http://maps.nyc.gov/doitt/nycitymap (accessed 9/30/13)

4.1.10 Future Developments in Greenpoint

Plans have been proposed for a massive development project in Greenpoint known as Greenpoint Landing, which would be located along the Brooklyn waterfront along the East River and curving along the entrance to Newtown Creek. As of writing, the project seems that it may go forward in some form, despite opposition from local community groups, with the developer,

Figure 68: Handel Architects, Greenpoint Landing (proposed), Early Concept Rendering

Park Tower Group, hoping to begin construction late 2013 or early 2014.[60] However, the project has not yet finalized the financing and Tower Group has been trying to move the project forward for the previous decade.

The recent project proposal calls for a 10 tower development with each tower being 30 to 40 stories each. The scale of these buildings is the major negative point for opponents, with nothing nearly comparable in height in the vicinity. The socio-economic shifts which could also threaten the character of the neighborhood and rising rental costs are the other major considerations voiced by opponents. The developer has plans for approximately 1,500 affordable housing units of some 5,500 apartments overall. In relation to building character, it seems the developer has strategically shifted from a scheme of sleek glassy towers to one which aims to suggest something more reminiscent of the brick

Figure 69: Handel Architects, Greenpoint Landing (proposed), Rendering

warehouses which have characterized some of the surrounding neighborhood area, but it is doubtful this move will placate project opponents.

Just east of the site proposed for Greenpoint Landing Project is smaller area which is being considered by developers for the 77 Commercial Street project which could include an apartment building up to 40 stories in height. Between this property, which currently contains a warehouse, and the other is a slightly larger lot which currently being used by the MTA but which may become a 3-acre public park, called Box Street Park. This building project is also being opposed by local residents who are concerned that the waterfront will contribute to socio-economic divide with the wealthy occupying the waterfront areas.[61] Across from this site is a brownfield site, which was formerly a rail yard, at 1133 Manhattan Avenue currently being cleaned-up for a mixed-use project with a seven-story residential building of 210 apartment units and 20,000 sqf of commercial and retail space.[62] [63]

Figure 70: Cetra/Ruddy, 77 Commercial Street (proposed), Rendering

4.1.11 Transportation Networks

Greenpoint is bounded to the southeast by the Brooklyn Queens Expressway (BQE) which is part of Interstate 278, and constructed in the Robert Moses postwar period. It connects with Queens to the north via the Kosciuszko Bridge which spans over Newtown Creek. To the south, the highway passes through Williamsburg before turning west at the Brooklyn Navy Yard and then generally following along the East River until crossing to Staten Island at the

Verrazano-Narrows Bridge. Access to and from the highway are at Meeker Avenue at McGuinness Boulevard at the southern end, and near Apollo Street/Vandervoort Avenue and Van Dam Street at the southeast. Approximately bisecting Greenpoint is McGuinness Avenue, which connects to Hunters Point by way of the Pulaski Bridge. Also connecting to Queens is the John Jay Byrne Bridge at Greenpoint Avenue. Franklin Street is the main route along the East River at the south, but the street grid is extended an additional block west by West Street. The street grid itself orthogonal, but with the sub-grid in the southwest aligned with Greenpoint Avenue and the remainder aligned with the upper section of McGuiness Boulevard. By automobile, the closest connection to Manhattan is the Williamsburg Bridge.

Bike lanes exist on a number of streets. In the east-west direction, they can be found at Greenpoint Avenue, as well as Eagle and Freeman Streets. In the north-south direction, they are on Manhattan Avenue north of Greenpoint Avenue, and along Leonard Street to the south, as well as at Banker Street to the southwest.

The G-Line of the subway system runs through Greenpoint along Manhattan Avenue, with stations located at Nassau Avenue and Greenpoint Avenue. The neighborhood is particularly well served by public transportation due to this subway line, since the maximum distance to one of these stations is no more than about a mile. The G-Line ends at Court Square in Long Island City to the north and Church Avenue in East Flatbush to the south. The nearest subway line to Manhattan is the L-Line in Williamsburg, but the G-Line also connects to Manhattan-bound E, M, and 7 lines at Court Square in Queens, the A and C lines at Hoyt/Schermerhorn Street in Downtown Brooklyn, and the F line at Bergen/Smith Street just south of there.

Greenpoint is also served by four bus lines. B62 Downtown Brooklyn – Long Island City Route stops at McGuiness Boulevard/Freeman Street. B43 offers service between Prospect-

Lefferts Gardens and Greenpoint at Manhattan Avenue/Box Street. B48 also travels to Prospect-Lefferts Gardens, from Meeker Avenue/Gardner Avenue at the east end of Greenpoint. B24 provides service to Sunnyside, Queens and Williamsburg, with Greenpoint stops at Greenpoint Avenue/Manhattan Avenue and Greenpoint Avenue/Kingsland Avenue. The nearest bus routes to Manhattan are by B39 over the Williamsburg Bridge or the BM5 by way of the Queens Midtown Tunnel.

The East River Ferry connects to Greenpoint at the pier at India Street. In the south direction, the ferry takes riders to N.6th Street in North Williamsburg, Schaefer Landing in South Williamsburg, Brooklyn Bridge Park in DUMBO, Pier 11 at Wall Street in Manhattan, and Governors Island (during summer weekends). To the north, the ferry line stops at Hunters Point South in Queens and Midtown Manhattan at 34th Street. The ferry leaves every twenty to thirty minutes during weekdays and approximately every forty-five minutes on weekends.

4.1.12 Climate Conditions

Understanding a project location's climate is necessary for effectively designing for the environmental conditions of a project site. Climate classifications are often used to help determine appropriate design strategies for specific regions. The International Energy Conservation Code (IECC), which divides the U.S. into eight temperature-based zones which are then subdivided into classifications based on moisture conditions, places Kings County in the 4A category. According to the Koppen Climate Classification system, the site region is considered as Cfa, a warm temperate climate, fully humid, with hot summers. The US Department of Energy classifies Kings County, NY, as having a Mixed-Humid climate, which is defined as a region having at least 20 inches of precipitation annually, with less than 5,400 heating degree days, and average monthly temperatures which drop below 45 degrees Fahrenheit during the winter.
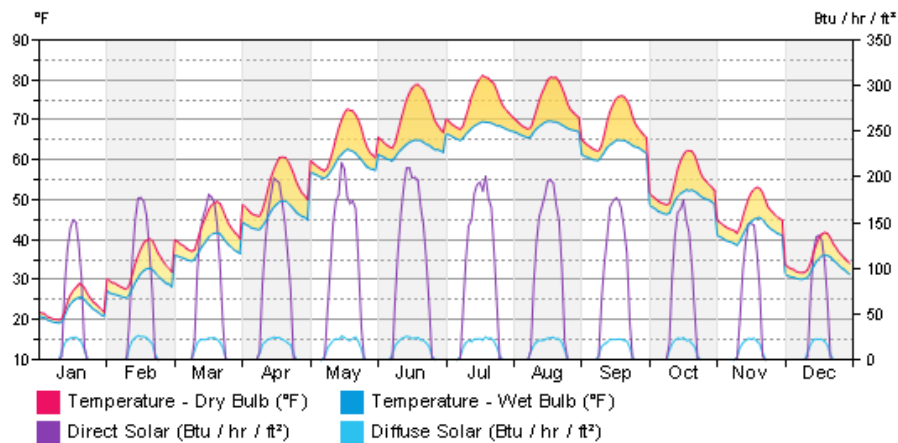
Figure 71: Diurnal weather averages

Seasonal temperature variations are significant, with dry bulb temperature averages with daily temperature averages reaching approximately 80 degrees Fahrenheit during summer months and dropping below 30 degrees during the coldest month, January. Relative humidity levels are relatively constant year round, with levels around 50% to 70% typical. Mornings tend

to have approximately 10% higher relative humidity than in the afternoons.
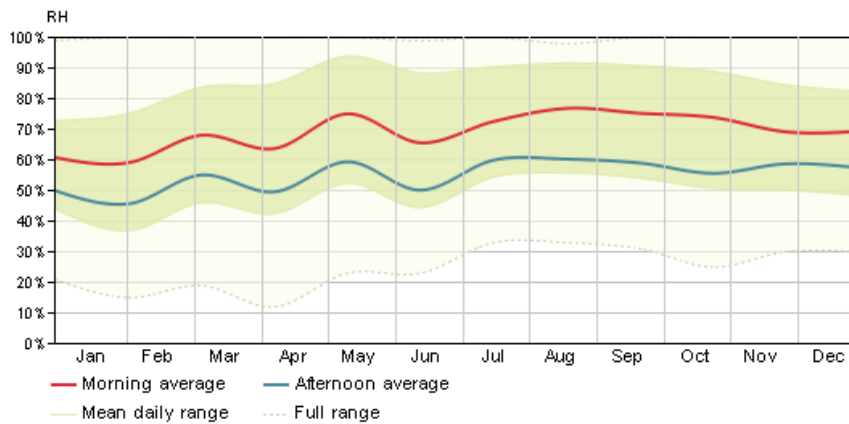
Figure 72: Relative Humidity

Mean wind speed for the area is approximately 12mph. Wind is most frequent from the western directions annually and during the winter, but southern and southwestern winds are most frequent during summer. During a typical summer day, winds tend to be from the southwest in the morning and south-southeast in the afternoon. Average cloud cover annually is around 55%. Monthly precipitation amount is typically in the range of roughly 75 to 110 mm.
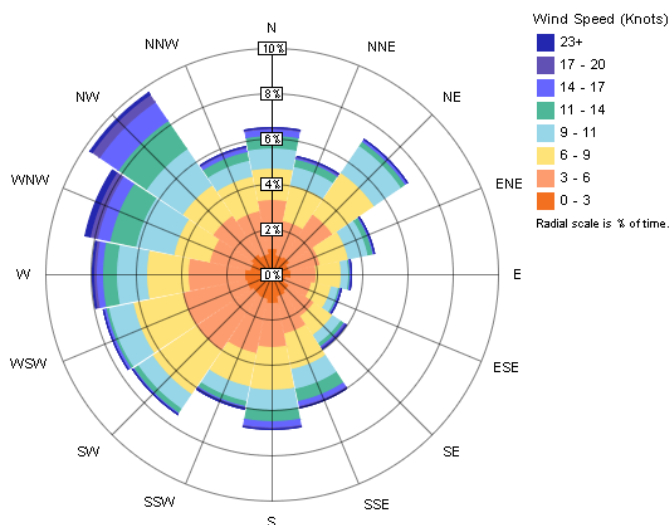
Figure 73: Annual wind rose
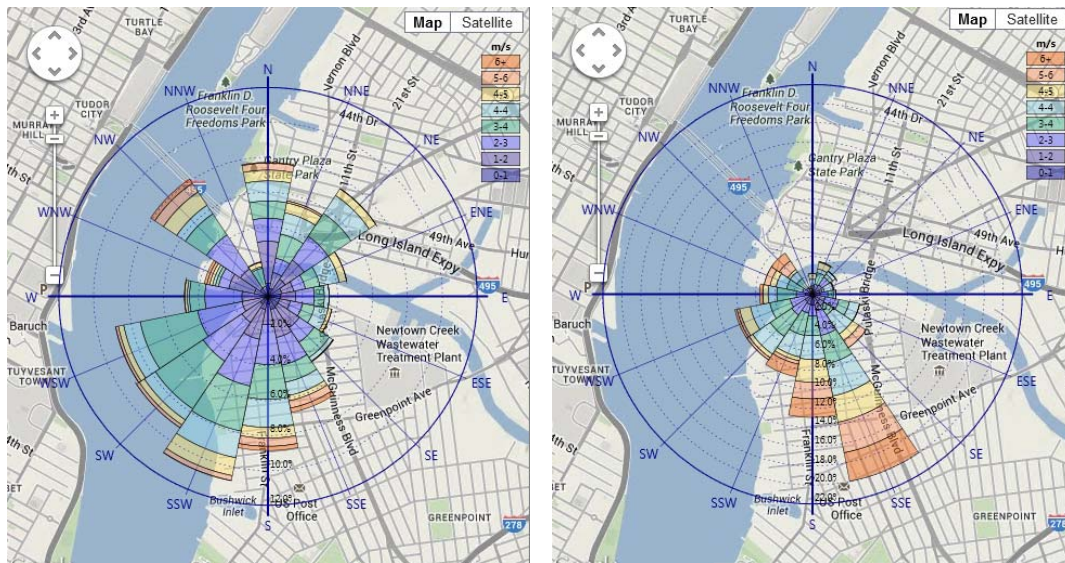
Figure 74: Wind roses for the summer months in the morning and afternoon respectively

4.1.13 Microclimate

More specific to the local conditions of the project site, a number of factors must be considered in relation to its microclimate. Located within a dense urban environment, it is subject to a heat island effect. The immediate proximity of the East River and the ocean also has a significant impact on temperature conditions, as well as affecting wind conditions. Buildings in the immediate vicinity also must be considered in affecting the solar as well as the wind conditions of the site. The assumed high rise development project along the waterfront to the southwest of project site would have some impact to the southwest area of the site as shown in the illustration. During the winter there may be some shading to the building, depending on its location and geometry, provided by the northernmost towers during certain hours of the afternoon.
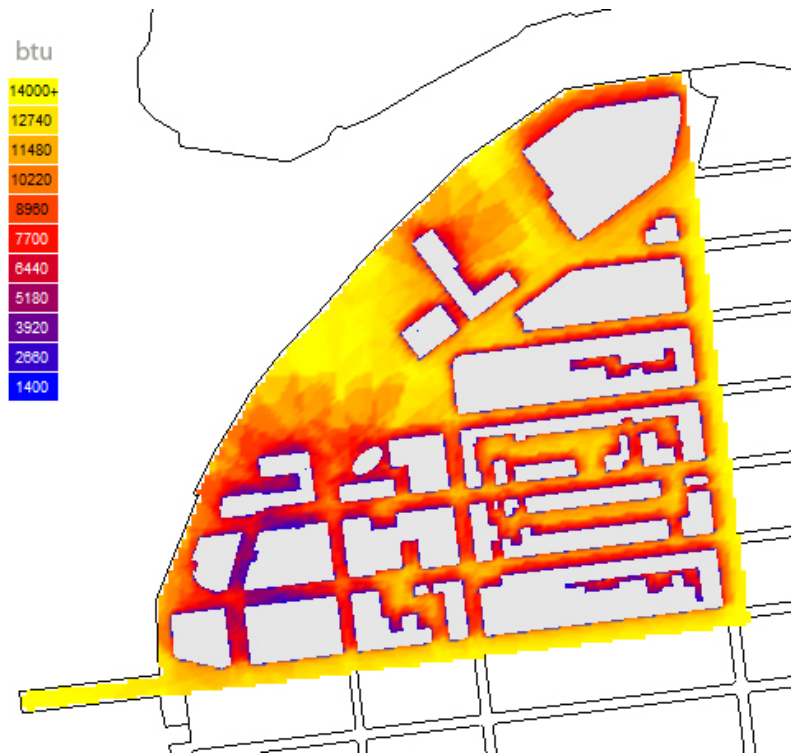
Figure 75: Site average daily insolation analysis given assumed waterfront development
(Image by author)

In terms of wind flow, the site is exposed to the north and west directions, while low

rise buildings occupy the areas to the east and south of the project site. From the southwest,
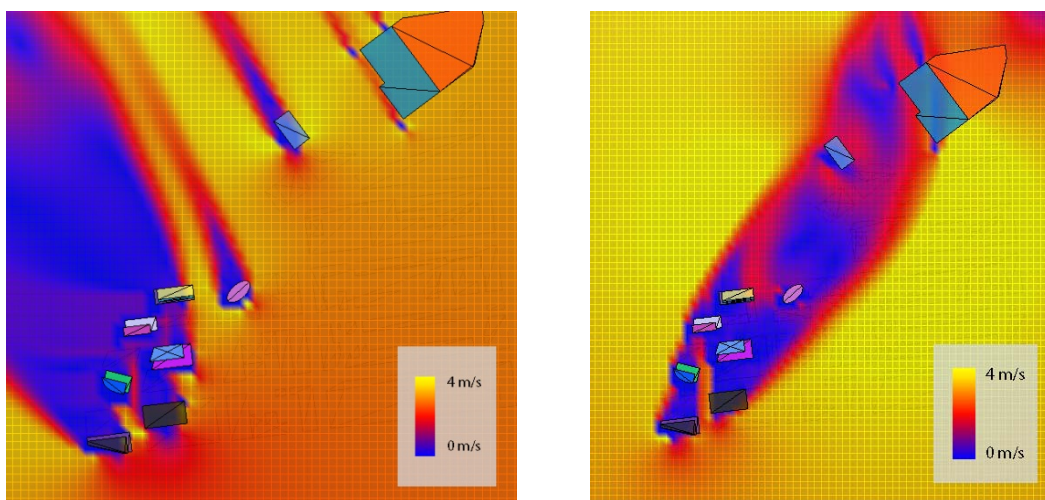
Figure 76: Study of effects of high rise towers on wind velocity, assuming 3 m/s wind velocity from SSW and SSE
respectively - created with Autodesk Vasari (Images by author)

wind would also be affected by the high rise towers of the assumed waterfront development. A

basic study of how wind from the southeast and southwest may be affected by the towers in

shown in these illustrations. Airflow velocity may be substantially reduced or slightly increased

on the site depending on wind direction.

Particularly important for the project is its relationship to views to the waterfront and

across the river to the Manhattan skyline, and how the building, in combination with this need

for views, will approach daylighting strategies while also preventing excessive heat gain or loss.

The below diagram attempts to map out some of these key features of the site in relation to the

annual sun path.
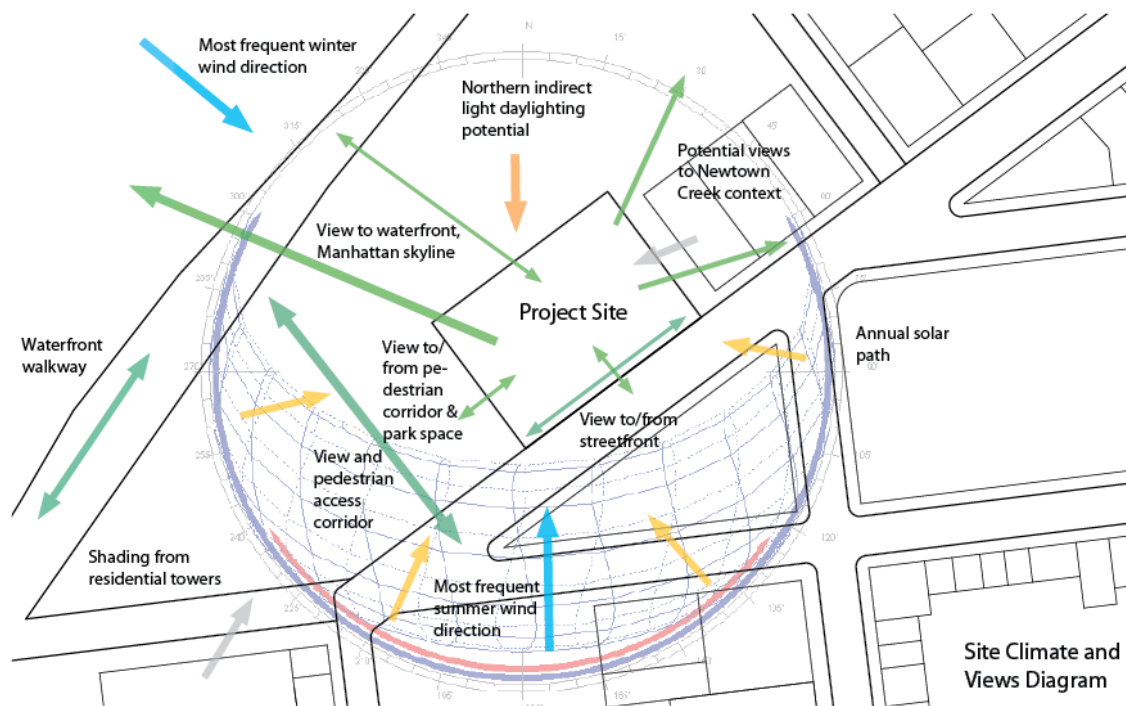
Figure 77: Site views, solar, and wind diagram (Image by author)

4.2 Building Program

The building program for the thesis design project is a research library, reference

material archive, and community center. It is envisioned as a public library, but one which offers

specialized collections and research space dedicated to the subjects of environmental studies,

sustainability, environmental protection and remediation. A diagram of potential overlaps and

synergies in environmental subject areas relevant to building program and site conditions is

presented in the accompanying image. Essentially the idea is for the building to act as a

knowledge hub for environmental subjects and provide meeting spaces and gathering places for

community environmental groups as well as

interested individuals. This aspect of the

project is intended to resonate with the

particular needs of Greenpoint, given both the

environmental challenges of the surrounding

area outlined earlier and the importance of

community groups and individuals in raising

Figure 78: Overlaps and potential synergies between
environmental subjects (Image by author)

awareness of these environmental issues and

bringing about actions to help solve these problems. Additionally, a key aspect of the project is

its response to its waterfront location, surrounding park space and pedestrian pathways.

A diagram conceptualizing a flow of information material processing is illustrated in the

accompanying image, with the accessibility of various types of information media made

available as the basis of interaction, and ultimately leading to greater environmental

engagement, whether that be through local activism for environmental remediation or

protection, the pursuit of more sustainable lifestyles or design decisions, or other positive

outcomes.
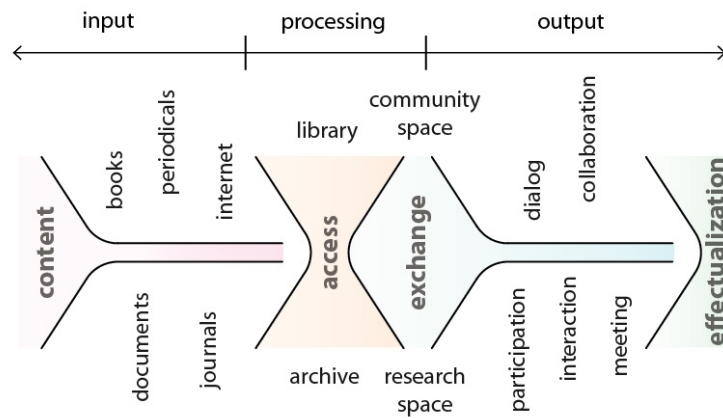
Figure 79: Conceptualization of information material processing flow (Image by author)

Furthermore, with increasing development and the recognition that buildings need to

be built to a higher standard in regard to performance and energy efficiency, the availability of

information pertaining to these subjects becomes a potentially valuable resource for designers,

engineers, developers, and public in general. As such the building should exhibit high-

performance building features, potentially allowing for learning opportunities in sustainable

design considerations and practices. The building would also allow for exhibit space for

educational material. Libraries today should not be considered as solely being repositories of

information in various media, new or old, but as also providing public space for social

engagement, community events, and
group study or presentation areas, as well
as personal reading or work spaces. The
building should also make accessible
information technologies which may not be
available to all segments of the population,
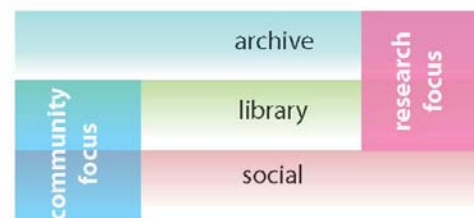
Figure 80: Potential content and connective foci (Image by author)

whether this is internet and computer access, digital presentation spaces, or other more

innovative features and spaces.

This project envisions common spaces for both general community usage and more

research focused areas. These might be considered as connective spaces between various media

or content zones as suggested in the accompanying illustration. The content itself may be

envisioned as consisting of layers of increasing or decreasing densities of accessibility, from

historical or technical archival documents, to books and academic journals, to internet or social

networking content. These might be further envisioned on temporal and geographical scales,

with each programmatic area suggesting information referring to past knowledge and

experiences, interactions in the present, or future engagements and opportunities.
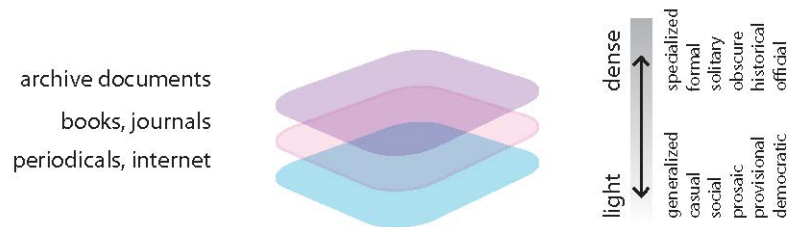
Figure 81: Concept of layering of information content densities (Image by author)
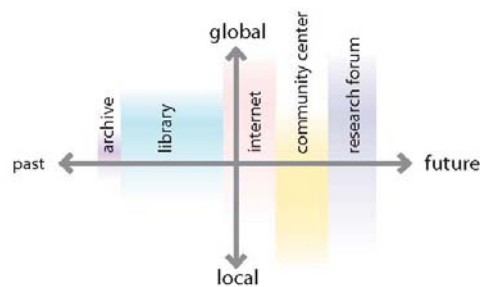
Figure 82: Diagram of associated temporal and geographic scales by program element (image by author)

[1] Ostrander, Steven M. (1894). *A History of the City of Brooklyn and Kings County*, Amazon Digital Services, Inc.: 1894.

