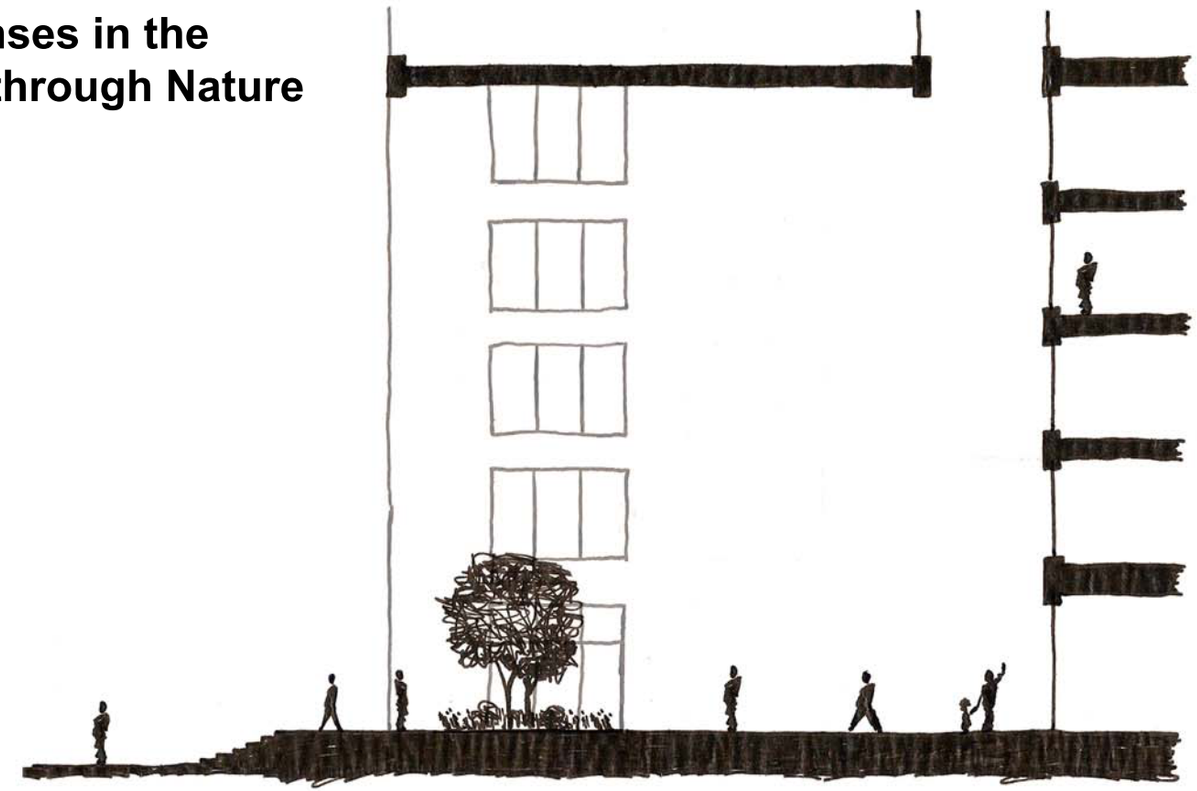
Experiencing Sustainable Architecture

Stimulating the Senses in the Built Environment through Nature



John Keegan

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Stimulating the Senses in the Built Environment through Nature

Thesis submitted to the faculty of Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of Master of Architecture.

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The prevailing approach to sustainable design focuses on low environmental impact objectives rather than the enhancement of the connection between people and the natural environment. According to Edward O. Wilson, biophilic design attempts to place an emphasis on the human to nature relationship in the built environment under the ideology that we have an innate affinity for the natural world because of our evolutionary development. In order to properly apply biophilic design, it is necessary to study and understand what it is about specific elements in nature that creates a sense of pleasure and well being. Nature is rich with sensual features, and the expression of these biophilic traits in architectural design is really what “sustainable design” is all about.

The purpose of this thesis is to explore Wilson’s theories of biophilic design through the development of an office skyscraper. The driving force behind the project is the design of the sensory oases, which are vertical extensions of the ground plane that contain features intended to stimulate the senses.

By John Keegan

Acknowledgements

I would like to thank my committee members Hans, Steve, Jim and Michael for their guidance and feedback throughout my thesis.

I would also like to thank my wife Marisa and my parents John and Colleen for their continued patience, love and encouragement while I worked on this thesis. I could not ask for a more supportive family.

