

ABSTRACT

Title of Document: POTENTIAL THROUGH ENCLOSURE

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The goal of my thesis is to improve the typical office building's performance as well as the work place by reimagining the zone of the building's enclosure. My position is that building enclosures which are usually thin and flat wrappers could instead, be zones of space that serve multiple functions contribute positively to both the building's interior and its performance. On the urban scale, a network of these buildings could have a large impact on the city. By rethinking what the enclosure could be, I hope to improve the relationships between the urban fabric and the building, the people working there. Building enclosures are not meant to be thin and flat wrappers, they are meant to be dynamic elements of the building that serve multiple functions that improve the surrounding environment.

POTENTIAL THROUGH ENCLOSURE
IMPROVING THE WORK PLACE AND BUILDING PERFORMANCE BY RETHINKING THE
ENCLOSURE

By

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Preface

Potential through Enclosure is an exploration into an area that I feel is under developed in buildings, more so office buildings. These commercial building types have facades that hold a large amount of unrealized potential. Once in a while, we will see a building with a façade that has some dynamic element to it, such as a living wall or solar responsive louvers. These are examples of the direction we should be pushing our building enclosures, however they don't need to stop at doing one thing well. A truly dynamic enclosure is host to many functions and can accommodate all of them successfully. The enclosure should not stop at repelling the elements well, nor should it stop at being the most efficient for itself. The building enclosure especially that of the office building in an urban environment should not only enclose a building well, it should also be a productive part of the building system. Productive enclosures give back to the building, its occupants and to the surrounding environment.

In my thesis I move away from labels like skin and façade because of their connotations, which are packed with attributes that imply a thin layer between the exterior and the interior. Rather, the building enclosure is the term that will be used, because it can be read more as a zone of the building, and less as a barrier between two spaces. The goal is to improve the interior and exterior spaces of a building in the urban setting, by approaching the enclosure from a different perspective. The enclosure will become a multifunctional element and zone that organizes the surrounding spaces and provides various services to the building, its urban environment, and the people that inhabit it.

The order of the following document is based on my process of research. Chapter one deals with identifying the problem, and breaking it down to different scales. The next chapters deal with my research and findings, and the lessons learned. Chapter five deals with identifying how a building enclosure could improve the buildings spaces and context. It will also cover the two main aspects the enclosure, the technical aspect and human aspect. Chapter six will then introduce and study the site, both for its negatives and positives. The final chapters after this will cover my design solution and the conclusions to be made from my thesis.

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I would like to thank my parents, for all of their support during this six year endeavor.

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Chapter 1: Why Office Buildings look the way they do

What is typical?

The typical office building is a simple form. Almost all of these modern buildings share a generally similar parti, designed to allow for maximum floor space and flexibility. This is to allow for a wide variety of configurations for various future tenants. Typically the core and circulation for the building is located close to, if not in the center of the building. This allows for a structural center and equal access for all renting tenants. (Although more recently, an open center parti has also become common, allowing for natural light and an atrium in the center of the building.) Other common plan types include the central atrium element which pushes the core away from the center. This building type still shares the common goal of maximizing floor area for office space rental. The main difference being a central element that allows light deeper into the building. This requires the core to occupy a different place in the general floor plan. Typically this is off to the side of the atrium element, allowing for office program to still occupy the outer edge of the building. Another common floor plan parti for the typical office building is the parti wall. In this case, the buildings

service and circulation cores are located along a back or side wall, allowing for a large open floor plan. These plans work best when adjoining an existing building, where windows are not an option. Of all this plan types the baseline goal remains the same, which is to make the most area for rental space as possible. The more efficient the plan, the more effective it is. “Floor layouts within the typical North American office building have also been evolving. In the 1960’s the typical office building was composed primarily of private offices. The status of the individual occupying an office was reflected by the size of the room (number of window modules wide) and its furnishings. Today most U.S. companies - and to a varying extent those all over the world – use predominately an open plan.”¹ Regardless of the parti, almost all office buildings share a highly orthogonal modular floor plan. This is in part because of the structural systems used to support the floors, as well as the need for a modular grid. This is a result of the desire for regularity in the office plan. The more regular the plan, the easier it is to furnish, build out and design for a tenant or for the tenant to use in an open plan layout. It is much more cost effective to specify one type of desk, door, cubical, etc. rather than building custom pieces for each office. This grid is then reflected throughout the building as it becomes a major underlying element. The economy of mass production helps keep costs down, which is arguably one of the most important factors for the developer, when building commercial space. “One of the strongest forces in the design of an office building is the real estate market.”² This is one underlying reason that typical office building facades tend to be flat and thin.

¹ Kohn, Eugene A., and Paul Katz, eds. 2002. *Building type basics for office buildings*, ed. Stephen Kliment. New York: John Wiley and Sons.

² Kohn, Eugene A., and Paul Katz, eds. 2002. *Building type basics for office buildings*, ed. Stephen Kliment. New York: John Wiley and Sons.

The restraints of the building size, such as Floor Area Ratio or other zoning codes, means the developer wants to maximize the area of rentable space, in order to maximize profit. As a result, the typical office building becomes more of an exercise in finding the most space to enclose.

The Role of Others

The typical office building is influenced by many factors ranging in scale from global market trends down to the site's characteristics. The role of others, or anyone besides the architect and their office, is an important factor in why the typical office building looks the way it does. First and foremost, the owners or developers of a project play a large role in deciding everything from the shape to the finishes of an office building. They are interested in achieving the best result for the lowest cost, and often are interested in a project with the highest possibility of success and the lowest factor of risk. For the developer, risk management and the bottom line are the two main driving factors. Time is arguably a close second. "The complex buildings of today are no longer the product of one mind, but are the outcome of one idea through the efforts of many specialists. Without appreciating the responsibilities and limitations of these men [and women] the process of design cannot be understood or improved."³

Another major influence on the shape of office buildings are the local codes, and the city or governing body. Zoning, building code, and city officials all play a role in the final product. Floor Area Ratio codes for example can dictate the shape and set backs of a building. For example, in San Francisco, the city planning

³ Manasseh, Leonard, and Roger Cunliffe. 1962. *Office buildings*. 1st ed. New York: Reinhold Publishing Corporation.

commission limited new construction to 900,000 square feet per year, making for a highly competitive market.⁴ The result is developers now pay more attention to the exterior of the buildings because the standards for approval are much higher. The completion created by the limited amount of development each year means that developers must make their projects more attractive to the city and the public. This results in a better looking city, as each building is reviewed for its contribution to the city before being built. Another major factor in the shaping of typical office buildings in the economy.

Developers and lenders are influenced by the economy. A strong economy will push developers to invest more in buildings in order to offer more services, amenities and value to potential tenants. The economy can also dictate the type of construction used for the building and what structural system is used. For example, in Washington DC, concrete is primarily used, although it is more expensive, it allows for thinner ceiling to floor dimensions, and helps fit more floors into the allowable building heights. However in Baltimore, where those restrictions are less severe, steel, the cheaper of the two structural systems, is used. There are many factors that shape the final design of an office building, many which are out of the Architects control, however it is still the duty of the architect to work within and push these limitations in order to produce a strong and well planned office building. The architect plays an important role in the design of the office building and should make the case for positive changes that may not initially appeal to developers or the cities governing body.

⁴ Kohn, Eugene A., and Paul Katz, eds. 2002. *Building type basics for office buildings*, ed. Stephen Kliment. New York: John Wiley and Sons.

ECONOMY AND ENVIRONMENT

WHY OFFICE BUILDINGS LOOK THE WAY THEY DO

- *Developers/ Owners*
- *Market Conditions*
- *Budget/ Profitability*
- *Existing Site Conditions*
- *Social Implications*
- *Environmental Impacts*



SYSTEMS AND METHODS

WHY OFFICE BUILDINGS LOOK THE WAY THEY DO

- *Construction Practices*
- *Materials Available*
- *HVAC and Mechanical Systems*
- *Structural Systems*
- *Existing Typologies*
- *Contractor Expertise*
- *Technology Limitations*



REGULATIONS AND GOVERNMENT

WHY OFFICE BUILDINGS LOOK THE WAY THEY DO

- *Zoning Requirements*
- *Building Codes*
- *Planning Commissions*
- *Political Influence*
- *Life Safety and ADA Laws*
- *Historical Preservation*
- *Master Development Plans*
- *Local Community Groups*



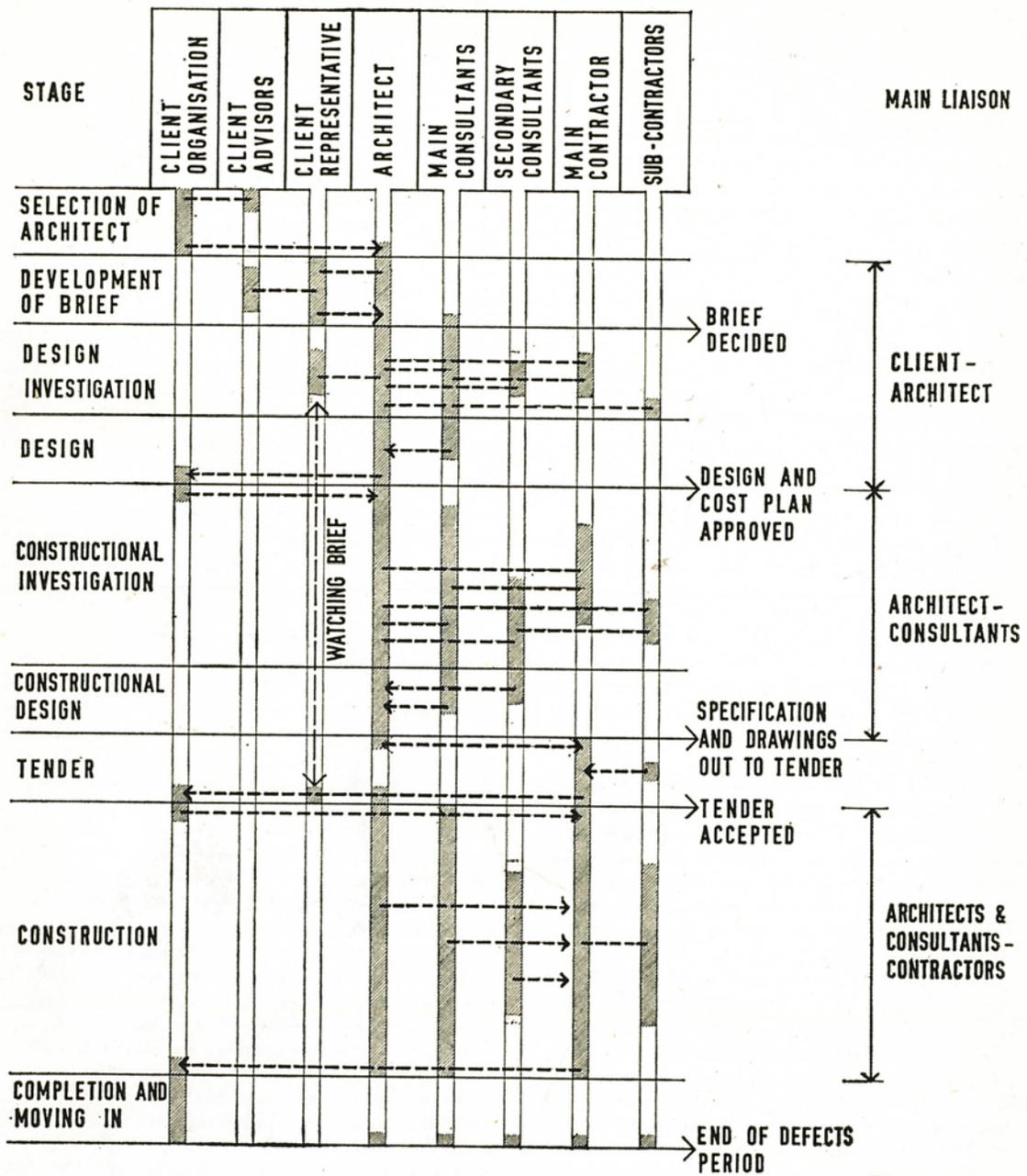


Table (1) The Design Process in relationship to the people needed to construct the building

The Role of the Architect

The role of the architect is an important one in influencing the design of the typical office building. The architect is the master mind behind coordinating the entire process, and is responsible for the design of the building and its facades as well. The architect has a duty to the client to complete his part of the job in a timely manner and on budget. However he also is responsible for ensuring the safety of the design, as well as making sure it complies with all building and zoning regulations. “The evolution in planning and design of commercial buildings is rooted in two stimulating factors. One is the search for maximum economy in structural methods, the other is our growing awareness of the importance of healthy work environments”⁵ Beyond that the architect has a duty to the city, and its citizens to design a building that benefits everyone as much as possible. Architects are civil servants in this sense, as the architect is often required to consider all the constraints of a project and still produce a strong design. Yes the architect should consider the cost, time and deadlines of the client. Yes the architect should listen to the city planning office, and help make the most of the site. But the architect should also consider the users of the building, the people who will walk past it, and the adjacent buildings around the site. The architects should be the one to make the case for a more sustainable design. They are the ones with the widest base of knowledge and must sway the other parties involved to make the right and responsible choices. It is the duty of the architect to balance the needs of everyone, and still produce a thoughtful design. The architect must be the one to push for change, because they are the ones in the position to do so.

⁵ Rosenauer, Michael. 1955. *Modern office buildings*. 1st ed. London: William Clowes and Sons.

Chapter 2: The opportunity of the problem

The Disconnected Nature of the Typical Office Building

There is a major disconnect between the typical office building and its surrounding environment. The office spaces are uninspired and designed around the bottom line. These low cost buildings are outfitted with the most basic functions for inhabitation, and often lack any spatial quality that would make them memorable. Furthermore, the building skin exacerbates the problem by acting only in the interest of keeping the artificial air in, and the glare of the sun out.

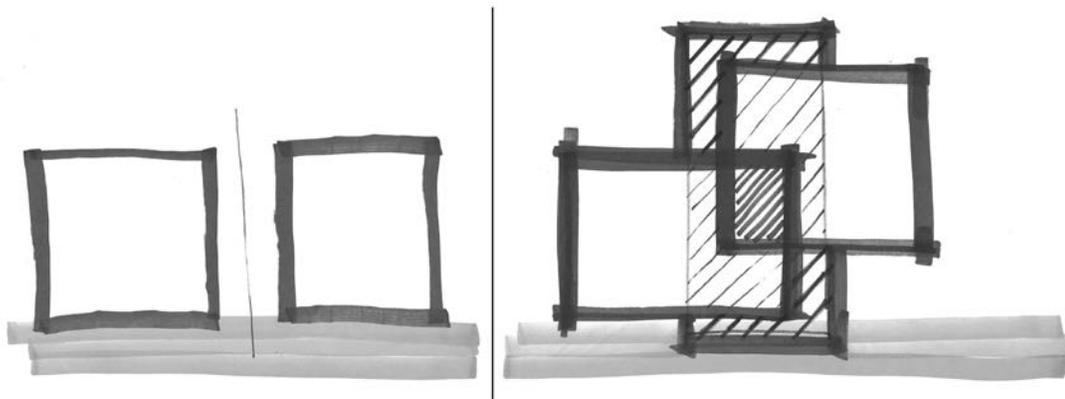


Diagram 1. The current response of the façade in comparison to the proposed ideal

The facades are made to be as thin as possible, with no real means of natural ventilation. Often times these facades fail to regulate the indoor environment well, and parts of the building end up being too hot or too cold. Natural light is treated as an unwanted variable. It is often replaced with fluorescent lights, in part because the building is too deep for natural light, or because the glare of the sun makes the interior unusable. The building enclosure seals off the inside from the exterior, and in

doing so, further disconnects the typical work place from the outside world, the people in it and the very building it encloses.

On the exterior, the story is no better. The facades are flat, and lack depth. They often end up being mirror of the world around them because of the glare control. This causes the building to disappear into the city block, the heavy tint making it almost impossible to see in. The street front is left to be filled with glass lobbies, and coffee shops, but no over hangs or places to sit, as the façade offers none. This results in a fast moving and slick street, people speed by, with nothing to slow them down. The already disconnected office worker goes further unnoticed, as there is no opportunity for any human connection. The lack of interaction makes the street seem dead, its absence of people do no favors for the sea of concrete and paving. This makes the street even less desirable, and in turn makes the buildings less desirable, adding to the isolation of the city street, the building and the people that must use it.

The Urban Street Problem

The typical urban office building has several problems in the way it engages the urban context around it. Often these buildings serve as a defining street edge, but in the case of the typical office building, the structure may a hard edge, but it fails to engage the street on any other level. The flat thin nature of the façade forces a street face that lacks depth and dimension. Furthermore, the often modular nature of the facades creates a repetitive and monotonous pattern on the street face. While, the modular nature of these facades may have been good for ease of construction and keeping costs low, they lack the character that makes an urban street active and engaging. This causes people to move through the street quickly, further reducing the

connection to the building and street. The street fronts are also void of depth, as the buildings typically are right at the build-to line for maximum rentable space. This creates a hard street edge on the ground floor, which offers no places of rest or pause for pedestrians on the street. The result is a street with no street life, as the people are kept moving. With nothing to engage them, they have no reason to stop, leaving the street feeling empty and artificial. The lobbies of the building have no public program other than the occasional coffee or bagel shop to offer a node on the street. As it stands the typical office building really has nothing to offer the street context besides that hard edge. It doesn't engage the urban fabric or benefit the city, and leaves the street empty. This is in contradiction to the urban planning ideals found in Thompson's *Urban open space in the 21st century*. "Rogers proposes that we ". . . create beautiful places (in our towns and cities) that are socially cohesive, avoiding disparity of opportunity and promoting equity and social solidarity""⁶ In short, every aspect and street should be designed with attention to the urban environment it is a part of.

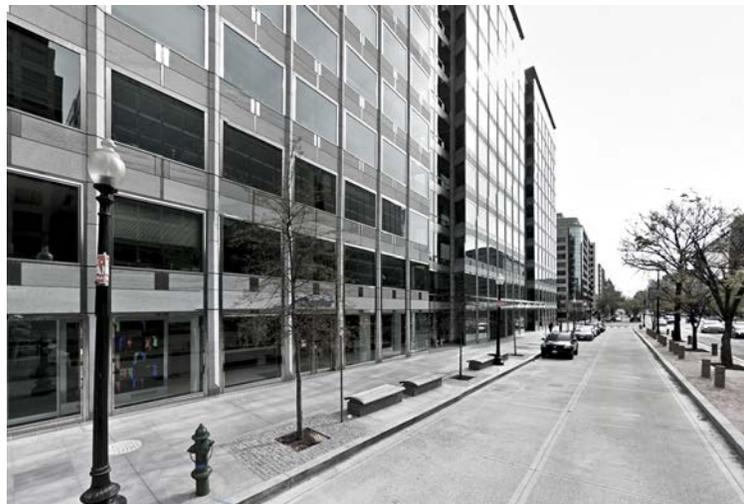


Figure 1. View of K Street, Washington, DC during the day

⁶ Thompson, Catharine W. 2002. Urban open space in the 21st century. *Elsevier Science B.V. Landscape and Urban Planning*(60): 59-72.

While the building enclosure is not responsible for all of these problems, it can solve a great deal of them. The building enclosure can become an element that breaks up the regimented monotony of the street face, while still offering a reasonable area for rental space. By activating the enclosure, a street with a reason for being can start to take shape. This could breathe life back into the street, and create a place for interaction and connection. The building enclosure also represents an important role, as not all sites or applications would warrant the use of ground floor program to create a dynamic streetscape. It could offer an ulterior reason for people to become active and engage the street. Ideas such as vertical parks would help places that did not have the draw for retail on the ground floor. This would also help with the amount of impermeable surfaces, allowing for a more natural environment.

All of these approaches using the building enclosure are designed to improve the urban space around the building in a way that facilitates connection between people in the buildings and on the street. This activation of human interaction would add life to the street and help create a place that is seen as a place to go, rather than one to pass through. The result would be a tighter urban fabric, with the building becoming an active member in the urban context.

The Enclosure Problem

The enclosure of the typical office building is perhaps where the most potential is left unutilized. The façade of the current model is a thin wrapper around the building. It really only serves to keep the artificial air inside the building. The façade typically offers no options for operable windows, limiting the possibility of

natural ventilation. It does not allow people in the building to connect with the urban environment outside. It also creates a barrier between the street life below and the people working in the building. Further, the thin and flat dimensions of the façade don't allow light to reach all the way back into the already deep building. This increases the reliance on artificial lighting and the use of energy by the building. It also creates problems with the heating and cooling of the building, as the glass allows heat in, creating zones of uncomfortably hot areas, while the interior spaces remain too cold in an effort to compensate. The current facades also lack any real means of serving the building and city. They offer no connection to the environment, and are static in their approach to function. This, although not directly detrimental to the connection between the building, city and users, is a missed opportunity.



Figure 2. The facades of K Street, Washington DC

The building enclosure of the typical office building falls short of being a dynamic element in the urban fabric, however by reexamining what it could be, some possible solutions surface. First the idea of the building enclosure serving a singular function is one that must be replaced. Rather, a building enclosure should serve an

array of functions, ranging from helping the city, to conserving energy. “Finally the façade system delivers the greatest performance to the building owner and occupants when it becomes an essential element of a fully integrated building design.”⁷ The enclosure is meant to be a dynamic zone, not a static skin. It should become an organizing space, which could filter storm water, or foster a better street environment and facilitate connection between people in the city. The enclosure should not be a barrier between two environments, but rather the element that unties them. “In a high performance building the façade solution must have the capacity to respond and adapt to these variable exterior conditions and to changing occupant needs.”⁸ Problems such as the reach of natural light can be addressed with the enclosure. This would reduce the need for artificial light, and the use of energy. Living walls that filtered water and created vertical parks that reduced the heat island effect are all possible with the right building enclosure. This would help re activate the street and it would connect people to the environment, both in and outside the building. The building enclosure should be seen as active member of the urban fabric.

The Office Space Problem

Currently, the typical office building is seen as a necessary place for employees to gather, it is designed to facilitate communication among the workers and provide a workspace for collaboration and individual tasks. However, there are several problems with the current office work space. Factors such as air quality and daylight represent major areas that need improvement. Other problem areas include

⁷ Selkowitz, Stephen E. 2001. *Integrating advanced façades into high performance buildings*. Tampere, Finland: Lawrence Berkeley National Laboratory, LBNL-47948 WG-431.

⁸ Selkowitz, Stephen E. 2001. *Integrating advanced façades into high performance buildings*. Tampere, Finland: Lawrence Berkeley National Laboratory, LBNL-47948 WG-431.

office layout as well as access to plant life. The current model of office design leaves a large percentage of people feeling disconnected and at odds with their work environment. These office conditions have negative effects on the health of employees as well as office productivity. They can even influence offer patterns that indirectly effect the profitably of the company. Several studies have linked both directly and indirectly the work environment to physical and mental disorders. Some practices are so severe, that they have been linked as possible causes of different cancers.

The effects of a poor office environment are far reaching, everything from employee health to the productivity of the company can be effected. “Work ability of white-collar workers in commercial services industry was strongly associated with psychosocial factors at work, such as teamwork, stress handling, self-development, and, to a lesser extent, with stressful life events, lack of physical activity, and obesity. Work ability was strongly associated with mental and physical health. Determinants of mental health were very similar to those of work ability...”⁹ It is critically important to address these typical subpar conditions, as it directly related to the design and layout of the space.

This not just a mental problem either, as the current office environments can also adversely affect the physical health of employees as well. In Japan, factory workers combat this with routine breaks for quick exercise during the work day. (See Figure 3) This approach, although effective in keeping employees active, doesn’t address part of the underlying problem. The work space today is often poorly

⁹ T. I. J. van den Berg, S. M. Alavinia, F. J. Bredt, D. Lindeboom, L. A. M. Elders, and A. Burdorf. 2008. The influence of psychosocial factors at work and life style on health and work ability among professional workers. *Int Arch Occup Environ Health* 81 (DOI 10.1007/s00420-007-0296-7): 1033.

constructed, built with lowest cost in mind. To add to the problem, employees often don't take ownership of their workplace, past the normal desk items. This leads to a lack of investment in the work place, and ultimately a lack of community and connection. "The strong associations between psychosocial factors at work and mental health and work ability suggest that in this study population health promotion should address working conditions rather than individual life style factors..."¹⁰ If we as architects and a society were to invest in better workplaces, companies would see direct and indirect improvements. "From the organization's perspective, the quality of the workplace is an important consideration that can give rise to substantial direct and indirect costs: direct such as energy and waste treatment costs, and indirect such as non-productivity and sick leave."¹¹ This approach is not a particularly radical one to take, as investing in employees can be seen as an investment in the company.

In John Berg's study and analysis, there are several recommendations made for the improvement of the work place. The tables below indicate factors that may cause a problem for employees, as well as the general office place factors. From these factors, it becomes clear was aspects of office space must be carefully designed, in effort to create space that is not counterproductive to the wellbeing of the office and its workers.