[2] Ibid.

[3] William L. Felter (1919). *Historic Green Point*. P. 16-18

[4] Ibid.

[5] Ibid.

[6] < http://www.newnetherlandinstitute.org/history-and-heritage/digital-exhibitions/a-tour-of-new-netherland/long-island/boswijck/> accessed 24 July 2013

[7] Felter (1919) P. 16-17

[8] T.W. Field (1868). *Historic and Antiquarian Scenes in Brooklyn and Its Vicinity: with Illustrations of some of its Antiquities*, self-published, P.75

[9] Ostrander, Steven M. (1894)

[10] Ibid.

[11] Felter (1919). P. 25

[12] Ibid.

[13] <http://www.newnetherlandinstitute.org/history-and-heritage/digital-exhibitions/a-tour-of-new-netherland/long-island/midwout/> accessed 24 July 2013

[14] <http://www.nyc.gov/html/bkncb4/html/about/history.shtml> accessed 26 July 2013

[15] "Greenpoint Historic District Designation Report," (1982). P.1-5

[16] Field(1868). P. 40-48

[17] Ibid.

[18] J.T. Bailey (1840). *An Historical Sketch of the City of Brooklyn and the Surrounding Neighborhood*, New York: self-published. P.30-31

[19] <http://www.prospectpark.org/about/history/historic-places/lefferts> accessed 24 July 2013

[20] "Greenpoint Historic District Designation Report" (1982). P.1-5

[21] Ibid.

[22] Ibid.

[23] Federal Writers Project, *The WPA Guide to New York City: The Federal Writers' Project Guide to 1930s New York*, New York: New Press, 1995, P. 459-460

[24] Felter (1919). P. 32

[25] <http://www.nyc.gov/html/bkncb4/html/about/history.shtml> accessed 2 Aug 2013

[26] "Greenpoint Historic District Designation Report" (1982). P.1-5

[27] Ibid., P. 7-8

[28] Felter (1919). P.56-57

[29] Ibid. P.8

[30] Federal Writers Project, P. 459-460

[31] <http://www.nyc.gov/html/bkncb4/html/about/history.shtml> accessed 2 Aug 2013

[32] <http://www.nyc.gov/html/dcp/html/greenpointwill/greenplan3.shtml> accessed 2 Aug 2013

[33] "Greenpoint Historic District Designation Report" (1982). P.1-5

[34] John Hill, *Guide to Contemporary New York City Architecture*, New York: W.W. Norton & Co., 2011, p. 191

[35] <http://www.nyc.gov/html/dcp/html/greenpointwill/greenoverview.shtml> accessed 20 Aug 2013

[36] <http://www.nyc.gov/html/dcp/pdf/greenpointwill/incl_housing_web.pdf> accessed 20 Aug 2013

[37] <http://www.nyc.gov/html/dcp/html/greenpointwill_con/index.shtml> accessed 20 Aug 2013

[38] <http://www.nyc.gov/html/dcp/html/greenpointwill/greenwateraccessplan.shtml> accessed 20 Aug 2013

[39] Ibid.

[40] <http://www.nyc.gov/html/dcp/pdf/zone/art02c04.pdf> accessed 21 Aug 2013

[41] <http://www.nyc.gov/html/dcp/pdf/zone/art06c02.pdf> accessed 21 Aug 2013

[42] <http://www.nyc.gov/html/dcp/html/neigh_info/bk01_info.shtml> accessed 22 Aug 13

[43] < http://www.nyc.gov/html/dcp/pdf/lucds/bk1profile.pdf#profile> accessed 22 Aug 13

[44] Ibid.

[45] <http://www.nyc.gov/html/dcp/pdf/census/puma_socio_08to10_acs.pdf#bk1> accessed 23 Aug 13

[46] <http://www.nyc.gov/html/dcp/pdf/census/puma_housing_08to10_acs.pdf#bk1> accessed 23 Aug 13

[47] William L. Felter, *Historic Green Point* (1919). P.13-14

[48] <http://www.brooklyn.net/neighborhoods/greenpoint.html> accessed 24 Jul 13

[49] <http://www.nyc.gov/html/dep/pdf/wwsystem.pdf> accessed 22 Aug 13

[50] Ibid.

[51] Ibid.

[52] <http://www.epa.gov/Region2/superfund/npl/newtowncreek/newtowncreek_review.pdf> accessed 22 Aug 13

[53] Ibid.

[54] Ibid.

[55] Ibid.

[56] <http://www.riverkeeper.org/campaigns/stop-polluters/newtown/effects-of-the-spill/> accessed 8/29/13

[57] <http://newyorkview.net/2012/08/mother-of-greenpoint/> accessed 26 July 13

[58] < http://www.newtowncreekalliance.org/about/> accessed 26 July 13

[59] <http://www.newtowncreekboa.org> accessed 26 July 13

[60] <http://ny.curbed.com/archives/2013/05/06/greenpoint_landing_towers_could_break_ground_this_year.php#more> Accessed 11 Jul 13

[61] <http://therealdeal.com/blog/2013/05/07/chetrit-bistricer-will-pay-8m-to-create-greenpoint-park-paving-way-for-apartment-project/> Accessed 11 Jul 13

[62] <http://ny.curbed.com/archives/2013/07/03/northwest_greenpoints_quiet_waterfront_awaits_new_towers.php#more>

[63] <http://www.thedomaincos.com/project.php?id=2&pid=21> Accessed 11 Jul 13

CHAPTER 5

CONCEPTUAL AND SCHEMATIC DESIGN

5.1 Conceptual Design

The conceptual design phase began with a series of studies to investigate potential building design ideas which would accommodate the program previously described while responding to the specific context and constraints provided by the site. To this end a number of study models were created which explored possible massing configurations for the building. Many of these schemes considered the idea of breaking up the building into distinct programmatic zones which would then be separated by atriums and corridors extending the full height of the building.
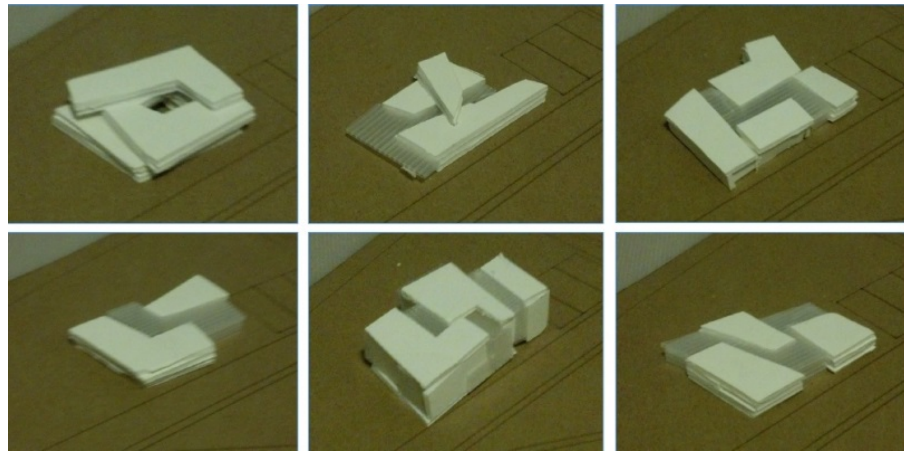
Figure 83: Concept Massing Models (Images by author)

The final chosen concept envisioned the building as three primary zones dedicated to primary use for library, community, and researcher/staff space. The interstitial space could then be used for common purposes, including reading areas as well as circulation. Additionally, the interstitial area was conceptualized as being transparent while the three spaced volumes would be as opaque masses which were sliced and offset to provide the intermediate spaces. The atria would also provide necessary daylighting to interior spaces by means of a continuous skylight

while also acting as a thermal buffer zone and potentially means for thermal stratification which could aid in facilitating natural ventilation.
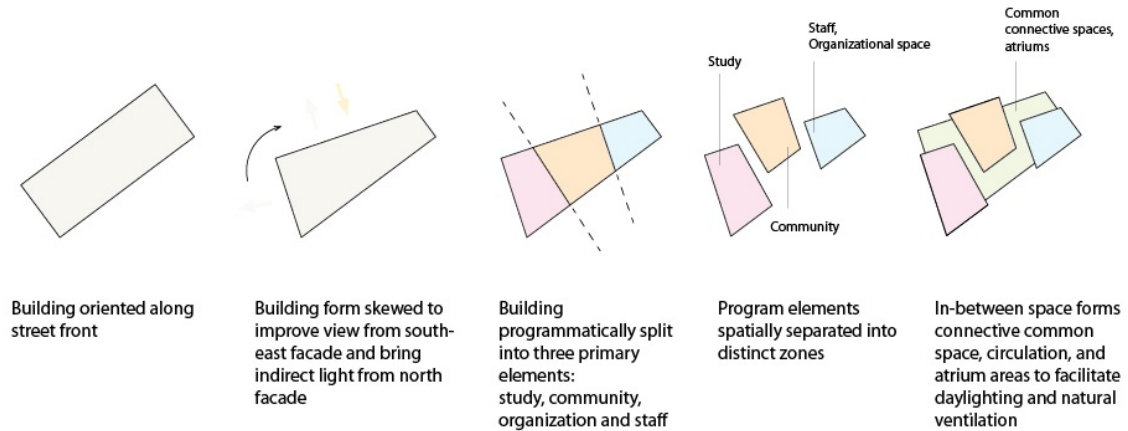
Figure 84: Design Concept Process Diagram (image by author)
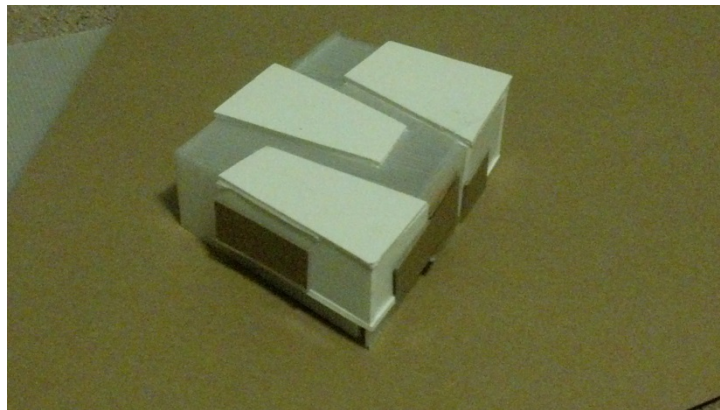
Figure 85: Study Model (image by author)

An additional design decision made early in the design process was to include a constructed artificial wetland which could be utilized to process building wastewater for reuse. This feature could additionally be utilized as a landscape feature, as well as provide an integrated educational opportunity to teach visitors about natural processes which could be used as an alternative to more energy-intensive conventional off-site wastewater treatment systems. This element seemed particularly appropriate for this project given the existing

environmental hazards in the community caused by the overloading of the municipal combined

sewer system. A series of concept models were made which explored potential configurations

for the landscaping which would incorporate this type of wetland system.
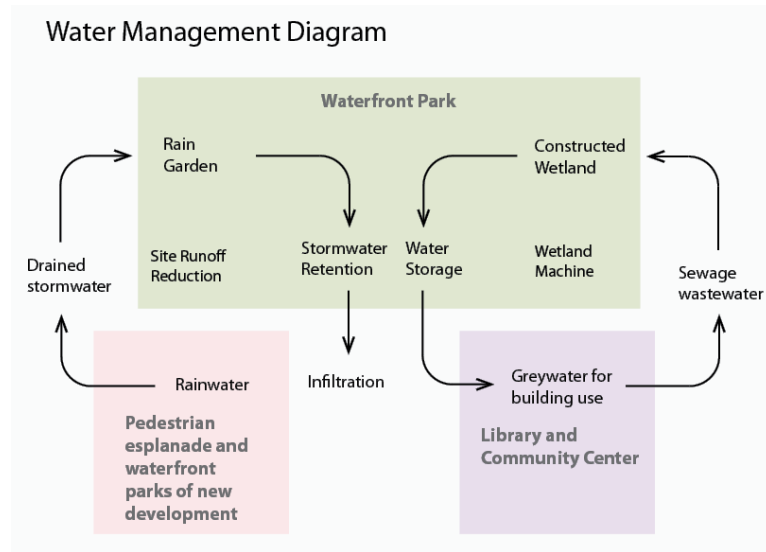
Figure 86: Site Water Management Diagram (image by author)

Ultimately it was decided to use a series of terraces to the northwest of the building

which would step down towards the waterfront, providing outdoor space and seating with

views the waterfront in addition to allowing for the gravitational flow for the wetland system.

An additional consideration was for a storm water retention pond or rain garden which could

occupy the western portion of the site. The water passing through the wetland system might be

contained there or a containment tank until building use.
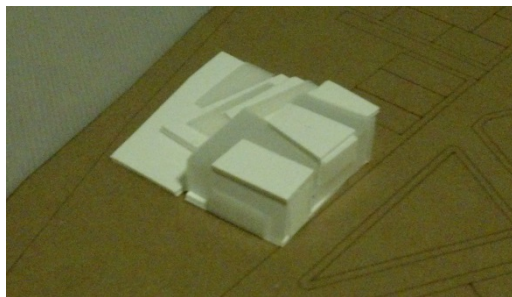
Figure 87: Study Model showing preliminary
landscape concept (image by author)

5.2 Schematic Design

5.2.1 Parametric-simulation Studies

Having established an overall building concept and approach towards the project site, a number of studies were undertaken to explore design variations with the goal of improving environmental and daylighting performance. Parametric design tool Grasshopper and the simulation program DIVA were utilized to investigate potential effects on environmental performance of varying geometric parameters and to gain insight into possible trade-offs resulting from differing design variations.

5.2.1.1 Massing Study 01

In the first parametric study, variations on the form of the overall building massing were evaluated. The intent was to consider the potential for unobstructed views from the building towards and across the East River, the amount of solar irradiation to the facades, and the amount of daylight to the interior in relation to variations on the overall shape of the building. It was considered to maintain a constant linear edge along the street front and the east façade which is adjacent to a building on the next property, while varying the angles of the west and north facades, and keeping the area of the building footprint constant among the variations for comparison purposes. The view potential for each of these configurations was evaluated by projecting sets of view lines perpendicular to each of the facades and, by determining whether these intersect with obstructions to the view across the river, determining the percentage of such view lines which were unobstructed. For evaluation of the potential heat gain on the facades, the total solar irradiation during a typical summer week was determined for each iteration. To compare the effects of the shape on daylighting, resulting average daylight factors

were determined. These were determined based on work planes 3'-6" above each of four

assumed levels for the building, and assuming for simplicity fully glazed exterior walls.
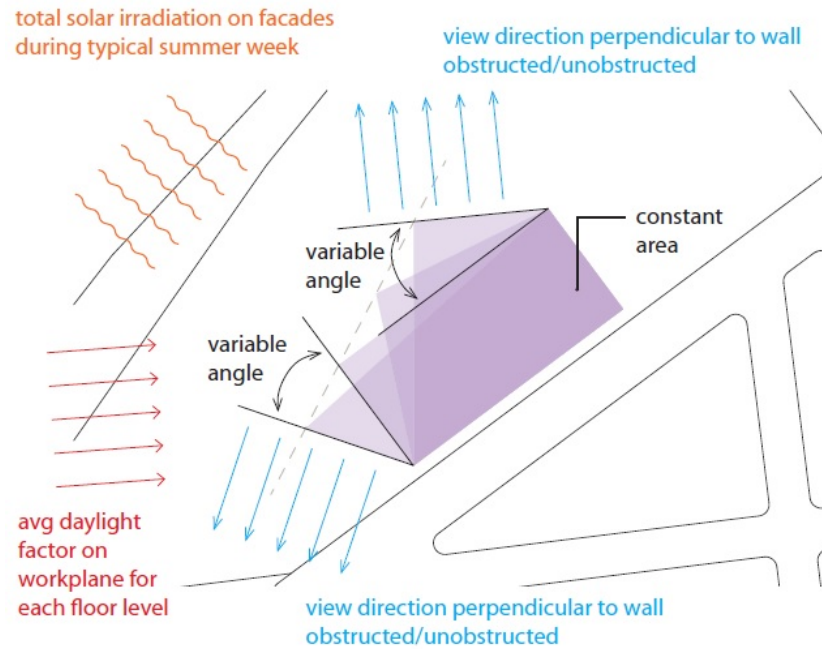
Figure 88: Illustration of set-up for parametric massing study 01 (image by author)

Figure 89: Example of single iteration of parametric massing study 01 (image by author)

Figure 90: Sample of simulation iterations of parametric massing study 01 (image by author)

The results for this study are shown in graphical form, having plotted the DIVA and Grasshopper output values in Excel. The "angle" column values refer to the angle of the west façade from a line perpendicular to the street edge. It can be seen that the summer solar irradiation on the facades is lowest for the massing option with the west façade edge angled in the range of approximately 10 to 25 degrees. This also coincides with the range which allows for 50% unobstructed view lines, which means the views perpendicular from all points along the north and west facades are unobstructed for views across the river to the Manhattan skyline. The building forms within this range also allow for the least overall surface area of the building, while maintaining the same usable floor area, thus allowing for reduced transfer through the overall envelope and consequently reducing energy usage. A potentially negative consequence for the building forms within this range is a reduction in interior daylighting due to the reduced surface area, at a low average of approximately 6.65 DF from the peak average of 7.10 DF. However, this study has only considered an overall simplified building form and not considered

the potential use of skylights and atriums which would allow for increased daylight into the interior. In conclusion, the study results suggest that of the building forms considered, those with the west façade angled between approximately 5 and 20 degrees would be best, with 18 degrees perhaps the best choice given it has the smallest façade surface area for options within the lowest range for summer solar irradiation and the maximum percentage of potential for unobstructed views.
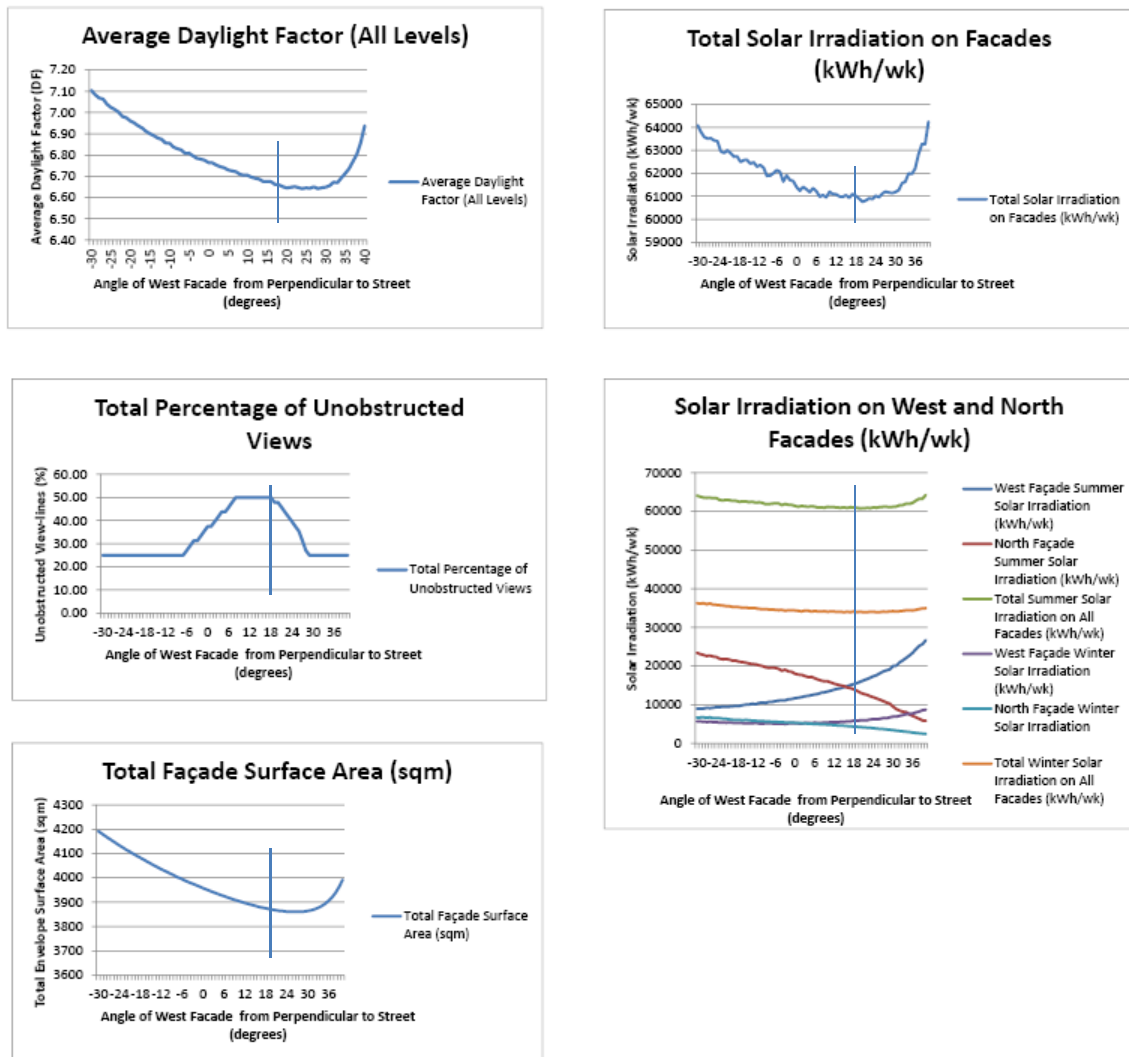
Figure 91: Graphical results of parametric massing study 01 (images by author)

5.2.1.2 Massing Study 02

In the second parametric study, variations on the positioning of the three programmatic volumes of the building (library, community, and research/staff) were tested along with the size and extent of the skylights over the intermediate circulation and common spaces in order to determine the effects of these variations on daylight levels of the interior spaces. A number of sets of iterations were tested. Within each set, each iteration of the study increases the horizontal distance between each of the programmatic spaces. The additional sets of iterations repeat the same series of offsets, but after having moved also the central volume back an additional 6 feet perpendicular from the street edge.
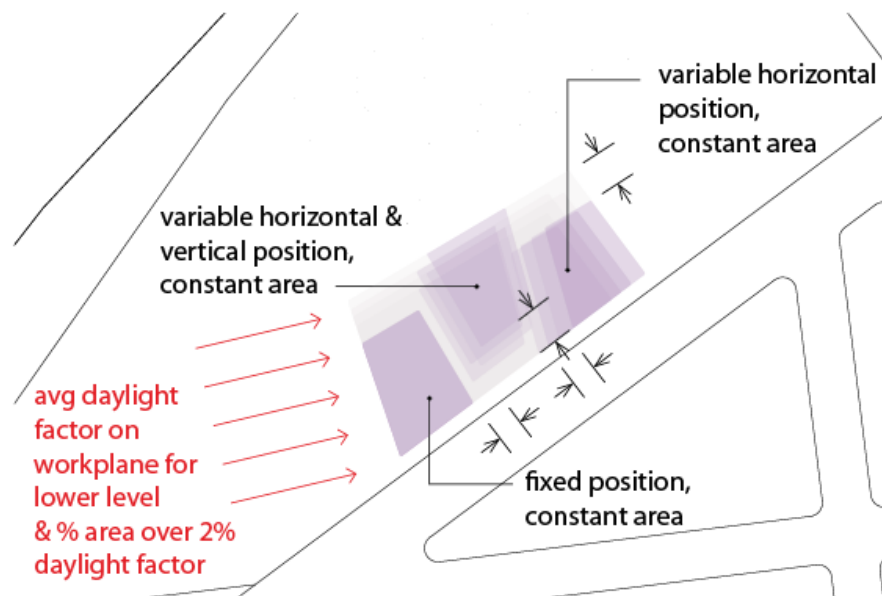
Figure 92: Illustration of set-up for parametric massing study 02 (image by author)

This interstitial space at the front of the building is envisaged as the main street-front

entry lobby and atrium. These "in-between" spaces are assumed open to the full height of the

building. The material assumptions for the parametric model simulated are a fully glazed double

pane wall at the façade and roof of the interstitial spaces and atriums, exterior walls of the

programmatic volumes having 50% window to wall ratio with "punched" windows, and single-

pane glazed walls at the interfaces between the programmatic volumes and the interstitial

spaces. It should also be noted that the effects of potential shading devices for the skylights is

not included in this model. The specific outputs from the simulations are the daylight factors at

a work plane positioned 3'-6" above the floor level. For this study, the ground floor level was

chosen since it would likely receive the least light from the skylights above the interstitial

spaces.