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Introduction

My inspiration for this thesis came when I read about Edward O. Wilson's theory of biophilia and subsequent studies about biophilic and restorative environmental design. According to Wilson, biophilia is an innate human affinity for the natural world, and access to nature is a basic human need. Millions of years of evolution have left modern humans with a partly genetic predisposition for responding positively to nature. The human mind, body and culture was developed in a sensory world dominated by environmental features such as light, sound, odor, wind, weather, water, vegetation, animals and landscapes.[1] As these qualities differ from region to region, cultural diversity was inevitably formed as the regions developed their own defining characteristics: the creative use of available foods; clothing designed in response to the climate; and shelter built to provide comfort based on the local conditions nature created.[2] Our relationship with the natural environment has shaped human culture and still today we continue have an inherent need to nurture that relationship.

Biophilic design is defined by Stephen Kellert in his contribution to the book *Biophilic Design* as the deliberate attempt to translate an understanding of the inherent human affinity to interact with nature into the design of the built environment.

Wilson's theory of biophilia is only one of many schools of thought concerning the relationship between humans and nature. I chose to explore Wilson's theory because it was particularly inspirational to me, and I must note that my committee chairman does not necessarily share the same views about that relationship as I have expressed in this thesis.

I have always been interested in "sustainable" design and continue to appreciate the movement's efforts of reducing the environmental footprint of our buildings. While these intentions are admirable and necessary, however, I think that the principals behind the movement are currently failing to address a critical point: the user experience. In many cases, the "sustainable" features in our buildings are only working to a fraction of their potential because they are completely hidden from the users of the building. Why put vegetation on a building's roof that will never be seen? Or collect rainwater through concealed conduits where it will never be heard? While the building may gain credit for these features in regards to sustainable design point systems, the environmental design movement gains little acclaim in the eyes of the users. It is for this reason that I believe we need to integrate biophilic design principles into our sustainable strategies.

"Human satisfaction and well being are reliant on perceiving and responding to sensory availability."
–Stephen Kellert [3]

One of the most "sustainable" qualities a building can have is longevity; sustainability is as much about keeping buildings in existence as it is about constructing new low-impact-efficient designs. This is why Kellert stresses the importance of restoring and enhancing people's positive relationship with nature in the built environment. Without the positive benefits to the users and their associated attachment to buildings and places, people rarely feel obligated or responsible to keep them in existence over the long run. Low-environmental-impact design strategies typically result in little net benefit to productivity and health on their own, but it is when the user's senses are able to interact with nature in the built environment that the impact is made.[4] Thus, in order to make the most of our "sustainable" features, it is necessary to consider the potential sensory enhancements that the feature has to offer in addition to the environmental benefits.

Fig 1.1

The development of the human mind and body is dependent on our senses of sight, sound, taste, smell and touch. The stimulation of these senses is critical to our well being, and the built environment that we experience daily plays a large role in fostering those opportunities. This design thesis is an office skyscraper that integrates multiple outdoor spaces into its footprint that are meant to stimulate the senses with elements of nature.

The Design Project

Fig 2.1 Graphic plan of downtown Roanoke

Fig 2.2 View of Roanoke from Mill Mountain

I chose downtown Roanoke, Virginia for the site of my proposed design because I wanted to use the scenic terrain as a backdrop for the sensory oases. Roanoke is located in Southwest Virginia and is surrounded by the Blue Ridge Mountains and the Jefferson National Forest.

I was also intrigued by the scale of the buildings in the downtown area, and thought that a skyscraper would be a positive addition to the city's skyline.