¹⁰ T. I. J. van den Berg, S. M. Alavinia, F. J. Bredt, D. Lindeboom, L. A. M. Elders, and A. Burdorf. 2008. The influence of psychosocial factors at work and life style on health and work ability among professional workers. *Int Arch Occup Environ Health* 81 (DOI 10.1007/s00420-007-0296-7): 1035.

¹¹ Bergs, John. 2002. The effect of healthy workplaces on the well-being and productivity of office workers. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

<p>Need for <i>change</i>. An environment with insufficient or no signals or stimuli (e.g. temperature, air, light, sound, visual contact) makes people uncomfortable.</p> <p>Ability to <i>act</i> on the environment and see the <i>effects</i>. If this is impossible, people have to suppress their needs and desires and constantly adapt their behaviour. This causes stress.</p> <p><i>Meaningful</i> stimuli. An ever-present non-identifiable smell causes a chronic state of distress.</p> <p>One's own <i>territory</i> to satisfy the need for an identity, safety and protection. Open-plan offices are virtually void of these elements.</p> <p>An <i>environment</i> that is <i>as natural as possible</i> with contact to the outside (view).</p>

Table 2: *Psychological aspects that play a role in complaints related to office buildings (Vroon)*

<ul style="list-style-type: none"> - privacy: nuisance caused by other people at the workplace, incl. interior noise - comfortable temperature: feeling chilly, cold feet, temperature fluctuations and draught (summer and winter), feeling hot (summer and winter) - air quality: dustiness, cleanliness (no odour), satisfaction with cleaning and relative air humidity - arrangement (functional and aesthetic): size of working and storage space and satisfaction with and influence on the arrangement and furnishings (posters, plants, etc.) - individual climate control: the control workers have over sun-blinds, ventilation and temperature - siting: accessibility of the building and amenities in the vicinity of the building - noise: noise nuisance from adjacent rooms and noise from outside the building - natural light and view: satisfaction with the amount of natural light, quality of view - visual comfort: amount of artificial light, quality

Table 3: Factors for distractions and complaints in work environments

His study argues the use of plants to improve the work place, as well as natural light over florescent light. Air quality and temperature also played a large role in the usability of the office. “Plants are capable of absorbing numerous (chemical) pollutants in the air. Many laboratory studies and experiments have demonstrated this

(Wolverton).”¹² Finally office layout was a deciding factor in the health and productivity of the typical employee. Berg cited several studies in his report, one which estimated that 15% of productivity loss was directly related to the work environment and building. Employees were quoted reporting that “...building-related complaints have a (highly) inhibiting influence on their productivity.”¹³ The office space as it stands needs a critical evaluation in order to improve the connection between people and the building they work in. Furthermore, the office space of the future should not only benefit employee health, but it should also engender a community among the work force employed there. The building enclosure will surely place a vital role in this objective, as an organizer of space and program.



Figure 3. Employees practice their morning routine outside their place of work.

¹² Bergs, John. 2002. The effect of healthy workplaces on the well-being and productivity of office workers. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 10

¹³ Bergs, John. 2002. The effect of healthy workplaces on the well-being and productivity of office workers. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 8

The Opportunity Within

In conclusion, we see that there are a number of problems that affect the current office building model. From the street face to the design of the work space, there are areas in need of improvement. The building enclosure is the starting point, with its potential, comes a opportunity to address and improve several flaws of the typical office building as it stands. With all problems, there is opportunity, in this case it's the practice of re skinning office buildings. This common practice affords us the change to change from skin to zone, and from static to dynamic. The following chapters begin to examine examples of what might help guide the design of this new building enclosure. Staring with the urban scale, the chapters work their way down is scale, allowing for a truly in depth study.

Chapter 3: The Urban Context

Introduction

In this chapter, the urban street and its relationship to the building is examined. The goal of this chapter is to establish a better understanding of how the street relates to the build, and how a building's enclosure could either positively or negatively impact the urban environment. My primary interest lies in the first floor of these streets and buildings, as that is often where the most interaction can occur. Secondly it is also important to still consider what happens above the first floor, as this will undoubtedly impact the design of the final building enclosure.

In order to better understand how the urban street works, a few examples of active streets have been selected. The sites vary in use, program and density among other things, but they all offer an example of a lively and engaging urban environment. Finally this chapter will briefly examine some urban scale problems such as the heat island effect and what possible solutions could come from the building enclosure. One of the major underlying elements of my thesis is idea that the building could and should help its surrounding urban context. Can the building and the urban fabric have a symbiotic relationship? Can each benefit and help the other? I hope to show the building enclosure is a way to strengthen this symbiotic relationship.

Streets to learn from

M Street – Georgetown, DC

M Street in northwest Washington DC, is a prime example of an active and engaging street. It offers countless opportunities for interaction between the pedestrians and the buildings as well as the city. The particular section I am referring to, is the segment between 28th and 34th streets. The ground floors and building fronts provide an environment that is rich in detail, walkable and filled with life. M Street is also an attractive scale and proportions, the building masses are reasonable in relation to the width of the street. Elements such as gas lamp provide an attractive backdrop as well as an extra layer of detail. The building facades themselves are rich with detail, making for a visually interesting street elevation. In the photograph below, pedestrians can be seen moving about with the buildings in the background.



Figure 4: A view of Georgetown during the day.

Although M Street is a strong example, with many aspects I wish to reproduce, it does have some flaws. For example the sidewalks are too small to accommodate the busy traffic as well as the store fronts. All of these elements squeeze the sidewalks, making for the occasional awkward interaction between pedestrians. Another problem with the street is the lack of vegetation, while present in some spots, the design lacks cohesiveness and is sparse. Below are a few diagrams that start to tease out the main ideas behind M Street.

Broadway Avenue – NYC

Broadway Avenue in New York City is another strong example of a street that has many qualities that would be beneficial to K Street. The avenue itself runs the entire length of Manhattan and changes dramatically from top to bottom. However the section of the Broadway that provides the best feedback is around time square and 7th Ave. While Broadway and M Street share some similarities, the larger scale and higher density of NYC changes the street section. The ground floors are related that they both offer retail options and engage the street through that program. However Broadway offers a higher density of this retail program. It can be observed in the street vendors and the plazas that occur from the angular cut Broadway makes while crossing the grid. The scale of Broadway also proves that larger buildings are just as capable of being connected, as their smaller counter parts. Furthermore, while the proportions of the street are changed, they still work. This is partly because of rich and detailed facades, but also attributable to the higher density of New York City. The result is two very different streets that accomplish the same thing. However there are some problems with the height of the building faces on Broadway. For example,

the buildings can block sunlight, and create a canyon effect. They also reduce the views from other buildings, resulting in the office windows looking out onto another façade. Still, the detailed nature of the facades offer some relief from the regular grid. This is not as present in the facades of K Street, which poses a problem. Another critique of this section of Broadway is the lack of vegetation. In the photo below, the active nature of Broadway is clear.



Figure 5: A view of Broadway Ave in NYC, during a typical afternoon.

Gensler's lobby

Gensler's Washington DC office presents a unique experience in relation to the street. Although the building is not completely public, its lobby is designed more to look like a café and lounge for employees, rather than the traditional office building lobby. The result is a street face that presents and offers visual connection and interaction without actually using a retail program. This is interesting, because in places where retail is not a viable option, this could help engage the street. It does, however come at a cost. The lobby is not meant for pedestrians off the street, so this occasionally leads to confusion and it does not offer a truly authentic connection to the street. However, examples like the Unilever office building or public gardens on the ground floor could help complete the picture. This would allow for lobbies like Gensler's while still offering a public oasis from the street. In turn, this would create a richer street environment, and offer a deeper connection between the building and urban fabric. The photos below offer a glimpse into the lobby as well as show the outside experience of the office lobby.

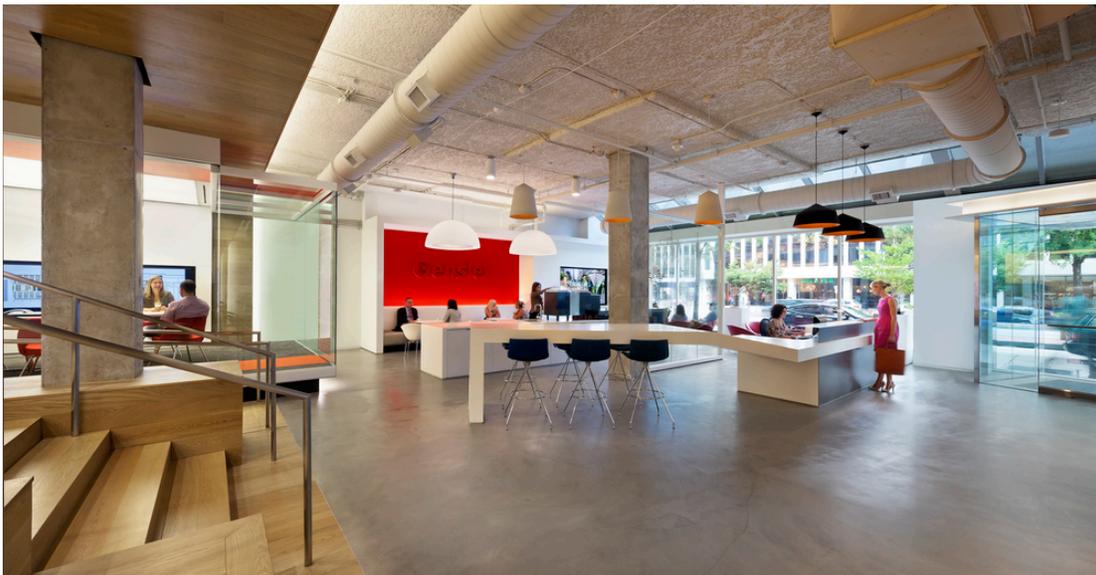




Figure 6: (Previous page) an interior view of the Washington DC lobby for Gensler.
Figure 7 (Above) a view of the exterior of the Gensler office.

The Vertical Park

The concept of the vertical park is one that I feel is important to the urban context of the building. In a nut shell, the idea of the vertical park is to create a landscape of greenery using living walls, or vertical bioswales to add interest to the street while helping to reduce pollution in the city. While cities, especially Washington DC, go to great lengths to incorporate parks, one of the more under developed areas is the idea of the living wall. “Parks serve many functions in urban America. Principal among these is that parks provide sites of active and passive recreation for people in surrounding neighborhoods.”¹⁴ Although the living wall is arguably more complex than a traditional park, it offers a unique way to engage the street. In places where retail may not be a viable option, adding in a well-planned

¹⁴ Solecki, Willian D., and Joan M. Welch. 1995. Urban parks: Green spaces or green walls? *Landscape and Urban Planning* (32) (Oct 25): 93-106.

park or living wall can help increase the street presence as well as better connect buildings to the urban fabric. By creating a visual point of interest, the living wall helps engage the surrounding environment. Living walls also offer an environmental benefit to the city, helping to reduce emissions and filter water. From a social perspective, the vertical park can be a great connector for smaller parks, making a liner system that connects all parts of the larger urban context. It also offers an opportunity to provide great visual interest for pedestrians and cars alike. This is of course, on top of the other more performance based aspects of these parks, like the reduction of the heat island effect. The vertical park can provide a different canvas for the city, while connecting buildings and providing environmental services for the building and city alike. It would also reduce the monotony of the typical office façade and provide an interesting and engaging backdrop for the street and city.



Figure 8: A rendering of the vertical park idea.

The Heat Island Effect

The heat island effect is a major problem for many larger cities. In short the density, energy use and pollution of the city cause the ambient temperature to rise and hold at a higher rate and number than the surrounding region. This is a result and indicator of the amount of greenhouse gases being released into the atmosphere. This effect is caused by several factors, “In a city, modifications of the energy balance can result from any or all of the following: 1) furnace heating, 2) limited amounts of surface moisture, 3) urban structures, 4) atmospheric pollution.”¹⁵ The problems this causes for the city are numerous as well. Typically in larger buildings, cooling is predominately the issue, so a rise in temperature can drastically increase the operating cost of the buildings as well as tax the city’s energy infrastructure. On top of this, the heat island effect can create uncomfortable living conditions as well as poor air quality. These can cause problems with the health of people living in the city on a physical and physiological level. In fact, it is common practice to line roofs of buildings in urban environments with a light or white gravel or surface to reflect as much sun light as possible. However green roofs and living walls have been shown to reduce this temperature rise even further, by reducing greenhouse gas emissions and retaining a higher level of moisture, resulting in a better evaporation process. The use of these roofs and walls on buildings could help reduce the heat island effect and return the city to a more stable temperature, closer to the ambient temperature of the region. This would help remove polluted air from cities and help improve the quality of the air for the city. This is critical as global warming is increasing the overall

¹⁵ Bornstein, Robert D. 1967. Observations of the urban heat island effect in New York City. *Journal of Applied Meteorology* Vol 7 (Oct 19): 575-86

temperature further compounding the problem. On top of this, greenhouse gases are a leading cause of global warming, meaning that cities are playing a direct role in contributing to the over production of CO₂ gases. On the next page, the image helps diagram the flow of hot and cold air through cities, and the regional effects the higher temperature has on the surrounding region.

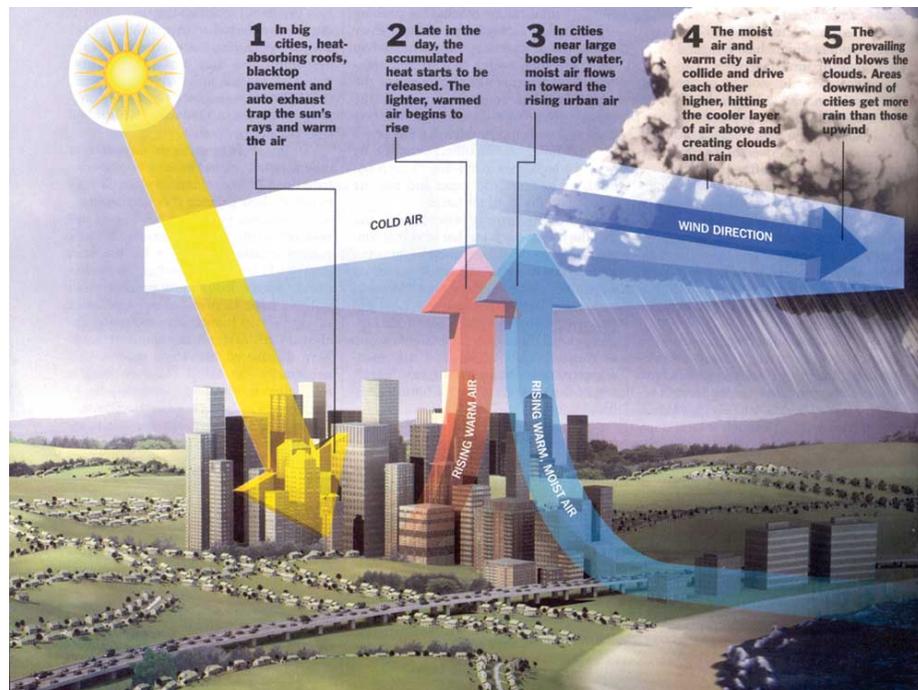


Figure 9: A diagram of the heat island effect

Chapter 4: The Façade Study

Introduction

Chapter four is an in depth look at various parts of the building enclosure. The purpose of this exercise is to reach a better understanding of these components, while also reviewing the technical details that make up these enclosures. The goal of this chapter is to organize and document the study of façade precedents in order to summarize the findings. The summery of these findings, in combination the typical construction details, will be the basis for the research catalog. This catalog will inform the design of the final project, both from a technical and theoretical level. It is critical to understand the base ideas of building enclosure before moving forward, because the foundation of the final project will rest firmly on this base. While these facades may not offer the dynamic elements needed for the success of the final project, they do offer insights into the possible directions for the final design. The main part of the enclosure research is the building enclosure matrix, while the actual architectural details are broken up into the three categories noted below.

The Matrix

In order to understand and catalog the various facades of buildings that may influence the final enclosure, the matrix was created. The matrix is a grid that allows the facades to be arranged according to different variables, with the intent of understanding what attributes of each façade could be useful or unnecessary. Currently the matrix is laid out according to general categories regarding different classifications, such as living walls, etc. These categories are the base columns of the

grid, while the rows begin to inform the user of the level of intervention. For example, an enclosure lower down the column would be considered to be a heavier intervention, meaning that the enclosure is more integrated into the building as a whole. This means the enclosures that are lower on the grid, are also more dynamic and offer more potential solutions for creating a more connected enclosure. The matrix is a research tool, designed to better equip me with the information needed to approach the design problems outlined in Chapter One. Each of the five inch square tiles on the matrix contain a façade and some basic information about the façade in the form of icons. There is also a number, this number correlates to a PDF file that contains a more detailed page examining each façade. These one page information flyers, as well as a detailed key for the Icons are in the following pages. Below is a diagram of the matrix, the table is top down and allows for varying degrees of completion. The squares are representative of one façade study.

The Icons

-  • The AIR Flow icon is used to indicate that the building enclosure has elements that help with air quality or natural ventilation. These enclosures will provide some benefit to the air outside or inside the building.
-  • The LEAF icon is used to indicate that the building enclosure has elements of a living wall or support plant life. These enclosures will help with the environmental impacts of the building.
-  • The WATER icon is used to indicate building enclosures that respond to storm and rain water. These enclosures may be collection or filter points for water.
-  • The SUN icon is used to indicate building enclosures that respond to natural light or collect solar energy. These enclosures may provide energy for the building or effectively control solar exposure.
-  • The LAYER icons indicate the type of building enclosure in relation to skins. I.e: Single vs. Double skins.
-  • The DEPTH icon indicates the depth of the building enclosure.
-  • The DYNAMIC/STATIC icons indicate whether the building enclosure responds to its surrounding environment or has moving components that interact with outside inputs.
-  • The SOCIAL icon indicates whether the building enclosure has a social element. These enclosures either allow for occupation of space or engender connection between people.
-  • The GLASS icon indicates the amount of glass the building enclosure has, in a percentage value.

Façade Details

In short, this section of chapter four is focused on understanding the basic technical details behind enclosure elements such as the living wall or green roof. The following details are designed to give a basic understanding of the composition of these building elements. Although the final design may be a hybrid or vary from these details, it is important to have an understanding of how each of these aspects work before the design process begins.

Green Walls and Roofs

Green walls and roofs vary from design to design, however there are some typical elements found in most details of these building components. The green wall and roof must perform a few functions well, in order to be beneficial to the building. First these details must perform as a regular wall or roof would, keep the rain and water out, insulate the building and enclose it. The added challenge is in supporting the green element, such as plant or grass life. These systems must have a stronger structural system in order to support the added weight of the plants, dirt and other components. The green wall or roof must also have a system for irrigating the plants without damaging the building. Another challenge of the green wall or roof is maintenance. These systems need to be serviced to varying degrees, an important factor to consider in designing them. Despite the added challenges of these green systems, they also have many benefits as well. Green walls for example can filter storm water and reduce carbon foot prints of buildings. Green roofs can even reduce

the heat island effect in cities and cut cooling costs and energy use.¹⁶ On top of these performance gains, green systems also provide a visually pleasing environment. As noted in the following chapter, plant life can positively impact the productivity and health of people. These green systems can serve a multitude of functions that benefit the building and urban environment. With careful consideration in regards to placement and location, these green systems can provide huge benefits to the building and its surrounding context. Below are examples of the typical construction of both a green wall and green roof.



Figure 10: A diagram of the construction of a living wall.

The typical green wall is comprised of a structural element, such as a CMU or steel wall that can support the added weight of the plant life and growing media. The wall is then comprised of several weather liners that keep moisture and water off the structural wall. From there, an insulation and mesh system for holding the growing media are applied. Finally the growing media, typically a mineral and vitamin rich

¹⁶ Takebayashi, Hideki, and Masakazu Moriyama. 2007. Surface heat budget on green roof and high reflection roof for mitigation of urban heat island. *Building and Environment* 42 : 2971-9.

dirt is attached with the plants already growing. This creates the basic living wall, although the method for attaching the plants can differ. Another important note is that some walls will have internal drip systems for watering the plants. Other systems may capture rain and storm runoff for watering the plants. A green roof is similarly made, however extra attention is paid to the structural loads from the growing media. Other important factors include water proofing as the horizontal surface is more prone to standing water and possible leaks than a vertical one. The green roof may have a thicker slab for more robust plants, or it may offer a smaller scale growing field. These smaller scale roofs rely on grass and other low care plants which offer less maintenance requirements and work better in drier environments. Below is an example of a typical green roof construction.

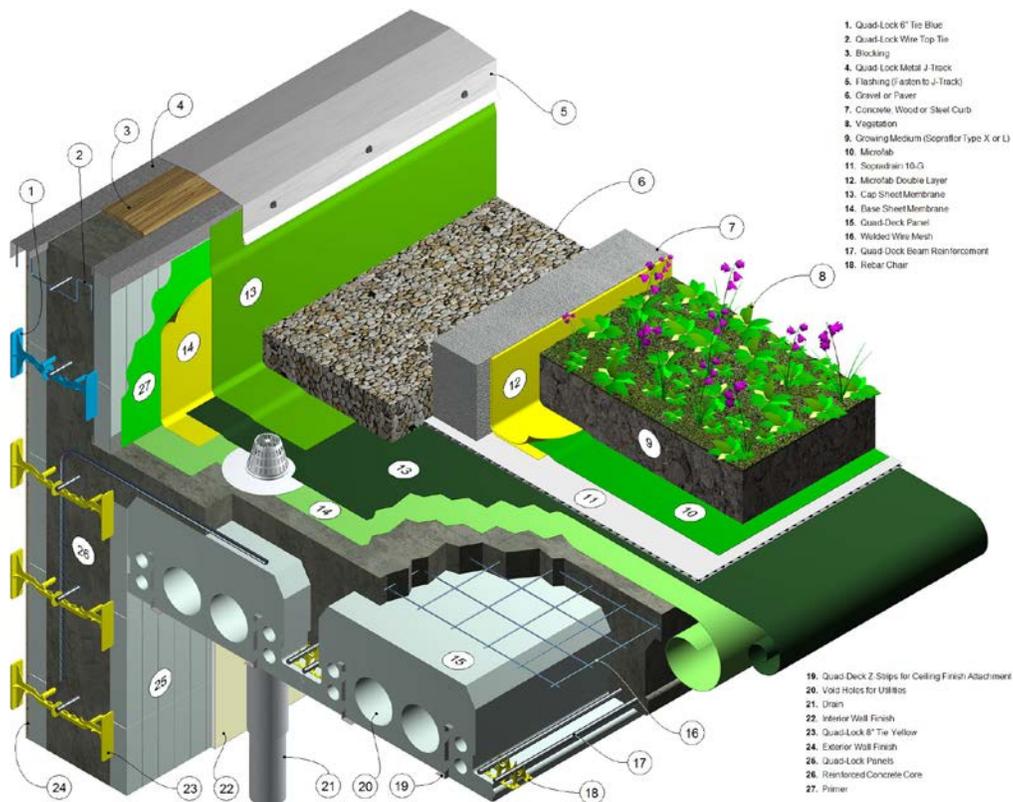


Figure 11: A diagram of green roof construction components.

Solar and Light Controls

Another critical element of the building enclosure is the control of light and admission of sun into the building. The building must be able to filter and regulate direct sun light, while still allowing natural light in. In most applications, the diffuse glow of natural light is a valuable asset. On the other hand, the direct and UV rays of sun are undesirable because of the heat they produce and the fading they can cause. This is especially true in office building environments as direct light and natural light have direct correlations to the health and productivity of the employees. There are many ways to control and admit natural light into buildings via the enclosure. Mechanisms such as light wells, louvers, solar shades and light boxes are all valuable tools in regulating light. On top of those tools, different window types and tints can also help control the sunlight. It is important to consider carefully what application should be used, given the site and context of the building. A building's siting can influence whether sun shades are vertical or horizontal. The time of year and season can also play a large role in the best choice for controlling light. In the case of office buildings, a larger amount of diffused natural light is good, so window systems and shade controls that block direct sun are good. They must however, allow for decent views out, as well as let light in on cloudier days. Dynamic controls, such as automated shades or even double skins that react to the amount of sun light hitting the building are good at regulating the light in real time. However these systems can be costly and require more maintenance than static systems. Simpler systems like screens and louvers, although cheaper, have tradeoffs as well. Clear views can become compromised when using screens and louvers. Other problems may include

the integration of these systems into the building's design and function. It is important to design the controls from the start, and to use a variety of tools, in order to produce the best results.