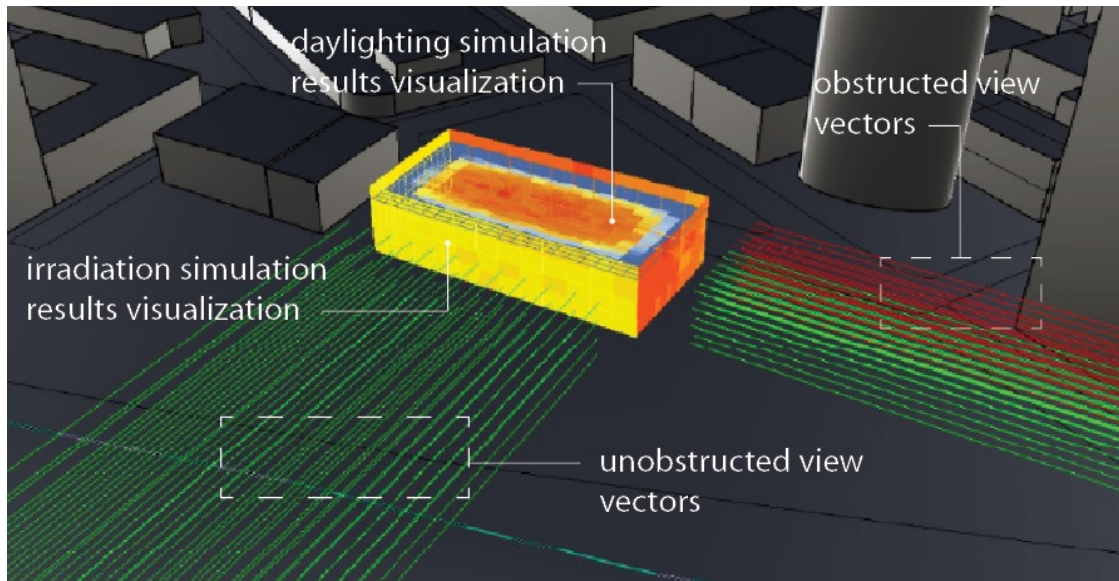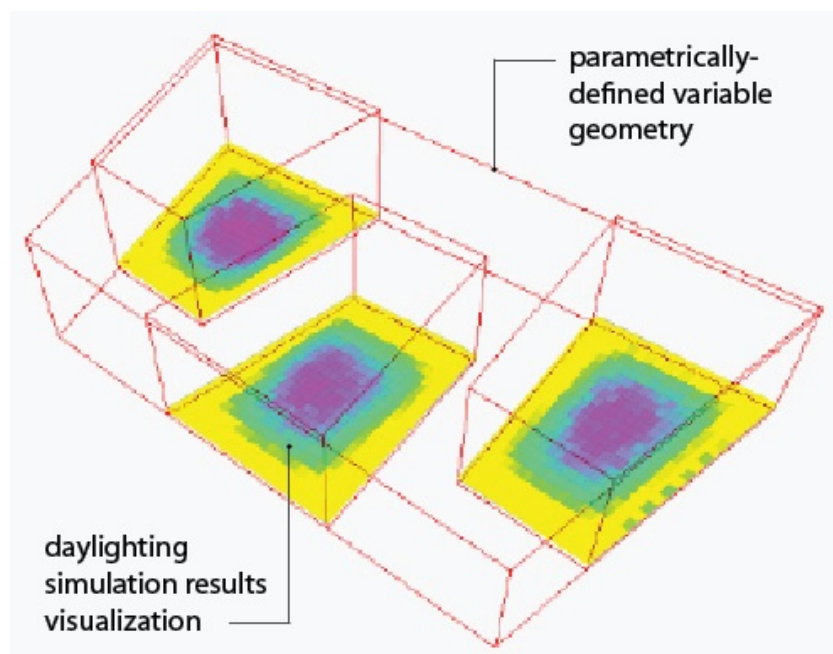Figure 93: Example of single iteration of parametric massing study 02 (image by author)
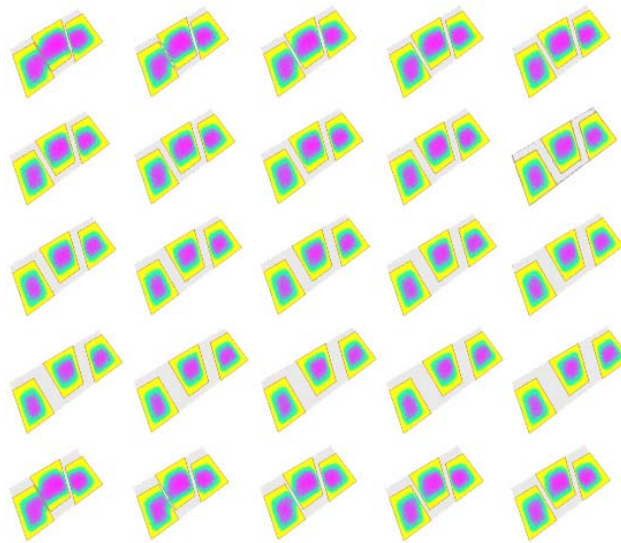
Figure 94: Sample of simulation iterations of parametric massing study 02 (image by author)

The results of the study are shown in table and graphical form. It can be seen from the results, as would be expected, that increasing the width of the interstitial spaces and offset of the central volume increases the daylight level of the interior. The exception is that the volume containing the Research/Staff spaces begins to receive less light when it becomes positioned increasingly close to the adjacent structure. The increase in the average daylight factor for the Library and Community space can be seen to be approximately linear with increased spacing. However, the percentage of area with a daylight factor above 2% has a more curvilinear relationship to the increased spacing, with the initial iterations having a greater affect than the later iterations. This suggests a relative decrease in the daylight advantages of increased spacing after a certain point, specifically after about the 10th iteration, which corresponds to a spacing of about 7 meters, or 23 feet in the later sets of iterations. In conclusion, it would seem reasonable to pursue an option with the larger atrium spaces, of about 30' to 35' in depth from the perimeter, and an interstitial spacing of approximately 20' to 25' given that this results in approximately 70% of areas having a daylight factor above 2%. However, this can also be

improved by reducing the widths of the programmatic spaces, perhaps by 10', and locating the

cores or support spaces if possible towards the interiors of these spaces.
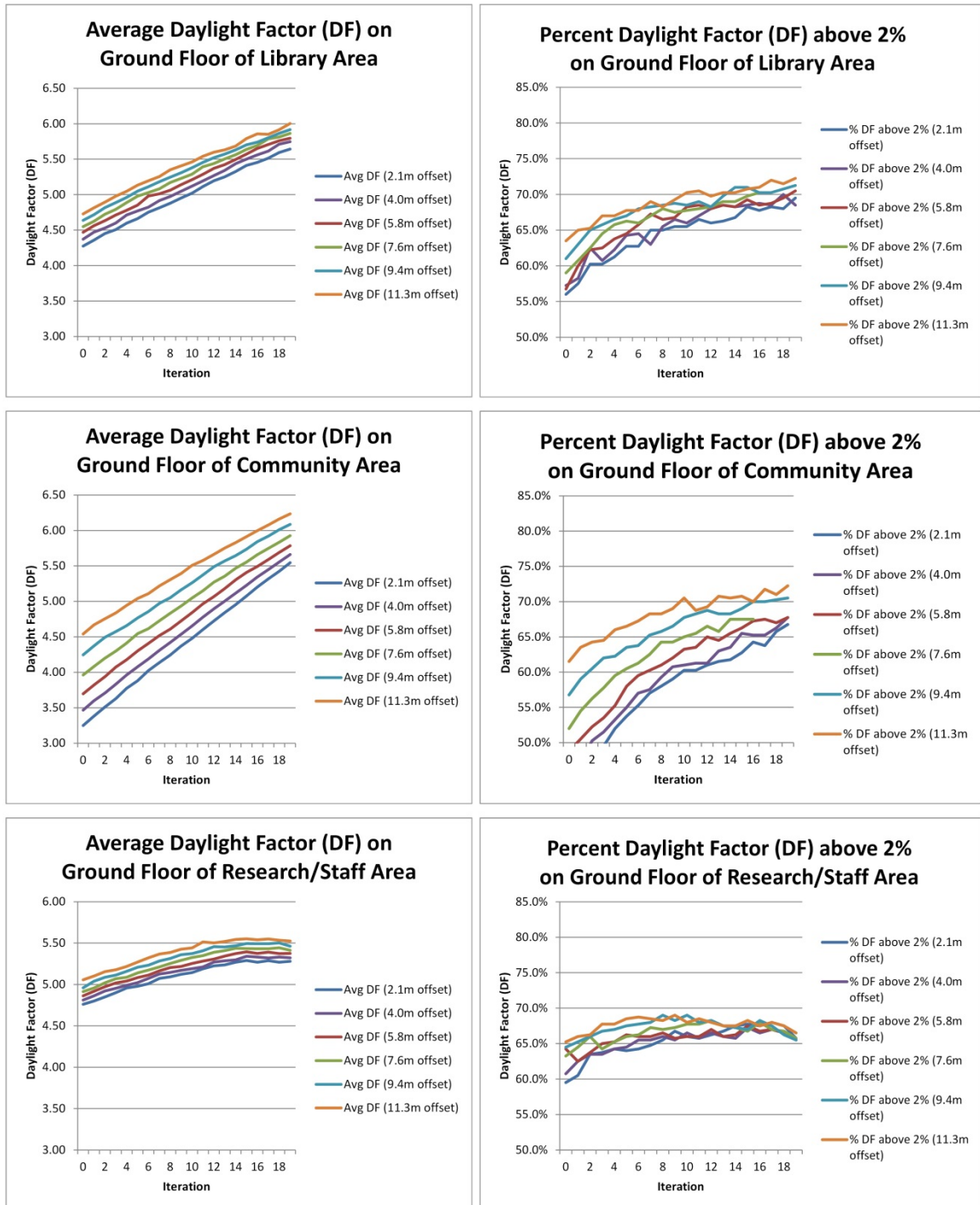
Figure 95: Graphical results of parametric massing study 02 (images by author)

5.2.1.3 Study 03

In this parametric study, as in the previous, variations on the positioning of the three

programmatic volumes of the building were tested to observe the effect on daylighting of the

interior. However, the width and proportions of these areas have been revised in response to

the results of the previous study which suggested that narrower floor plates would be needed to

improve daylighting to the central areas of these spaces where needed. Only horizontal shifting

and corresponding increases in skylight widths were tested while the depths of the atria

remained constant, but variations were tested for different widths of the skylights so that, for

example, the relative effect of having a narrow skylight along the west corridor and a wider

skylight on the east corridor could be observed. Otherwise, assumptions for the model were

similar to the previous model.
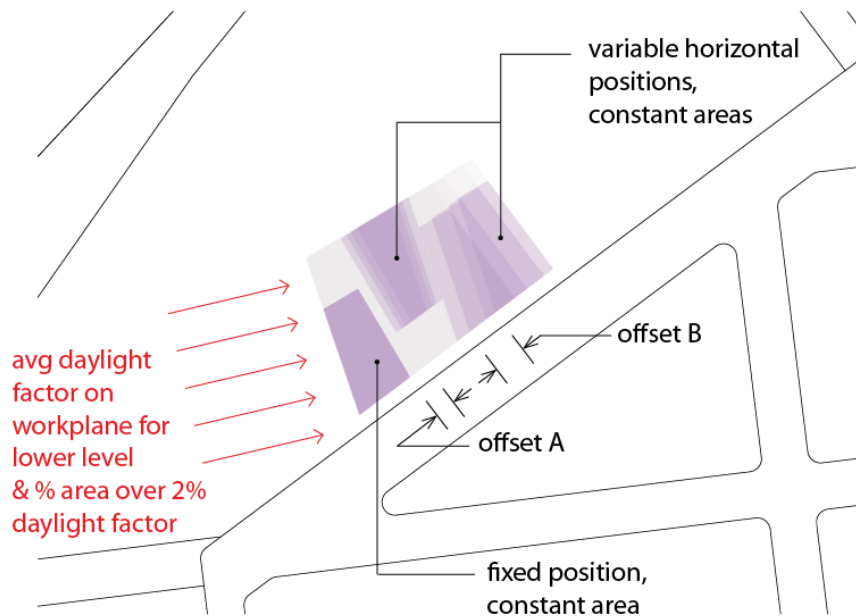
Figure 96: Illustration of set-up for parametric massing study 03 (image by author)

The results of the study, shown in graphical form, indicate an improvement in daylighting levels in comparison to the area shapes considered in the previous study. "Offset A" in the tables and graphs refers to the offset of the central area, which increases the width of the west corridor skylight, and "offset B" to the eastern area position relative the central area, the separation forming the eastern corridor and skylight. While increasing the western skylight width improves the daylighting in the library and community areas, it can be seen that an increase in the eastern skylight width has a somewhat larger impact on the daylighting of the community area spaces given the particular geometries assumed. The design response based on these results was to utilize a relatively wider sky-lit atria corridor between the community and research areas. An east atrium corridor width of approximately 36' was chosen in response. Also significant in the Percent Daylight Factor graphs is the curvature of the plotted results. The initial steepness of the curve indicates a relative large increase in daylight in relation to the increase in atrium corridor width, while the gentler slope towards the right side of these graphs indicates a diminishing return in terms of increased daylight per increase in atrium corridor width. Since ideally it would be desired to maximize daylight without over-widening the atrium corridor, as this would increase surface area of the atria roof glazing and consequently thermal transfer, a value of approximately 21' was found to be appropriate for the width of west atrium corridor for the final design.
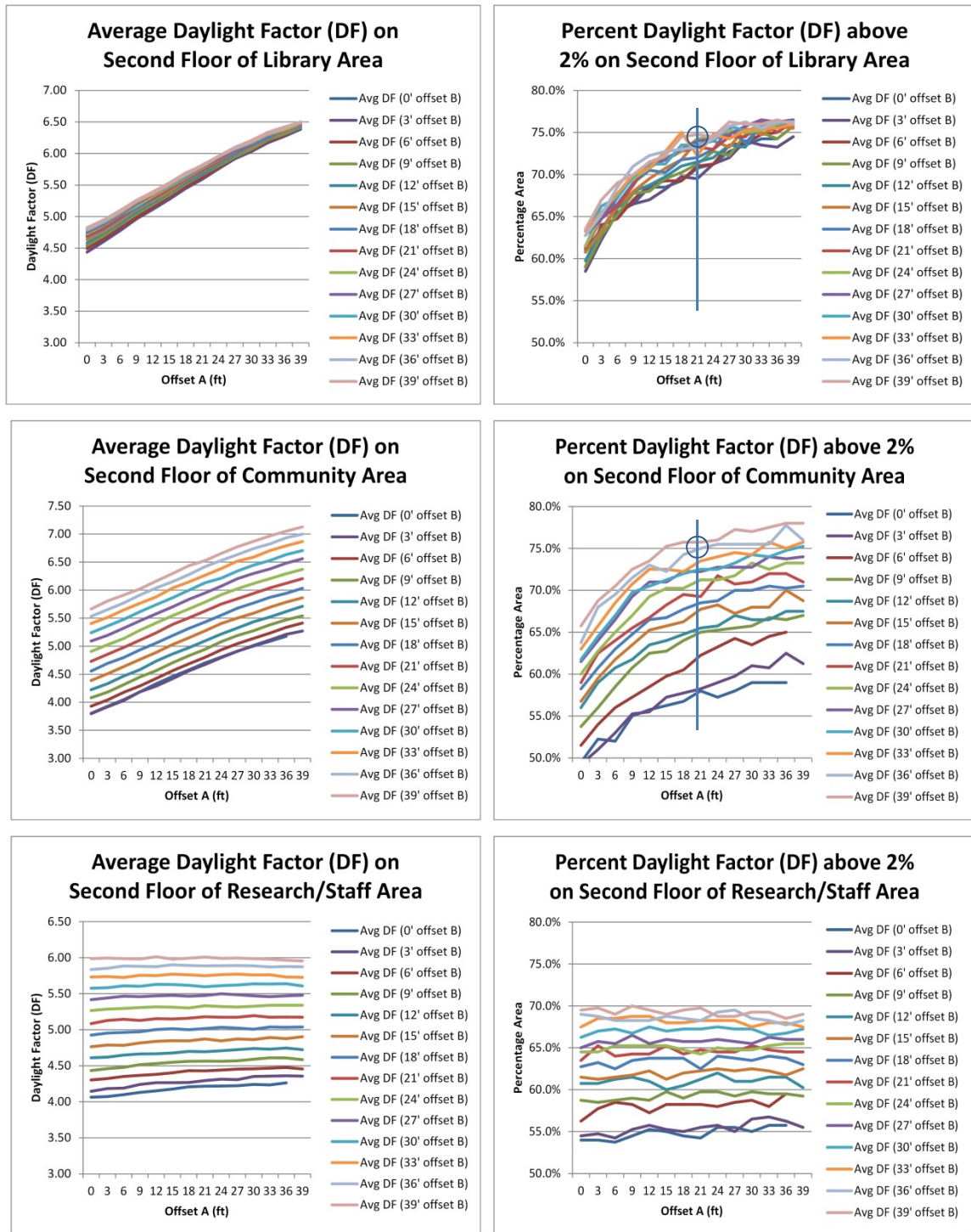
Figure 97: Graphical results of parametric massing study 03 (images by author)

5.2.2 Preliminary Design of Constructed Wetland Wastewater Treatment System

Constructed wetland wastewater treatment systems may be surface flow (SF) or subsurface flow (SSF) systems. In the given project context, a subsurface flow wetland is most appropriate as surface flow wetlands may produce odors and may not be safe for contact with persons in a public area. Options for subsurface flow systems include "vertical" and "horizontal" flow systems. These systems work on the principle that the organic components of wastewater can be effectively broken down and removed by microorganisms which grow upon plant roots embedded within a gravel base through which the wastewater flows. While vertical flow systems, in which water flows vertically through a mix of gravels, requires less space than horizontal systems and is consequently more efficient, these systems require pumps to move the water between beds and consequently would require an external energy source to function. Due to this requirement and the fact that the project site has an ample amount of space for the system, which is also envisioned as a landscaping element, the decision was made to use a horizontal subsurface flow system. These systems typically range between approximately 1.5' to 3' depending on the plant species used. The most common plant species utilized in constructed wetlands are bulrushes (Scirpus), cattails (Typha) and common reeds (Phragmites Australis). The roots of cattails generally do not extend past a depth of 1' and are consequently not as effective as bulrush or reeds. Given the typical common reed depth of 1.5' as well as the potentially more attractive appearance, growing to a height of over 6', the common reed was chosen as the plant for the system.
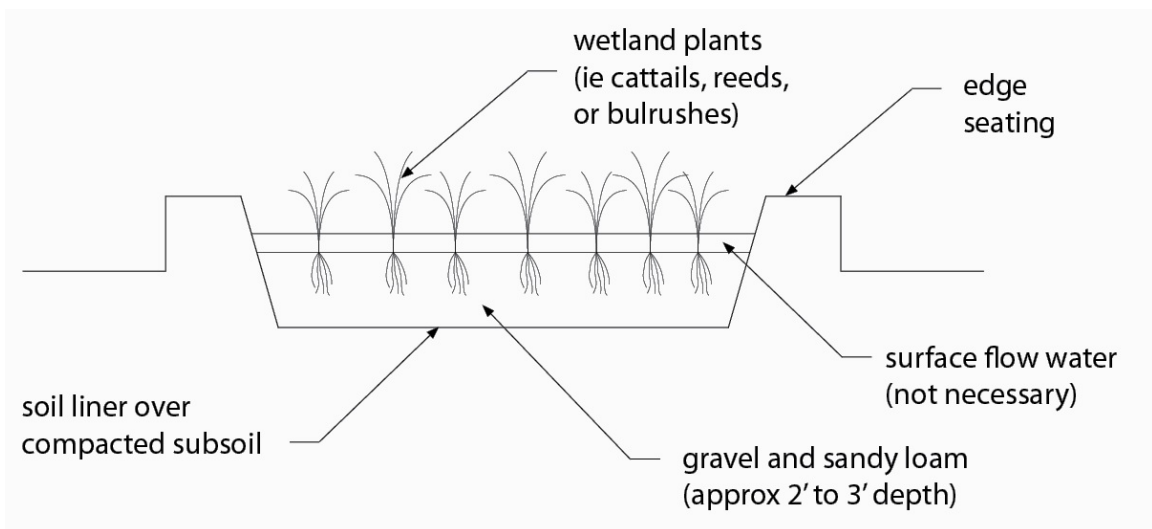
Figure 98: Wastewater Treatment Wetland Typical Section (image by author)

A preliminary approximation of the minimum required area for the system can be made through a basic calculation procedure.[1] The calculation, along with the necessary assumptions made for the design of the system, follows:

Calculation of minimum required area for subsurface flow treatment
wetland system

Assumed max number of visitors per day:	400	visitors
Assumed water usage per visitor per day:	3	gal/visitor/day
Total water flow	1200	gal/day
Total water flow (metric), Q	4.54	m^3/day
Assumed influent BOD, Co	300	mg/L
Assumed desired effluent BOD, Ce	5	mg/L
Typical water temperature	12.78	degrees C
Approx. Temperature-dependent rate constant, Kt [where Kt=1.104*(1.06)^(T-20)]	0.72	
Depth of gravel bed, d	0.61	m
Porosity of gravel, n	0.4	
As = (Q*(ln(Co)-ln(Ce)))/(Kt*d*n)		
As =	105.22	m^2
As =	**1132.62**	**sqf**

Assumed number of employees or
full-day researchers per day: 25   persons

Assumed number of employees or full-day researchers per day:	25	persons
Assumed water usage per visitor per day:	10	gal/person/day
Total water flow	250	gal/day
Total water flow (metric), Q	0.95	m^3/day
Assumed influent BOD, Co	300	mg/L
Assumed desired effluent BOD, Ce	5	mg/L
Typical water temperature	12.78	degrees C
Approx. Temperature-dependent rate constant, Kt [where Kt=1.104*(1.06)^(T-20)]	0.72	
Depth of gravel bed, d	0.61	m
Porosity of gravel, n	0.4	

As = (Q*(ln(Co)-ln(Ce)))/(Kt*d*n)

As =	21.92	m^2
As =	**235.96**	**sqf**
Total As = 1132.62 sqf + 235.96 sqf =	**1368.58**	**sqf**

The Hydraulic Residence Time (HRT) is the duration of time which would be expected for a water molecule to travel from the beginning to the end of the system, thus giving an indication of the hydraulic capacity of the system over time. The HRT for the system with the areas calculated above would be determined as follows:

HRT= Volume/Flow = (Area*Depth)/Flow= (1136.89sqf*2')/193.88ft^3/day= 11.73 days

The full-cycle components of the system are shown in the accompanying diagram. Wastewater from the building first receives preliminary treatment by means of a sedimentation tank, where heavier solids settle and are removed from the cycle. The water then passes through a series of three treatment cells where microorganisms adhering to the gravel and plant roots breaks down the majority of the remaining organic content of the wastewater.

Afterwards, effective ammonia removal is accomplished by means of a trickling filter. The water

then proceeds to a storage tank before being reused as grey water within the building.
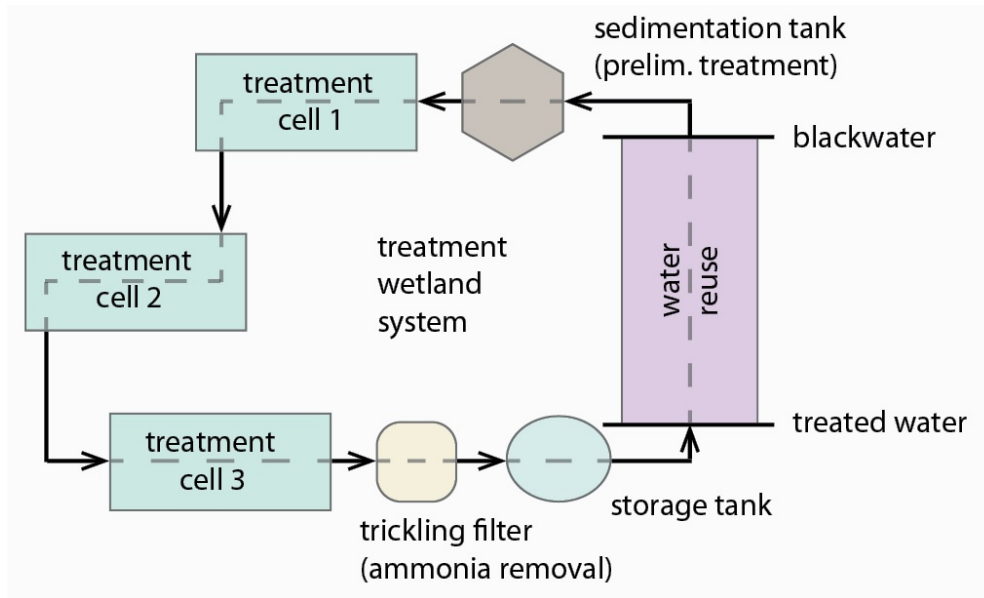
Figure 99: Wastewater Treatment Wetland Flow Diagram (image by author)

[1] Campbell, Craig S. and Ogden, Michael H. (1999). Constructed Wetlands in the Sustainable Landscape. Chichester: Wiley.