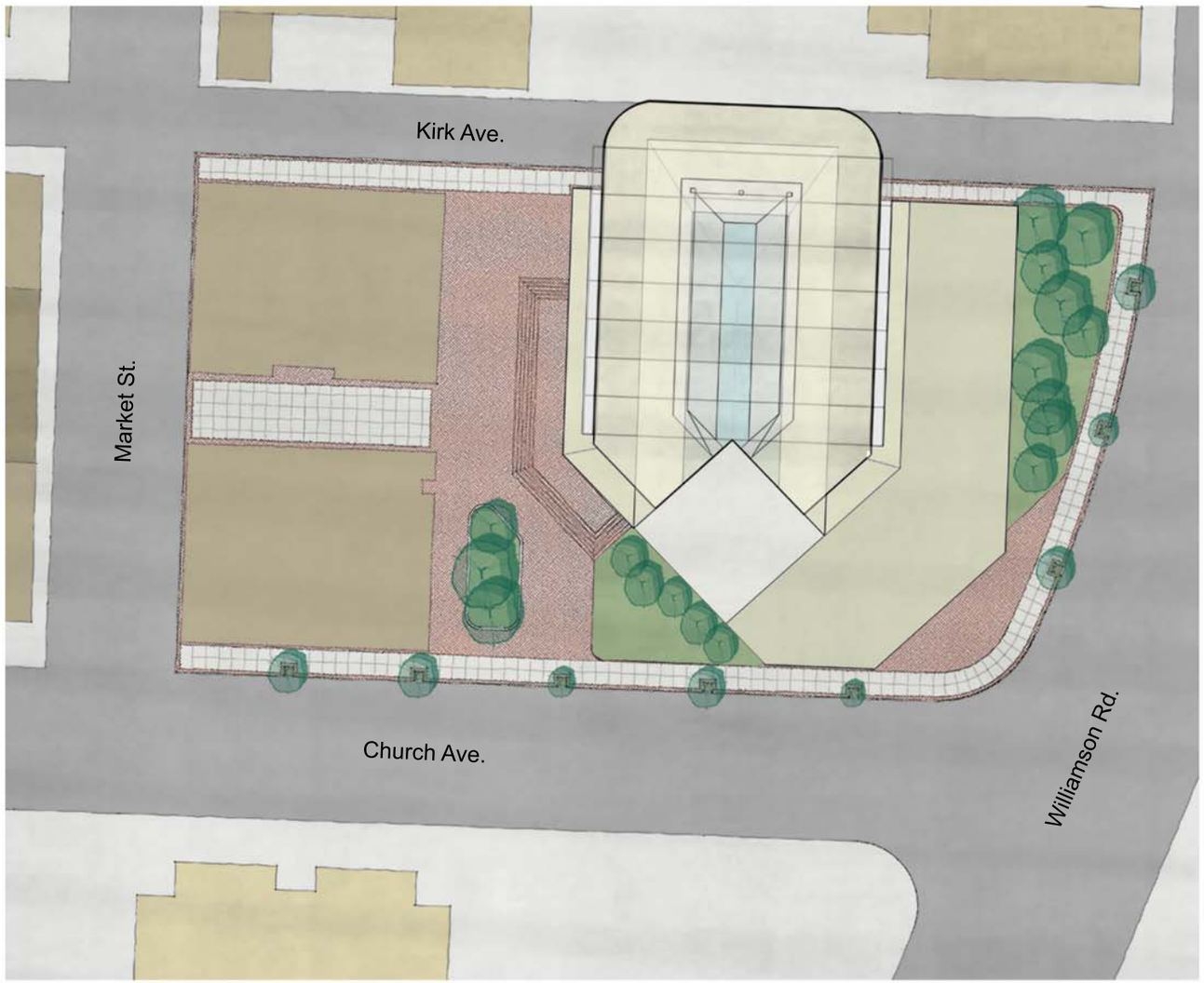


Fig 2.3 Site Plan

Fig 2.4 View of site from southeast

I selected a surface parking lot on the intersection of Church Ave. and Williamson Road as the site for the office building because of its corner location and its high exposure to both pedestrian and vehicular traffic. This particular corner is a major traffic intersection, and the addition of street frontage in the void that is currently a parking lot is appropriate to extend the urban fabric. The site is also favorable because of its proximity to Market Street, which is bustling every day with pedestrians. I envisioned the main business entrance on the street corner and a secondary entrance through the ground floor sensory oasis facing Market Street. There is a narrow alley between the buildings on Market Street that creates a dramatic pedestrian approach to the sensory oasis entrance.

Fig 2.5 The approach to the first floor sensory oasis through the alley from Market Street.