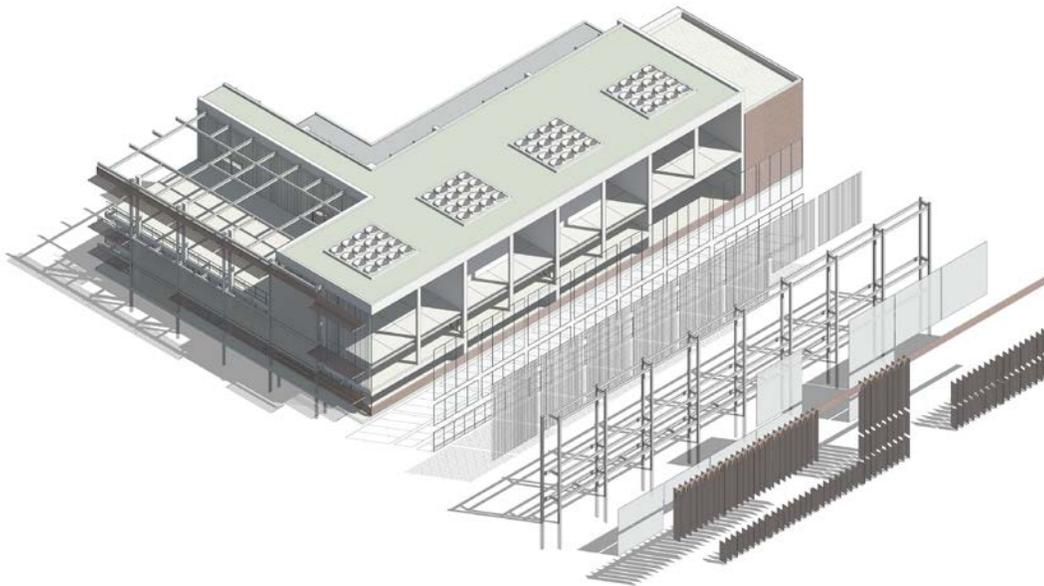


Figure 12: A diagram of a layered structural systems for light control

Another major aspect of sun control is energy collection. The sun produces enough energy every hour to power the world's electrical demands for a year. The problem is collecting it. Still, solar louvers using photovoltaics are a valuable part of building enclosures. They can provide a large amount of renewable energy for the building and help offset energy costs. This will not only put money back into the building owner's pockets, but also reduce the strain on the city's energy grid and help reduce the use of energy city wide. Photovoltaic arrays work well with existing louvers, because they require little more than a flat surface. This makes retrofitting an existing building easier. The thin nature of the panels makes them very flexible and

allows them to be placed with ease. The louvers can then become dynamic, and track the sun for maximum efficiency, producing the most power possible. At the same time, these louvers would also block out the unwanted light more effectively as well. Overall, shading and control systems combined with energy collection make the building enclosure a highly productive part of the urban fabric, while offering many benefits for the building and its occupants.

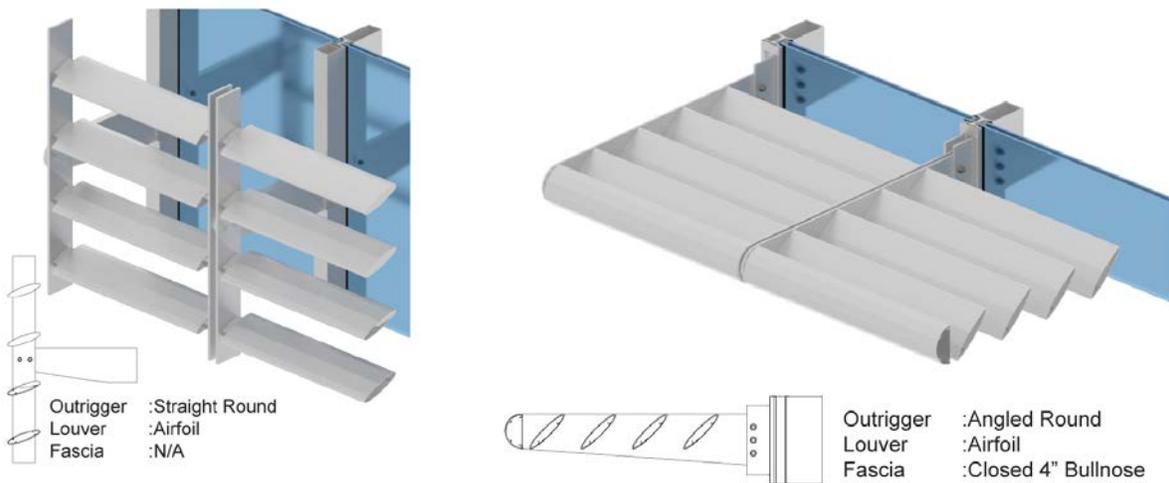


Figure 13: A detail on louvers for light control and energy collection.

Wind, Rain and Air

Air quality and control is extremely important to the usability of building, this is paramount in the workplace, as poor air quality or temperature problems can cause a serve drop in productivity. On top of that the indirect cost of over cooling or over heating can cost the company valuable money in the long run. The building enclosure plays a direct role in the control and regulation of the building temperature and the indoor air quality. Like the human skin, the building enclosure can allow for natural ventilation and regulation of temperature. At the same time the enclosure must also protect the building and its users form harsh weather and temperatures. Elements such

as operable windows can help cycle natural air throughout the building. More complex systems like double skin enclosures can provide natural ventilation even at high levels, where wind is a problem. The building enclosure can also use this system to cool the building naturally. While tall buildings face problems with high wind, the building enclosure can capture these winds, turning them into energy for the building. The use of wind mills on buildings has shown that a considerable amount of energy can be collected from the higher altitudes of the city. An enclosure that integrates this into its design would allow for a more dynamic building. Another aspect that building enclosure must tackle is the weather, particularly rain.



Figure 14: The San Francisco Federal building by HOK. The building uses a double skin to offer occupants natural ventilation

Rain is a major challenge for most building enclosures, as the water can be very disruptive over time, however this storm runoff also presents a unique

opportunity. The enclosure can collect this rain water, while keeping it off the building and use it for watering the site or even filter it for the city. In effect, this would make the building enclosure a productive part of the urban fabric. Currently, rain screens and curtain wall systems focus on channeling water away from the building. A more dynamic façade would be able to capture that water and use it for the benefit of the building and even the surrounding context. Current rain screens work by presenting an outer shield that the rain can drip down, keeping the bulk of water off the building. This is a smart practice, because the building doesn't need to be protected from water infiltration as heavily, allowing for the use of natural ventilation, and a more pleasant indoor environment. Below is a typical detail of a rain screen and flashing detail. The water is allowed to infiltrate the first layer, but the inner layer is protected by the water proofing. Rain screens also offer shading opportunity's as well as potential structures for living walls.

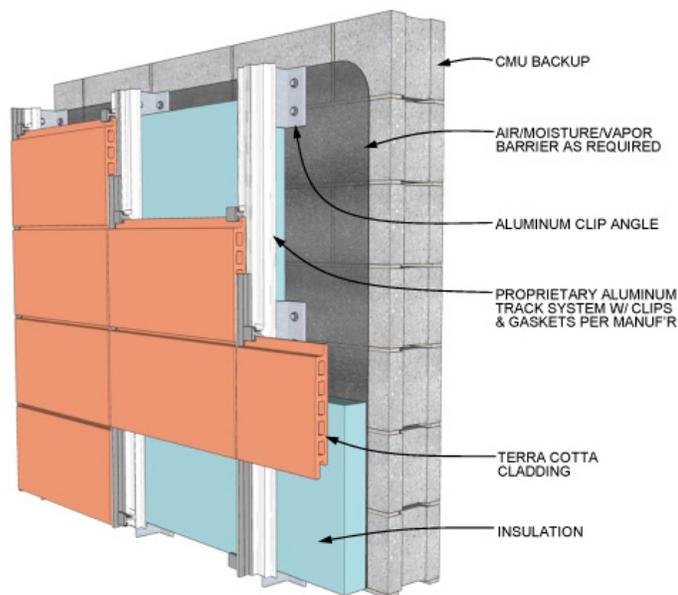


Figure 15: A diagram of a rain screen detail.

The Catalog of Elements

PAGES 44-58



Sihlcity Carpark Facade

Zurich, Switzerland

Architect: Theo Hotz

Date: 2007

- The parking structure hosts a mesh system that supports the growth of the ivy, while keeping the building separate.
- The mesh frame sits 700mm from the face of the garage
- The rough size is eight stories by 25m
- The plants are a mix of Chinese Wisteria and Birthwort



One Central Park

Sidney, Australia

Architect: Jean Nouvel

Local Architects: Johnson-Pilton-Walker & Peddle-Thorp-Walker

Date: 2013

- The building is the largest vertical garden built to date
- 15000m of stainless steel cable used to support the gardens
- Contains over 2500 climbers and vines



Vertical Living Gallery

Bangkok, Thailand

Architect: Shma + Sansiri PCL + SdA

Date: 2011

- Art Gallery with modular plantings
- Hanging plants watered with drip system
- Tokyo Dwarf is plant used due to its hearty nature



Process Zero Building

California, USA

Architect: HOK / Vanderweil

Date: 2011

- Algae filled tubes used for multiple functions, including fuel
- Reduced energy use of existing building by 84%
- Algae is fed via waste water of building



Tour végétale de Nantes

Nantes

Architect: Edouard François

Date: 2012

- Plants best suited to rocky conditions will be used
- Stainless steel tubes recreate growing conditions
- Building showcase the collection of species found



Green Renovation

Hanoi, Vietnam

Architect: Vo Trong Nghia Architects

Date: 2013

- Steel rods hold vines together
- Tropical plants used to keep ecosystem in check
- Serves as a small scale model for tropical green walls



Metropolitan Green Building

Brooklyn, NYC

Architect: Mark Helder

Date: 2009

- Solar panels become part of facade
- Buildings façade is modular to work with panels
- Uses solar power, in combination with passive cooling and heating



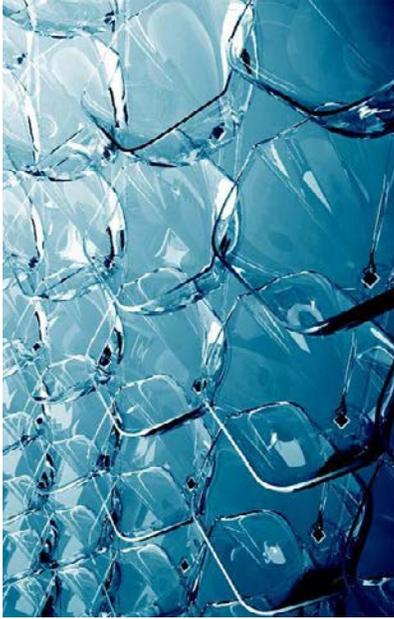
Al Bahar Towers

Abu Dhabi, UAE

Architect: Aedas Architects, Abdulmajid Karanouh

Date: 2012

- Computer controlled shades reduce solar gain by 50%
- Based on the Muslim mashrabiya
- 2m of the interior wall, with its own support frame



Concentrating Solar Glass

Architect: The Center for Architecture Science and Ecology

Date: On going

- Glass shape focus light and tracks sun through out the day
- System is more efficient with smaller panels, and greater visibility
- Cost effective shape increases natural light in building



Israel Museum

Jerusalem, Israel

Architect: James Carpenter Design Associates

Date: 2010

- Terracotta rain screen
- Shades and protects glass in building
- Static in nature and use



Indigo Bio-Purification Tower

Architect: Ted Givens, Benny Chow, Mohamed Ghamlouch
Date: Concept

- Building façade filters air and produces water
- Tower broken down into three bars to maximize the surface area
- Uses nano coating of titanium dioxide to filter elements



The Facades of NOLA

New Orleans, LA

Architect: -
Date: -

- Building faces offer a mixed zone between public and private
- 2 to 3 Story typology facilitates connection to the street
- Planting, and iron work add shade and detail to facades
- Rain is kept off the face of buildings
- Natural ventilation is possible through large openings



The Facades of Madrid

Madrid, Spain

Architect: -

Date: -

- Building faces offer a mixed zone between public and private
- Typology creates a social connection
- Form and proportion aid human connection
- Smaller spaces hang over streets



Mongkok Residence

Hong Kong S.A.R., China

Architect: Aedas

Date: Concept

- Stepped structure helps increase views
- Modern take on a crowded typology
- Form and proportion aid human connection



IT University Building

Copenhagen, Denmark

Architect: Henning Larsen Architects
Date: 2004

- Cantilevered spaces connect to the atrium
- Glass walls create abundant visual connection
- Public spatial lay out rethinks typical space design



Praham Hotel Restaurant

Melbourne, Australia

Techne Architects
2013

- Modular pipe system makes space in facade
- Glass walls create abundant visual connection
- Facade becomes a programmatic space



Hong Kong High rises

Hong Kong

Architect: -

Date: -

- Cantilevered spaces connect to the atrium
- Lack of space forces tight program
- Form and proportion not at human scale



Mexico City Hospital

Mexico City, Mexico

Architect: Prosolve370e

Date: 2013

- Nano coating eats smog, with Ti Dix compound
- Dual skin structure
- Also acts as a sun shade



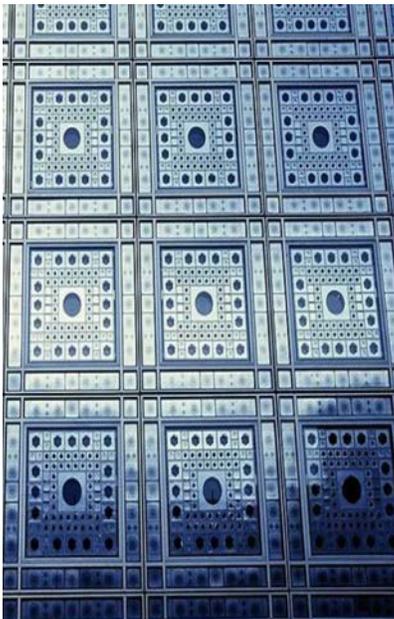
Iluma Shopping Center

Singapore, Thailand

Architect: Realities united

Date: 2012

- Plastic and composite façade lights up to display info
- Modular construction creates easy service
- Structure found behind, connects the building walls



Institut du Monde Arabe

Paris, France

Architect: Jean Nouvel

Date: 2010

- Metal panel responds to light
- Light and heat cause panel to close up
- Based on Arab architecture



NOI Hotel

Vitacura, Chile

Architect: Jorge Figueroa
Date: 2009

- Wood rain and shade system
- Reduces heat gain
- Very sustainable, light weight and easy to service



Galleria Centercity

Cheonan, Korea

Architect: UN Studio
Date: 2010

- Creates dynamic optical illusion
- Two layers of aluminum panel and cladding
- Back of each panel waved, to create light effects on building



Media-TIC Building

Barcelona, Spain

Architect: Cloud 9
Date: 2011

- ETFE cells open in winter and close in summer, keeping building in comfort zone
- Opacity changes to shade and cool building or let in light
- System based on computer controlled sensors, that optimize building energy use



Vertical Park

Coyoacan, Mexico

Architect: Jorge Hernandez De La Garza
Date: Concept

- Mesh like structure allows for multiple uses, including urban farming
- Other elements such as water reclamation and solar energy collection
- Modular design allows for incremental growth



PARK ROYAL Hotel

Singapore

Architect: WOHA Architects

Date: 2013

- Elevated balconies allow for vertical gardens
- Variety of plants used to create tropical gardens
- Building also uses outdoor hallways to further connect to the gardens



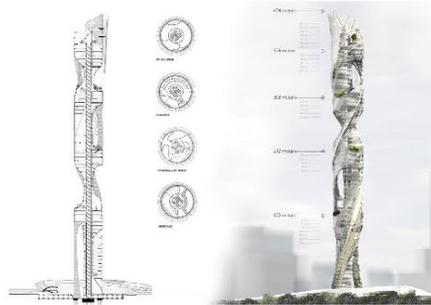
Taiwan Tower

Taichung, Taiwan

Architect: Raymond PAN/HMC Architects

Date: Concept

- Building captures wind through openings in the facade
- The building can produce up to 185% of its energy needs
- The design also acts as a vertical museum, showcasing the cultural history of Taichung





BLOOM

California, USA

Architect: DO|SU Studio

Date: 2011

- Layered metal responds to temperature changes
- The curling motion allows for natural ventilation to occur
- Currently undergoing more testing for market applications



Federal Building

California, USA

Architect: Morphosis

Date: 2007

- Building allows for operation of windows
- Double skin façade acts as a rain screen and shading device
- Navigates need for security and public access



Responsive Kinetic Facade

Budapest

Architect: Peter Sugar, Laszlo Benczur

Date: 2006

- Building responds to input from environment
- Sensors track wind, temperature and light to create a different facade
- Using light, contrast and color, the building communicates the environment around it



LED Action Facade

Madrid, Spain

Architect: Maria Langarita, Victor Navarro, Juan Palencia, Roberto Gonzalez

Date: 2008

- Building facade is comprised of LED panels
- Screen is used for multimedia
- Using light, contrast and color, the building communicates the environment around it

The Take Away

In conclusion, most of the facades studied offered singular uses. There are a few exceptions to the rules, such as the Process Zero Building by HOK. However the bulk of the buildings cataloged demonstrated a strong execution of one objective, but they failed to be truly dynamic in the sense of acting in multiple capacities. This does not mean, however that they should be ignored. Rather all of the facades in the matrix offer unique insight to the function of active and passive features. This collective knowledge can and will be used to direct the design of the final project, specifically the enclosure. The goal of this study was to reach a better understanding of what has already be tried, and perfected. It was also an exercise in understanding more about the technical aspect of the building enclosure as well as the possible materials available. Furthermore, this study can begin to shed light on the effectiveness of each of these approaches as well as the cost of the building enclosures. This will provide useful information when the design process is at a more developed stage.

Chapter 5: A Better Work Place

Non Traditional Work Places

NPR

The NPR Headquarter building in Washington DC is an adaptive reuse project, designed by architectural group Hickok Cole. Completed in 2013, the modern office building is part new construction, part historic renovation. The office building supports the typical office space program as well as the broadcast studios for NPR. There are several key aspects about the building and spatial layout that make it an outstanding example of a positive work space. First the use of natural and artificial light is well balanced, a large clearstory above the main floor slab and allows for a large amount of natural defused light to enter the office space. On top of this, a crisp white artificial light has been used, to reduce the harshness of florescent light. The result of this, is a well-lit and even distribution of light in the work space. The open floor plan allows for maximum benefit, either from large side windows or the atrium light. The open plan is also balanced with private work stations as well as rest areas, allowing employees to focus themselves, if needed. The open plan is effectively balanced with the private rooms of the building. Another key aspect, is the movement of the circulation program to the exterior edge of the floor plate. This allows for community spaces to develop close to the large windows, making the most of the natural light. The cubicles also benefit, as their views out are not as obstructed by the

open hallways. This direct sun light is tempered by a vertical sun shade system comprised of blue panes of glass. This diffused the direct light and creates a colorful pattern on the floor of the circulation paths around the building. Furthermore, the community spaces are comfortable, open and abundant. Bright colors in the scheme lighten the work place, and offer visual interest. Although the building's façade is still a thin wrapper, the movement of circulation and collaboration space to the outer edge makes for a balanced work place. This combined with the excellent light quality of the space help create inviting and comfortable work spaces. The building does not have natural ventilation opportunities, and workers in the open areas do not have as much control over the temperature of the air in their work spaces, however the building still exemplifies many other positive qualities in regards to office design.

Figure 16: Interior of NPR office building

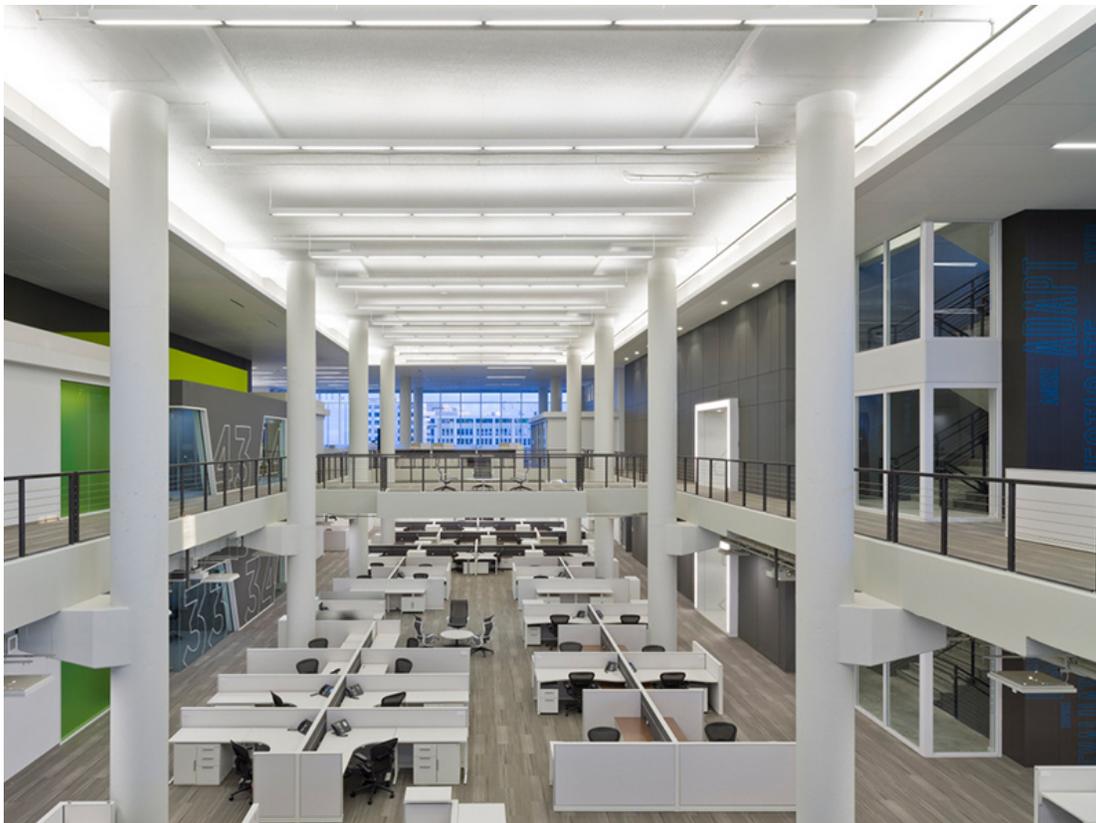




Figure 17: Hallway of NPR office. Below: Figure 18: Private space for office employees.





Figure 19: View of café in NPR office. Below: Figure 20: View of NPR lobby.



Unilever Building Headquarters – Germany

The Unilever building in Germany shares many of the same qualities of the NPR building. Completed in 2009, it serves as the flagship building for Hochtief Unilever. The 215,000 square foot building is located in Hamburg, and offers spectacular views of the water. Behnish Architects designed the building with its maritime context in mind, describing it as “ship moving out to sea.”¹⁷ The building enclosure is a double skin system, comprised of a standard curtain wall, as well as a ETFE membrane that wraps the entire building. It is one of the largest in the world, and offers each employee personal control over the temperature of their work space. This is achieved through operable windows found in the inner layer. These windows can be used rain or shine, because of the double skin, resulting in more comfortable and personalized work environments. Natural ventilation is fully available to the building, as each room has operable windows. The building also controls and uses natural light very well, the atrium has a massive sky light that allows the sun to light the building from the outside and inside. This results in very well lit office spaces, and the soft glow through the day. The building also uses the double skin to shade the offices from direct sunlight. Other innovative factors include the circulation patterns of the building as well as the first floor. All the hallways are around the atrium, with communal and collaboration spaces off of them. This results in a shared space with open views throughout the building. The atrium itself is a like a mall, with the first floor being dedicated to shops and a cafe that captures the view of the bay. The building is truly mixed use, and offers places for the employees to relax and meet

¹⁷ Kerstin Zumstein, and Helen Parton. 2011. *Total office design : 50 contemporary workplaces*. 1st ed. London: Thames & Hudson.

outside the typical office plan. Although the building does not have a large open plan layout for the work space, it does have smaller zones of offices that allow for communication very easily. All the offices are connected by the hallways lining the atrium, allowing for easy inter zone communication. The Unilever building is a fantastic example of a well-planned work space. Its sustainable and thoughtful design allows employees control over their work spaces. This, in turn creates a more productive office, and a healthy work place. The building's use of natural light as well as natural ventilation makes for an ecofriendly environment, as well as a comfortable place to work. The layout of the office and the mix use elements allow the public into the building and offer employees a variety of options. All of this makes the work place less of a temporary setting and more of a personal experience.

Figure 21: View of hallway in Unilever building.





Figure 22: View of atrium in building. Below: Figure 23: View of exterior of building.





Figure 24: View of lobby desk. Below: Figure 25: View of ground floor of building.