CHAPTER 6

DESIGN DEVELOPMENT AND FINAL DESIGN

6.1 Design Development

6.1.1 Development of Program Organization and Environmental Performance Strategies

Having defined an overall building massing approach and distribution of main program areas, the organization of the building was further refined by conceiving of individual functional areas as volumetric components within the larger composition of the building massing concept. The intent was to enable the perception of a differentiation of program elements for the building exterior, allowing users a more legible or intuitive sense of program distribution. The program organization is shown in the accompanying diagrams.
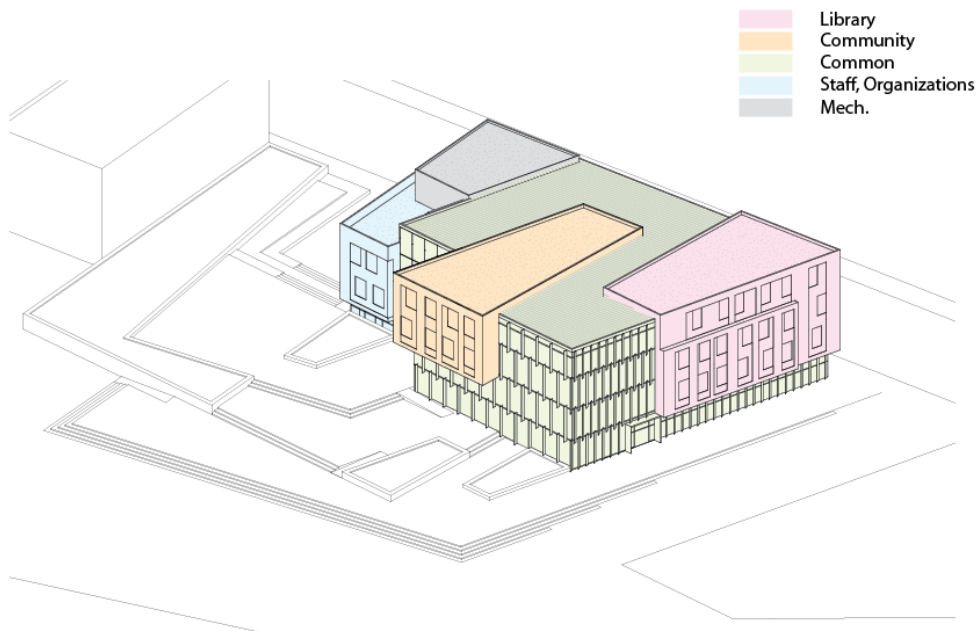
Figure 100: Northwest Axonometric (image by author)
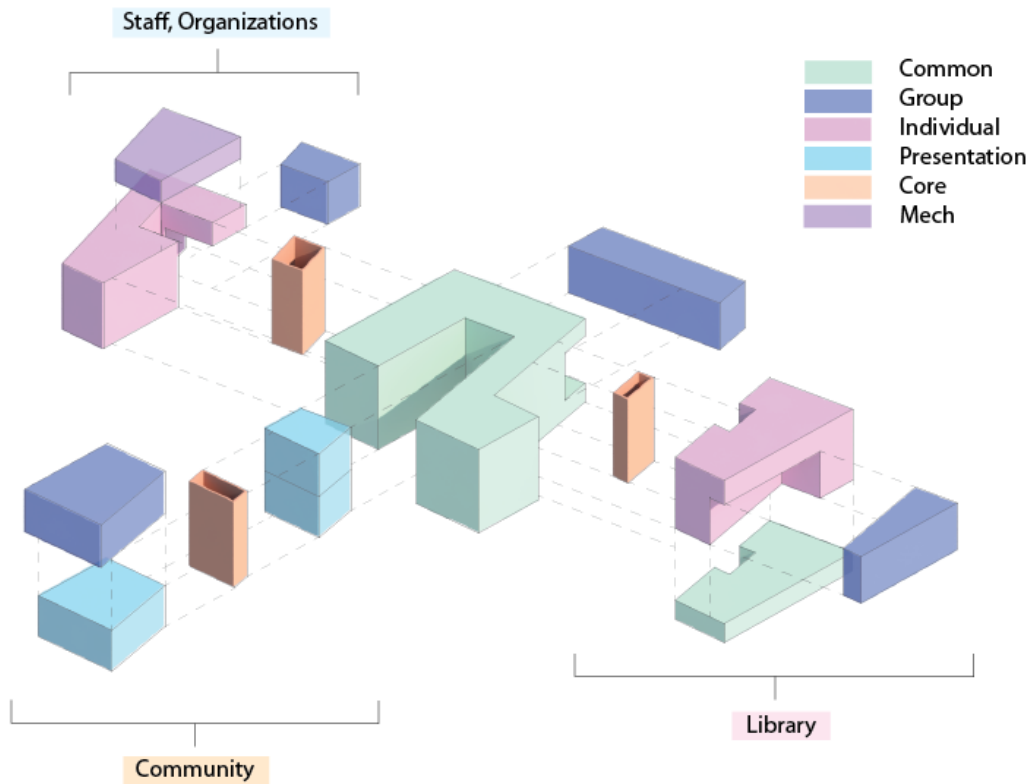
Figure 101: Program Distribution Diagram (image by author)

In terms of the relation between building and site, various circulation possibilities were considered which examined the relationship between movement through the building and adjacent landscape terraces' geometry. The chosen configuration is shown in the following diagram, which conceptualizes flows through the site.
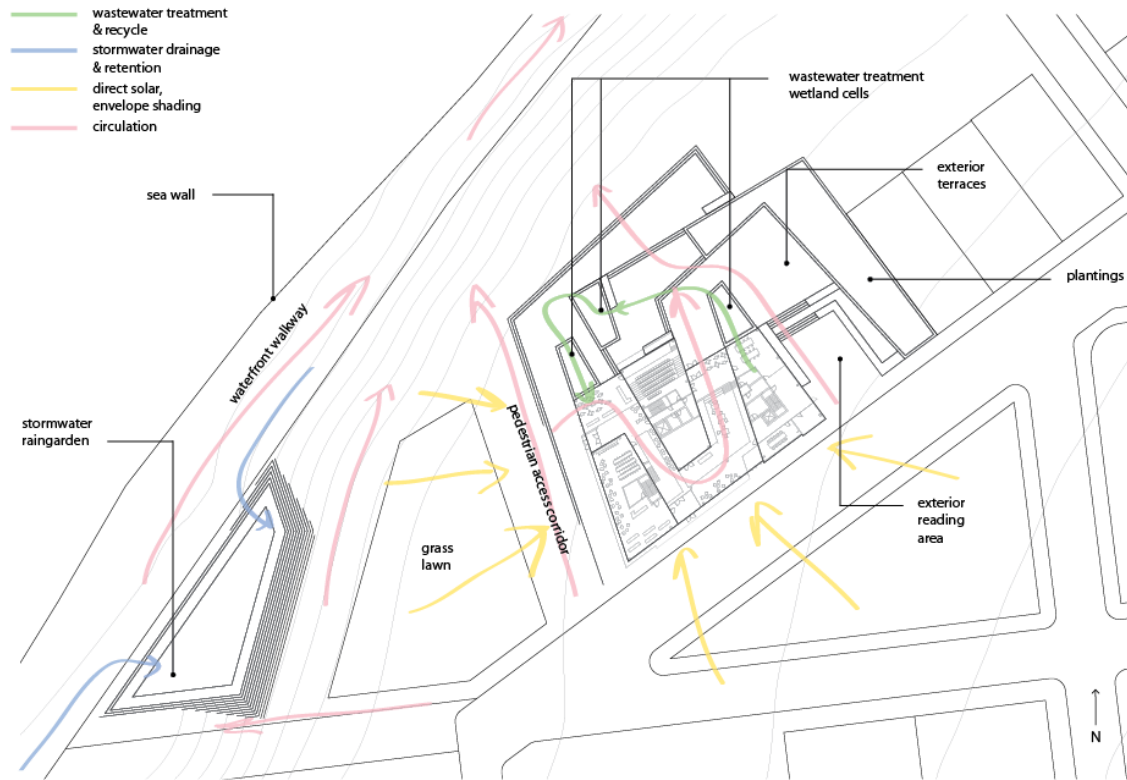
Figure 102: Site Landscape Plan and Flow Diagram (image by author)

A number of additional design decisions were made with the intention of improving

building performance. The use of a geothermal system with ground source heat pump and

radiant slabs was chosen for the active heating and cooling system. The ample size of the project

site would likely allow for a horizontal distribution of the geothermal arrays. The use of such a

system with accompanying heat pump would allow for substantial energy savings in comparison

to conventional systems. A hydronic system with radiant slabs would likewise reduce energy

consumption as such systems require less heat input in comparison to air distribution systems.

Ventilation would be provided naturally when seasons allow, but when not possible due to

exterior conditions, mechanical ventilation would be utilized to ensure adequate air exchange. A

heat recovery unit would be utilized to pre-heat or cool supply air as needed to reduce energy

usage for the ventilation system.
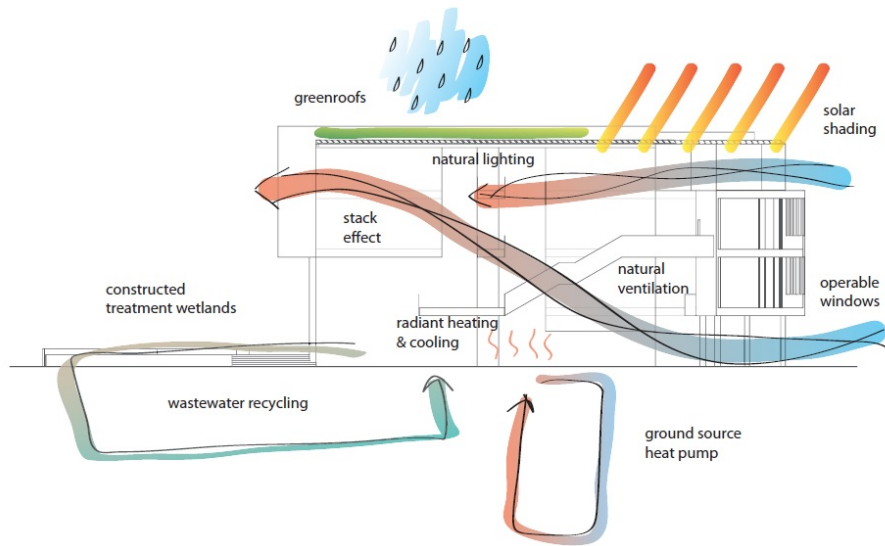
Figure 103: Environmental Performance Strategies Section Diagram (image by author)
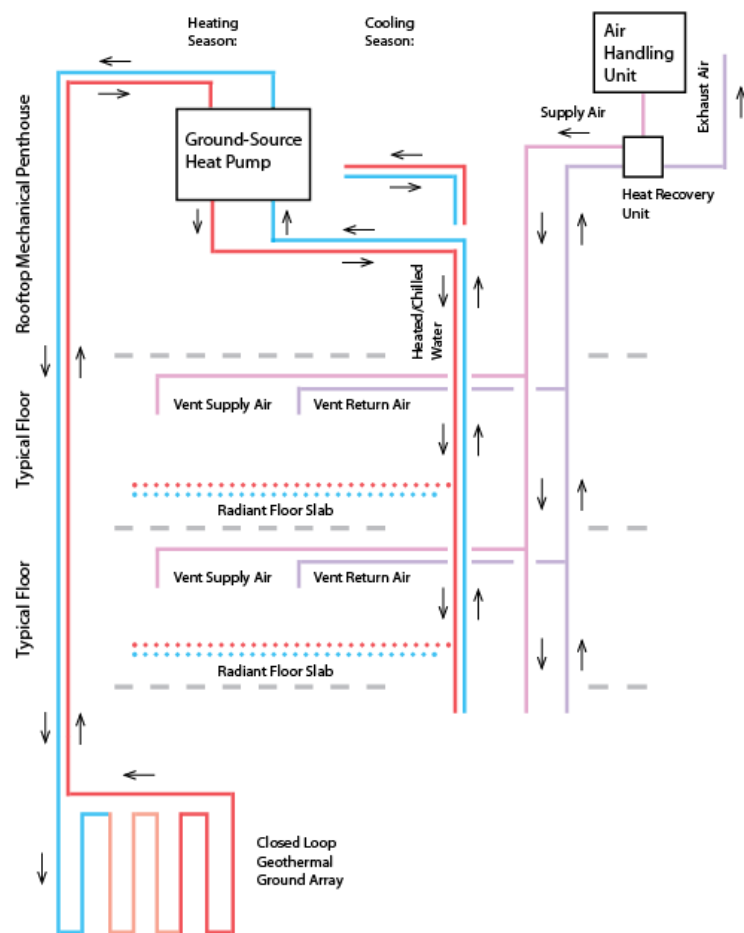
Figure 104: HVAC System Diagram (image by author)
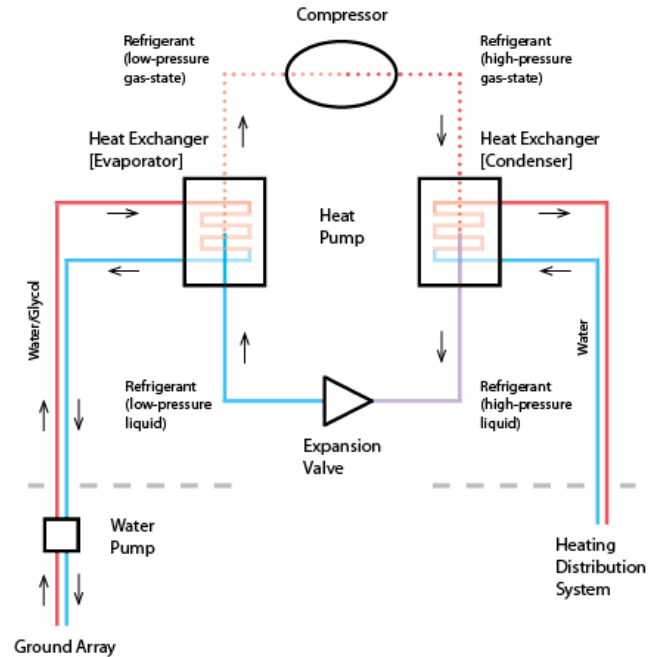
Figure 105: Ground-source Heat Pump Detail Diagram (image by author)

A simulation study was done for solar irradiation on the exterior of building was done to determine where exterior shading devices would be needed. A visualization of the results is shown in the accompanying images. The results were also used for comparison purposes with shading solutions explored parametrically, as described in the following section.
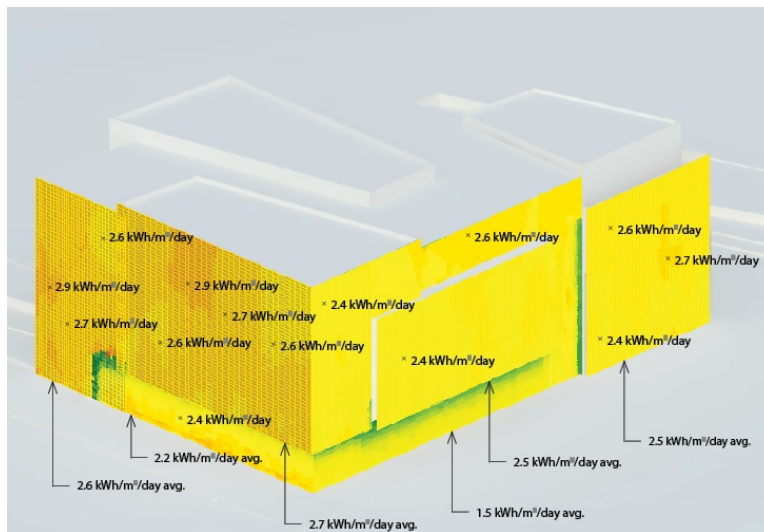
Figure 106: Solar irradiation on building massing on typical summer day – southwest axon (image by author)
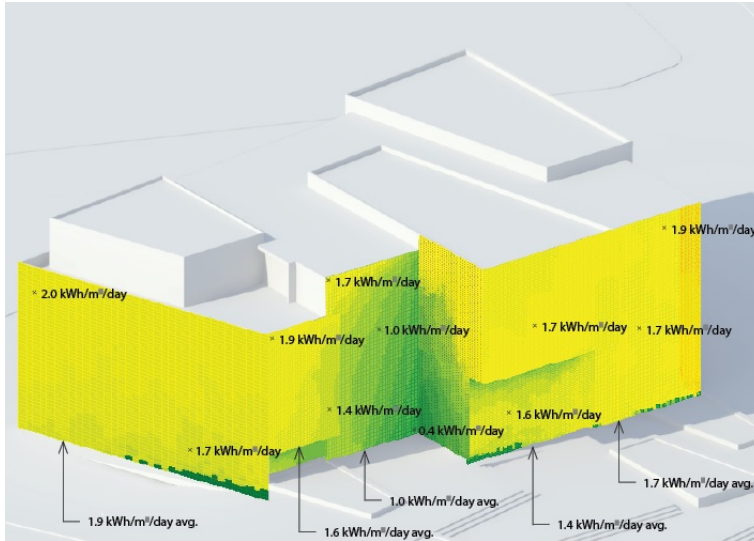
Figure 107: Solar irradiation on building massing on typical summer day – northeast axon (image by author)

6.1.2 Parametric-simulation Studies

Parametric studies for design development stage of project consisted primarily of studies focused on the potential geometries of shading devices and their effect on interior daylighting levels, as well as their ability to reduce heat gain of glazed surfaces of the exterior envelope. To follow are descriptions of studies concerning vertical shading fins and an option for the design of atria skylight louvers.

6.1.2.1 Skylight Louver Study

The purpose of this study was to determine the best angle for a system of fixed louvers to shade the glazed roof of the atria spaces. This study assumed that clear glass would be utilized for the skylight glazing. A series of variations were tested, evaluating a series of positions through 180 degrees from northwest to southeast. An analysis plane was established at roof level for calculation resulting solar irradiation during summer season, as well as analysis planes at work plane level at the third floor of each of the three interior zones.
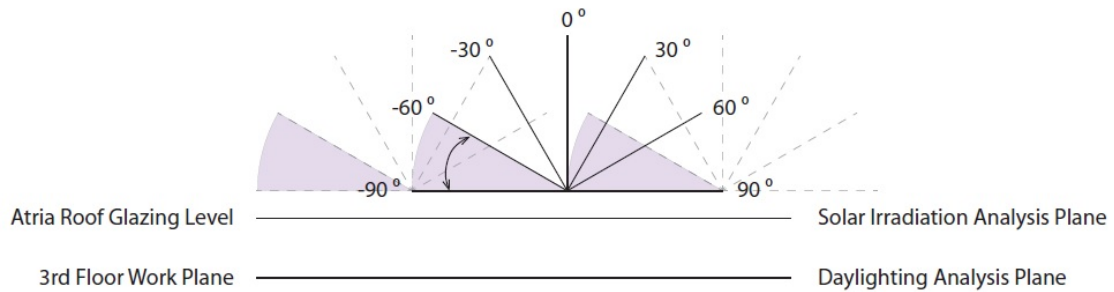
Figure 108: Illustration of set-up atria louver parametric study (image by author)

The following image illustrates a sample of the study variations with a visualization of the analysis output. In the atria, a color scale from purple to blue is used, showing the amount of solar irradiation reaching the atria skylight. In the three interior spaces can be seen color gradients from red to green, indicating the relative amount of daylight reaching these spaces.
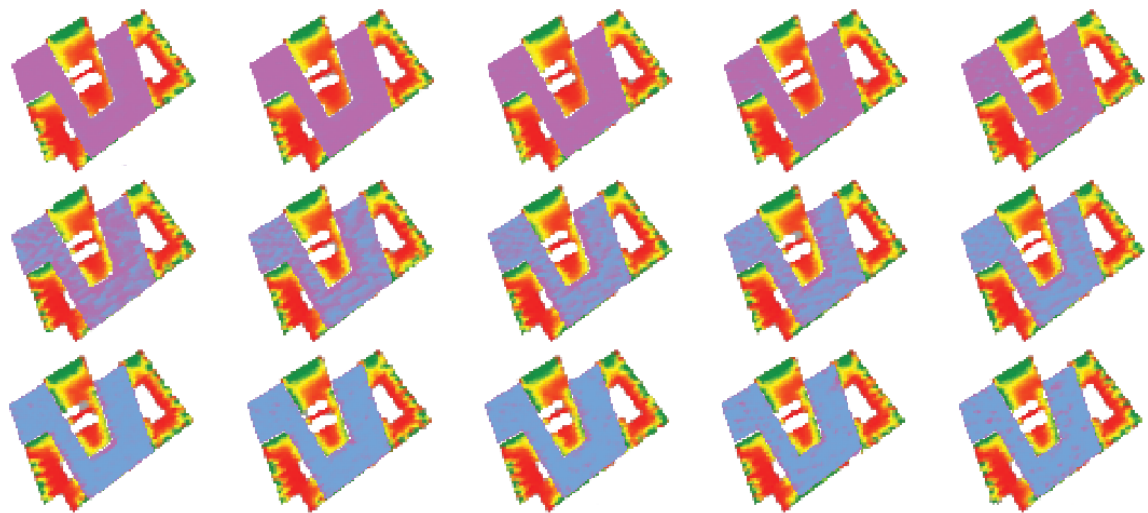
Figure 109: Sample of simulation iterations of atria louver parametric study (image by author)

To evaluate the daylighting levels, the percentage of floor area with daylight factors above 1% and 2% were plotted for each of the geometric variations and is shown in the accompanying graph. Average solar irradiation (for typical summer and winter weeks) on the atria roof for each geometric variation is shown in the second graph.

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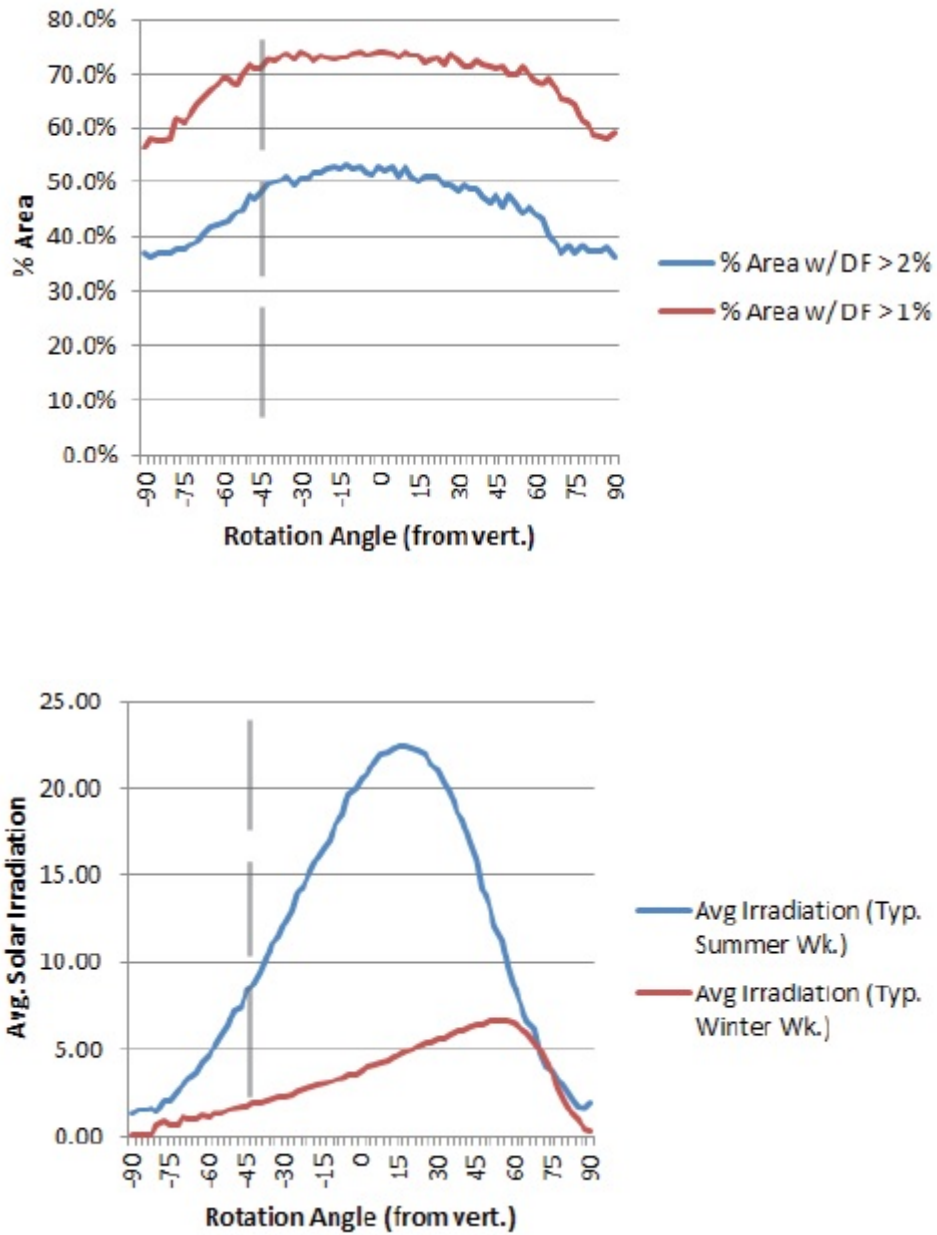
Figure 110: Graphical results of atria louver study (images by author)

Based on the results, it can be seen the percentage of floor area where the daylight factor is at least 2% reaches a plateau at approximately 73% between about -45 degrees and +45 degrees louver rotation. Meanwhile, solar irradiation continues to increase until a peak at approximately 20 degrees beyond vertical. Thus a louver rotation at approximately -45 degrees

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would be most suitable to maximize interior area exposed to at least 2% daylight factor while

reducing solar irradiation to a reasonable minimum during the summer months. Although a

variable louver system was eventually chosen for the final design, along with a translucent

insulated sandwich panel for the atria roof glazing, rather than the fixed louver system with

clear glazing which the study assumed, the study allowed for insight into how variations of the

louver geometry would affect interior lighting levels and solar irradiation on the atria roofs. The

intention behind using the translucent sandwich panels was to allow for glare reduction while

providing increased insulation for the winter heating season.