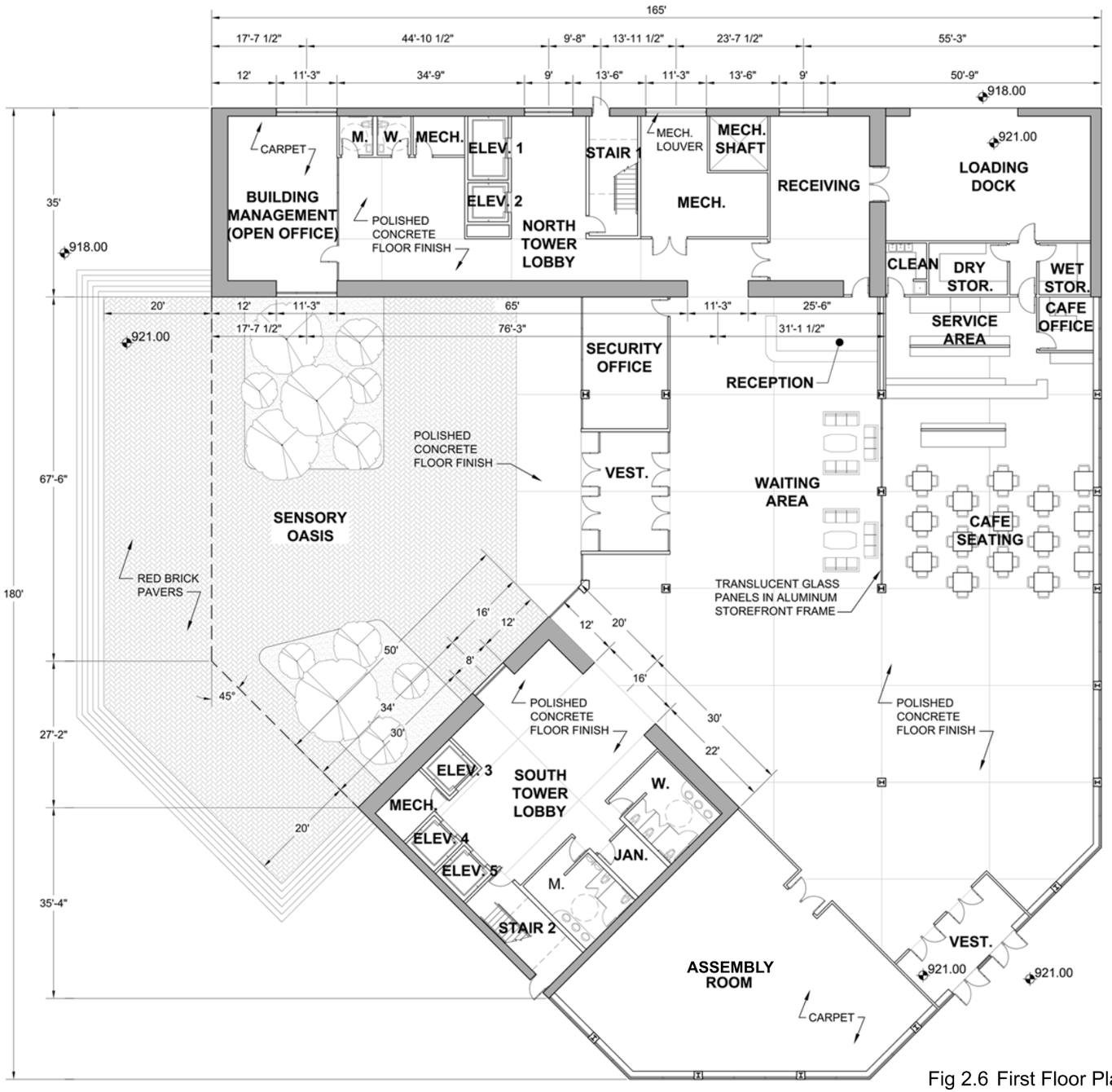


Fig 2.6 First Floor Plan

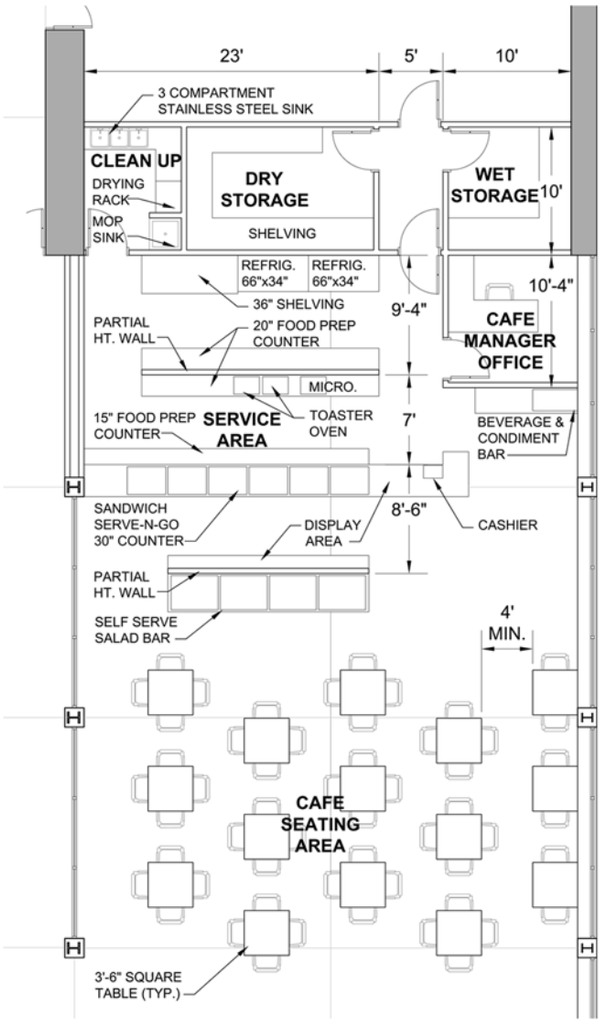


Fig 2.7 Enlarged Cafe Floor Plan

The first floor sensory oasis is intended to extend the