Microsoft Dutch Headquarters

The Dutch headquarters for Microsoft is located in Amsterdam, the project was completed in 2008 by architectural group SevilPeach. The 117,000 office is a homage to the past, with a retro aesthetic throughout. The office is designed to showcase the power of Microsoft's programs in regards to work productivity. The entire office has no dedicated desks or offices, rather the space is comprised of open plan work stations. Café tables and single work stations provide the work space for the employees, leaving large amounts of space for community and collaboration areas. Conference rooms of various sizes are available throughout the building to help facilitate meetings. The central stair case is the heart of the open plan building with all the group work space pushed out towards the windows. This allows natural light to fill these spaces, while sheer curtains help control the direct sun light. What's most notable in the Microsoft office space is the abundance of community spaces, the ratio of private work station to open space is vastly different from the typical office plan. The office encourages people to work where they feel most comfortable, and as a result, they have. The office has seen a decrease in the use of traditional work spaces, in favor of more open community space. Areas like the café and food corner are most popular.¹⁸ Furthermore, the switch to community space over private space has improved the communication of the employees, as well as the productivity. The building also offers opportunities for employees to work outside, weather permitting. Although the layout of this office is an excellent example of open plan office space, the building still does not offer natural ventilation or personal control over the

¹⁸ Kerstin Zumstein, and Helen Parton. 2011. *Total office design : 50 contemporary workplaces*. 1st ed. London: Thames & Hudson.

temperature. Although one is free to move to a more comfortable area, as the “desk” is seen as extremely flexible. While the building does offer lots of natural light, it does have problems getting the light all the way into the heart of the building. There are some skylights that help with this problem, although the levels of light are not ideal. The color scheme of the office does offer a bright and cheery atmosphere, which helps. The furniture is also designed to be comfortable as well as flexible allowing employees to adapt spaces to their needs. This adds a personal element to the space, helping to offset the lack of dedicated desk space. Overall, the different approach to office layout seen in Microsoft’s building offers a fresh perspective on what the work space could be. The architect’s nod to the past with the retro decor, while looking to the future of the work place is not lost in the building’s program.

Figure 26: View of office cafe





Figure 27: View of main atrium in office. Below: Figure 28: View of conference room





Figure 29: View of outdoor space. Below: Figure 30: View of open plan work space



Energinet Headquarters

The Energinet headquarter building is more of an open plan mall than office. The building is centered on a singular large atrium, with the collaboration space located in the center. The building was completed in 2007 and is just under 200,000 square feet in size. Architects Hvidt and Molgaard designed the building to be extremely energy efficient, while also being very easy to maintain. As a result the building's finishes are heavy duty and easy to clean. The building controls light in order to filter out direct sun light. The result is a large open space with a glow of diffused natural light. The offices use both exterior windows and the atrium to maximize the natural light while reducing the use of artificial light. To control the light, the building enclosure has a system of vertical and horizontal louvers that protect the deep inset windows. These louvers still offer largely unobstructed views out, allowing people to connect with the surrounding landscape. The building program on the first floor is a large open plan with a focus on group and social interaction. The ground floor program helps reinforce this, while keeping the offices on the second floor open to the atrium as well. The building's south façade uses solar panels to offset the use of energy, while an effective ventilation system keeps the building cool during the day. Although the building does not offer direct natural ventilation, the fresh cool air is cycled in overnight. This keeps the building air quality high, without having operable windows. The Energinet headquarters is an example of what a traditional office building planned well could look like. Although this building is not as ground breaking as the other examples, it offers a well measured and executed design approach that yields good results.



Figure 31: (Top) View of exterior of building. Figure 32: (Bottom) View of atrium.





Figure 33: View of common space. Below: Figure 34: View of plant life.



The Open Plan: Positives and Negatives

The open office plan has been around for a while, some of the first call centers for example reflected this type of office arrangement. It wasn't until recently however that companies began to move away from the cubicle model and adopt even more open office work stations. While these open plan type offices have their positive aspects, they also have several negatives. The open plan office succeeds at a few key ways, it allows light to enter the building much deeper, in comparison to the closed rooms of older style offices. It does connect people to their coworkers and surrounding environment more effectively because of the lack of doors. It also is easier to build from a construction stand point, as it requires very little in the way of walls, doors, etc. Typically there is a circulation core at the center of the plan, possibly with a small community space, like a kitchenette. The windows are open to the whole floor, with the exception of the executive offices. (These may be on another floor, or take up a small segment of the open plan.) This allows natural light to be seen from any cubical. However, there are a few problems with these plans as well. First these plans rely heavily on the use of artificial light, because the floor slab is often too deep for the natural light to reach all the way into the building. The ceiling heights also affect this, as they are kept as low as possible to maximize the floors in the building. This artificial light can cause employees to lose productivity.¹⁹

Another problem with the open plan is the lack of private space. While it may be assumed that having less privacy would make for more productive workers, the opposite is actually true. "such things as privacy, bothersome reflections, furnishings

¹⁹ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

and the appearance of the work environment, as well as other aspects of open plan offices (being heard, being seen, people walking by, trouble concentrating) detract from productivity.”²⁰ Berg further noted that the drop in productivity in the open plan office was directly related to the imbalance of private space. While the open plan office does connect the employees better than the closed office model, it also brings the unwanted distraction of a large open space. The layout of the space is also very important, just filling an open floor with cubicles would yield poor results. Locations of various services such as printers and community spaces like conference rooms can also effect productivity of the office worker. This is especially true for larger office buildings, as the distances walked can be greater. “Studies of Dutch open-plan offices also demonstrated that extra negative influences on productivity relate to dissatisfaction with ancillary services like reproduction, quality and availability of copiers, of conference rooms and service related to climate aspects.”²¹

The open plan office has many benefits, but it also comes with a set of problems unique to its type. The open office plan allows for a level of interaction that helps keep employees connected. The plan allows for larger floor slabs, because it lets light deeper into the building. The plan’s lack of dividing walls allows for more light than the traditional closed room plans. It is very efficient in the use of space, its modular nature makes it easy to work with and change quickly. As Berg pointed out, a poor layout can negatively impact productivity, however a more naturally flowing plan can negate those problems. So it is important to realize that the open office plan, while more distracting to employees, has benefits that outweigh the negatives. The

²⁰ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

²¹ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

goal then, would be to find the right balance of public open plan, with private work space. By improving an already working design, the problems of the open plan could be reduced, making for a very productive, healthy work space.

Elements of a Good Workplace

What makes up a good working office? While there are many physical and social factors, there are a few key elements in regards to the building environment that can make large impacts in a positive or negative manner. Factors such as air quality, natural light, office layout and the use of plants in the building can be used effectively to create work places that are healthy and positive environments. While the design of a building cannot control all factors of the workplace, it can offer a very good base for the office to build off of, and promote the best possible work place.

Air Quality

Indoor air quality is very important to the health of a work place. Offices with poor air quality experience a higher rate of worker complaints in regards to their health. Irritants or allergens in the air can cause employees to feel sick, or uncomfortable. This affects their productivity directly and the companies profit indirectly. Offices that have poor air quality also show a correlation between a higher amount of sick days claimed, reducing the profitability of the office overall. “Two Dutch studies revealed that a considerable proportion of sick leave can be attributed to quality of the workplace (complaints). “The Preller report (1990) showed that 25 to 30% of total absence can be attributed to (building-related) health complaints, while the Schermer report (1992) concluded that about half of all employees occasionally

stays home because of such complaints.”²² Another factor is the air temperature, offices that are too cold or too hot also experience a drop in employee productivity and workflow. Problems can also stem from dry air or a lack of natural ventilation. In a study conducted by Center for the Built Environment, in Berkeley, California, over 34,000 people were surveyed about the comfort of their work place. The study found that “Overall, more occupants are dissatisfied (42%) than satisfied (39%), with 19% of occupants neutral.”²³ with the thermal comfort of their work environments. The study also looked at the air quality of these spaces and found that “74% rated “air is stuffy/stale” to be a major problem, 67% rated “air is not clean” to be a major problem, and 51% rated “air smelling bad (odors)” to be a major problem.”²⁴ These results were wide spread, the study covered 215 buildings, of which 90% were in the United States. The major complaints were with the thermal comfort of a building, as the bulk of the dissatisfied noted building temperature as the cause. The study also conducted a series of surveys, questioning whether people had control over their climates in the building. Not surprisingly, the study found that people with control, were much happier than people without any form of personal climate regulation method. “...personal control over environmental conditions (e.g., thermostat or operable window) has a significant positive impact on occupant satisfaction. One means of achieving higher occupant satisfaction would be to provide such control to more occupants.”²⁵ Air quality in the office is critical to a good working environment.

²² Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

²³ Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. Arens. 2006. Air quality and thermal comfort in office buildings: Results of a large indoor environmental quality survey. *Proceedings of Healthy Buildings* Vol. III (March 6th): 393,393-397.

²⁴ Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. Arens. 2006. Air quality and thermal comfort in office buildings: Results of a large indoor environmental quality survey. *Proceedings of Healthy Buildings* Vol. III (March 6th): 393,393-397.

²⁵ Huizenga, C., S. Abbaszadeh, L. Zagreus, and E. Arens. 2006. Air quality and thermal comfort in office buildings: Results of a large indoor environmental quality survey. *Proceedings of Healthy Buildings* Vol. III (March 6th): 393,393-397.

If the quality is poor, complaints and sick days will rise, and the productivity of the office will decline. Good air quality can help keep these complaints to a minimum and maximize office productivity.

Natural and Artificial Light

Natural and artificial light play a very large role in making a healthy and productive office environment. Several studies have linked natural light, with better productivity and a healthier work place. These studies have also linked the use of artificial light to a drop in productivity in the work place. In Germany for example, office building codes and zoning dictate thin buildings to allow natural light to pass through the entire building. “Occupants in daylit and full-spectrum office buildings reported an increase in general wellbeing. Specific benefits in these types of office environments include better health, reduced absenteeism, increased productivity, financial savings, and preference of workers. Benefits to the office worker are so great that many countries in Europe require that workers be within 27 feet of a window (Franta and Anstead 1994).”²⁶ Here, the floor plate is typically thicker, this leads to difficulties with getting natural light into the deeper parts of the building. To correct this low light problem, florescent lights are used to for adequate lighting throughout the work space. This, however does not bring all the effects of natural light into the building. As a result, office productivity and employee health declines. To solve this, it is important to maximize the natural light as much as possible, without creating over lit conditions that could reduce productivity. In the case where this is not possible, full spectrum light can be used. “Full-spectrum bright lights allow day and night workers

²⁶ Edwards, L., and P. Torcellini. 2002. *A literature review of the effects of natural light on building occupants*. Golden, Colorado: National Renewable Energy Laboratory, NREL/TP-550-30769.

to adjust their internal clocks or circadian cycles to match their work cycles. Improvements in productivity, a decrease in accidents, an increased level of mental performance, improvements in sleep quality, and an increase in morale among night shift workers have also been attributed to better lighting (Luo 1998).”²⁷ It is also important to deal with negative natural light as well. A diffused glow is idea for work environments, however direct sun light is not. Direct light is not only seen as a distraction to the office, but it creates hot spots and uncomfortable rooms. The intensity of direct light can also cause headaches and over saturate the work space. “Studies show that daylighting can provide substantial benefits to staff and employer’s alike, but improper usage can lead to unpleasant conditions within the structure. The benefits of daylighting will only be realized if it is implemented correctly. Improper use of daylighting can reduce productivity and increase employee absenteeism due to the possibility of extremely high lighting levels, excessive glare, and high temperatures.” It is very important to balance and regulate the type of natural light entering the office space, as well as its intensity. Natural light needs to be diffuse in order to provide the best work environment. Lots of indirect light, for clarity, but no harsh rays of indirect light that cause distraction or hot spots. Devices such as clearstories, light wells and screens can help filter out the intensity of the direct light while maintaining a good glow. This, in combination with a dynamic lighting system, can create a well-lit and productive work environment. “It is generally accepted that these changes in daylight have a positive influence on mood and stimulation, and evidence exists to indicate that these positive influences can

²⁷ Edwards, L., and P. Torcellini. 2002. *A literature review of the effects of natural light on building occupants*. Golden, Colorado: National Renewable Energy Laboratory, NREL/TP-550-30769.

largely be duplicated with dynamic indoor lighting. An extensive study under office conditions has shown that people prefer high additional electric lighting in an office environment (average 800 lux on top of the prevailing daylight contribution)”²⁸

Layout and Circulation

The layout and circulation patterns of an office space are very important to the productivity of the office employee. Locations of key community spaces like conference rooms or the printers and copiers can seriously detract or improve office productivity. Berg notes this as a factor in his study, stating “negative influences on productivity relate to dissatisfaction with ancillary services like reproduction, quality and availability of copiers, of conference rooms and service related to climate aspects.”²⁹ In more traditional offices the circulation of the space can be confusing and compact, creating tight corridors not conducive to connection and collaboration among employees. These plans also tend to limit the amount of natural light in the office space. On the flip side of that traditional office layout, is the open plan. While this approach to office layout solves some problems such as light, it also has set backs. Problems such as noise control can be distracting. The open plan still offers a great approach to office layout, despite these problems. “In 1983, Lockheed Martin designers successfully increased interaction among the engineers by using an open office layout with integrated daylighting in their offices in Sunnyvale, California (Romm and Browning 1994). This increase helped boost contract productivity by 15%. Lockheed officials believe that the higher productivity levels pertaining to

²⁸ Begemann, S.H.A., et. al., “Daylight, artificial light and people in an office environment, overview of visual and biological responses”, International Journal of Industrial Ergonomics, (1997).

²⁹ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

daylighting helped them win a \$1.5 billion defense contract (Pierson 1995).”³⁰ A balance in these two different approaches is needed to offer the best office environment. This, in combination with careful attention to the location of services like bathrooms and the printers, can help bolster office productivity.

Plant Life

Plants can play a large role in the health of a work environment. They are an effective way to bring nature into an office, in a manageable capacity. Plants are natural filters of the air, and thus can help keep the air in an office cleaner and better for employees. They also present a visual element that can be conducive to calm and productive working environments. “Greenery can have an influence through the other factors, especially air quality and arrangement of the workplace (aesthetic). Plants can also have an indirect influence on neurological health factors (influencing stress).”³¹ The major benefit of plants in work environments are their contributions to air quality. “Plants are capable of absorbing numerous (chemical) pollutants in the air. Many laboratory studies and experiments have demonstrated this (Wolverton).”³² They also can add humidity to dry air environments, reducing complaints about nose, mouth and throat problems. This is especially prevalent in winter and other dry air seasons. Other studies have also concluded that plants can affect the perception of the work place, and improve it. “In light of results of studies into the psychological benefits of plants, this seems a plausible assumption that plants can influence people's perception of a building and workplace (Wood 1995) and, by extension, their

³⁰ Edwards, L., and P. Torcellini. 2002. *A literature review of the effects of natural light on building occupants*. Golden, Colorado: National Renewable Energy Laboratory, NREL/TP-550-30769.

³¹ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

³² Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

wellbeing and productivity.”³³ Although plants can play a significant role in improving office space, it is important to note that careful consideration must be practiced, when choosing what plants are acceptable for indoor use. Plants for indoor spaces should not produce a large amount of allergens, and plants that cause more common allergies should be avoided, so as to create a good work environment for all employees.

³³ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: Ben R Adviseurs Voor Duurzaamheid Amersfoort, Print. 1-12.

Chapter 6: Building Enclosure as Problem Solver

How can the building Enclosure improve the office, building and city?

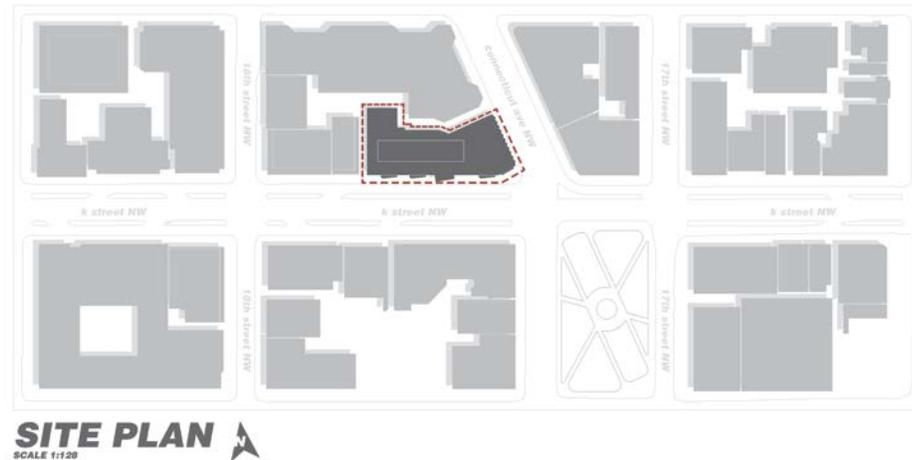
Currently, the typical office building relies on a thin skin around the building for enclosure. These curtain wall systems are designed to be easily assembled and modular. This helps reduce costs, but it also creates a flat, monotonous façade. The goal of this thesis is to challenge the idea that the façade should be this flat static element of the building. By redesigning the building enclosure to become a more occupiable space and a more dynamic element of the building, I believe that the enclosure can help improve the office space and the urban street, as well as the building's appearance, and performance. Starting with the smallest scale, the work place, the enclosure can help provide a better work environment. The buildings enclosure could offer means of operable windows for natural ventilation. This would help employees regulate the air quality and temperature on multiple levels. The result would be a more comfortable work place. In this same vein, the building enclosure could also help provide natural light deeper into the building, helping to create a light filled and productive work environment. At the same time, this new dynamic building enclosure could also regulate and block the unwanted glare and heat from direct solar gain. From an aesthetic stand point, the dynamic enclosure could house plant life, bringing nature into the work place, while making for a visually pleasing environment. Finally the enclosure could become an inhabitable space, with circulation and community spaces becoming a part of the enclosure zone. This would help connect people, and collaboration would occur within this zone.

From a building stand point, the idea of a new, more dynamic building enclosure has a large amount of potential. From a performance aspect, the building could benefit greatly from an enclosure that helped offset energy costs by capturing solar or wind energy. The introduction of living walls could also help shade, cool and offset the building's heat island effect. This would result in a lower operating cost, as less energy would be used to cool the building. Furthermore, the enclosure could help the building obtain certifications such as LEED or other tax incentives that would help offset costs. A dynamic enclosure would also provide better opportunities to deal with rain, and storm runoff, reducing the buildings need for maintenance, through the use of rain screens. From an aesthetics point of view, the enclosure would offer a more visually interesting appearance. This could make the building more notable, and even help promote the building's tenants by creating a landmark in the city. This concept can be observed with the Discovery Communication building in Silver Spring, the building has a unique lighting scheme that has created a local landmark. A dynamic enclosure would also be capable of boosting the buildings connection to the city and to people, helping to promote a richer social interaction with the building. The enclosure could offer mix media and digital displays that enhanced to look of the building, and created visual interest for the surrounding buildings. Again the Discovery Communications building in Silver Spring, Maryland comes to mind as one of its main elevations has a large mural that gives the street life.

On the urban scale, a dynamic enclosure could help the city in a multitude of ways. An enclosure that helped a building become more sustainable, would also, by default help the city as well. The enclosure would reduce power usage by the building and even put power back into the grid. This would reduce strain and stress on the city's infrastructure. The buildings enclosure would also respond to the surrounding site, and help to create a better and richer urban context and street. This in turn would bolster the city's appeal and over time help raise the land values for the area. The enclosure could also offer a vertical park, where appropriate, to help connect the larger park system and produce a more visual attractive city. From an environmental stand point, a building with a dynamic enclosure would also help the city with heat, noise and pollution problems. The building would be able to filter storm water through its enclosure, reducing the impact of pollution, while helping to provide the city with reusable water. The enclosure could also "eat" smog, with technology like titanium dioxide coatings. This would help improve the air quality of the city as a whole. It would also help mitigate the effect of the heat island effect, keeping the city's cooling and energy costs down. To further this, the use of green roofs and living walls would also help offset the city's carbon foot print. Overall, the flat, static nature of the office building enclosures today fall short of all this potential. A more dynamic and engaging enclosure is needed to truly make the most of the office buildings in our cities today.

Chapter 7: K Street, Site Study

The Site



Intro

The site for my thesis project is located on K Street in NW Washington DC. The site sits in the 1700 block of K Street, diagonal Farragut Square. The corner lot is on the face of 17th Street NW, and offers a sweeping view of the square. It is also the junction point and ultimately the terminus for Connecticut Ave. K Street is terminated by route 29, at the end of Georgetown on the west end of the city. On the east side, K Street merges into Florida Ave, the old edge of the city. K Street cuts through the District horizontally, and serves as the primary entrance into the city's heart from the Virginia, via the K Street Bridge. It is, in effect a connector for the city, and a main travel route to and from the Virginian side of the Potomac. The zoning of K Street is primarily commercial on the NW side of DC, with the site located in the thick of it. The site represents a unique opportunity in that is located on three major street corners, while still maintaining the typology of K Street. Thus, it represents a strong

place to express a possible future direction of office buildings. The current office building on the site also embodies many of the negative qualities that this thesis aims to improve. The site was developed later than most parts of DC, along with K Street, and as a result the buildings are of less notability than other parts of DC.

About the Building

1000 Connecticut Avenue is the office building that currently occupies the corner site discussed above. The 565,000 GSF building is a 12 story commercial office building with a retail ground floor, which was completed in 2012. The architectural design was a partnership between WDG architects and Pei Cobb Freed. The building is rated LEED Platinum, primarily because of its HVAC system and the large green roof. The building was built for the Arent Fox law firm, which occupies 70% of the building. The building uses a post tensioned concrete slab and column structural system that allows for a floor to floor height of 10' 7.5". The first floor has a floor to floor height of 12.5'. There are also three floors below grade for parking, also constructed out of concrete. "1000 Connecticut Avenue Office Building's structural system is comprised of a reinforced concrete flat slab floor system with drop panels and a bay spacing of approximately 30 feet by 30 feet. The slab and columns combined perform as a reinforced concrete moment frame. The substructure and superstructure floor systems are both comprised of an 8" thick two-way system with #5 reinforcing bars spaced 12" on center in both the column and middle strips and 8" thick drop panels. The below grade parking garage ramp is comprised of a 14" thick slab with #5 reinforcing bars provided both top and bottom with a spacing of

12” on center.”³⁴ The enclosure of the building is a stick based curtain wall system that uses a low E value glazing with a heavy tint. The enclosure construction consists of precast stone panels and glazing, with metal mullions. The building’s south face and north east face are 80% glass, while the other faces are approximately 40 to 50%.

I will be proposing a renovation of this existing building in order to examine the ability to adapt and retrofit the new enclosure to an existing structural system. In effect I will be removing the flat and thin glazing system and replacing it with a more dynamic enclosure with zones for various elements. This will keep the existing structure intact with the exception of the few changes to the slab edge. The new enclosure will then house systems that help reduce the building’s overall energy use, and generate power. These systems will also help to clean the air and water that comes into contact with the building, while better regulating solar gain and natural lighting conditions in the office spaces. Because I am renovating an existing building the ground floor program will remain unchanged, while the upper office space will receive a minor layout adjustment to accommodate the new interactive enclosure. Below are several existing floor plans and sections of 1000 Connecticut Avenue. These drawings will serve as my base set moving forward, and highlight the structural elements of the existing building, which will allow me to accurately tie my renovations into the building’s structure.

³⁴: Johnson, Gea. 2011. 1000 connecticut avenue. Masters., .

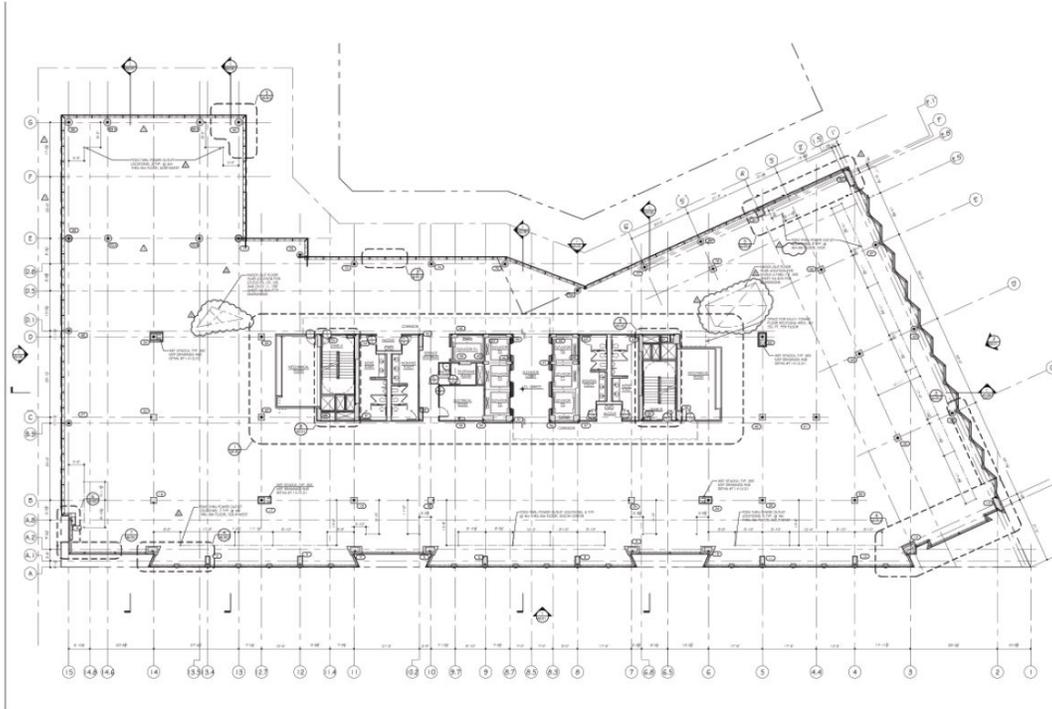
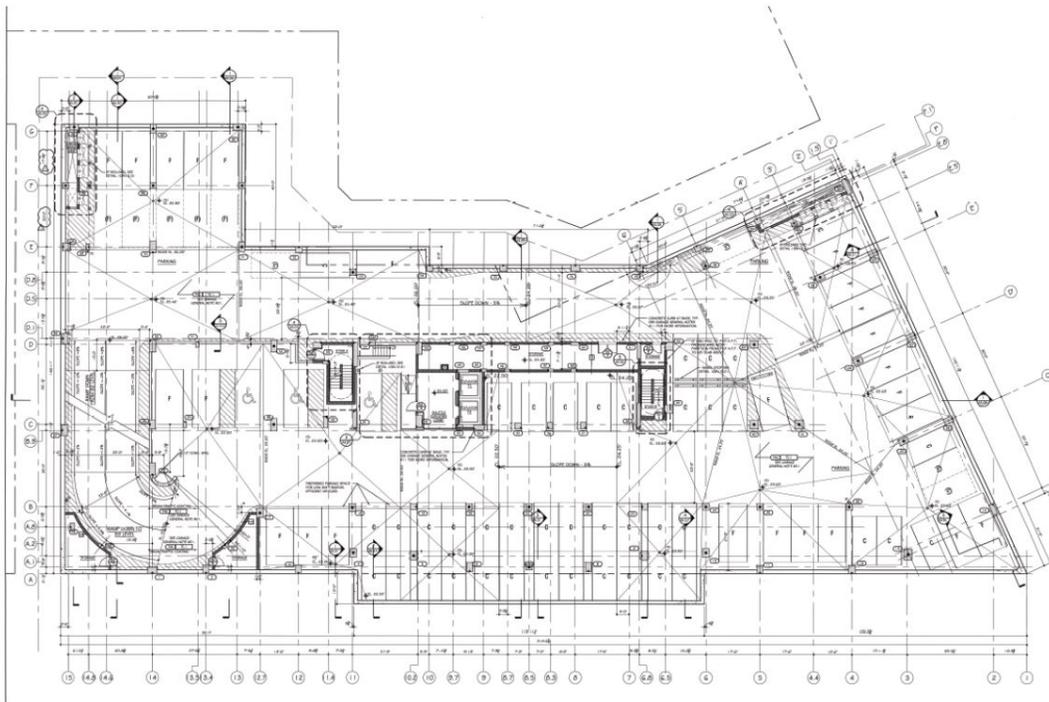


Figure A: View of typical office floor plan, 1000 ConAve.