6.1.2.2 West Atrium Vertical Shading Fin Study

The purpose of this study was to study the effect of shading fin spacing and rotation on

façade solar irradiation as well as daylighting to interior spaces. The study assumed that 1'-6"

deep vertical fins would be used, oriented vertically, and, for simplicity of reading results, that

the fin spacing on the north façade would be positioned at 4' on center, perpendicular to the

façade.
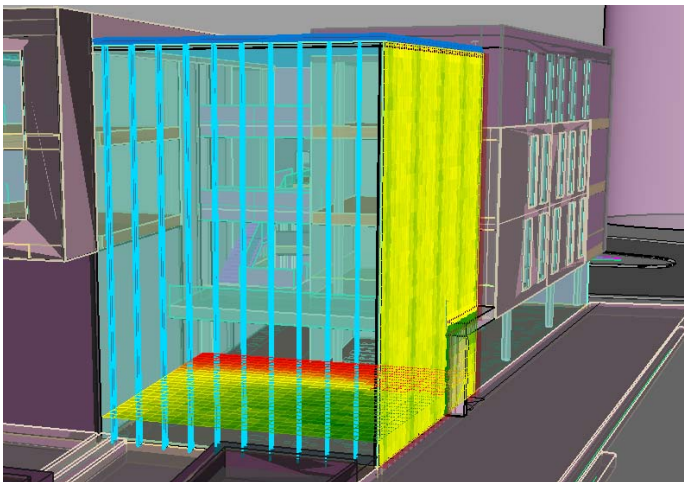
Figure 111: Example of single iteration of west atrium shading study (image by author)

The parametric definition was set up such that when run, it would first cycle through various spacing options between 2' and 5', then rotate the fin 10 degrees about the vertical axis, test the spacing options for that rotation angle, and repeat in this manner until all the considered combinations of rotation angles and spacings were tested. The results are shown in the accompanying graph.
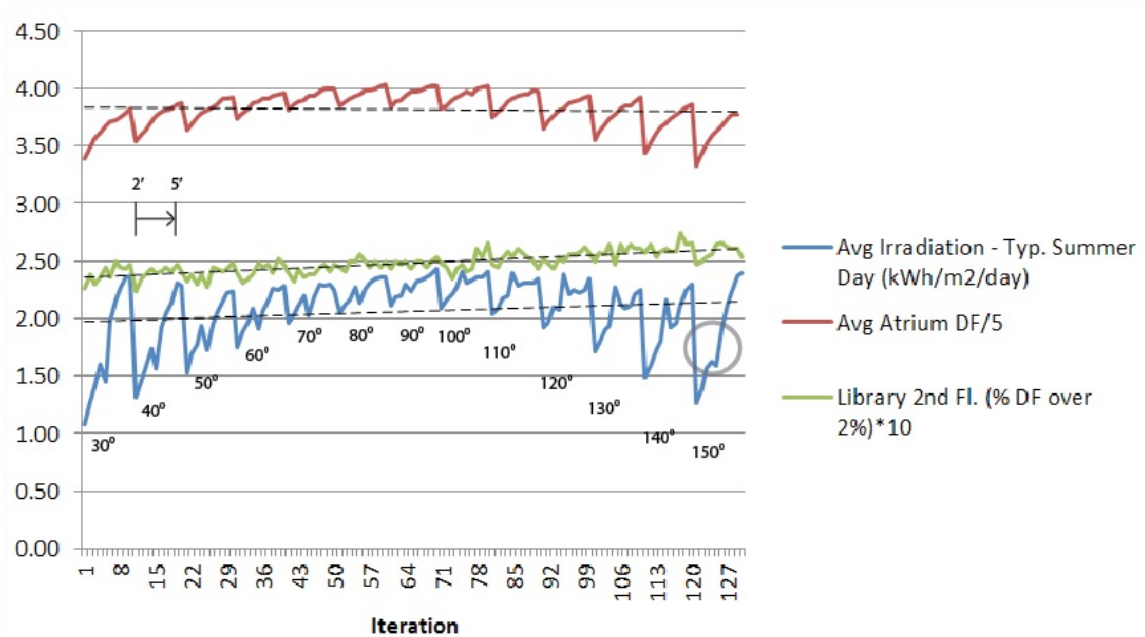
Figure 112: Graphical results of west atrium shading study (images by author)

As can be seen, increasing the spacing amount increases the amount of solar irradiation (shown in blue) reaching the façade as well as interior lighting levels. More useful to observe is the effect of the changing rotation angle of the fins. As all of these options would provide more than adequate daylighting to the west atrium space (shown in red), an analysis plane was positioned at the 2nd floor work plane of the library portion of the building (shown in green). As can be seen in the graph, there is a general upward trend in library daylighting levels as the rotation angle increases. This corresponds with a rotation towards the northwest, rather than the southeast, as would be expected. Based on these results, a fin rotation of 150 degrees was

chosen spaced at 4' on center. This choice would provide a reasonable balance between maximization of daylighting, substantial reduction in solar heat gain, and fin spacing adequately large to ensure adequate views to the waterfront from the building interior. Fin material in final design was chosen as translucent glass to further increase interior daylighting. Fin spacing along the north wall was increased to 8' on center since this façade receives significantly less irradiation than the west façade.

6.1.2.3 Street Facade Vertical Shading Fin Study

A similar parametric study was done for the vertical fins along the street façade, specifically at the fourth floor level. A spacing of 4' consistent with the west façade was chosen, of translucent glass material, and variations of the shade angle were tested. Given the adequate amount of daylight provided by the skylight at this level, the study looked solely at the effect of the fins on solar irradiation values on the façade.
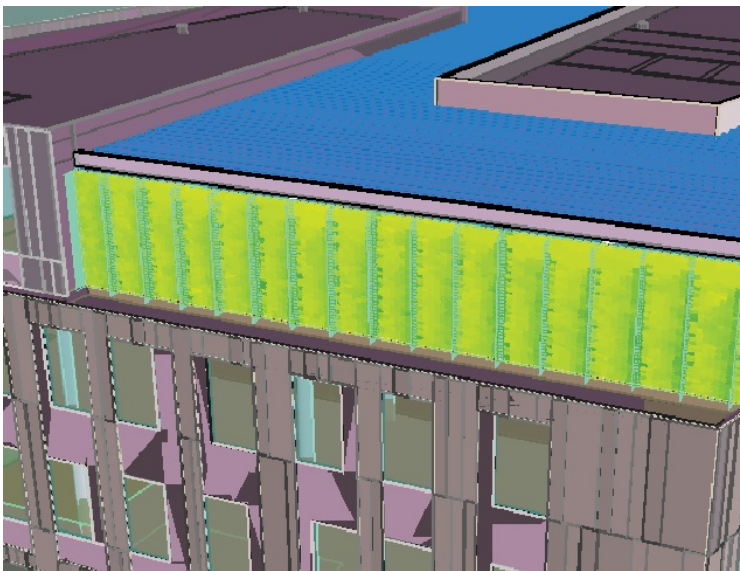
Figure 113: Example of single iteration of street facade shading study (image by author)

Average irradiation values for typical summer and winter days were calculated for each iteration of the study. Rotation angles test were from 30 degrees (towards the south) to 120 degrees (towards the east). As can be seen from the graph of the results, solar irradiation during the summer was found to be at a maximum value when the fins were close to perpendicular to the façade. During winter, when increased solar gain is beneficial, the maximum irradiation value was found to be between 60 and 75 degrees. In response to the study results, it was decided to use a fin angle of 60 degrees in order to allow a relatively larger amount of winter solar gain and reduced summer solar gain.
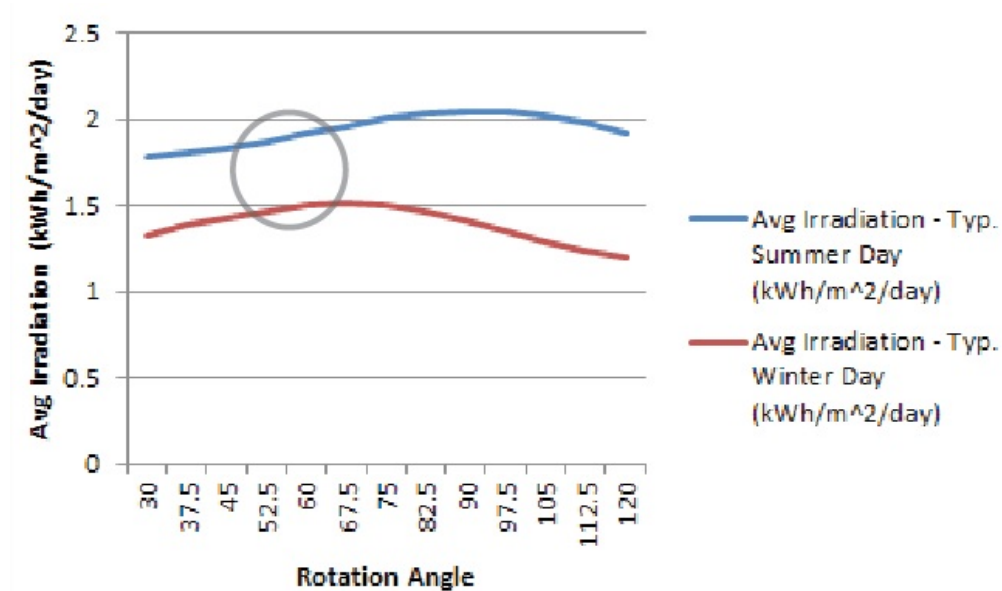
Figure 114: Graphical results of street facade shading study (image by author)

6.2 Final Design

In the final design phase of the project, floor plans were finalized, the building elevations and façade design furthered, and details for the building envelope developed. Additionally, a more detailed study of interior daylighting was done to verify adequate daylight provided by the skylight system and façade design.

The daylight study looked at illuminance at work plane height for all levels of the building, assuming the proposed translucent skylight panel and shading louvers positioned at 45 degrees (opening towards the northwest). The date and time chosen for study was the summer solstice at 12pm, noon, when a 45 degree angle for a rotatable louver system was found to be appropriate. The study considered both clear sky and overcast sky conditions. From the results it can be seen that under clear sky conditions adequate illuminance values of at least 300 lux are provided in most used space, with the exception of the exhibition gallery on the first floor and some areas of the classroom spaces, particularly on the second floor. During overcast conditions, a number of other spaces would also require supplementary artificial lighting, although areas such as the common space of the atria and staff offices remain largely daylit. The skylight system proposed utilizes integrated drainage channels at supports in order to drain rainfall from the minimally sloped skylight roof. Green roofs at the remaining roof area were provided to allow for decreased runoff and increased insulation values. A publically-accessible rooftop terrace is provided at the northeast of the building, as the culmination of the circulation spine established by the main staircases of the atria, allowing for a dramatic outdoor space overlooking the waterfront and Manhattan skyline in the distance.
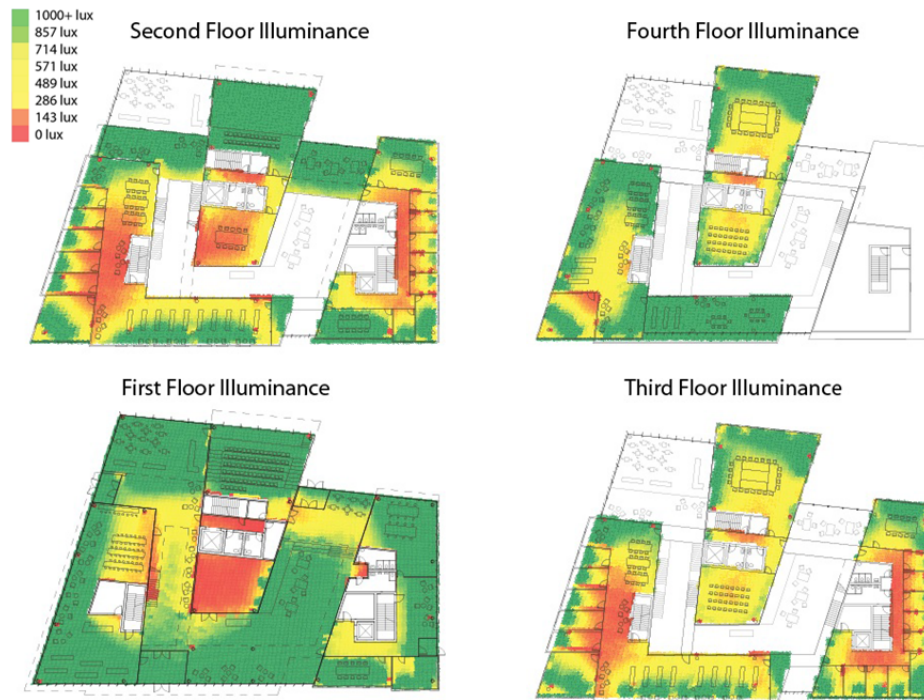
Figure 115: Daylight distribution study – illumination under clear sky conditions (image by author)
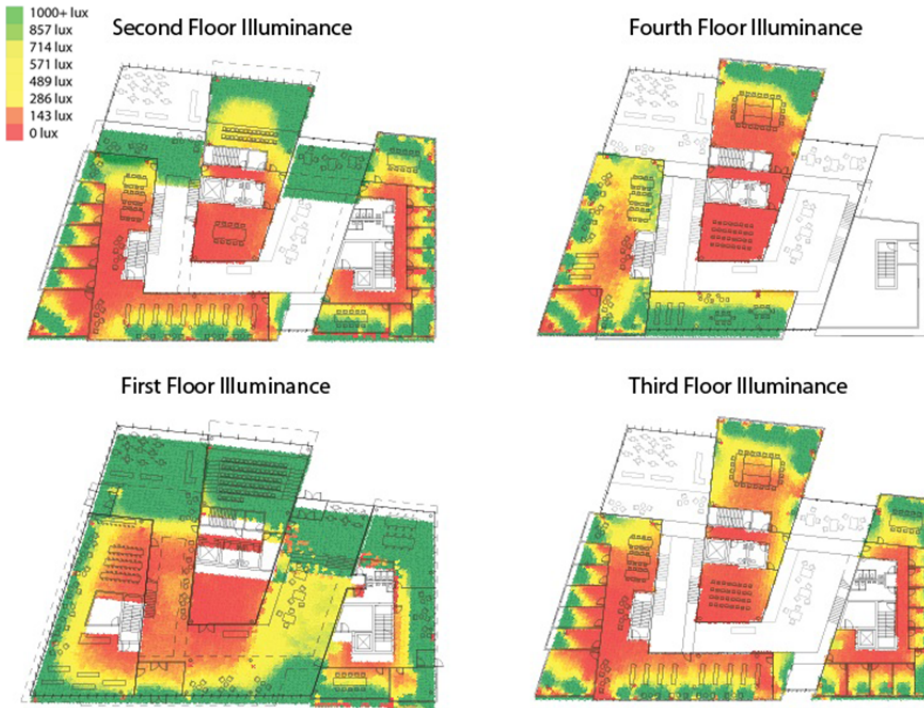
Figure 116: Daylight distribution study – illumination under overcast sky conditions (image by author)
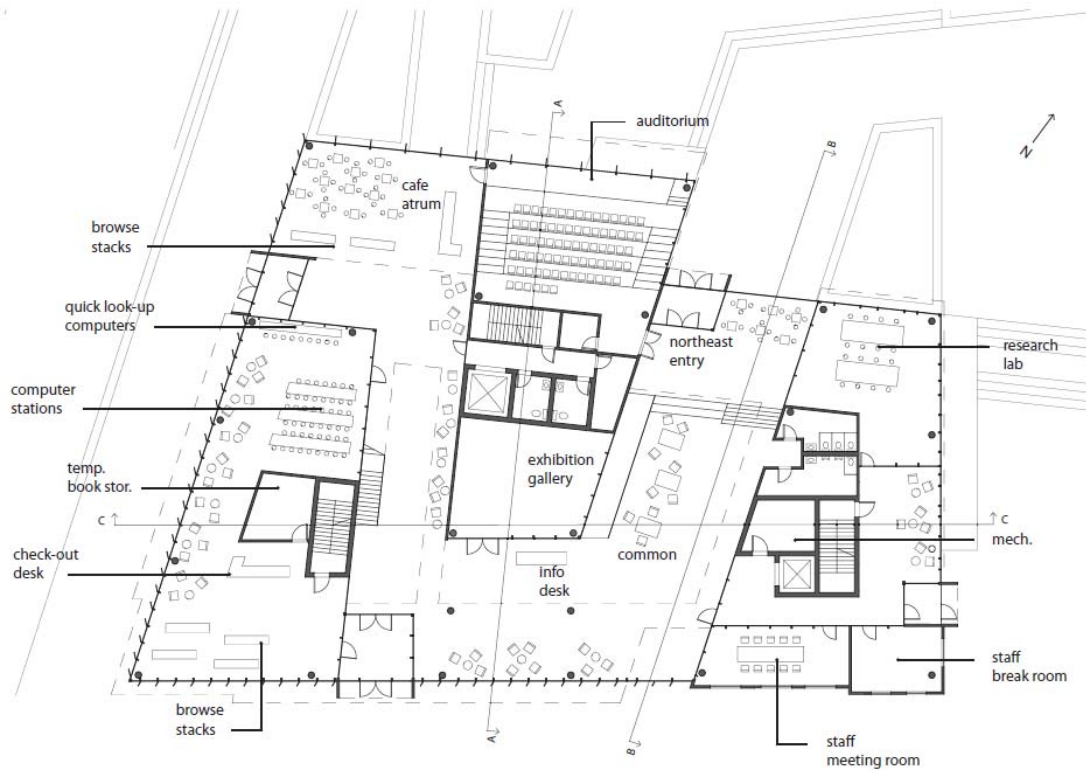
Figure 117: First Floor Plan (image by author)
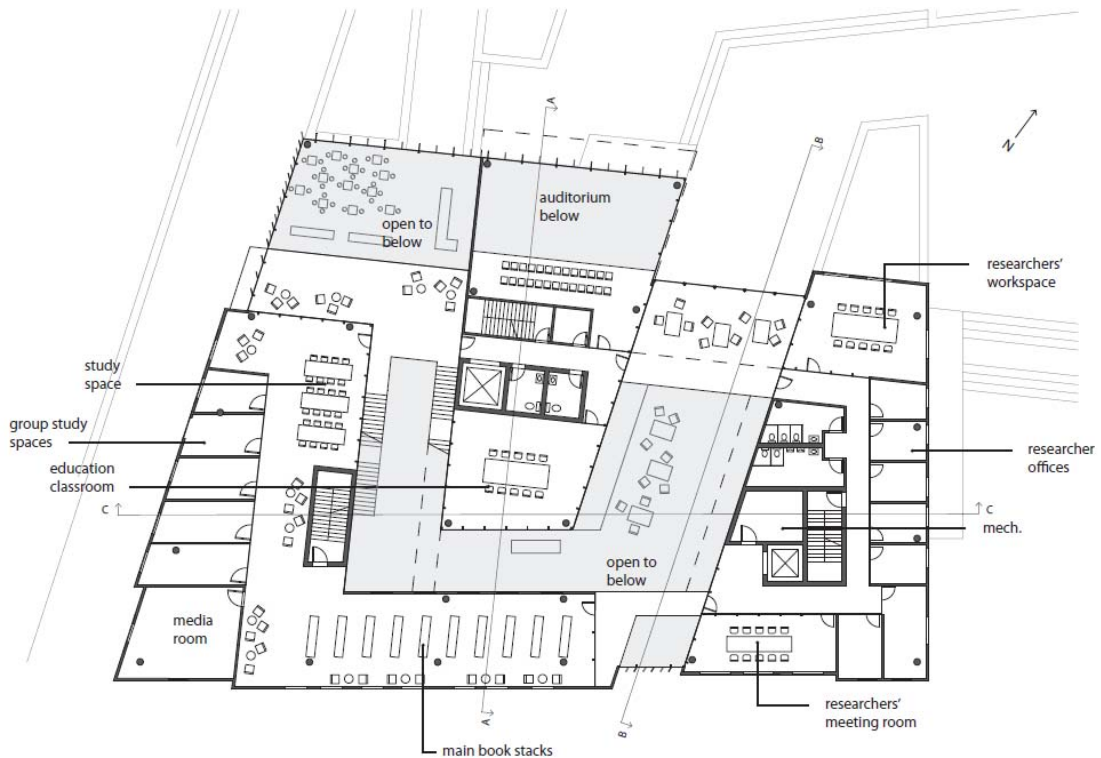
Figure 118: Second Floor Plan (image by author)
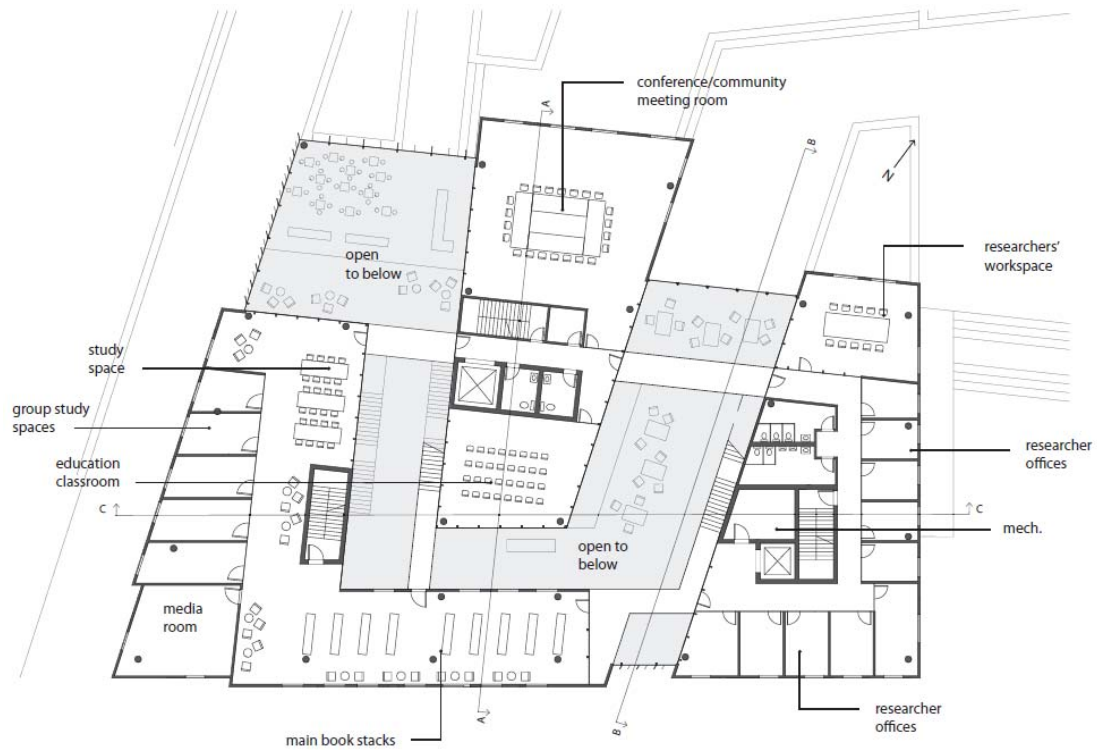
Figure 119: Third Floor Plan (image by author)
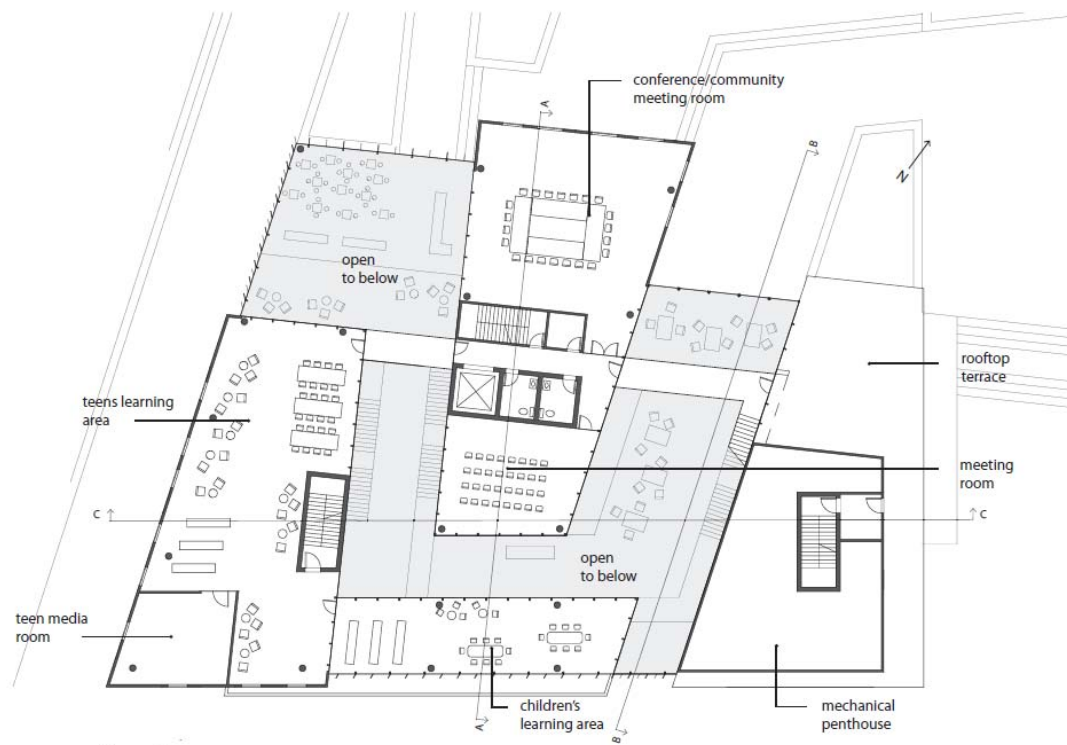
Figure 120: Fourth Floor Plan (image by author)
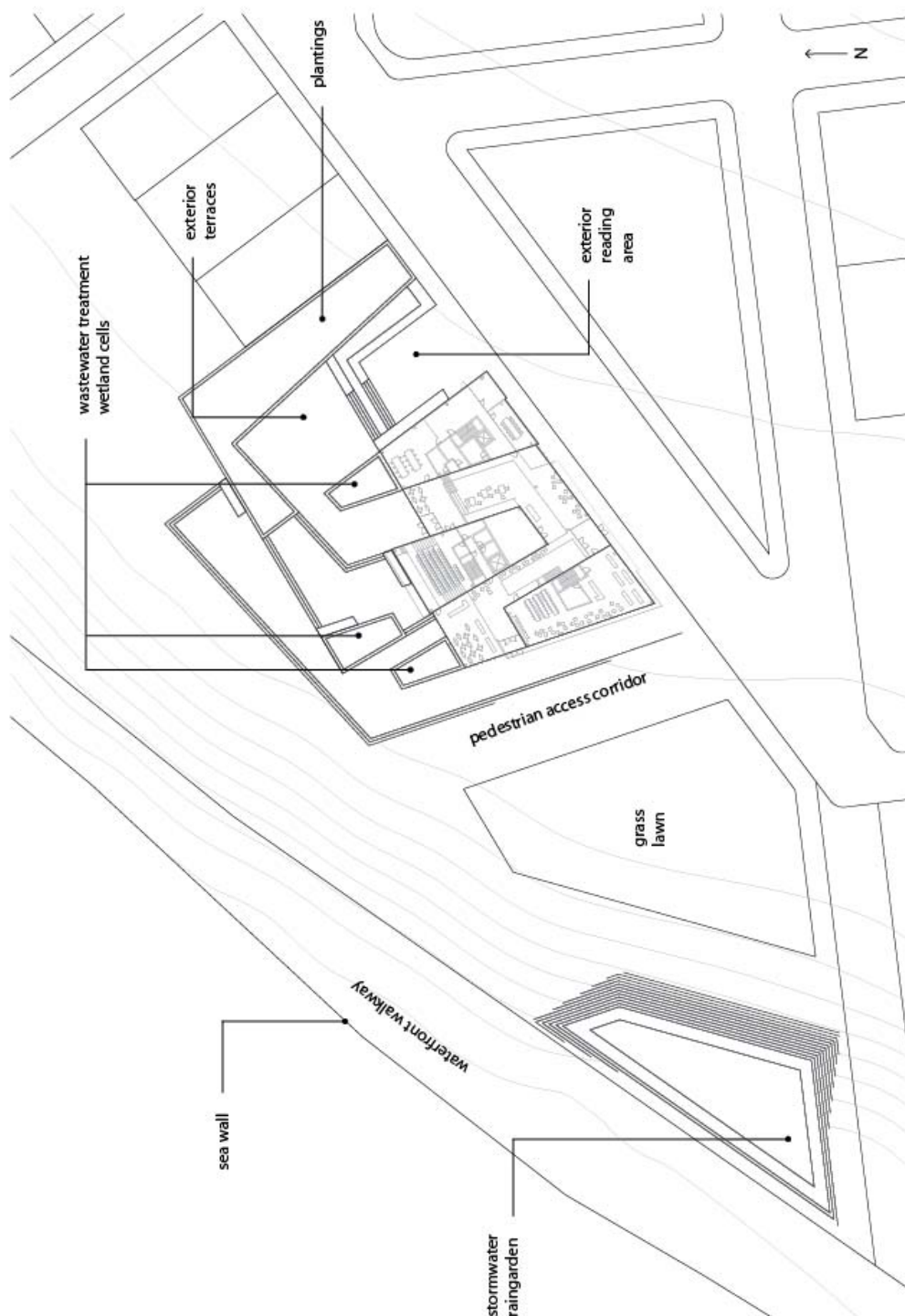
Figure 121: Site Plan (image by author)