Figure B: View of underground parking floor plan, 1000 ConAve.



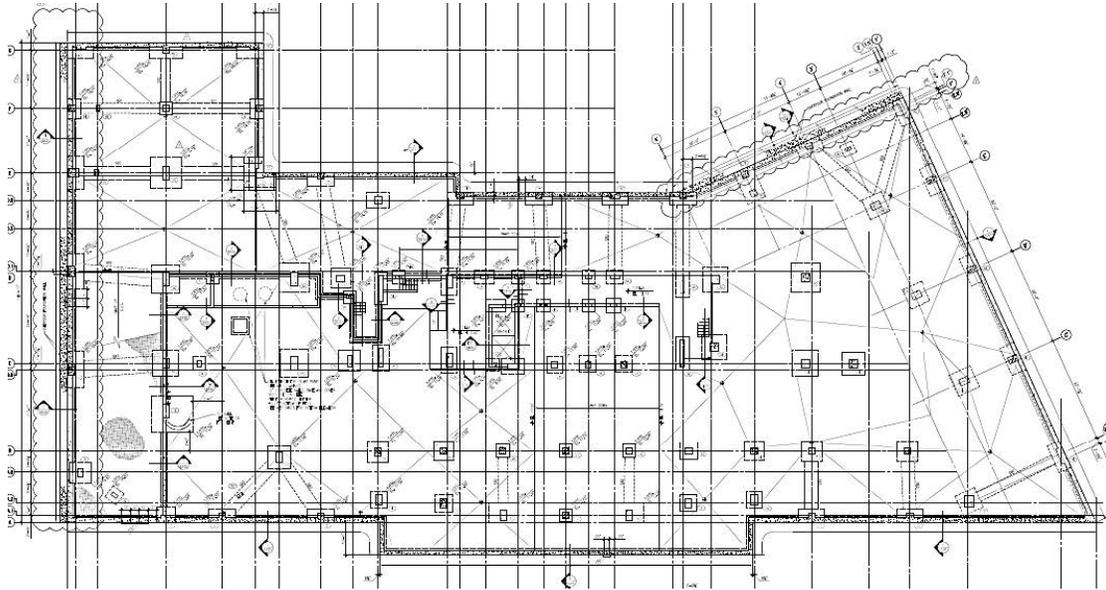
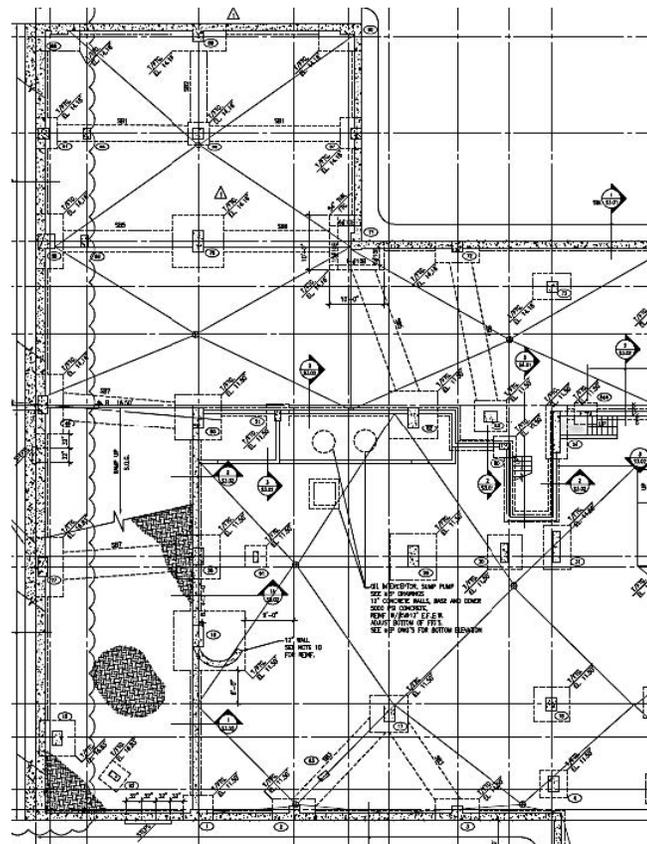


Figure C and D: View of foundation and structural plan, 1000 ConAve.



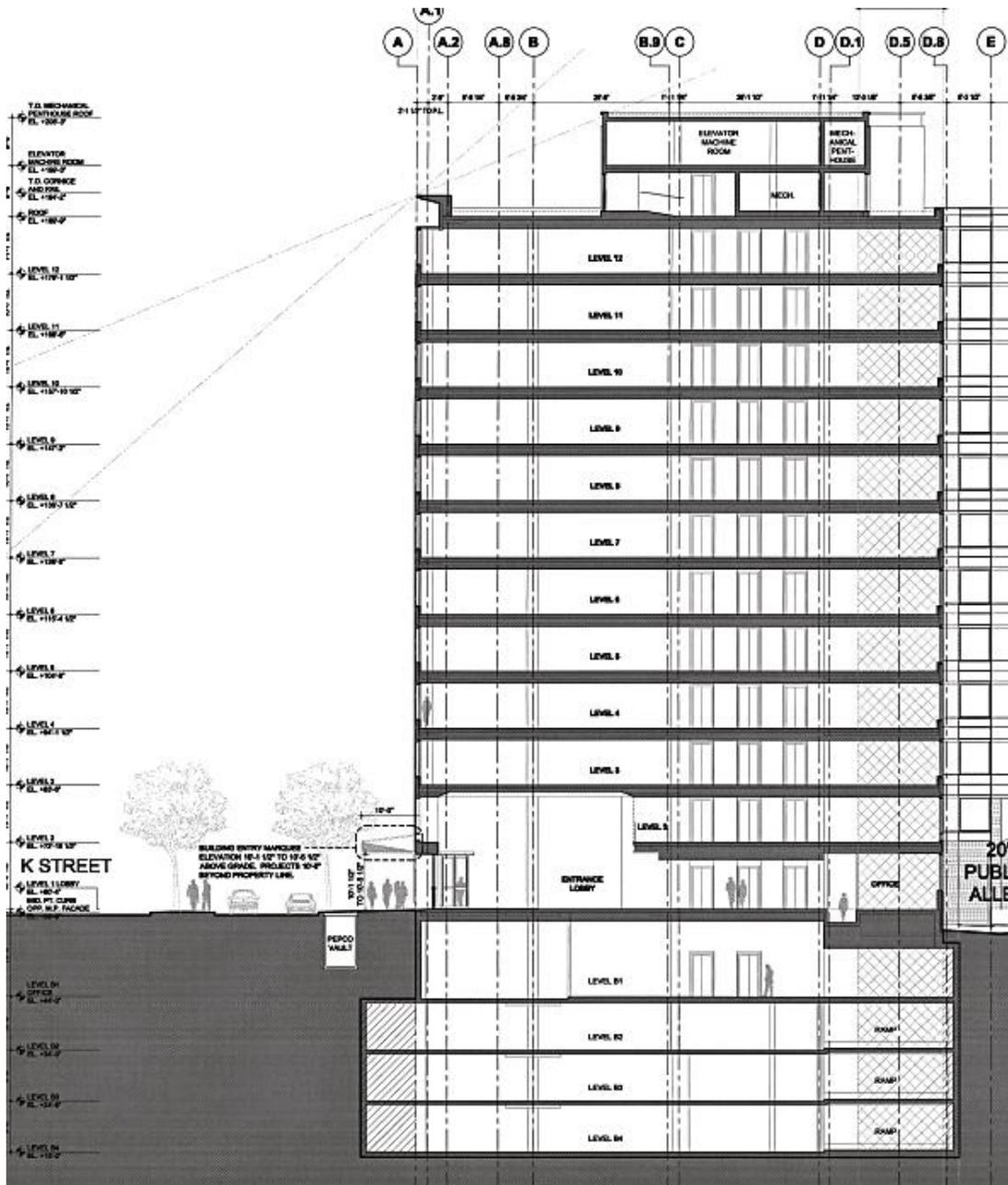


Figure E: View of building section, 1000 ConAve.

The Problem

Part of the reason I chose K Street for the site of my thesis, is because it exhibits the all the problems of the current typical office building. The façades are flat and lack the dynamic nature that could make use of their potential. On top of this, the site presents an unique opportunity in regards to the street front. As the street is a connector between nodes in DC, there is no real demand for retail that could activate the street. Thus an alternative method is required to achieve the same results.

Although that solution may include small or light retail that serves the pedestrian and office population. On top of this, K Street as it stands offers little to no sustainable practices. The street is essentially concrete from one curb cut to the other, and there is a real need for a bolstered green space or a vegetation element. The other problem with street is the lack of holding power it has, after 5pm or even mid-day, the street is almost void of pedestrian activity. This creates a barren landscape and makes the environment seem sterile. The site's location also offers a chance to promote and further develop Farragut Square, which right now is one of the lesser used parks in Washington DC.

The Benefit

The site, as previously mentioned, sits at the cross roads of several large streets. At the same time it still follows the “building as liner” typology of K Street. This makes the site unique, in that it offers the best location to positively impact the entire area with a new office building, centered on the enclosure element. This, combined with some small urban design moves could drastically improve this intersection of K Street. Finally the site is a gateway or along the main route into the city, so an

intervention here could help improve city's overall image. The site offers a lot of unrealized potential, and this project could provide a much needed opportunity to tap some of it. At the same time, the project could also serve as an example for the city, and office building construction everywhere.



Figure 35: View of K Street facades.



Figure 36: View of buildings on Farragut Square.

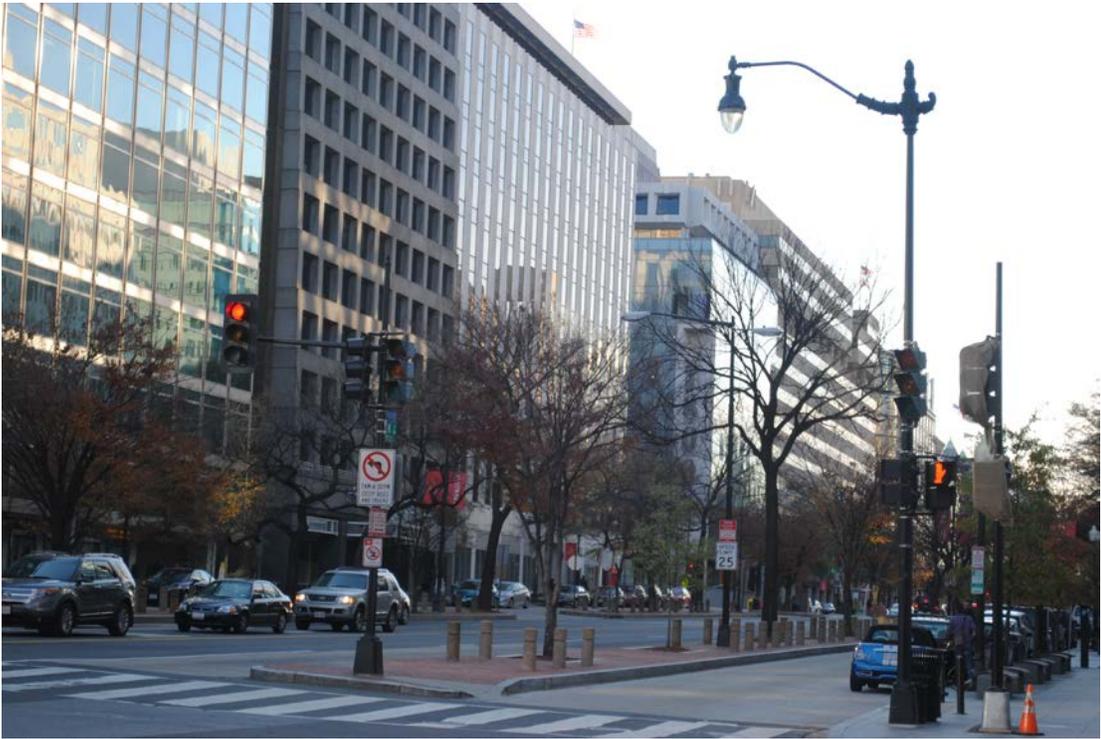


Figure 37: View of flat facades on K Street.

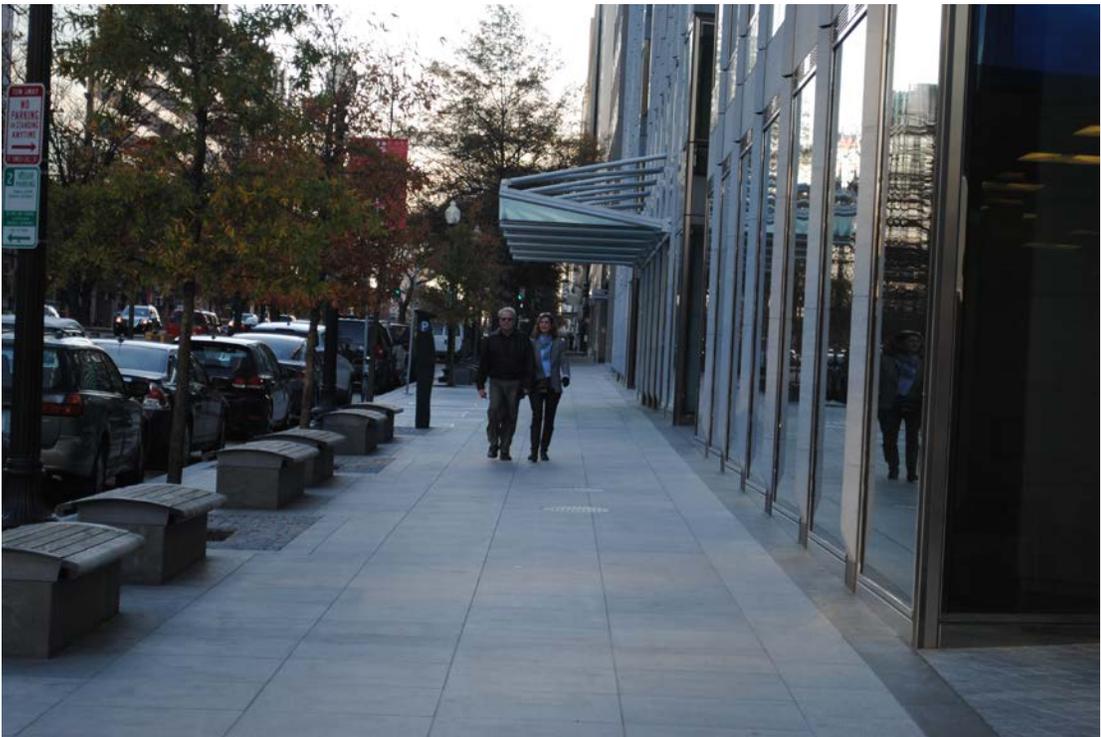


Figure 38: View of inactive street front.



Figure 39: View of façade pattern.



Figure 40: View of Farragut Square.

History

The history of K Street is as old as the city's original plan. Farragut square was set aside to be a park in Pierre L'Enfant's original plan of Washington in 1791, although, the park wasn't official designated as such until 1871, eighty years later. It was at that point, Congress authorized the construction of the Admiral David G. Farragut statue. The project cleared the temporary wood frame buildings from the park and stopped Connecticut Ave just before the park in 1881. The area remained a predominantly residential one, until about 1920. After the Second World War, the commercial development of K Street boomed. "According to the Historic American Buildings Survey, approximately thirty new commercial buildings were built between 1955 and 1960 in the vicinity of the park, almost all of them minimally-ornamented glass and steel buildings. The iconic Shepherd's Row was demolished in 1952, to be replaced by the distinctly modernist 1001 Connecticut Avenue office building that still stands there today designed by the Washington architect, Edwin Weihe."³⁵ It was in this time as well that K Street earned its association with lobbying firms, hence the term "K Street Lobbyist" However, by the 1980s, many firms had left the street, and today only one of the top twenty firms still has an address on K Street. In modern day the street is still busy with various office buildings lining it. The street has become more and more modern as building are torn down or re skinned. The street itself has transformed from a residential off shoot of the original Georgetown area to a busy commercial corridor in the city.

³⁵ DeFerrari, John. Streets of washington. in Blogspot [database online]. Washington DC, 2010 [cited 12/13 2014]. Available from <http://www.streetsofwashington.com/2010/04/farragut-square.html?view=magazine> (accessed 12/13/2014).



Figure 41: Historic picture of Farragut Square.



Figure 42: View of historic Farragut Square c. 1910.

Analysis

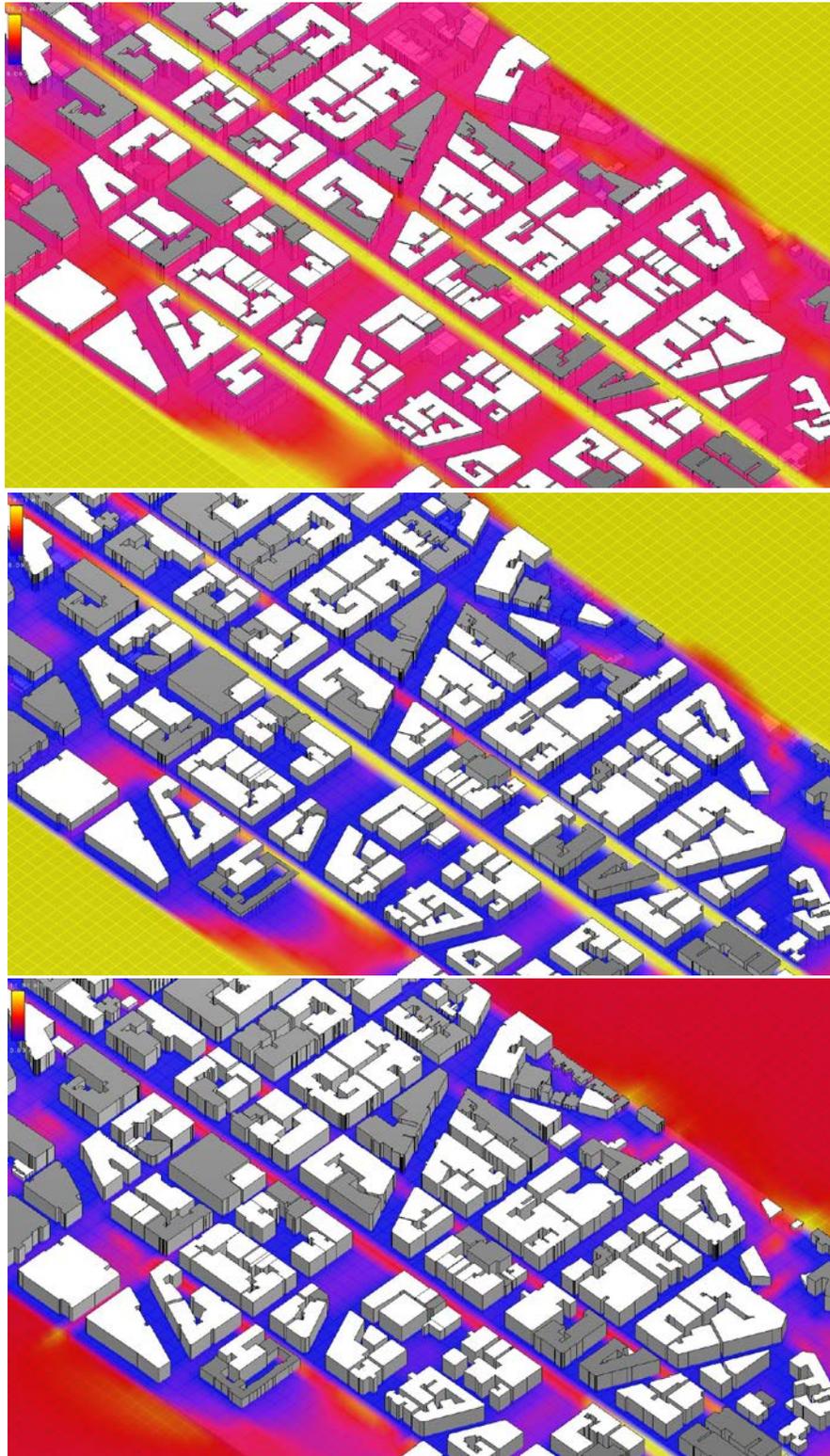


Figure 43: View of wind flows for 8 block radius of site.

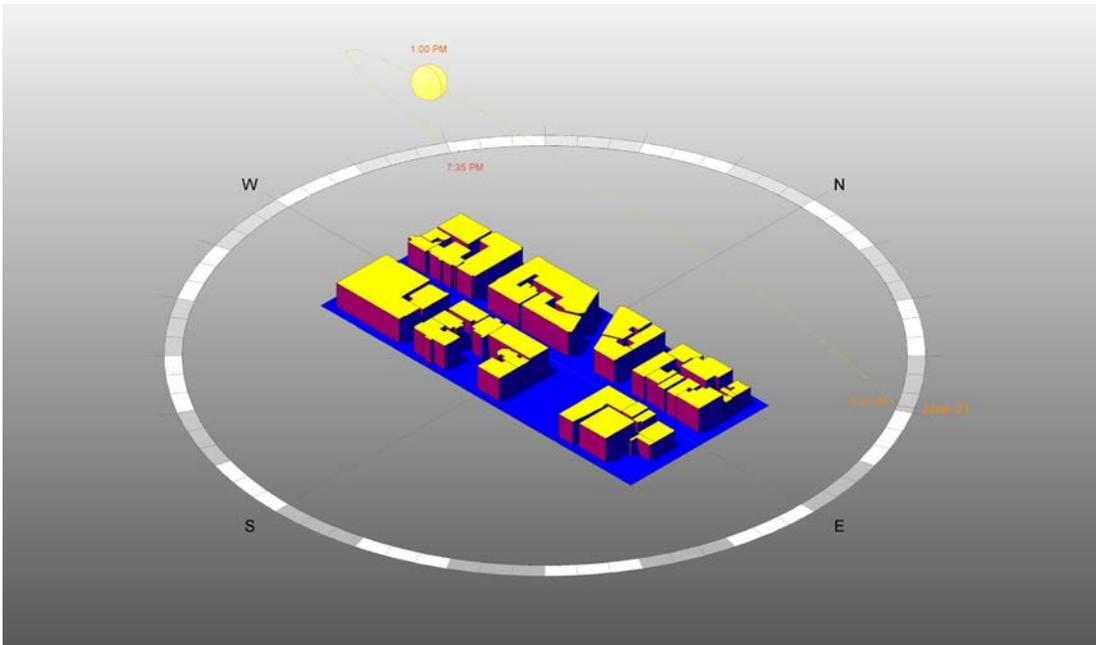


Figure 44: View of solar study and sun path for site.



Figure 45: View of typical office build problems.

Chapter 8: The Design Overview

There are four main elements to the redesign of the enclosure for 1000 Connecticut Ave. After studying the site and the existing building using modeling tools such as Vasari and Ecotect, these elements surfaced as the most prominent areas of opportunity for change at all scales. My research question became: could I improve the existing office building model using the enclosure alone, and if so, how would I do it? This quickly became a three part question, each focusing on the improvement opportunity at the human, building and city wide scale. It was with these questions that I set out to improve the elements I had chosen to focus on.

The Four Elements

The four elements are different areas of the enclosure that I felt could not only be improved upon from a performance stand point, but also become active areas that produced a better result for the city as a whole or the people directly using the building. First the solar element, the priority being the control of harsh sunlight and glare. At the same time, this element would also have to support the city, in this case, it would be power production. Finally the goal was to not only block the unwanted light, but get natural light deeper into the area of the building. This felt like a good place to start, as it was a rounded response to all scales on both an active and passive level.

Next came the wind element. Again, it was important to me to explore ways to not just mitigate the wind, but also use it for a positive gain. In this case, that would also be power generation, via windmills. I studied how the flows of wind currents

effected K Street, and the wind patterns for the city as a whole, in order to optimize the locations of these wind turbines. At the same time, I also looked at a system that would protect the higher floors from the harsh wind buffets along K Street. While studying the wind I also looked at the re-incorporation of living walls and vertical bio-swales.

While working on the plant element, I returned to my research questions and asked myself: how might this living wall help improve the typical office building at all scales? The answer was in the way I used it. Initially I wanted to have these green walls reintroduce plant life into the work environment for its benefit to productivity. However I soon realized that I could also use the walls to shade the building and clean storm water. This was also the case for the final element of air.

The air element focused on cleaning up the smog in the city, while also being integrated into the buildings other design elements. This led to the design of the panel filter system that also acted as a shading device for the north eastern face of the enclosure. At the same time, the double skin system was a collaboration between controlling the wind, and allowing office workers to control their micro climates. The integration of these elements made for an overall stronger enclosure. This double skin system was also tied into the solar louvers structural supports.

The Location of Elements

The next large challenges faced in redesigning the building enclosure was to determine where each approach would be most effective as well as how to support it. This posed a challenge at first, until I started to use the weather and site data to inform my choice for the placement of these elements. I completed several studies of

the building faces and the sun's travel path as well as shadow studies that accounted for the surrounding buildings. I also constructed a detailed site model of the surrounding blocks to assess how the shadows would change or affect the location of certain element types. In order to understand the wind paths I used 3D modeling programs to test the immediate building flows as well as 8 square blocks around the building site. This allowed me to understand the larger wind rose, as well as the microclimates around the site. The orientation of the building also helped in deciding what elements to use when where. I produced a series of diagrams highlighting zones for different interventions, as well as the diagram below, which combined the zones together to form a better understanding of how they would overlap. Finally I also obtained structural documentation of the building in order to figure out how better to tie my new systems into the existing building and its structural system. The majority of the slab edges were left alone. However in the places I did cut, the slab was reinforced with a wire mesh and tied back to the original rebar. I added only a few columns to support the heavier elements like the living walls, but the exterior elements like the double skin are designed to tie back into the existing columns and support themselves.

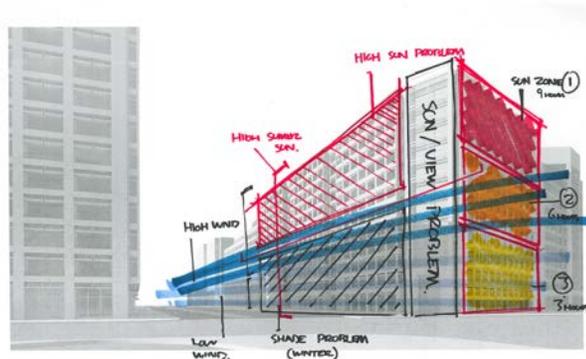


Figure 46: View of possible element locations and overlap.

Other Design Ideas

There are several secondary design ideas that take a back seat to the four main elements. First and foremost, the movement of the circulation patterning in the office. The enclosure is designed to become more of a zone and less of a plane. A large part of this means the movement of circulation and community spaces to the outer edge of the building and the switch to a large open plan office. This allows the enclosure renovations to have maximum effect. This layout also helps with inter office communication and increased workplace productivity. Below is a diagram of the new circulation pattern, woven into the enclosure zone.

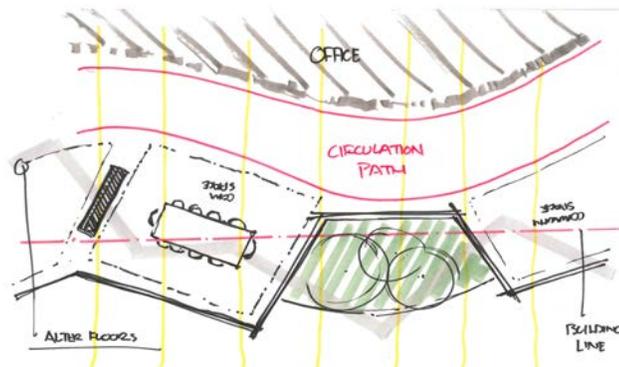


Figure 47: View of new circulation patterns.

Another important element is the way the shades for the building change the way the face of the enclosure looks. The louvers are controlled by the building as well as the people using the space. This means that the louvers will default to follow the sun path to make the building most efficient. However the human input will also cause changes to the overall pattern of the building. This means that the elevation will change daily based on the needs of the occupants of the building, allowing the enclosure to change every day, making it unique and breaking up the flat edge of the building elevations.

Chapter 9: The Solar Element

The solar element of enclosure redesign has three foci. First, the redesign includes the addition of adjustable louvers and fixed louvers on the south face of 1000 Connecticut Ave. These louvers are driven by the location and intensity of the sun, while also responding to human input. The building controls the louver systems electronically via computer programs. The next area of focus are the photovoltaic arrays which produce power for the building. They are located on the south face of the building and mounted to large scale louvers. Finally, the third aspect of the solar redesign is a fiber optic system that helps natural light reach farther into the building's core. These systems work with new LED task lighting to help reduce energy use and move more light into the central office space. Each of these systems is designed to work with the existing building structure while reducing the amount of solar glare and improving the lighting conditions for the building.

Louvers

The louvers are the main element of the solar aspect. There are two systems for the building, one being automated and the other being fixed. The fixed system is found on the south face of the building on the bump out spaces where conference and community spaces are located. They serve to shade these spaces while also providing a mounting structure for the solar panels on the south face. These louvers are designed to have a limited range of movement to track the path of the sun and aid the photovoltaics. They are made of a lightweight aluminum with an anti-corrosion coating to protect them from the elements.

The second type of louver is located on the standard wall surface, and is a dual purpose system. The primary use is for shading the building work spaces. The second responsibility of these operable louvers is to help support a double skin system that allows natural ventilation. The operable louver has two parts, the outer structural frame, and the inner shade device. This device has several slats that can be fully retracted or extended and angled down to offer the best shading possible. This system is normally controlled by the building and reacts to the amount of sunlight hitting the south face of the enclosure. However, the louvers are also controllable manually by office employees via electronic switches on the interior of the building. The operable louvers are fitted with two drive motors, one for controlling the angle, and a smaller unit for retracting the slats. Each louver assembly has its own servos, making the system infinity customizable. Below is a close up of the two motor gears, and the belt drive system for the slats. The louvers are made from a reclaimed wood, while the outer structural element and connections are aluminum.

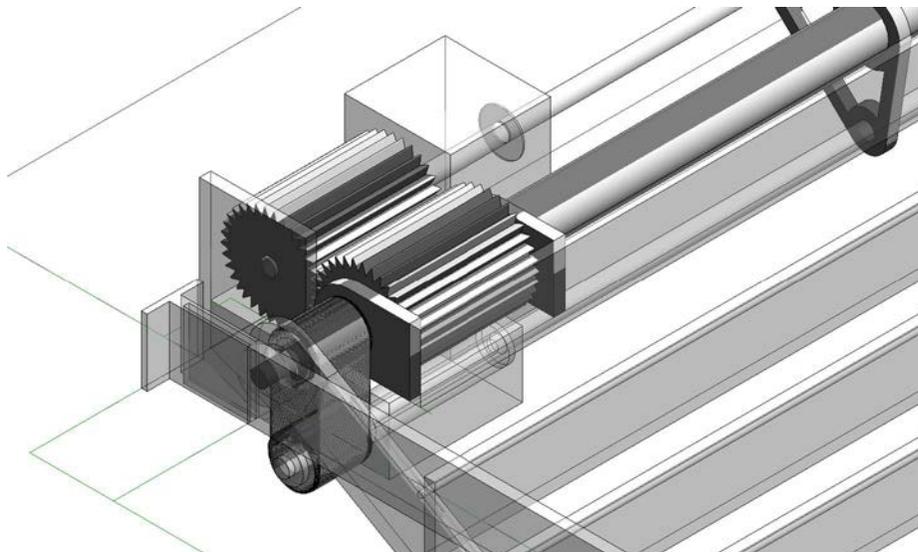


Figure 48: View of Solar louver Detail.

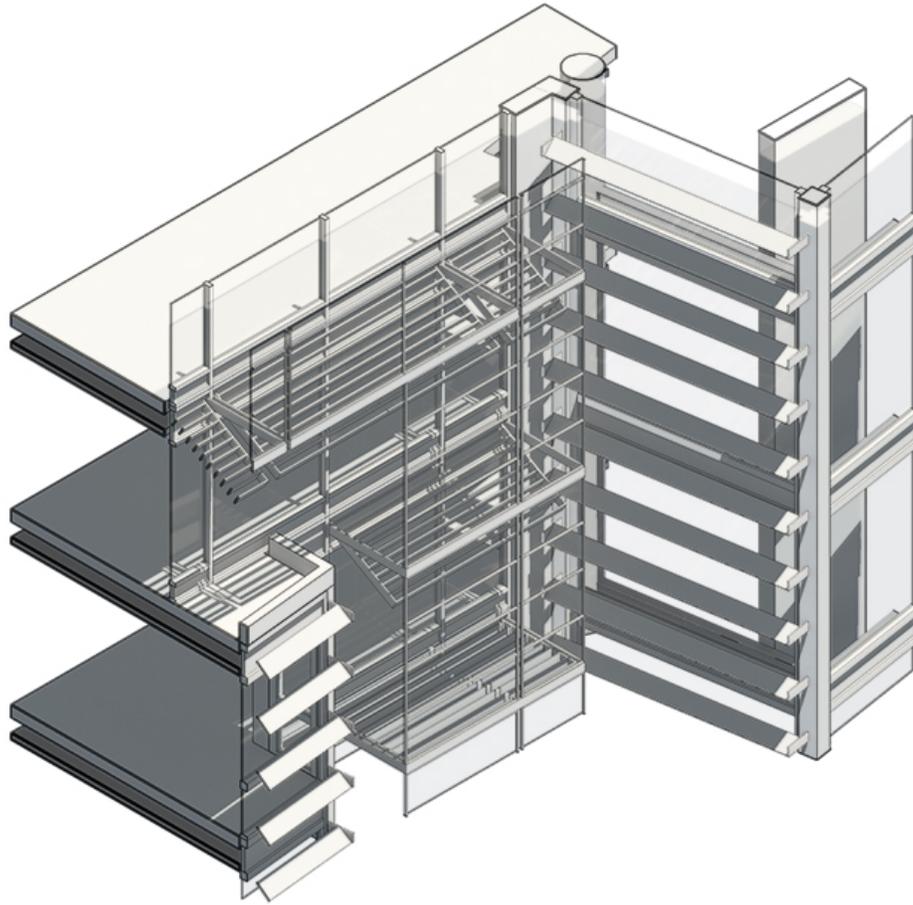


Figure 49: View of Solar louver Detail.

The system is designed to default to the optimal settings for the best energy savings. However because each louver bay is manually adjustable, the system will change in appearance every day, making the enclosure different each day, or even by the hour. This will help to set the building apart from its surroundings, while providing control to the employees occupying the building. Each day the building will reset the louvers, and return the system to same start point, allowing the whole display to reinvent itself the next day.

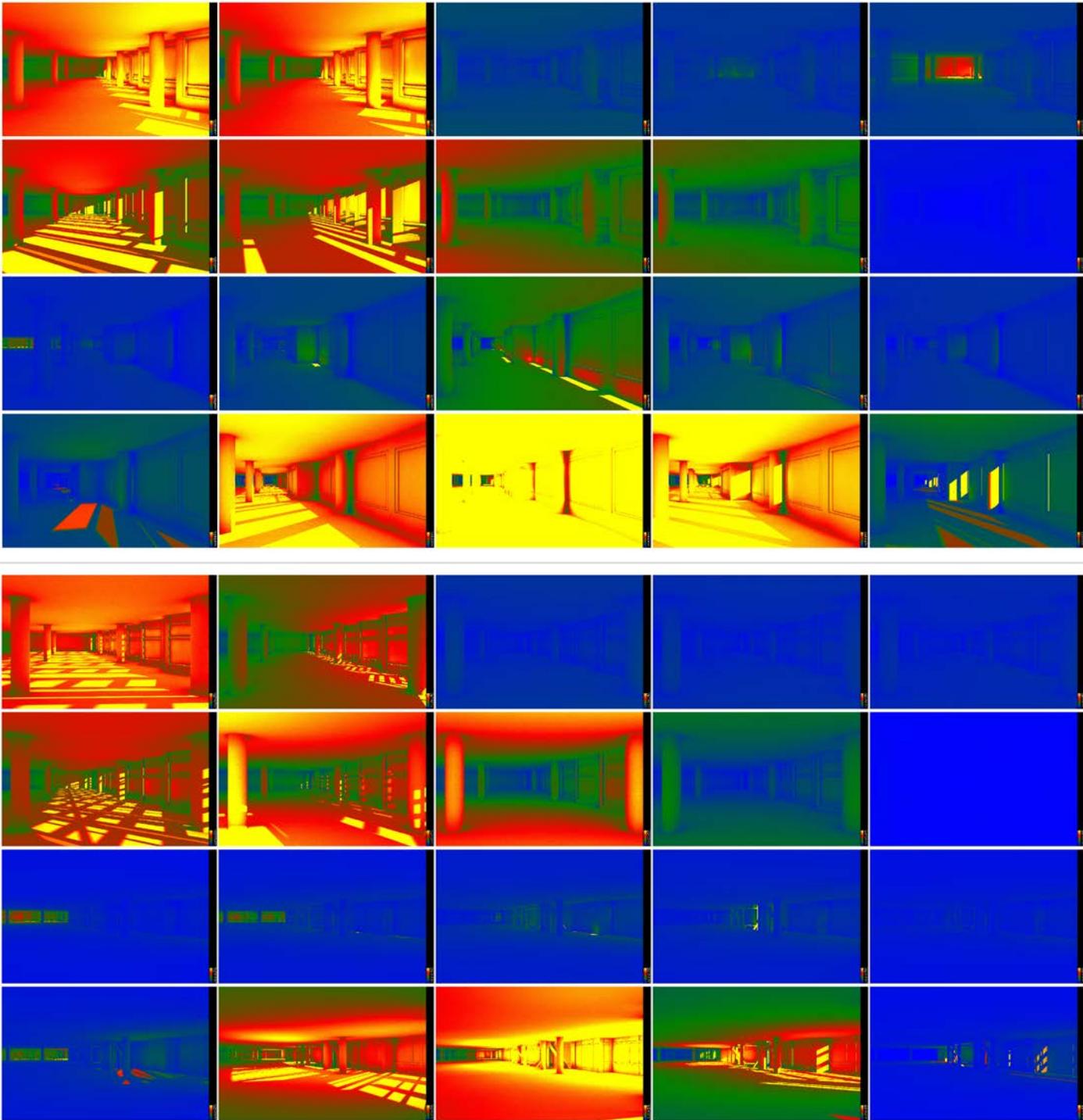


Figure 50: View of Solar Light Studies.

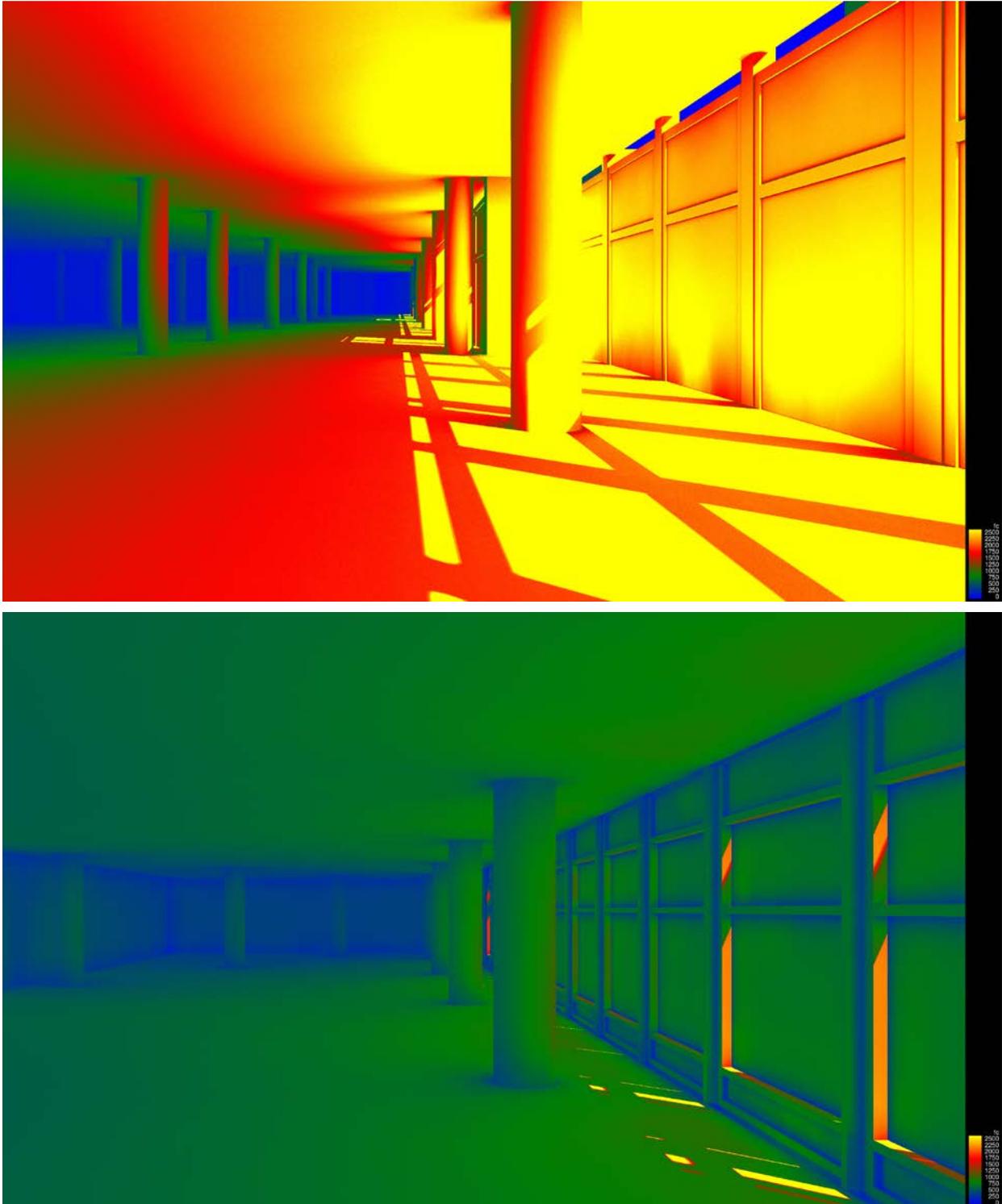


Figure 51: View of Sun study comparison.

Photovoltaics

The photovoltaic system for the enclosure is based on a simple angled panel design. Each array is tied back into the building's power grid, and allows the south face of the building to make energy for the building and the urban power grid. The system uses a fixed aluminum louver for support and is set to 38 degrees, the optimal angle for solar panels in Washington DC. The panels do have the ability to move a few degrees up or down to make the most of winter and summer solar paths. This is controlled by a single servo that nudges the panel to make the necessary adjustments. Each panel system is 30.5 SQFT of area which makes the total PV area 3690 SQFT. Following solar-estimate.org statistics for the power to area generation ratio³⁶, the total possible energy output is approximately 37 kilowatts per year. This would allow the building to make enough energy for most of its own needs and put some back into the city's power grid. The integration of these arrays will allow the building to make a lighter environmental foot print, as well as put money directly back into the pockets of the building owners.

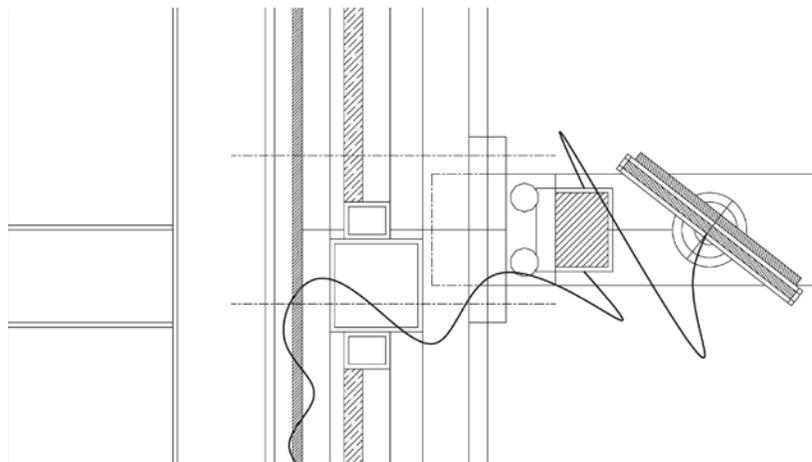


Figure 52: View of Solar louver Detail.

³⁶ Solar-estimate.org. in DOE [database online]. US, 2015 [cited 5/20 2015]. Available from <http://www.solar-estimate.org/?page=solar-calculations>.

Fiber Optics

The final aspect of the solar element for the enclosure redesign is the fiber optic system that works in unison with the LED task lighting for the work spaces. This system is a hybrid between natural and artificial lighting to make the interior office spaces better lit. The fiber optic cable is run alongside the wire harness for the lighting and brings the natural light from the outside deep into the building. Each bundle of optics is piped to the outer edge of the south face, just above the louvers and is terminated in a refraction housing. This housing serves to protect the cables, while also focusing and amplifying the natural sun light to maximize the effectiveness of the hybrid lighting. Each one of these collectors is fitted with ambient light sensors that, when paired with an electronic control system, adjust the brightness of the artificial LED task lighting to keep the lumen range constant and ideal for the work space. When the sun is at fully power, the LEDs will take a back seat to the fiber optics, and reduce energy costs. This will also allow more natural light in, which has the best color rendering index. During days when the weather is not conducive to natural lighting, the LEDs will step up, to keep the lighting even. On top of this, both the LEDs and fiber optic lighting will be defused light to create a soft even tone for better reading and working. Rather than having a recessed light box with a diffuser that creates harsh shadows, the lighting in the office space will be directed upward. This, in combination with a flat white ceiling, will help to diffuse the light even farther, making for an even glow. The fiber optic bundles are efficient at bending light and allow for a thin and flat system, which is important because of the low floor to floor heights in the existing building and throughout Washington DC. Directly

below is an axonometric of the bundle terminus, which is how the sun light enters the cables from the exterior. Also below is a detail section of the system in combination with the artificial lighting.

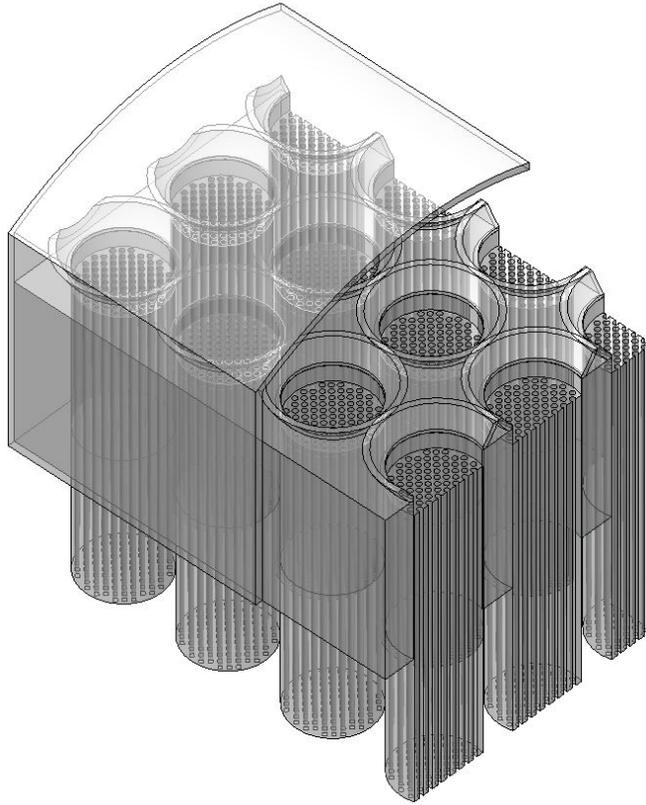
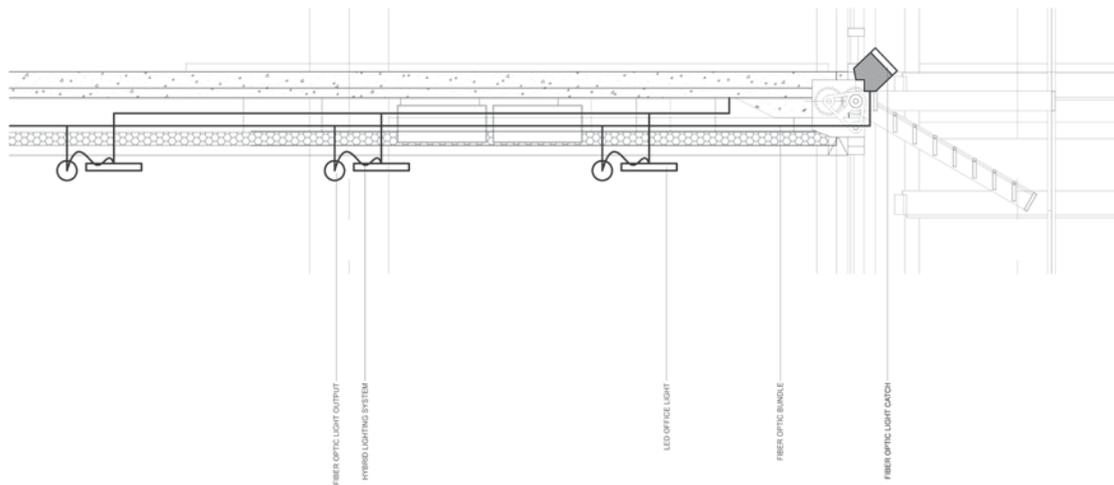


Figure 53 and 54: View of Fiber optic system.