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Figure 122: Perspective rendering from northwest (image by author)
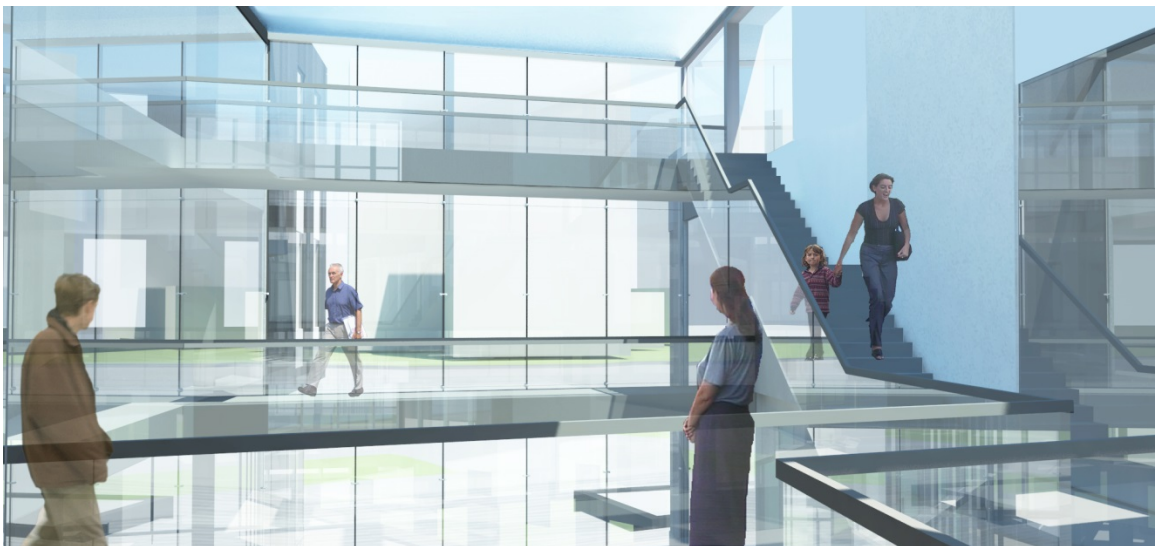
Figure 123: Perspective rendering from third floor of east atrium looking north (image by author)

Figure 124: Perspective rendering from east along Commercial Street (image by author)

Figure 125: Perspective rendering from northeast (image by author)

Figure 126: Perspective rendering from first floor of west atrium looking north (image by author)

Figure 127: Perspective rendering from Dupont Street (image by author)

Figure 128: Northeast Elevation (image by author)

Figure 129: Northwest Elevation (image by author)

Figure 130: Southeast Elevation (image by author)

Figure 131: Southwest Elevation (image by author)
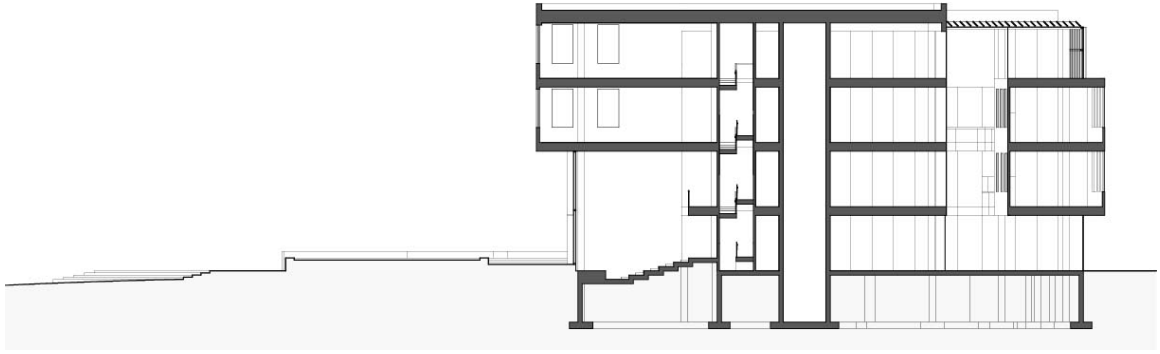
Figure 132: Section A-A (image by author)
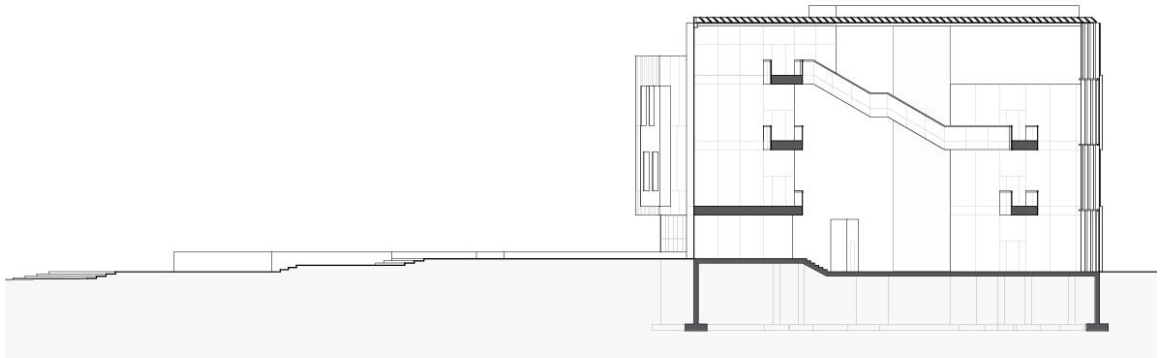
Figure 133: Section B-B (image by author)
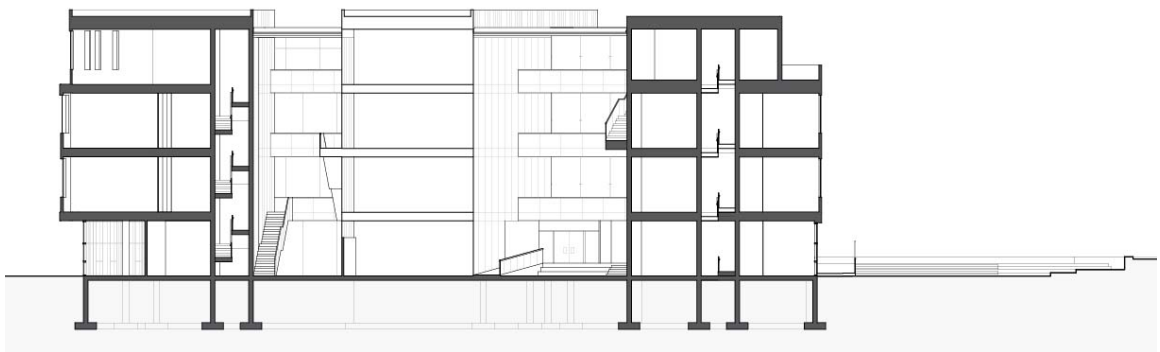
Figure 134: Section C-C (image by author)
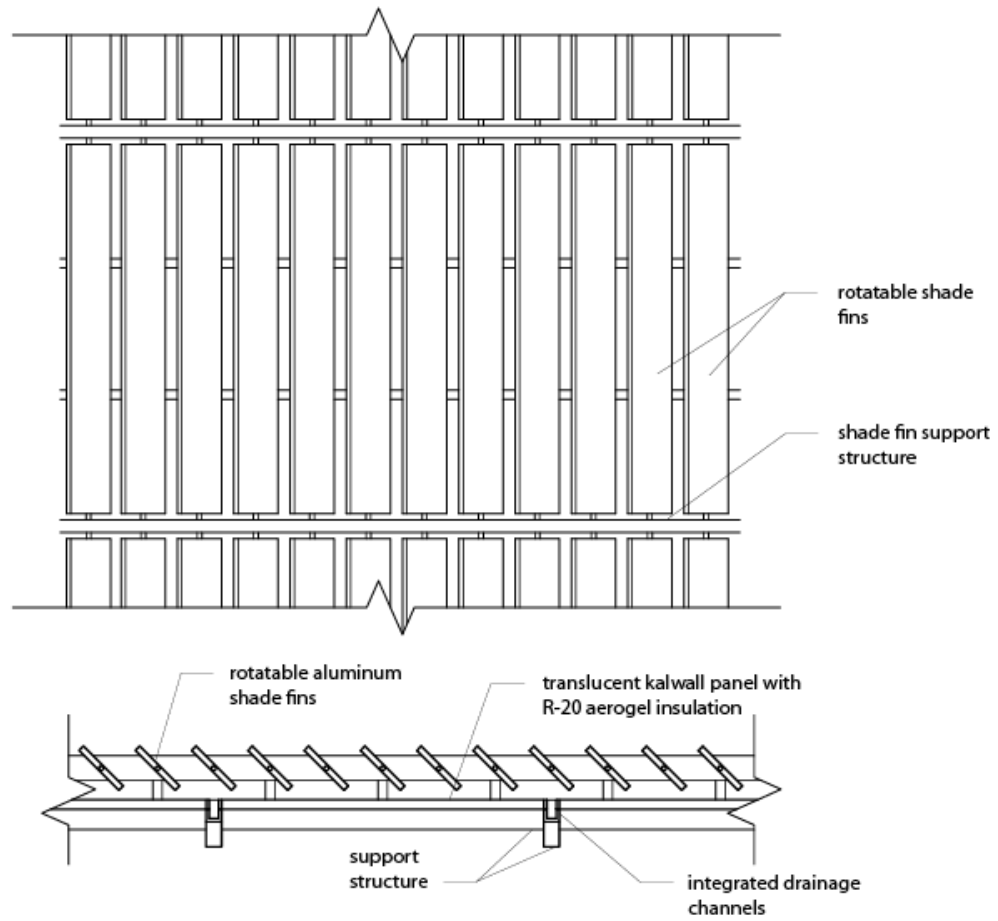
Figure 135: Skylight Roof Detail Plan and Section (images by author)
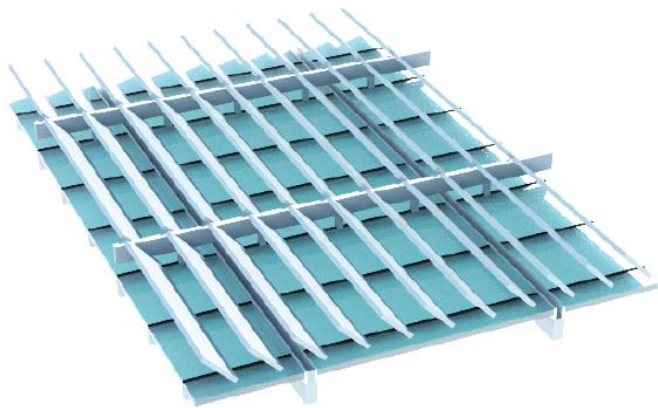
Figure 136: Skylight Roof Detail Rendering (image by author)

roof patio:

flashing

permeable pavers

green roof:

plantings
growing medium
filter layer
drainage layer
rigid insulation
waterproofing membrane

ventilation supply duct

ventilation return duct

structural concrete slab

suspended ceiling

operable awning window

gypsum wall board
steel stud wall
exterior sheathing

fiber cement panel

air space/ structural backing

rigid insulation

hydronic tubing

structural concrete slab

suspended ceiling

Figure 137: Typical Section Details (image by author)

vertical aluminum mullion

translucent glass shade fins

fin support sleeve

horizontal aluminum mullion

fin support fixing
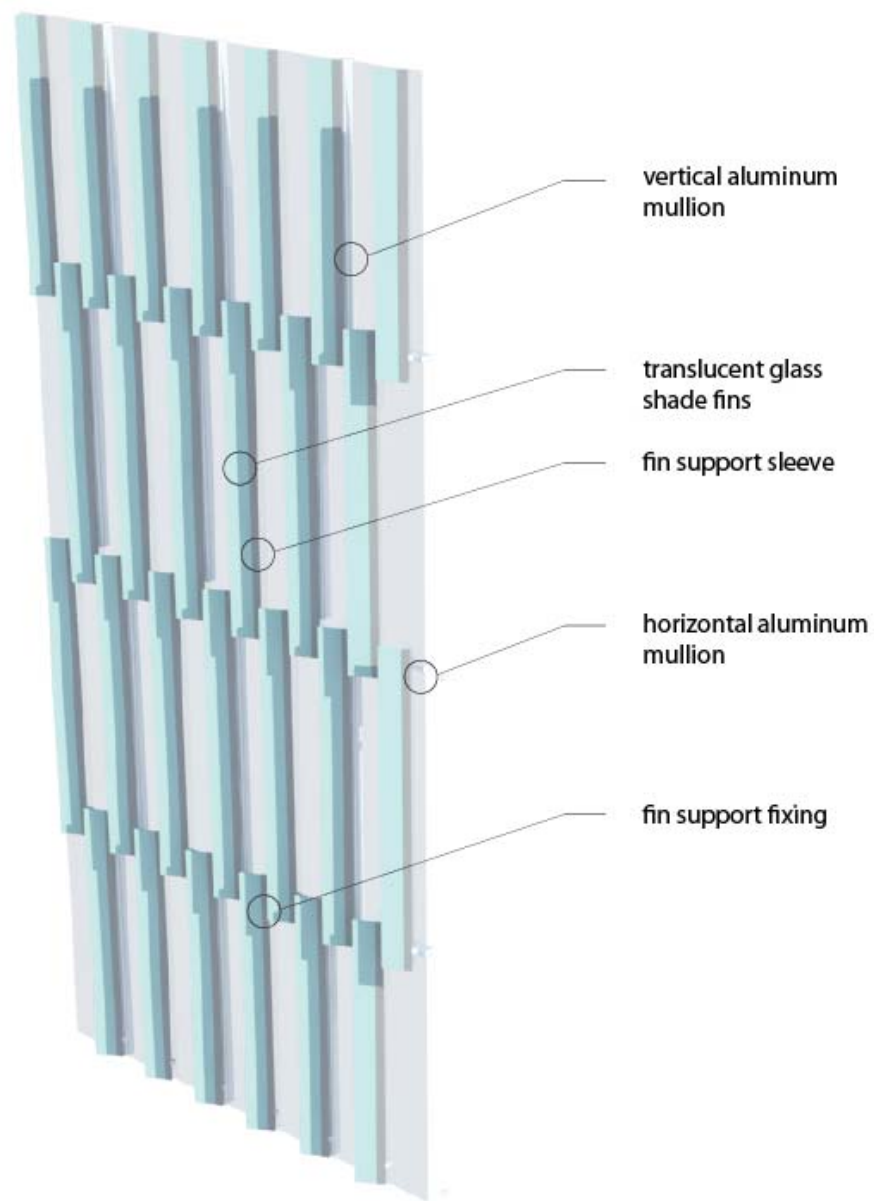
Figure 138: West Atrium Façade Detail Rendering (image by author)

structural support member

stainless steel clamp corner fixing

stainless steel intermediary point fixings

structural silicone horizontal joint

stainless steel pre-tensioned cable location

aluminum mullion system at entrance

glass spandrel panel

cable base slab anchorage location

structural silicone glazing
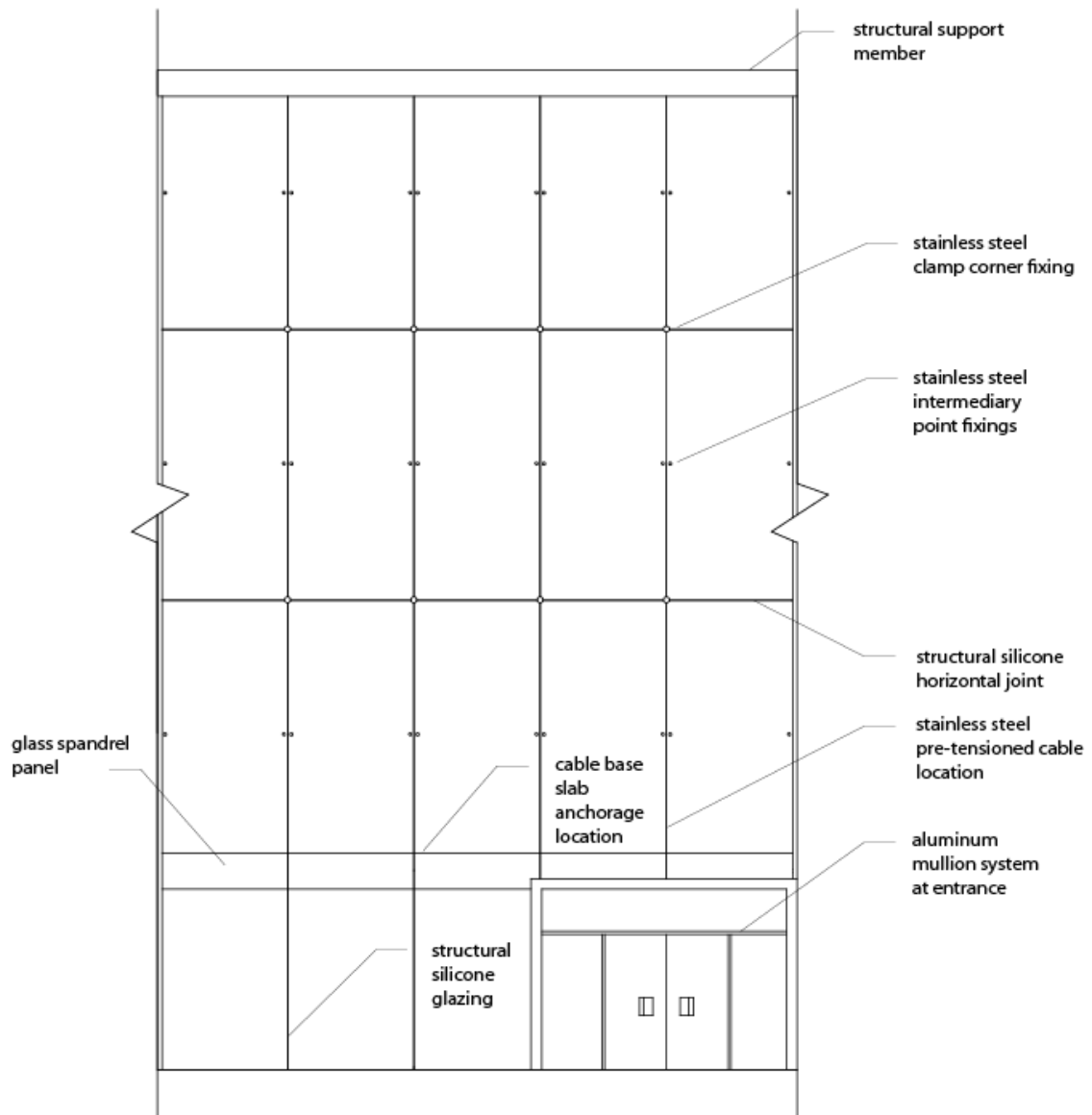
Figure 139: East Atrium Façade Detail Elevation (image by author)

cable anchorage to
structural member

stainless steel
clamp corner fixing

stainless steel
intermediary
point fixings

tension cable

slab anchorage for
tension cable

entryway portal

structural silicone
glazing
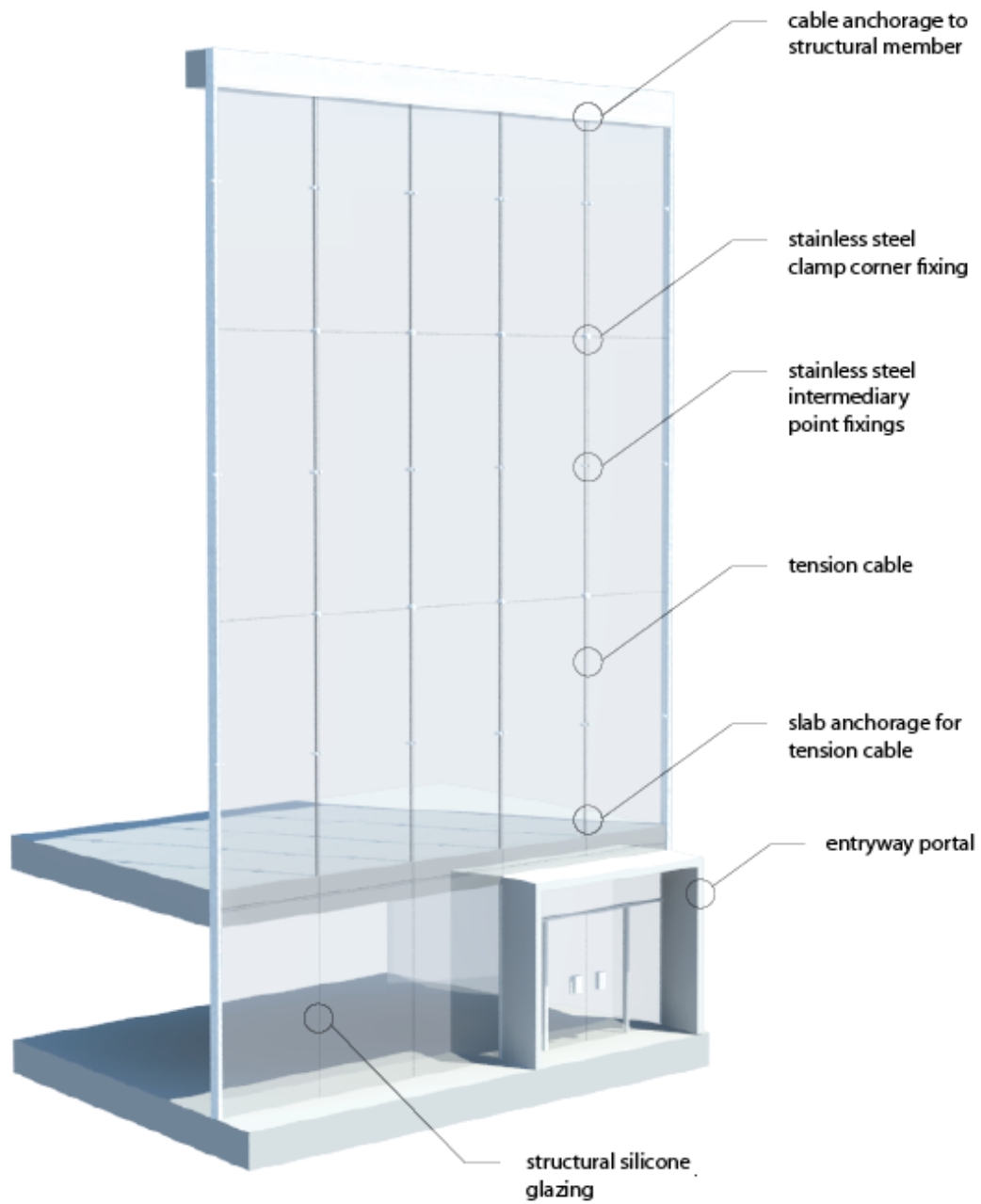
Figure 140: East Atrium Façade Detail Rendering (image by author)
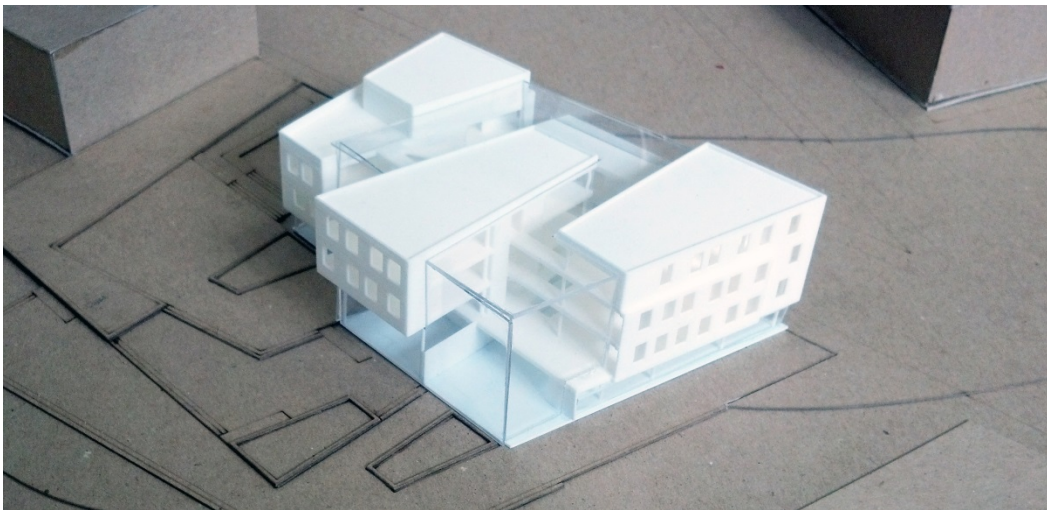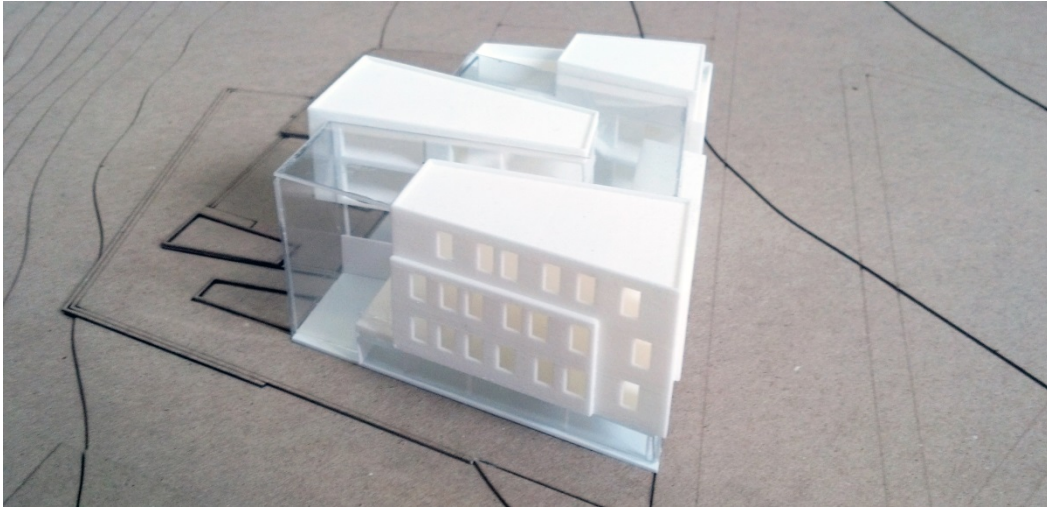
Figure 141: Photographs of the building model (images by author)

6.3 Concluding Summary

This research investigated the emerging potential of integrating the use of environmental simulation tools and parametric design processes in order to allow for improved workflows in the design of higher performance buildings, examined within the context of a thesis studio design project. It can be argued that while sustainability and parametric design are two topics which have largely dominated the discussion of progressive architectural practice and research over the previous decade, these areas of investigation have remained largely distinct and their potential intersections largely unexplored, at least until very recently. While building performance and the use of environmental data within parametric design workflows are increasingly being investigated in experimental research, potential methods and techniques for the integration of simulation into such workflows remains an open subject of exploration. Meanwhile, "parametric design" in mainstream architectural culture remains primarily perceived as a movement which advocates for a technologically-determined formalism or, worse yet, mere "unrealizable" virtual or conceptually-driven academic projects. This perceived association with the "non-practical" has been especially infelicitous for productive knowledge exchange with currents of investigation involved with "sustainable design," which has primarily placed priority on the practical concerns of building performance.

As new software capabilities become available for architects which allow them to implement environmental simulations within parametric workflows and generative design processes, it is important to note that how such technologies are to be utilized and employed within the working framework, constraints, and intent of a particular project is far from a given. The designer seeking to implement the use of such tools will need to determine precisely how they are to be utilized, towards what ends, and which priorities govern and motivate the design concept and goals. In this regard, a realistic appraisal of the usage and challenges of

computation is worth considering, especially for the typical designer who is not a specialist in computer science and programming. The architect cannot simply rely on the "intelligence" of the computer, which should not be overestimated. As Fabian Scheurer notes, "Far too often, computers are still mistaken for being incredibly smart. Actually they are just incredibly quick and embarrassingly obedient and both are being utilized to cover up how slow they are on the uptake. Their biggest handicap is that they cannot handle ambiguities, so you have to explain everything to them in much more detail than to a three-year-old child."[1] Even their being "incredibly quick" is debatable within the context of a project which seeks some kind of optimized solution which likely requires simulations to be run many, many times while searching through a solution space for a best-fitting iteration. This fact alone would require that careful consideration be given to the particular logic which is set up within the defining algorithm, and it limits the number of geometric parameters which can realistically be varied while searching for an "optimized" solution. Within these challenges, however, are opportunities for creatively investigating ideas for integrating environmental context and performance with parametric and computational logics to explore design potential.

A number of potential approaches may be considered which attempt to leverage the use of simulations in conjunction with parametric design, each with potential benefits and challenges. At the most basic level, a parametrically-defined model offers advantages over "manually" constructed models since variations on its geometry can be quickly made and according to a user-defined logic. This allows a much more efficient workflow than a non-parametric approach, which would involve constructing a building model using traditional modeling techniques, exporting the model to a separate software package, running a simulation, evaluating the results, and then rebuilding the initial model in order to test a different version of the design. To further take advantage of the coupling of simulations and

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parametric tools, methods have been sought to seek incorporate simulation feedback and

search out "optimized" design solutions, often involving the use of genetic algorithms, an

approach which offers a significant improvement over a blind testing of randomized

combinations of input parameters by effectively "narrowing in" on the combinations which

result in the best outcomes. Despite the great potential of genetic solvers in searching through

solution spaces, the challenges and current limitations to this approach should also be

understood.

David Rutten, developer of Grasshopper, in discussing the use of such solvers, and in

particular his Galapagos plug-in for Grasshopper, notes that "There is no guarantee that a solver

will find the best solution in a finite amount of time. There could not be. The best we can hope

for is a solution of acceptable quality in an acceptable amount of time."[2] These difficulties

amplify dramatically when an excessive number of variable input parameters enter into the

algorithm. In this research project it was found to be impractical to use the solver with multiple

input parameters when the DIVA plug-in was used within a definition due to the amount of time

it takes to run the simulations. Thirty or so seconds may not be long to run a simulation, but

when the simulation needs to be rerun repeatedly during the countless iterations of the solving

process, lengthy and uncertain run times become a significant impediment to finding a design

solution. In consequence, an alternative approach was used to find the best solutions to a given

problem.

This method, which is based on one described by Jon Sargent of SOM at a workshop in

2013,[3] involves "cross-referencing" lists of the parameter values to be tested so that all

combinations of these parameter values would be "cycled through" while the parametric

definition runs repeatedly until the list is exhausted. The simulation results from each iteration

are recorded so that they can then be graphically plotted (or a three-dimensional fitness

landscape constructed) and the results evaluated. Advantages of this method include the fact

that the "resolution" of the search can be varied based on the amount of time desired to spend

on the search, and, more importantly, that the designer can potentially gain a more intuitive

understanding of how geometric variations affect the environmental performance of the

building. Additionally, rather than obtaining a single "optimal" value based on a pre-determined

weighing of desired outcomes (when multiple criteria are being tested), the designer can make a

judgment afterwards, based on the plotted outcome from the simulations. While absolute

definitive answers to design questions may not necessarily follow from such studies, in the very

least the process aids the designer in making more informed decisions.

As Michael Hensel notes, "It is important… that the effort towards developing

performance-oriented architecture does not settle back into a singular hard deterministic

approach, stringent standards and overarching optimization modes. Instead it needs to provide

problem-specific reliable data and to remain open and adaptable to changing circumstances so

as to be able to be modified in relation to particular design problems and context-specific

conditions."[4] It was my aim that this design project might contribute towards exploring the

potential for such an approach.

[1] Scheurer, Fabian. 2013. "Encoding Design" from *Inside Smartgeometry: Expanding the Architectural Possibilities of Computational Design* (ed. Peters, Terri & Peters, Brady). John Wiley & Sons Ltd, Chichester, UK.

[2] Rutten, David. 2013. "Galapagos: On the Logic and Limitations of Generic Solvers" from *AD Special Issue: Computation Works: The Building of Algorithmic Thought*.

[3] Sargent, Jon. 2013. "Environmental Performance in Parametric Envelope Design" Workshop, Facades + Conference. New York.

[4] Hensel, Michael. 2013. *Performance-Oriented Architecture: Rethinking Architectural Design and the Built Environment*. John Wiley & Sons Ltd, Chichester, UK.

APPENDIX A

REVIEW OF RECENT SYMPOSIA ON BUILDING PERFORMANCE AND EMERGING TECHNOLOGIES

A1. Facades+ NYC 2013

The fourth annual Facades+ Conference in New York City took "Performance" as its overarching theme. A diverse group of speakers discussed aspects of façade technologies, materials, and design strategies in relation to this theme.

The keynote speaker at the conference symposium was Christoph Ingenhoven, whose firm, Ingenhoven Architects, has pursued an agenda of the "supergreen." To this end, the architects have worked closely with engineers and other consultants in the design of low-energy buildings. Ingenhoven believes that "form follows evolution," in the sense that architecture must continue to evolve in its use of new technologies towards environmental efficiency. In aiming towards zero-energy building projects, the three areas of waste, emissions, and energy must be carefully considered. His notion of the "supergreen" seeks not only utility but also beauty in building efficiency. He also noted the importance of creating "people places," by which he meant spaces which benefit the public and are conducive to social interaction.

After discussing these ideas, Ingenhoven offered a brief overview of some of his recent and noteworthy projects. The Lufthansa Headquarters at the Frankfurt Airport, completed in 2006, was the first BREEAM "Excellent"-rated project. The design scheme utilized ten office wings, or "fingers," separated by adjacent enclosed gardens which act as buffer zones while providing natural ventilation and daylight.

The Swarofski Corporation project, an office building for 500 employees located on the shore of Lake Zurich, also aimed at high performance sustainable design. Maintaining views of

the lake were of primary importance so a double wall façade system was utilized to increase energy efficiency while allowing for large expanses of glazed area. The façade utilizes a system of louver flaps which allow for the intake a release of air to ventilate the space. The project is also notable for its usage of lake water for both heating and cooling purposes.

The Main Station Stuttgart project, a large underground rail station set to be completed in 2022, will allow for extensive park land above the station. Distinctive light-wells were designed to bring natural light into the interior of the station. The elegant forms of the concrete shell construction have been designed for structural efficiency. The station is designed to be naturally ventilated by utilizing the air streams created by the movement of trains in and out of the station. Controversy has surrounded the project with protesters demonstrating against the felling of trees in the area. Ingenhoven notes that the discontent stems primarily from the expense of the new high-speed rail network being constructed in Germany of which the station is a part.

1 Bligh in Sydney, completed in 2011, exemplifies Ingenhoven's approach to public space as well as the energy-efficient envelope. The ground floor is maintained as a public plaza, while the building itself is oriented to maximize views along a "view corridor" toward the harbor. Column locations were established which would maximize usable floor area. As in other projects of the firm, the façade is a double skin system allowing for unobstructed glazed surfaces. Mechanically adjustable blinds between layers allow for glare control. Blades in the envelope channel ventilation while the atrium utilizes the stack effect for natural air flow out of the building. The project is also notable for its use of a biofuel energy system and the utilization of black water for the building's cooling tower and toilets.

Finally, Ingenhoven discussed his Marina One project, slated for 2017 completion, a new landmark building in Singapore's recently developing Central Business District. The design

concept is for an organically cut-out "green heart" public space within a complex of mixed-use buildings.

Audience questions after Ingenhoven's presentation focused on primarily on questions of the large expense of some of the building systems utilized in the project as well as the potential resource intensiveness they require. Ingenhoven noted in response that admittedly the payback period is often long-term, but that the industry still needs to change towards greater efficiency regardless. Particularly in the U.S., where high-efficiency envelopes are less prevalent than in Europe, the level of detailing required for such systems requires more monetary investment. Another question was if the buildings actually perform as well as they have been designed to. Ingenhoven replied in the affirmative, noting that the firm's interaction with engineers early in the design process has been an important part of realizing the design team's energy efficiency goals.

The symposium then shifted to an academic focus, with instructors from Columbia, Yale, and CUNY-CityTech discussing some of their current coursework which relates to the subject of facades and environmental response.

David Benjamin, of Columbia's Living Architecture Lab presented three projects. The first was ongoing research into a "gill"-like "breathing" façade system capable of kinetically responding to changes in environmental air quality through a connection to a data feed, the aim being to "make visible the invisible." Similarly, another project built in Seoul aimed at visualizing air quality, but in this case the strategy was to utilize a map-like structure dotted with led lights which represent environmental conditions for various areas of the city. For example, air quality differences between each of the city's districts could be visualized, or the change in conditions from one time period to another. The third project looked at establishing a method by which varying design options could be explored parametrically with instant feedback on energy use,

view access, and even space leasability. Ecotect was utilized within this system for solar

analyses. Benjamin noted that the project aims at a way to visualize the trade-offs of various

design options, and that the ability to filter results is important for evaluation purposes as

design priorities and aims shift during the design process.

Zach Downey, of CUNY-City Tech, also discussed how parametric design is being

explored in the studio in relation to environmental design. He highlighted his recent course in

which students are utilizing DIVA and Grasshopper to create façades whose panel variations are

driven by solar insolation data. Interior illuminance values could then also be checked utilizing

the same software. He also discussed the use of EnergyPlus, Vasari, and thermal imaging studies

for the project.

John Eberhart, from Yale, expressed his interest in BIM and digital fabrication

technologies, and then discussed how the tendency at Yale in recent years has been towards

integrative design studios. He then highlighted a number of studio projects including a façade

redesign project and another exercise in which students extensively mapped pedestrian

movements and used this data to explore design ideas. Another project looked at parametrically

exploring façade variations in relation to the geometry of louver devices and their ability to

shade the façade and reduce heat gain.

Ben Nesbeitt, of WORKSBUREAU, and Chuck Hoberman, of the Adaptive Building

Initiative(ABI), presented some of their explorations in using new technologies in building

facades. Nesbeitt first discussed the Hercules Public Library project which utilized glazed walls of

translucent and opaque fritting whose patterning also adds visual interest to the building

façade. The King Abdulla Financial District Portal Spa project, located in Riyadh, Saudi Arabia and

to be completed in 2014, features "titanium rainscreen jackets" whose "Tessellate" screens

were developed by Hoberman and ABI. The extreme climate of the project location necessitated

a strategy to deal with the heat of the intense summer sun. The kinetic screens, which consist of perforated metal sheets which slide past each other producing variable patterns, provides a reduction in solar gain and a dramatic visual effect produced by the "sifting" of incoming light. The question of potential mechanical failure was brought up by an audience member. Nesbeitt responded by noting that the system has been extensively tested, but also that the "Tesselate" system has been designed to use as few moving parts as possible in order to reduce the risk of possible maintenance issues.

Studio V's Jay Valgora and Nic Goldsmith of FTL Design Engineering Studio discussed the evolution of membrane structures and their usage in some recent projects. Fabric screens, for example, have been employed as shading devices on projects by architects such as Moshe Safdie and Perkins + Will. They also presented a casino project in Yonkers which utilized ETFE for a canopy structure. In this case, the system was utilized for an element intended primarily to provide visual interest, but elsewhere such systems have been utilized in a more integrative manner. Most interesting perhaps to this particular discussion was a point discussed in response to a question from the audience. When asked how well the ETFE "pillows" would survive extreme storm events such as hurricanes, Valgora noted that the installation of the ETFE system at the Yonkers project was completed just days prior to Hurricane Sandy and emerged from the storm undamaged. The reason is that the system was installed with an "emergency button." In the anticipation of such storm events the pillows can be "over-inflated," thus producing a more taut structure capable of withstanding high wind forces.

In a shift of focus, Ann Beha, of Ann Beha Architects, gave a presentation on how her firm has pursued interventions in the context of existing buildings. She described the importance of giving careful consideration to older buildings and the difficulties involved in their upgrading to improve performance while still respecting the cultural need for preservation. She

presented a number of projects in order to elucidate her approach for such projects. A project at

UPenn restored a deteriorating music building dating from 1892. A new addition sensitively

compliments the existing building while avoiding overt imitation by utilizing a terracotta

rainscreen façade. The project was the first on campus to receive a LEED Gold rating, which

indicates that both building preservation and sustainability goals can be achieved. A new

building for the University of Chicago likewise sought to upgrade existing facilities while

preserving the character of the existing building by adding a modern wing. The new building

connects a former seminary to two newly restored row houses. At Princeton, Beha recently

restored another campus landmark and added additional companion structure. The aesthetic

aim was to "create a distinction and integration between old and new."

The following segment of the symposium brought some perspective from developers.

Campbell Hyers of Control Group discussed the recent tendency towards what he referred to as

"user experience design." By this he meant electronically interactive displays which provide

consumers with product information. He stressed the importance for architects to understand

changes in consumer demand indicating, for example, changing traveler needs in airport

terminal waiting areas. Jeremy Moss of Silverstein Properties and Jeffrey Yachmetz of Thor

Equities discussed the importance of design in adding value to developer projects and the fact

that improved daylighting conditions improve worker satisfaction and productivity.

Hauke Jungjohann of Knippers Helbig Advanced Engineering discussed the topics of

parametric design and integrated material performance in the context of his firm's work. At the

Bao'an International Airport terminal in Shenzhen, designed by Massimiliano Fuksas, parametric

design tools were utilized develop the folded aluminum façade panels. The varying forms of the

panels were developed in response to interior lighting requirement. The firm has investigated

the use of elastic bendable and adjustable or adaptable parts in collaboration with researchers

at the University of Stuttgart. The Smart Materials House featured membrane screens with the ability to twist in response to environmental conditions. The One Ocean Pavilion at Expo 2012 in South Korea utilized a system of actuated GFRP strips. Among current research efforts is a façade system whose components unfold in response to environmental conditions through a calibration of the component geometry with inherent material properties. Jan Knippers' ICD/ITKE Research Pavilion investigated the embedding of material properties into a computational model such that the installation could be constructed simply by bending the CNC-cut members into position.

The next segment of the symposium focused on digital technologies and fabrication. Jonatan Schumacher of Thornton Tomasetti discussed the development of the large-scale GFRP components being utilized at the Basra Stadium project designed by 360 Architects. Schumacher also elaborated upon some of the interoperability challenges for complex design projects, specifically the fact that firms may be using 10 to 15 different software packages for a given project. Accordingly Schumacher and others are researching methods of coordinating the project data and geometry from these various sources into a unifying parametric system. Their model is being developed to give feedback on design variations for such factors as the embodied energy for particular given design iterations.

Stephen Van Dyck and Scott Crawford of LMN Architects presented a project for the University of Iowa School of Music to be completed in 2015. The design for the acoustic ceiling for the performance hall seeks to integrate multiple systems with its perforated panels. The architects utilized Grasshopper to integrate design documents from multiple consultants. The distribution of openings in the aluminum composite panels is based on a number of factors including reflectivity, speaker locations, spot lighting, catwalk access, house lighting, and sprinkler locations. Acoustic raytracing analyses were utilized for visualization purposes to

discuss options with the client and consultants. Further research is being conducted into developing greater integration of acoustic data into a parametric model.

Brendan Sullivan and Jason Sidelko of Gehry Technologies presented a case study for a project in Edmonton for which their team was called upon to develop the geometry of the project's façade system. The team developed a system for establishing document templates to efficiently establish the geometry for the manufacturing of the supporting structure components.

Cory Brugger of Morphosis discussed the development of the façade panels for the Perot Museum of Nature and Science. The concrete panels were created as a system of "families" in order to minimize the number of molds which needed to be created while still allowing for a façade which reads as a continual and non-repetitive modulation.

In a presentation entitled "Positive Response to Constrained Opportunity," Erik Verbook of Buro Happold and Brian McFarland of CetraRuddy discussed how city zoning regulations shaped the design for Cetra's recent residential towers in Manhattan. One Madison Park, a 50 story residential tower, has 6 story glass "pods" positioned to take advantage of views, ensured by zoning constraints for the surrounding area. The structural system was designed accordingly with the building core opposite the side with the primary views. Similarly, the design for the upcoming residential tower at 107 W. 57th Street was designed with zoning and views in mind. The building utilizes perforated "ripple" panels developed with A. Zahner Co. on the side of the shear wall which are to be backlit by led lights to add visual interest to the building. The glazed façade is notable for its use of apertures at the panel joints which provide ventilation for the units' bathrooms.

Elizabeth Bishop of Zaha Hadid Architects and Jonathan Wilson of Arup presented the King Abdullah Petroleum Studies and Research Center (KAPSARC) currently under construction

in Riyadh, Saudi Arabia. The building has been designed to achieve LEED Platinum status. The extreme environmental conditions of the site meant that a close collaboration with the engineers at Arup was necessary for the façade design in order to minimize heat gain. The design concept was for clusters of sheltering cells centered around exterior courtyards. Aperture locations and orientation as well as the positioning of shading devices needed to be carefully determined in order to reduce heat gain while still allowing for adequate day lighting conditions for the interior spaces. Materially, the project utilized glass fibre reinforced concrete (GRC) and aluminum panels on a steel structure. While some of the underlying contextual conditions of such a project make it not entirely unproblematic as "green" design, the project is interesting as a case study in the coordination of design architect and engineers to achieve environmental objectives for a geometrically complex building project.

A2. AEC Technology Symposium 2013

The AEC Technology Symposium presented by Thornton Tomasetti brought together a number of innovators in technology from the Architecture, Engineering, and Construction industries to discuss and present how their firms are utilizing new technologies for building design and construction.