Chapter 10: The Wind Element

The wind element of the enclosure redesign focuses on power generation for 1000 Connecticut Ave. using the wind currents along K Street. The vertical system is designed to generate power on an opportunity driven basis. The wind turbines will sit still most of the time, but when wind currents do flow, the turbines are located on the outer edge of the enclosure to make the most of them. Needing as little as 6 meters per second of flow, the wind turbines act as large alternators, they rely on copper coils to make power to supplement the power needs of the building and help the solar arrays convert energy to usable current. These vertical edges are located in three places on the south face of the enclosure and take up a small amount of floor plan area.

The wind currents for K Street come mostly from the west, and are stronger in the fall and spring seasons. Using computer modeling software, I was able to test several designs in a virtual wind tunnel, and noticed that K Street had several currents due to its canyon like effect with the buildings. I wanted to capture this potential source of energy, and therefore created the idea of the vertical windmill to do so. The south face of the enclosure has three bumps that project into the air flow patterns, and the double skin of the building helps direct and funnel this flow into the path of the turbines. Located on the next page are a few snap shots of the initial wind tunnel tests. In these tests you can see the higher air flow towards the outer edge of the street and the center section.

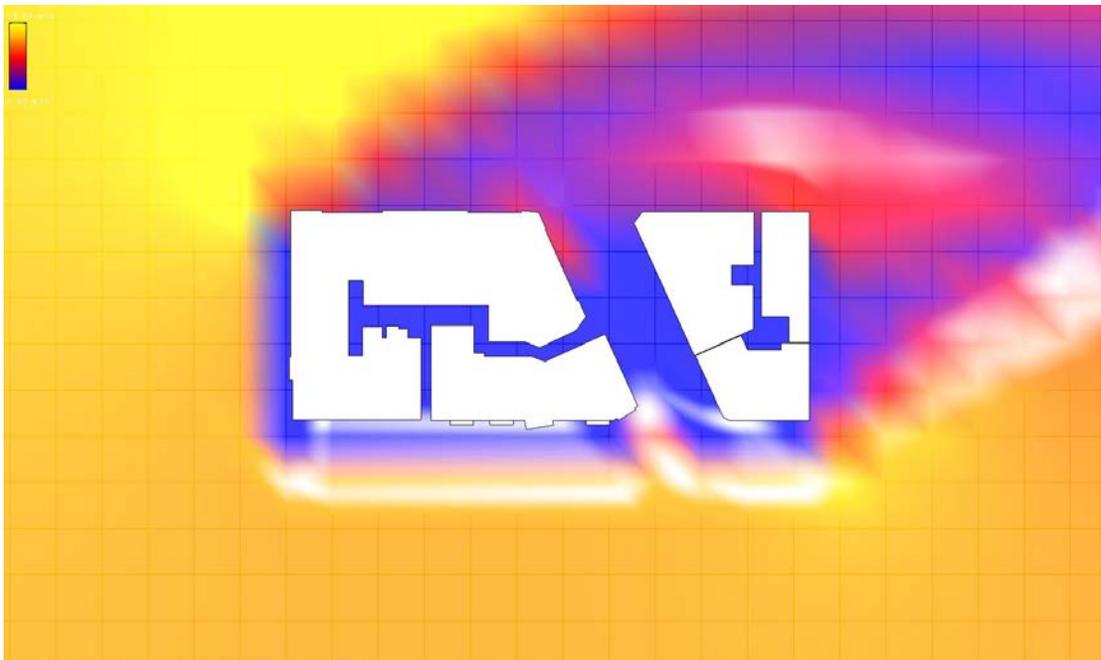
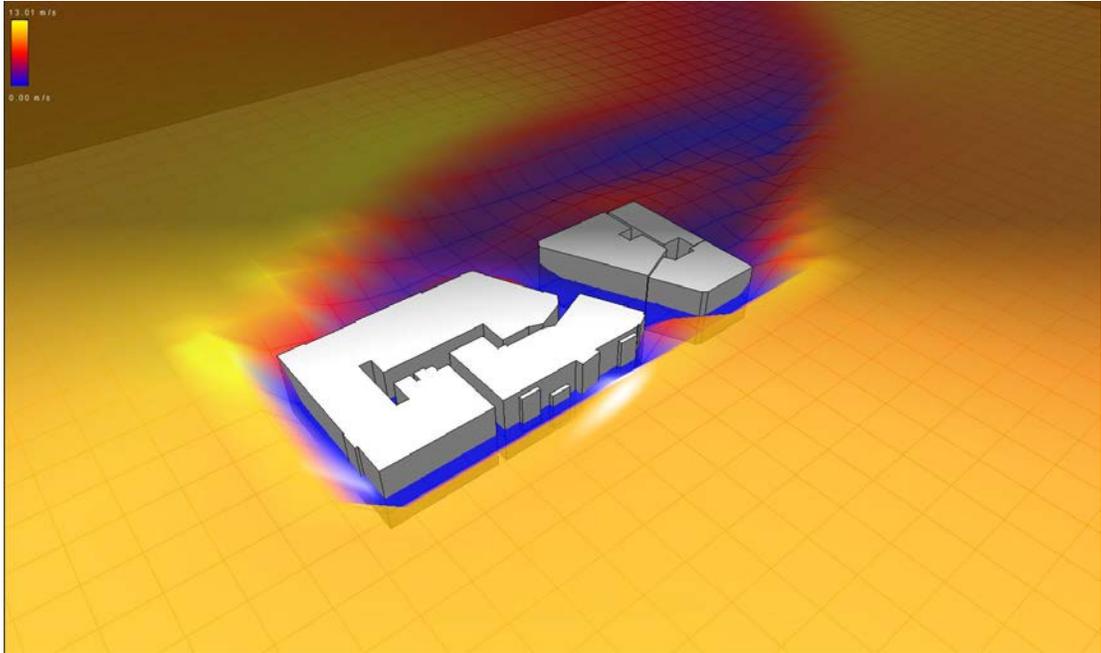


Figure 55: View of Wind Building Studies.

The wind turbines are comprised of three major components. First the outer shell which serves as a structural element and also to protect the turbine blades from foreign objects. These fine rounded triangle shaped discs are made of a lightweight aluminum, with an anti-corrosion coating to protect them from the elements. They stack and lock into place to form a long tube with many slits that help direct and channel air flow through to the turbine blades. The next component is the turbine fan itself, which is made from a lightweight carbon fiber resin. These blades are then press fitted into high flow bearings that allow for minimal friction. This allows the fan blades to rotate in minimal wind conditions. The final element of the whole system is the copper coil cores, the power transformers and the drive shafts and bearing clutches that control the speed of the turbine blades. The bearing clutches sit around the drive bearings and between the coil cores. They prevent over drive, which could damage the wind turbines. The actual drive shafts are made from a lightweight aluminum and help the carbon fiber fan blades keep their structure. Finally the transformer system stores and converts the alternator's spinning into usable power for the building, while regulating power surges. Below are a few details of the system showing the breakdown of the components.

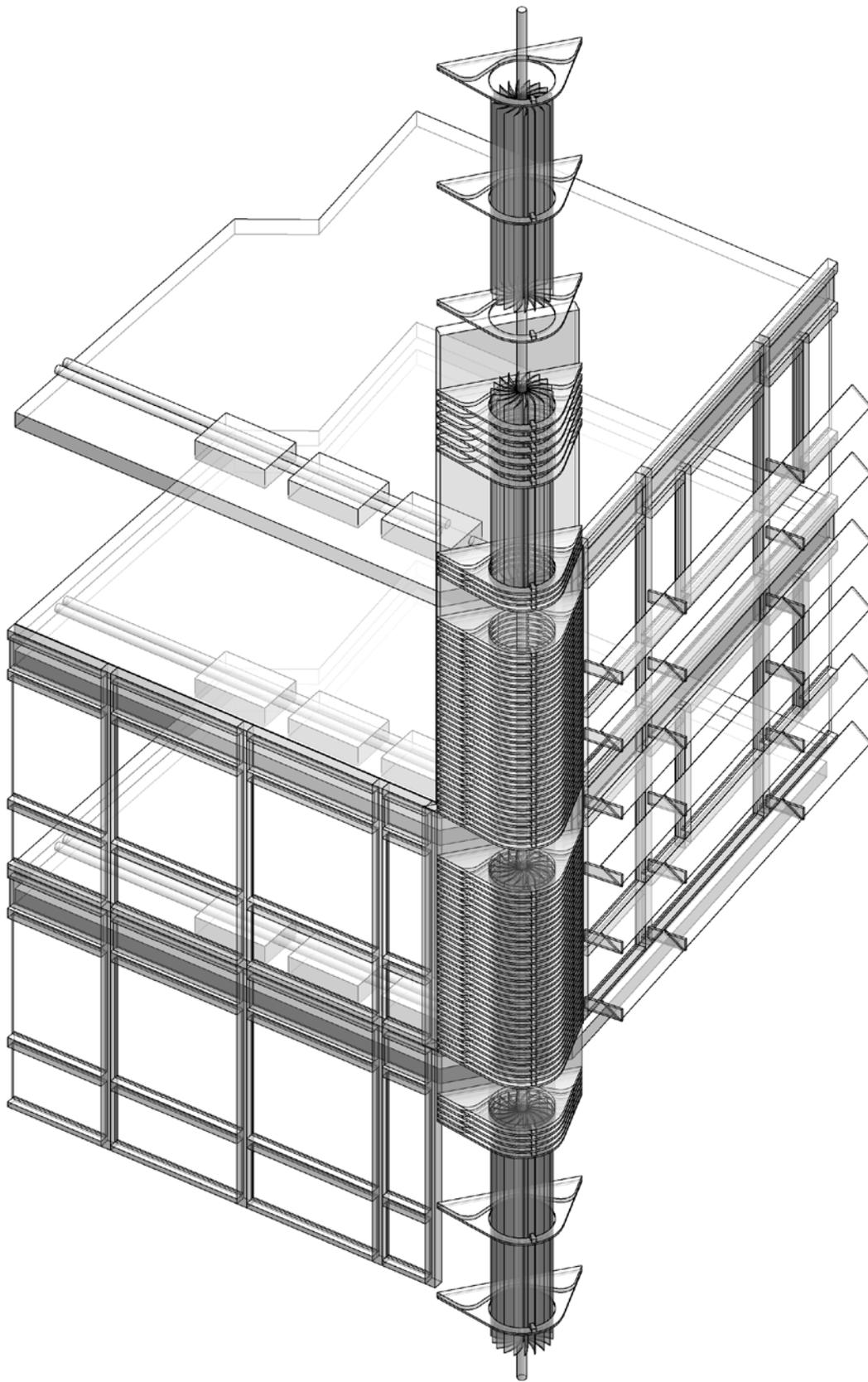


Figure 56: View of axon wind turbine detail.

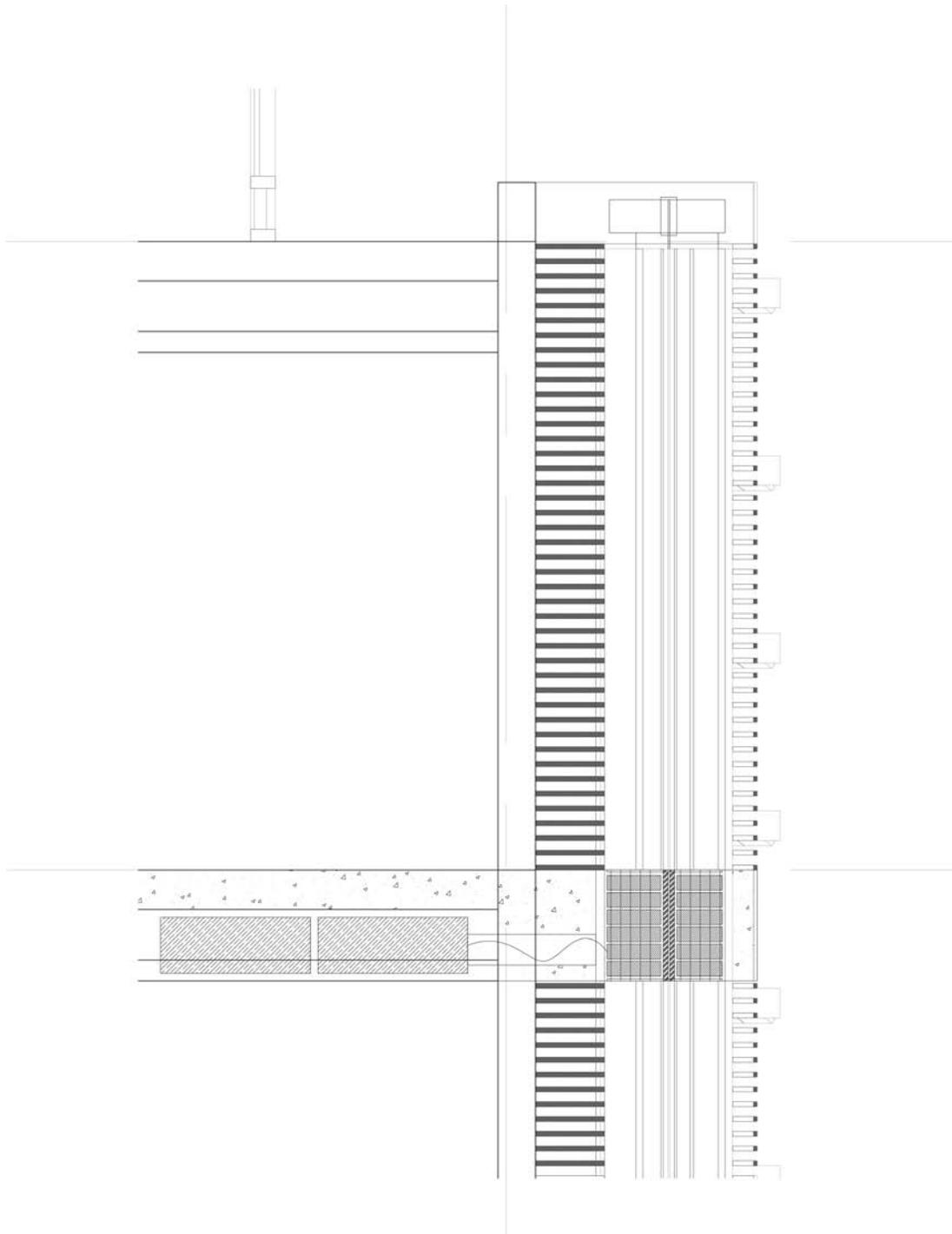


Figure 57: View of wind turbine section detail.

Chapter 11: The Plant Element

The plant element of the enclosure redesign serves multiple functions for 1000 Connecticut Ave. The primary function is water filtration for storm runoff. Secondly the vertical bio swales reintroduce plant life into the office spaces of the building. Finally they also help regulate air quality and provide cleaner air for the city. There are three small vertical walls located on the south face of the building enclosure that work in unison with the main living wall located in the lobby and atrium of the building. These walls also work with the existing green roof, to ensure that the maximum amount of storm runoff is treated.

Filtration and Remediation

The vertical bio swales primary function is the cleansing of storm water and polluted air. The walls are all fed via a series of roof drains and the runoff from the green roof. This system allows for easy maintenance of the plants, and more importantly allows the plants to clean the water as they use it. A specific selection of grasses and ivy were chosen for their various remediation traits. The ivy pulls the VOCs out of the water and air, as well as nitrates. The remaining grasses combat carbon monoxide and other pollutants like heavy metals and acidic rain. The long vertical length of each wall gives the plants enough time to clean the water not being used and return it to the city's waste management network. The three smaller walls are exposed to the outside climate, and also help to regulate the air quality around the building by removing pollutants and dealing with smog. The largest vertical bio swale is enclosed by the building and helps to regulate the internal air quality and humidity,

preventing the air from becoming too dry. At the same time, the wall terminates into several water features in the atrium which makes its way back into the city's network.



Figure 58: View of living wall plant types.

Structure

The living walls are comprised of several layers and a structural core of steel columns. The columns run the height of the building and tie into a truss system at the top of the atrium. The base of the walls in the lobby are seated in footings tied into the structural slab of the building. To further support the heavy walls, the lobby also has an exoskeleton beam system that takes some of the load off the internal columns. The three exterior living walls are supported in a similar fashion, the key difference being that they tie back into the existing floor structure with the addition of a mesh rebar system. Their footing system is also tied into the ground slab via steel wide flanges. This gives the wall the appearance of floating, however it is effectively pinned in all corners. Each wall is made up of a layer system that holds the water feed and drain pipes, the growing media and the pocket system for holding the actual plants in place. The layer system starts with a fiber mat that insulates the pipes and wicks the water towards the growing media which is comprised of top soil and organic debris rich in nutrients. To keep the media in place there are multiple semi permeable membranes that hold the dirt in place but also allow it to breath. On top of this, a stainless steel mesh helps support the weight of the media. Towards the outer

edge of the wall, the fiber mat pocket system is tied back into the mesh, allowing for the roots of the plants to dig in. This pocket system also holds more dirt, giving the plants some room to grow. The bottom cap then holds all the layers together and moves excess water towards the drain pipes hidden in the wide flange columns. This is then discreetly dumped into a shallow water pond in the lobby, which also catches any dripping from the plant walls. Below are several details and diagrams of this process.

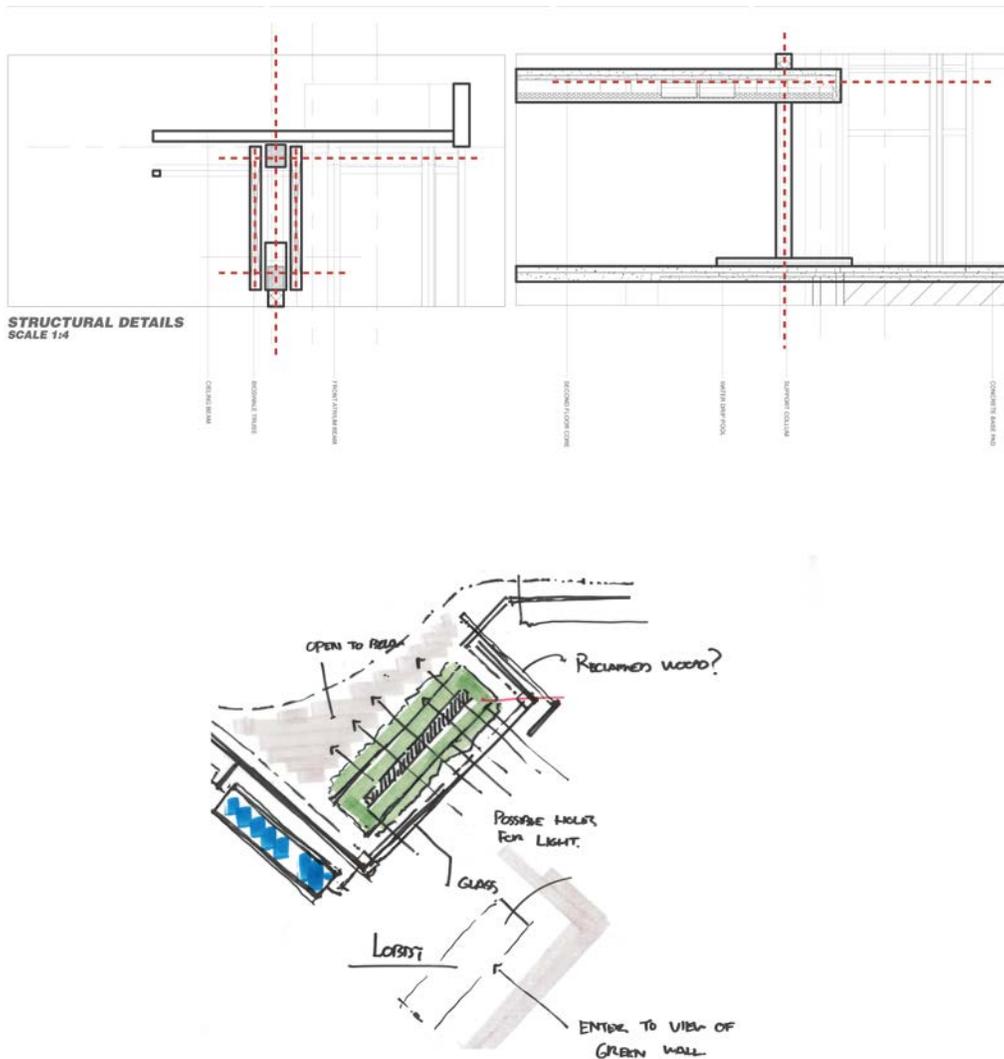


Figure 59 and 60: View of living wall structural detail.

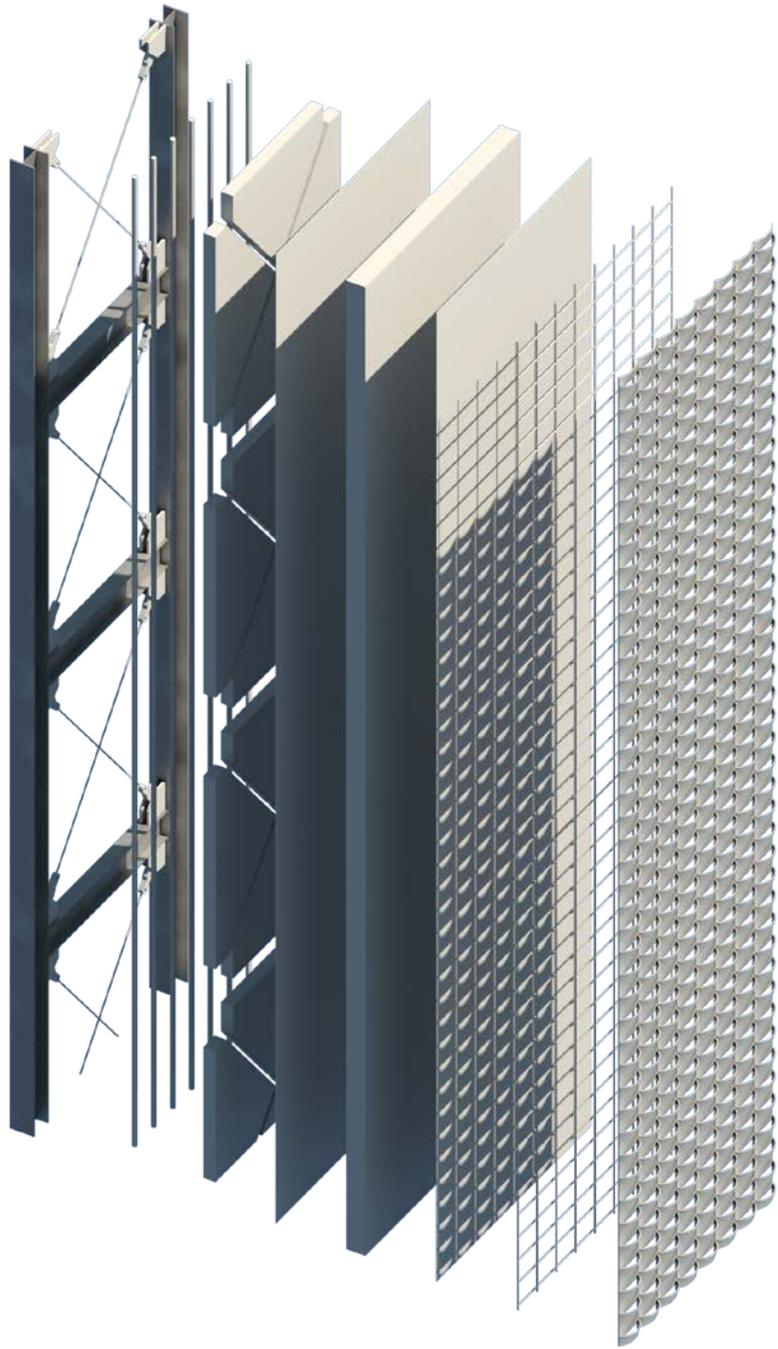


Figure 61: View of living wall layer system.