Sebastian Claussnitzer and Alexandra Pollock of SOM discussed the multiple levels at which research efforts related to computational design are being pursued at their firm. Such efforts may be self-directed, project-based, firm-wide, or industry-wide. They emphasized that for projects which employ complex geometry, it is important to understand and be able to describe such geometry well. Parametric and scripting methods can aid in this task and allow for more efficient design and construction. They presented a concept design for an "egg-shaped" building with a multi-layered façade for which they developed what they termed a "scripted

geometry control model." For projects with complex geometry, the deliverables to fabricators and contractors may take the form of a point-cloud, "recipes" of instructions, or a 3-dimensional model. An example of a project-based research is the design for the KAFD Conference Center. A tight schedule for a project with complex, faceted geometry meant that the team needed to develop an integrated design model to complete the design on time. The parametric model used took into account environmental, structural, and constructability factors. Among the sustainability strategies for the building are an enclosure system in which glazing areas are determined by solar exposure, a "solar chimney" used to facilitate ventilation through the building's atrium spaces, and a green roof containing indigenous grasses.[1]

Shane Burger of Woods Bagot presented a number of the firm's projects in Australia which utilized BIM and computational design strategies. The headquarters for the National Australia Bank in Melbourne features a series of "fissures" which break up the façade and feature panels whose colors indicate the amount of solar exposure on their face. Burger stated that these were determined by evaluating solar vectors rather than through solar irradiation analyses because the latter method is only very recently being incorporated into parametric workflows. Another project highlighted was the South Australia Medical Research Institute (SAHMRI). Ecotect analyses and Grasshopper were utilized for the façade design which is driven by solar exposure. The number of panel types was reduced to six in order to economize and simplify the construction, which Burger referred to as a "digitally augmented" but essentially manual process. Finally, the University of Sydney Business School was presented. The shading screen around the perimeter of the upper floors of the building was developed using multiple data inputs and establishes a level of visual complexity through a simple layering of data. The Chameleon plug-in for Grasshopper was used to export this geometry to a Revit BIM model.

Neil Meredeth of Gehry Technologies gave a presentation on the design and fabrication methods for Diller, Scofidio, and Renfro's Broad Museum for which they acted as consultants. The design for the geometrically complex façade, which was envisioned as a "veil" over the interior volume, required that fabrication and construction constraints be considered from the outset and incorporated into the computer model. For example, the fabrication of the pre-cast concrete panels (later changed to a GFRP and steel system) required that the edges of the panels could not be too sharp since the aggregate in the concrete mixture which would flow into the digitally fabricated panel moulds would not be able to fit into the crevices created by too sharp angles. The solution by the GT team was to incorporate a minimum angle constraint into the parametric model, created with GT's own Digital Project software, which would effectively ensure that all edges were beveled to the degree required for the casting process. Additionally, the parametric model needed to incorporate geometrical constrains for the panels so as to ensure that adequate space would be available to fit the reinforcement bars required for the design. The vaulting of the roof skylights also utilized a parametric model for the purposes of incorporating production constraints while allowing for the efficient evaluation of alternative geometries to meet design intent. As in many other projects of this scale and complexity, the interrelations between the various building systems needed to be carefully coordinated amongst the numerous parties contributing to the building design. For this reason the firm's "GTeam" software provided an online platform to improve team collaboration and sharing of project documents and 3D building information.

Kohn Pedersen Fox's Charlie Portelli described how custom computational tools and parametric models were utilized for the design of the Chongqing International Trade and Commerce Center (ITCC) at multiple stages of project development, from conceptual design to the construction phase. This 2.8 million square-foot mixed-use complex, which has LEED Gold

certification as its goal, features a torqued "supertall" high-rise building with adjacent mid-rise

towers, a retail podium, and an outdoor public plaza. Morphologically, the design suggests sail-

like forms which reference the boats of the adjacent waterway. The IGU façade utilizes a pattern

of panels derived from Chinese characters. Among the advantages of the parametric system

employed were the automation of tasks and improved interoperability workflows. Portelli also

described KPF's Al Bateen Wharf project in Abu Dhabi, a waterfront development which would

contain retail, hotel, and residential units. The design utilizes a design strategy which employs a

set of modular living units which are rearranged to create a variegated façade which reflects the

interior layout. Computationally, a process was developed which would take a layout

arrangement defined in Excel into a three-dimensional model. A script was then developed to

take information from this model back into a spreadsheet for the purpose of automating take-

offs so that the design iteration could be easily evaluated.

A panel discussion of the presenters first focused on whether computation ends with

construction. While efforts often focus on the conceptual or development design stages, the

participant stressed the importance of post-occupancy surveys and the evaluation of built

designs in order to better improve knowledge of performance for the design of future projects.

A question was posed as to whether computational processes could potentially "replace"

architectural design. While one participant suggested that in a general way it might, the majority

of the panel felt that the situation was rather the opposite, namely that computational and

technological developments generally get "absorbed" into architectural design, and that

architects should embrace the uniquely creative aspects of the profession which characterize it

rather than have them dissolve into solely analytical processes.

A series of presentations followed concerned with the topic of digital workflows. Chris

Zoog of HOK focused his presentation on the topic of façade design interoperability using IFC to

integrate algorithmic design tools with building information modeling (BIM) platforms. Essentially, IFC is a standard file format for BIM which allows for the exchange of information contained in BIM objects between software. This information includes such items as 3D and 2D geometry, but also object properties and attributes, and parametric relationships.[2] Among the opportunities for IFC is coordination between computational and BIM modeling. An IFC file, for example, can be built up in Grasshopper using the GeometryGym add-on. The output can then be imported into Revit as objects with full Revit attributes. This is particularly useful for ease of documentation purposes. Zoog also showed how the IFC format can be used to transfer parametric model information between Grasshopper and Revit's Adaptive Components system for developing parametric façade component object families. In addition to design authoring, IFC can aid in program validation by communicating between BIM models and program management software such as dRofus. In relation to performance-based design, IFC files can imported into Simergery, a graphical user interface currently under development for Energy Plus building energy simulation software. HOK's use of IFC contributes to their buildingSMART" approach which aims to "add value across all phases of design, construction and occupancy."[3]

The LiRO Group presented its use of "virtual construction" to improve coordination among project contractors and consultants. The LiRo Group is a firm which provides construction management, engineering, environmental, architectural, and program management services. Projects for which architectural design was provided include the recent High Bridge Library in the Bronx. The MTA East Side Access project was discussed within the context of the virtual construction strategy. The 6.3 billion dollar project is one of the largest and most complex infrastructure projects in the city's history.[4] With about 30 different contractors and a large number of consultants working on the project, the need for efficient and clear communication and coordination among parties is one of the primary challenges of the

project. For this reason, much effort by the group has focused on using new technology for visual communication. For example, four-dimensional animation models were developed to help contractors understand construction methods and scheduling.

Michael McCune of CASE Inc. provided an overview of the company and case studies for which they assisted with development of design workflows and computational tools. CASE Inc. is a New York City-based consultancy which seeks to "identify, implement and manage the technologies and business practices that enable more effective coordination, communication and collaboration."[5] They have worked with such firms as Grimshaw Architects, Cannon Design, and Kohn Pedersen Fox. For the Oslo-based firm Snohetta, CASE has provided support for their implement BIM in the company's New York office as well as project-specific support for the Ryerson University Student Learning Center in Toronto and SFMOMA expansion in San Francisco. McCune described custom parametric tools which were used to establish a framework for testing analyzing the performance results for variations on a façade louver system. For the wider community, CASE provides a set of tools and learning material through their website.[6] In collaboration with SOM they have also recently launched AEC-APPS.com, a website which seeks to provide a library of apps and plug-ins shared within the online user base.

In relation to the topic of façade design, Ben Silverman a designer from Enclos' in-house Advanced Technology Studio, discussed how he uses parametric modeling and optimization routines. By developing scripts based on equations which describe geometric relationships common to mullion and façade panel design, a method can be developed whereby a large number of possible variations based on these constraints can be rapidly analyzed for material usage (embodied energy) and cost while ensuring adequate structural capacity.

A presentation on SHoP's recently completed Barclays Center by John Cerone focused on the fabrication and assembly of the arena's sweeping weathered-steel façade. It consists of

approximately 900 "mega-panels" made up of a number of cnc water-jet-cut rainscreen panels and supporting structural members. The Catia software with its knowledge pattern scripting platform was utilized for both its parametric design capabilities and features which make for an easier transition to digital fabrication processes. The panels, which were pre-weathered off-site for a number of weeks to develop their patina, were each numbered during the fabrication process so their positions with the mega-panel assemblies could be determined by checking three-dimensional models and construction drawings.

Gensler's Corey Green presented a case study for the integration of analysis methods into the design process. On this particular project the analysis was brought into the design late in the design process when it was discovered that there was a potential for considerable glare issues in the proposed design. Two adjacent buildings in close proximity and off-axis in orientation meant that a study of solar reflectivity between the facades and the resulting glare needed to be studied. For this purpose a collaborative team was put together to utilize computational methods with a multi-platform approach using Grasshopper, DIVA, and Ansys tools to hypothesize, validate and interpret the solar reflectivity and glare on the facades.

The topic then shifted to "automation" with presenters Chien Si Harriman of Terabuild, who discussed environmental simulation, Ben Howes and Jonatan Schumacher of Thornton Tomasetti, who described their TTX Interoperability platform, and Skanska's Gregor Vilkner who discussed the use of the Building API methodology. Scott Crawford and Stephen Van Dyck of Seattle-based LMNts and Zak Kostura of Arup then discussed the topic of digital fabrication.

A3. Intersections 2013

Intersections 2013: Interoperable Workflow, Innovative Practice was a symposium held at New York City College of Technology which featured lectures and panel discussions by a

number of innovative practitioners and educators in the AEC industries. It focused on the three

topics of "tools," "innovation," and "making it work."[7]

In the relation to the topic of tools, Axel Kilian, an assistant professor of computational

design at Princeton University, presented a number of research projects and studies in which

parametric design was utilized in form-finding strategies as well as for fabrication purposes.

These include efforts include projects ranging from the scale of furniture to bridges, towers, and

catenary structures. Kilian has experimented with using computation to develop structurally-

efficient catenary structures inspired by Gaudi's methods of developing physical hanging models

for over a decade.

Federico Negro, founding partner of CASE Inc., discussed how tools are used in practice,

with each company developing specific "toolkits" made up of combinations of industry-wide

software packages depending on the needs of particular projects and the stage of design. He

stressed the importance of architectural design not being "tool-derived," but that designers

should customize and develop their usage of tools based on project design goals. In this way,

interoperability becomes an important theme since it allows for a designer to "build a bridge

between tools" as the need arises. He also emphasized the usefulness of computational tools to

automate tasks, potentially allowing for increased time for designers to focus on design issues

rather than repetitive tasks. In relation to the use of multiple software tools, he also suggested

the direction of industry as tending towards "passing information rather than files."

As a Senior Acoustic Consultant at global consulting firm Arup, David Rife described his

usage of computational and software tools as needing to fit the particular tasks which the

designer needs to accomplish. He contrasted the usage of pre-prepared "black box" software

with his own approach which has often meant developing his own scripts or the make-shift use

of various tools accomplish necessary tasks in an efficient manner. His jobs have included such

project types as music venues and opera houses where 3D acoustic modeling was utilized. The models used in such programs are simplified versions of the more detailed BIM or 3D models often used in architectural practice, meaning that specific procedures and strategies are needed to translate geometry from one software platform to another. For example, a typical Rhino model would need to be converted to mesh objects using a program like HyperMesh and then translated into a file format compatible with an acoustic analysis program such as CAD Acoustic. Rife stated that such programs as well as custom scripting methods which he has used with programs like MATLAB have dramatically reduced the amount of time required for acoustic analyses and visualizations. He stated how visualization is particularly important in communicating acoustic design requirements and intent to clients and other project consultants. Rife also described a project at Arup to construct a "comparative listening space," capable of reproducing the acoustic performance and experience at existing and proposed spaces.

Thornton Tomasetti's Jonatan Schumacher discussed the use of computational tools for preliminary structural design on projects like Bjarke Ingels Group's West 57th Residential building, currently under construction. With major changes to the design occurring on a continuous basis, the engineering team needed to be able to develop preliminary structural designs in short time periods, so methods were developed to utilize computational tools for common structural design tasks. Thornton Tomasetti will often use ETABS structural analysis software on their projects, but for this project Grasshopper definitions were also used to generate text files which could then be imported into the ETABS software, a strategy which allowed for changes to be made to a basic parametric model in order to save time the preliminary analysis process. In relation to the theme of interoperability, Schumacher also described early student research efforts in cross-platform software development at the Product

Architecture Lab at Stevens Institute of Technology in 2011. These projects included developing

scripting tools to link Ecotect with Catia, Grasshopper with Ecotect and Energy+, and Revit with

SAP2000 structural analysis software.[8] The goal for such projects was to teach students to be

able to develop their own tools and methods for accomplishing goals without relying on limited

functionality of single software platforms. This mentality continues in TT's in-house

development of custom tools such as with their embodied carbon calculation tool.

A panel discussion of these speakers summarized some of the key points. All seemed to

agree on the importance of customized tool development and a flexibility on the part of the

designer to engage with multiple platforms as necessary to accomplish design goals. The idea

that architects might "tinker" with technology rather than simply use it in pre-determined ways

was also brought up. Despite an emphasis on new technologies which is the focus of much

current research efforts, the panelists agreed on the importance of working with pencil and

paper, or whatever tool might best be used to develop and communicate design ideas. While

the development of skill in using new technologies is important for meeting challenges in the

industry, the need for the grasping of fundamental principles of design was also reiterated.

Anna Dyson, Director of Rensselaer Polytechnic Institute's Center for Architectural

Science & Ecology (CASE), provided the keynote presentation of the symposium. CASE is a

research collaboration of RPI and SOM which aims to "address the need for accelerated

innovation of Built Ecologies through the development of next-generation building systems" and

to "push the boundaries of environmental performance in urban building systems on a global

scale, through actual building projects as research beds."[9] Dyson described their efforts as

seeking "bio-compatability" in the built environment through a careful consideration of energy

flows through buildings at multiple scales. She highlighted an ongoing research project at CASE

which is developing a dynamic façade technology called an Electropolymeric Dynamic

Daylighting System (EDDS). The goals for the system are to achieve improved thermal

performance while meeting daylighting requirement by utilizing a "movable frit" of "staggering

pixels" similar to that on recent display systems such as that of the Kindle. A significant aspect of

this filtering method would be its ability to dynamically adjust to such factors as environmental

conditions and programmatic requirements, while offering the ability to program the display

with real-time user-interactive responsiveness as well as variable patterning for visual effect.

Although still in development and facing the similar challenges which most new material and

systems technologies face, it has been included in an SOM competition proposal for a public

space covering in New York City. Other technologies being researched at CASE include an

"Integrated Concentrating Dynamic Solar Façade" (ICSF) system, which seeks to incorporate

solar energy harvesting into facades with concentrating PV technology within a double façade

enclosure which also acts to capture solar heat gain.

A panel then followed which focused on the theme of innovation in design. David

Benjamin, director of the Living Architecture Lab at Columbia University, presented a number of

research projects which utilized innovative uses of computation and materials. For example, he

has been studying biological models, particularly bacterial processes, as a model for digital

fabrication processes of material depositing and accumulation. Through the patterned

alternation of rigid and flexible material, a digitally fabricated element capable of specific

geometric transformations could be envisioned. As with other experimental research projects

which engage with innovative use of materials for prototypes, the challenge in the development

for potential applications have largely to do with issues of scale among numerous other

obstacles.

Pratik Raval, Project Leader at Transsolar's New York office discussed the application of

thermodynamic analyses to innovative building design in a number of case studies. Transsolar is

a firm specializing in building energy and climate design which aims "to ensure the highest

possible comfort in the built environment with the lowest possible impact on the environment"

through "developing and validating climate and energy concepts through the recognition that

environmental conditions are influenced by all aspects and stages of design."[10] The firm utilizes

a variety of computational simulation tools in their analysis and design tasks such as TRNSYS, for

performing dynamic thermal simulations, RADIANCE for daylight simulations, and FLUENT for

computational fluid dynamics (CFD) studies. Projects to which the firm has contributed include

Steven Holl's Beijing Linked Hybrid building and the Main Station Strasbourg designed by AREP.

Raval discussed the design for the 700,000 square-foot Manitoba Hydro Corporate Head Office

Building in Winnipeg, Canada. Strategies aimed at increasing the energy efficiency of the

building included optimized orientation for passive solar gain, high ceilings to increase natural

daylight, buffering envelope zones for pre-conditioning air, heat recovery, fresh-air

displacement (non-recirculating) and natural ventilation, and thermo-active hydronic tube slabs

heated and cooled in part by a geothermal heat exchanger. Despite the cold climate in which

the building is situated, the designers aimed to reduce energy consumption by sixty percent,

achieving LEED Platinum level and a number of industry awards for its numerous sustainable

design features.

Branko Kolarevic, Professor and Chair in Integrated design at the University of Calgary

and author and editor of several influential books concerned with the use of digital technologies

in architectural design and production, gave a presentation on the topic of dynamic building

elements, a subject about which his forthcoming book is concerned and the focus of a recent

symposium at the University of Calgary. Kolarevic also co-directs the Laboratory for Integrated

Design (LID) at the university, a multi-disciplinary research group "in which methods, processes,

and techniques are discovered, appropriated, adapted, and altered from elsewhere, and often

digitally pursued."[11] Kolarevic's talk focused on recent trends towards what has variously been termed adaptive, flexible, interactive, and responsive architecture. For example, many researchers are interested in incorporating electronic control systems such as those utilizing the Arduino programming platform and microcontrollers to drive dynamic or reactive building elements. He suggested that the origins of such recent approaches to dynamism lie in ideas explored the 1960's and 70's, for example Gordon Pask's conversation theory, Cedric Price's concept of anticipatory architecture, Negroponte's work at MIT and his book Soft Architecture Machines, and Chuck Eastman's idea for an interactive adaptive-conditional architecture. Classifying current approaches in four categories (dynamic facades, transformable structures, bio-inspired materials, smart materials), he described the characteristics and inherent problems and challenges in each of these modes. A LID research project for a prototype dynamic façade was shown which consisted of an array of truncated cones capable of independent rotation according to programming input. The project, once constructed, quickly began to show problems due to the friction developed between elements, the common primary problem with the functioning of dynamic facades according to Kolarevic. Alternatives to motor-based movement, actuation-based systems may be hydraulic, pneumatic, or material-based. An approach based on a biological paradigm is also being explored by researchers. So-called smart materials being researched include shape memory alloys and polymers, which change based on temperature, and piezoelectric and electroactive polymer materials, which can be altered by controlled electrical flow. A recent book by Rashida Ng and Sneha Patel of Temple University, *Performative Materials in Architecture and Design*, focuses on the emergence of such new materials in research efforts. In summary, Kolarevic expressed interest not solely in the environmental or functional performative role of responsive or adaptive systems but also how they affect the user's encounter and experience of an environment.

Ken Tuttle, a project manager at the engineering firm Werner Sobek, presented their F87 "Efficiency House Plus with Electromobility" project. For this project, an interdisciplinary design team sought to develop a prototype high-efficiency residential unit in a modernist idiom capable of realizing a surplus of energy, enough to power a pair of electric vehicles. An important aspect of the project in terms of sustainability is that it was designed and built to be completely dissembled and its materials recycled at the end of the building's useful life. Solar panels are sleekly incorporated into the building's cladding. The project illustrates the feasibility of surplus-energy-generating buildings of high material efficiency in terms of their recyclability.

A presentation by Doris Sung, of DOSU Studio, focused on the architect's research and material explorations, particularly with "thermobimetals," which consist of laminated composite metal sheeting. By coupling metals with different coefficients of thermal expansion, a material which responds to heat through bending is created. This shape-changing property has been investigated in a number of research and installation projects, most notably the Bloom outdoor installation for a gallery in Los Angeles, which seeks to "stich together material experimentation, structural innovation, and computational form/patternmaking into an environmentally responsive installation."[12] Thousands of unique metal pieces were calibrated to curl at the occurrence of high ambient temperatures. Sung is currently researching how bimetals might be used as a part of a dynamic sun-shading system in which the material might be used between glazing layers and be calibrated to block out solar gain by bending into a closed form at high temperatures.

A series of presentations followed focused on architectural geometry and fabrication. Aleksey Lukyanov-Cherny, partner at SITU Studio, discussed the group's work. Starting in 2005, SITU began specializing in the production of high-end 3d printed models, some costing well into the five figure range. Soon the group was using CNC machinery to produce architectural

components and assemblies for their clients. In addition to architectural installations and

projects, the team has also worked on the fabrication for other types of projects such as fine art

sculptural pieces and gallery installations. Noteworthy architectural projects include the lobby at

One Jackson Square, an 11-story residential tower designed by Kohn Pedersen Fox Associates.

Situ Fabrication provided services ranging from preliminary design to fabrication for the flowing

interior space which utilizes of bamboo walls of double curvature which were produced through

CNC milling 64 different 13 foot tall panels. SITU's work has extended beyond the design sphere

in recent research work such as a collaboration with Princeton University to utilize CT-scanning

technologies to image and reconstruct fossils for which custom machinery had to be developed.

The machine automates a process of carefully grinding away and scanning layers of material in

order to generate detailed virtual models of the microscopic fossils contained within.

Michael Eigensatz discussed some of the work of Evolute, a consultancy which offers

services and software to aid in projects which utilize complex geometry. Eigensatz noted how

the term "freeform" to describe architectural geometry is often mistaken in that in reality

project geometry needs to be not only computationally defined and communicated, but also in

that specific geometric constraints are necessary in order for such projects to be constructible.

As an example, he described the design for the façades of the new pavilions to be constructed at

the Eiffel Tower. Initial sketched design ideas by the architect, Moatti et Riviere, called for

glazed façades of double-curved glass panels. However, in order for this scheme to be

economically realizable, the steel sections supporting the glass would need to be such that they

could be produced through bending the metal in only a single-direction. Evolute determined

that this would mean that the supports would effectively need to follow the iso-curves of the

surface. The surface geometry was then adjusted and possible glazing support configurations

explored so as to determine aesthetically acceptable solution. The glass panels themselves were

produced through mould-forming methods which utilized data output from the computational model. In addition to design consulting, Evolute also provides custom and free-distribution software tools for rationalizing complex geometries.

Finally, mechanical engineers from Buro Happold discussed the used of computational modeling at their firm, where simulation tools such as CFD analysis are often used to analyze the requirements for building ventilation systems. By investing the time and effort in simulation modeling and analyses, a number of alternatives can evaluated and the least energy-intensive system can be implemented in the final design of a project.

End Notes:

1   <https://www.som.com/project/kafd-conference-center> accessed 29 May 2013
2   <http://open.bimreal.com/bim/index.php/2013/01/21/ifc-what-it-is-and-why-you-
        should-care-recorded-presentation-christopher-zoog/> accessed 5 June 2013
3   <http://hok.com/thought-leadership/hok-buildingsmart/> accessed 5 June 2013
4   <http://www.liro.com/projects/mta_east_side_access.htm> accessed 5 June 2013
5   <http://www.case-inc.com/about> accessed 5 June 2013
6   <http://www.designreform.net/> accessed 5 June 2013
7   <http://openlab.citytech.cuny.edu/fuselab/event/intersections-2013/> accessed 8 June
        2013
8   <http://www.architexted.com/> accessed 8 June 2013
9   <http://www.case.rpi.edu/CASE.html> accessed 9 June 2013
10   <http://www.transsolar.com/> accessed 11 June 2013
11   <http://buildingdynamics.org/about-lid/> accessed 11 June 2013
12   <http://www.dosu-arch.com/bloom.html#> accessed 21 June 2013

APPENDIX B

TABLES

Table B.1: NYC Building Code Information for Group A-3

Group	Height (Feet)	Type of Construction								
		Type I		Type II		Type III		Type IV	Type V	
		A	B	A	B	A	B	HT	A	B
		UL	160	65	55	65	55	65	50	40
	Stories	UL	UL	6	3	6	3	6	3	2
A-3	Area/Floor	UL	UL	17500	9500	14000	5600	15000	8400	5500

Table B.2: Summary of NYC Bulk Regulations for Community Facilities in Zones R6 and R8

	Zoning District	
	R6	R8
Community Facility Use Groups	3, 4	3, 4
Maximum Floor Area Ratio (FAR)	4.8	6.5
Maximum covered area percentage of lot	70*	75*
Required distances from lot lines		
- Front	None	None
- Side	None*	None*
- Rear	30'	30'
Front Setbacks and Maximum Heights		
On narrow street:		
- Initial Setback Distance	20	20
- Maximum height of front wall within Initial Setback Distance	60	85
- Slope of Sky Exposure Plane	2.7(v) to 1(h)	2.7(v) to 1(h)
On wide street:		
- Initial Setback Distance	15	15
- Maximum height of front wall within Initial Setback Distance	60	85
- Slope of Sky Exposure Plane	5.6(v) to 1(h)	5.6(v) to 1(h)
Side Setbacks	None	None
Rear Setbacks		
- Height at which setback applies	125'	125'
- Depth of rear setback from lot line	20'	20'
Misc		
-Street tree planting required	Yes	Yes
-planting strips required	Yes	Yes

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