Work Place Productivity

The living walls also serve the office space in two ways, first the walls help introduce plant life back into the office, without making a large foot print, and second, the vertical living walls also helps regulate the air quality of the office space. Plant life in office spaces has be linked to higher productivity, and it provides a more simulating environment. At the same time, the plants also keep the air fresh, and help to prevent it from drying out. This allows HVAC systems to run as normal but without all the complaints of the air quality being too poor. This in turn also increases productivity, making for a healthier and better work place.³⁷ According to a study conducted by Berg, plants could have a major impact on the productivity of office personnel.³⁸ The locations of the walls also help shade the community spaces of the office on the south face of the enclosure.

³⁷ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: B en R Adviseurs voor Duurzaamheid Amersfoort

³⁸ Bergs, John. 2002. *The effect of healthy workplaces on the well-being and productivity of office workers*. The Netherlands: B en R Adviseurs voor Duurzaamheid Amersfoort

Chapter 12: The Air Element

The Air element of the enclosure redesign for 1000 Connecticut Ave has two main design ideas driving it. The first is improving the air quality for the office spaces while the second is reducing air pollution around the building. To do this a double skin system is used to allow for natural ventilation of office spaces. This also helps reduce the energy use of the building as a smaller area is controlled by HVAC. To help clean up the air outside the building, the design uses a coating on louver systems already shading the building. This coating helps remove VOC and greenhouse gases via a chemical reaction. The entire north east face of the enclosure uses this system to help clean the air around the building. The double skin system is used on the south face of the enclosure.

The Filter System

The filter system idea of the enclosure is actually a hybrid of two different elements working together. On the north east face of the enclosure, a louver system is needed to help reduce the sun glare in the mornings. These louver panels provide the perfect structural support for a Nano-coating material called PROSOLVE 370e. The coating removes smog and other pollution from the air by attracting the particles to the coating itself. This allows for the construction of a large scale air filter with the louver panels acting as baffles for the flow of air. To increase the surface area, small circular stepped holes are punched in the louvers creating a shade screen that also maximizes air contact with the coating, making it more effective. The panel system is then bolted on to the existing wall and tied back into the structural components of the

floor, making the system fully adaptable to an existing building enclosure system.

Below are detail axons of the systems, where you can see the perforated panels with the coating.

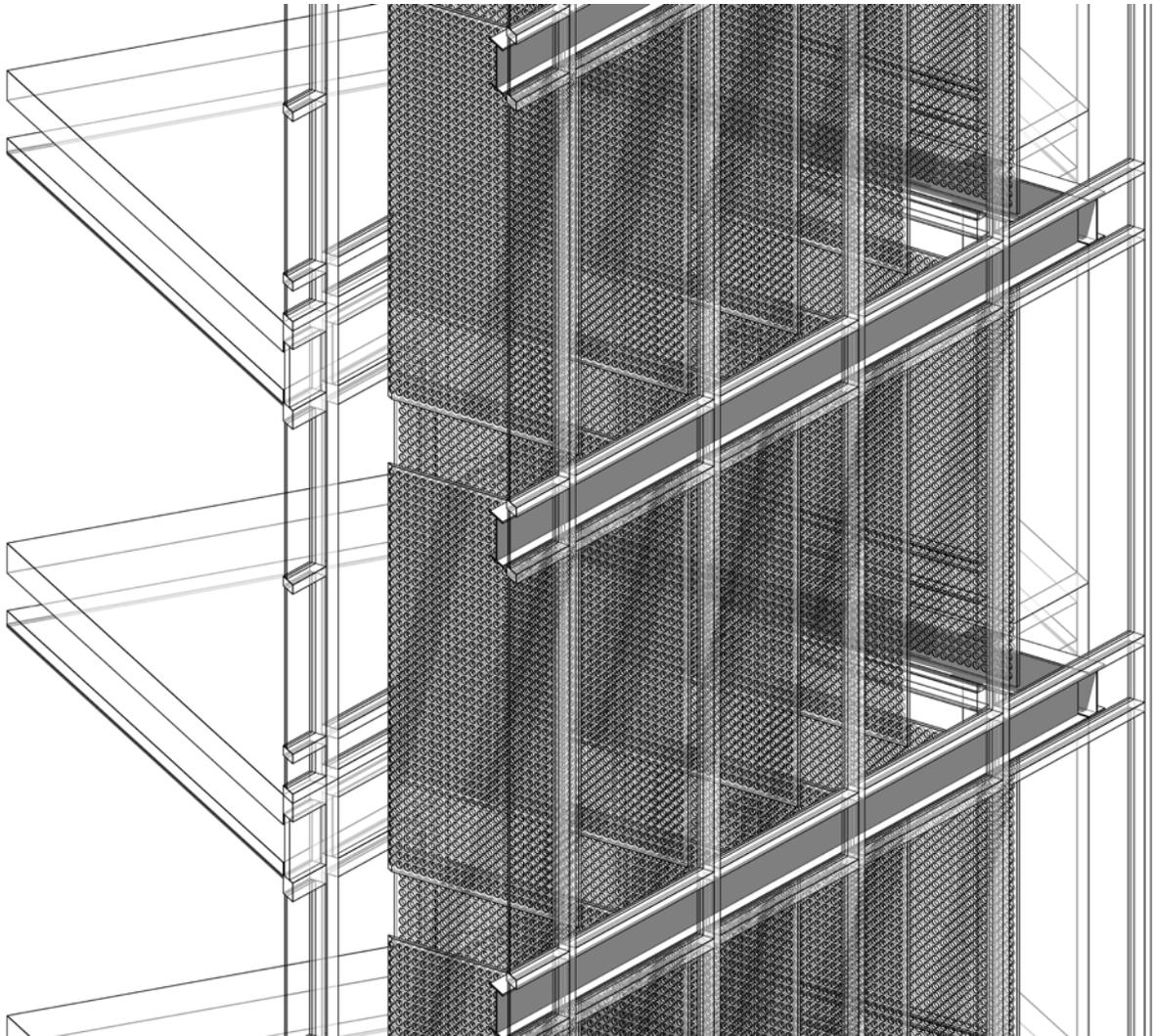


Figure 62: View of Air Filter Wall Detail.

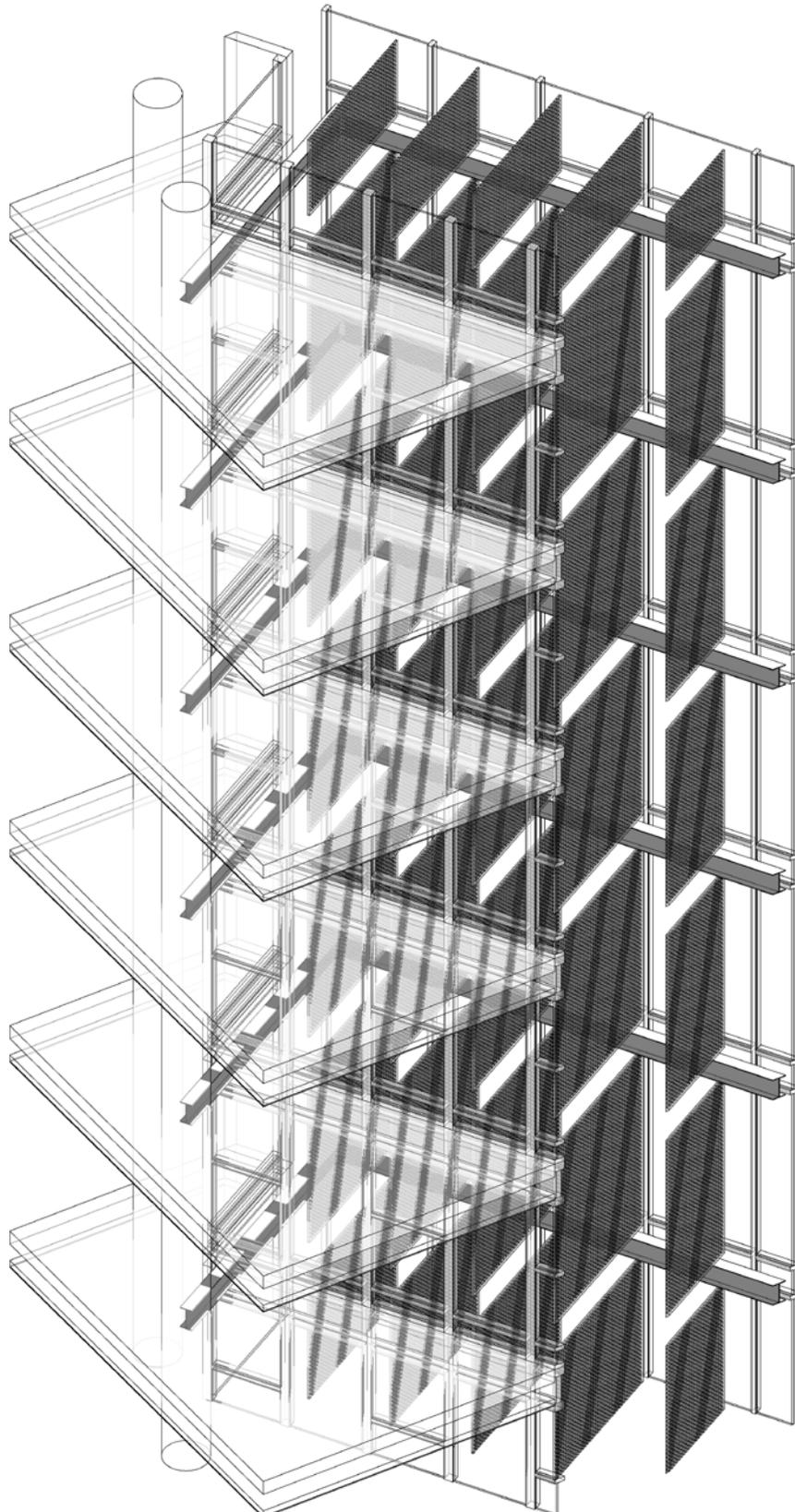


Figure 63: View of Filter wall axon.

PROSOLVE 370e

The main element in filtering and cleaning air pollution in the filtration system is a Nano-coating called PROSOLVE 370e. This coating is made up of a “superfine TiO₂ embedded in a polysiloxane base and containing a cementitious matrix.”³⁹ Titanium Dioxide is the active element that pulls pollution from the air. Using the sun as a driver, the TiO₂ magnetically attracts the particles of pollution to itself, removing them from the air making it cleaner. The coating was developed by Elegant Embellishments, a design firm in Berlin, Germany. Daniel Schwaag and Allison Dring, along with Structural Eng: Buro Happold New York, Kiwa MPA Bautest GmbH, TU Berlin, Fraunhofer IPA Stuttgart and Joshua Socolar helped develop the project and get the first version installed on a large scale. Over 2500 square meters of the coating are in use in Mexico City, helping a hospital reduce the carbon foot print of the city. Below is a transcript from the PROSOLVE 370e product page, which details the way the coating works.

“The modules are coated with a superfine titanium dioxide (TiO₂), a pollution-fighting technology that is activated by ambient daylight. This is the nano photocatalytic version of conventional TiO₂ commonly used as pigment and already known for its self-cleaning and germicidal qualities. It requires only small amounts of naturally occurring UV light and humidity to effectively reduce air pollutants into harmless amounts of carbon dioxide and water. When positioned near pollution

³⁹ Schwaag, Daniel, and Dring, Allison. prosolve370e. Germany, 2015 [cited 5/20 2015]. Available from <http://www.prosolve370e.com/> (accessed 5/20/2015).

sources, the coated tiles break down and neutralize NOx (nitrogen oxides) and VOCs (volatile organic compounds) directly where they are generated.”⁴⁰

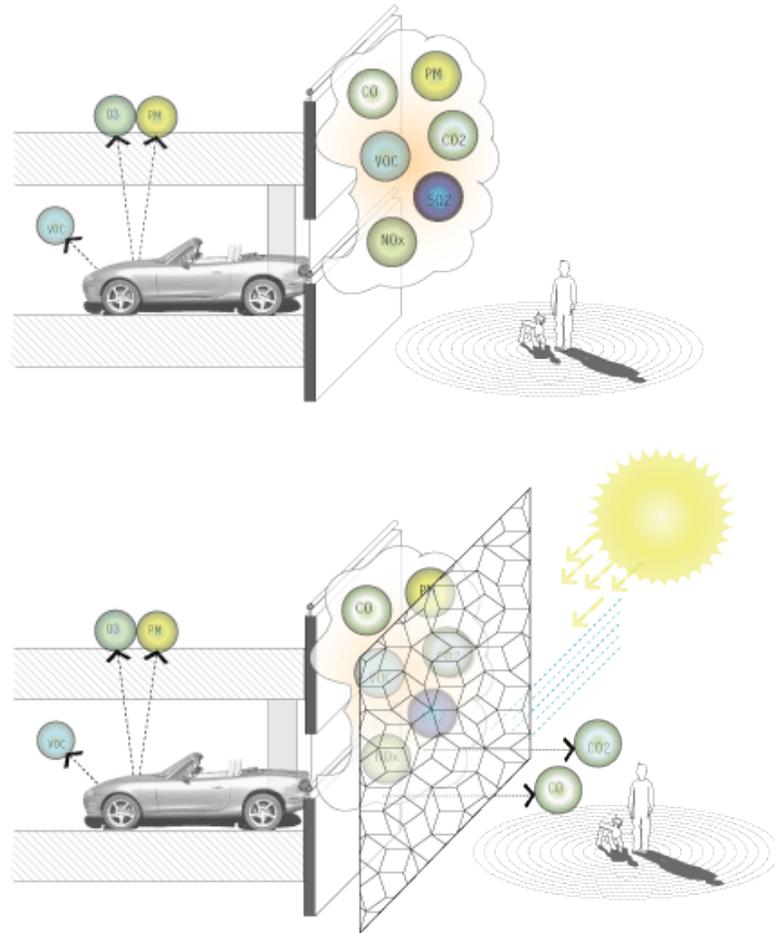


Figure 64: View of PROSOLVE 370e coating chemical reaction.

While I chose not to use the specific form of PROSOLVE 370e, the coating is widely customizable and can be applied to almost all surface shapes. In this case, it was the flat and punched holes of the shading louvers that provide the structural backdrop for the coating, allowing me to reach approximately the same area as the Mexico City project.

⁴⁰ Schwaag, Daniel, and Dring, Allison. prosolve370e. Germany, 2015 [cited 5/20 2015]. Available from <http://www.prosolve370e.com/> (accessed 5/20/2015).

Double skin and Natural Ventilation

The other major aspect of the air element redesign is the addition of a double skin glazing system that allows for natural ventilation and operable windows even at the top floors of the building. This system is also a hybrid between the solar louvers. The outer frame of the louvers provide the structural support for the second wall of glazing that protects the open windows from the elements. This design also creates a neutral zone that works like a heat chimney. Hot air is drawn up through the space, and out the top of the double glazing area. This allows for cooler air to be sucked up and into the building. The window system itself has a set of multi directional swings, allowing for an awning style opening or a hopper style swing. The clearstory also opens inward to help vent hot air even in rainy conditions. The wind currents are blocked by the second skin, allowing windows to be open on cooling day, while the system also provides an air barrier for a better mitigation of heat.

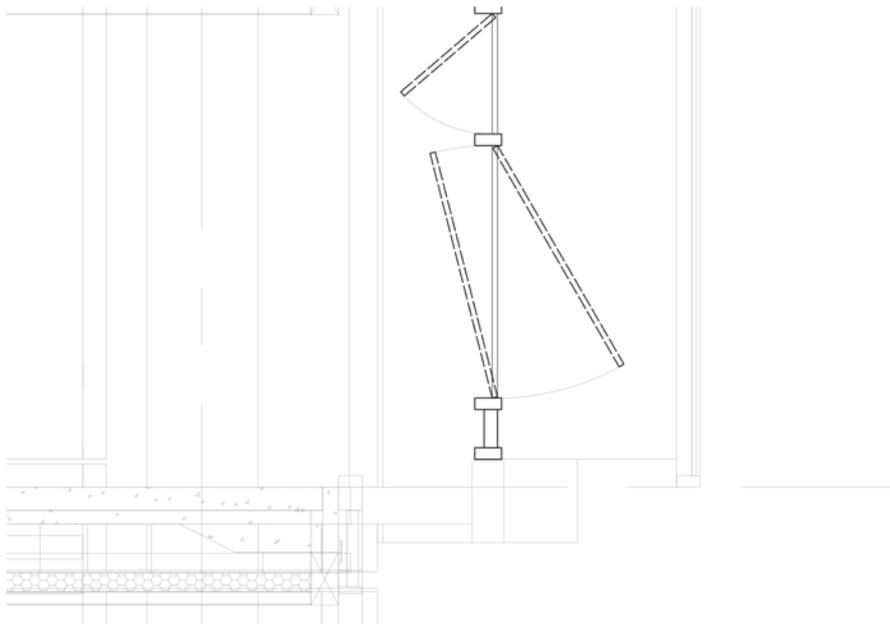


Figure 65: View of operable windows.

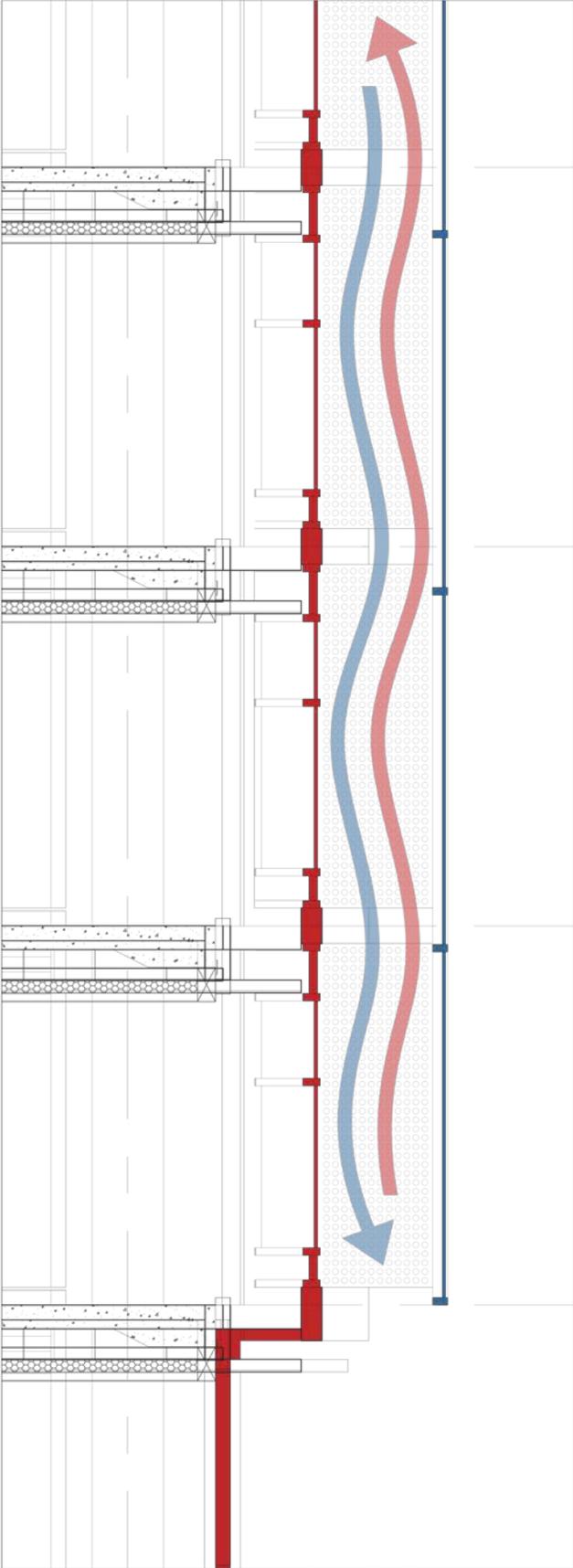


Figure 66: View of double skin heat transfer.

Chapter 13: Conclusions and Future Applications

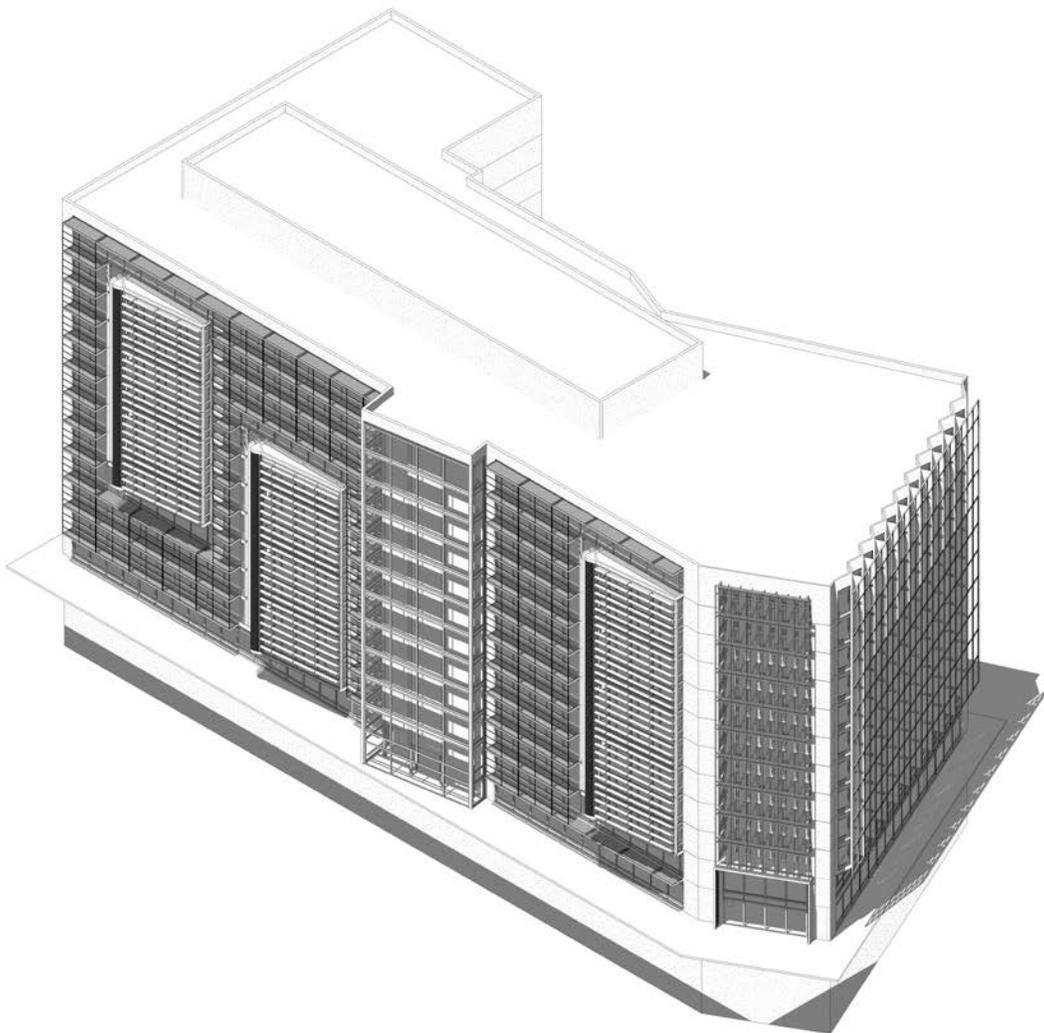
Reflection

As my research on the first iteration comes to a close, I find that there are still many opportunities to push this project further. While hind sight seems to always be 20/20, the advice and direction it provides are invaluable to this project. I set out to initially trying to improve an existing model of a specific building type. However after working on it for the better part of a year, I find that what has come to light is far more important to the future of this thesis. While I feel confident in arguing that I have found a method by which the office building typology can be improved, I feel that I have not yet answered the question of how. Could I move the needle in each area of my focus? Yes, I could, but to say I have figured out how is not yet the full truth. Perhaps the most important development of my thesis is an uncovered opportunity to use the system developed over the past year to improve upon my initial improvements. I believe that through iteration and testing, the how could feasible be answered. It is with this acknowledgment that I will continue to study the integration of these systems and others into the enclosures of office buildings.

The Future: Version 2.0

The future of this thesis lies in iteration. While the first version proved the concept possible, the final results will be found in further exploration. This approach to designing building enclosures could yield a vast catalog of elements that are fully adaptable to new and existing building enclosures. More testing and design would be needed to improve the effectiveness of these elements as well as develop new ones.

Another major objective carrying forward would be the integration of these systems into each other, making the element itself more versatile. For example, solar panels with louver systems that also had an air purifying coating. The possibilities are endless, and while this thesis has done a good job of starting the conversation, there is still lots more to be said, and hopefully implemented.



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