sidewalk into an inviting plaza for the building users and pedestrians alike. Its open form blurs the footprint of the building with the surrounding context.

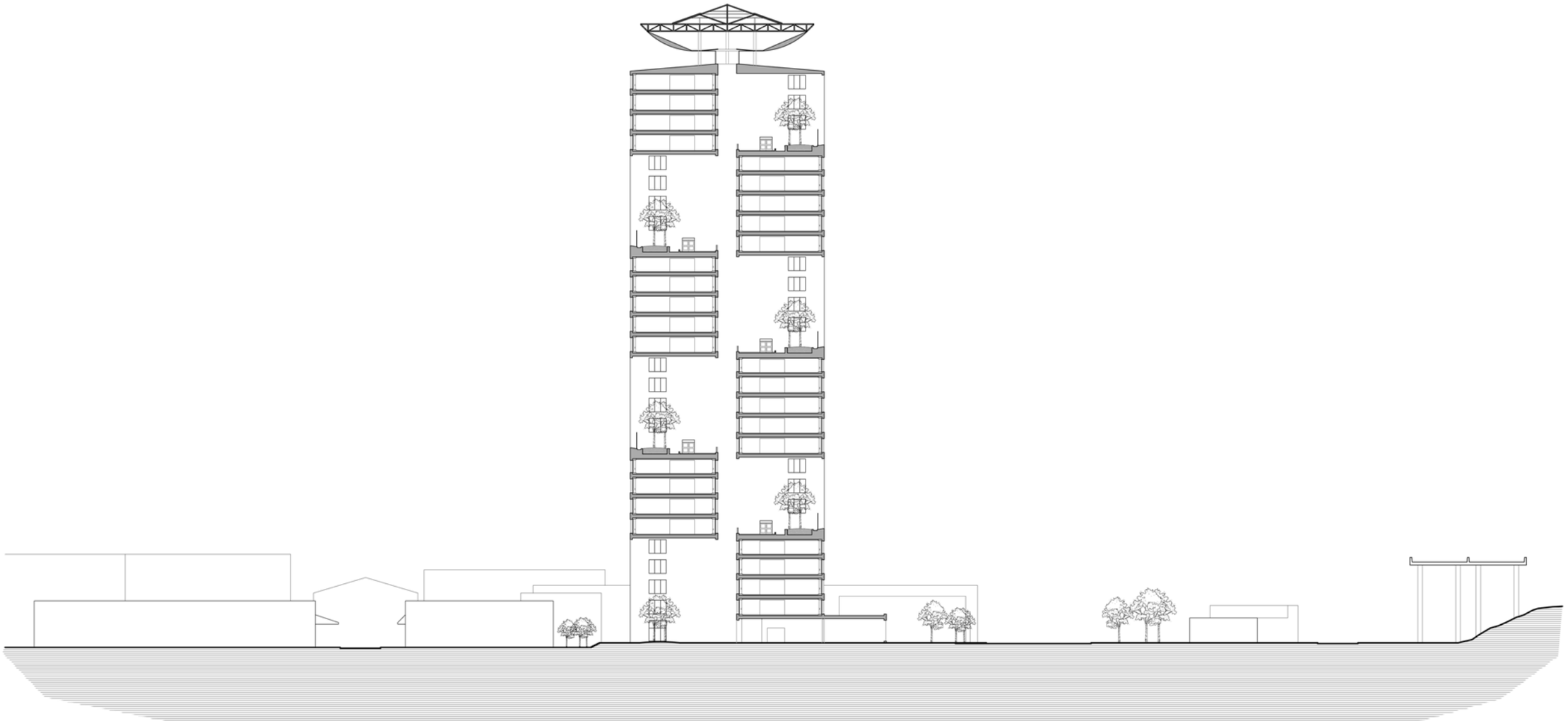
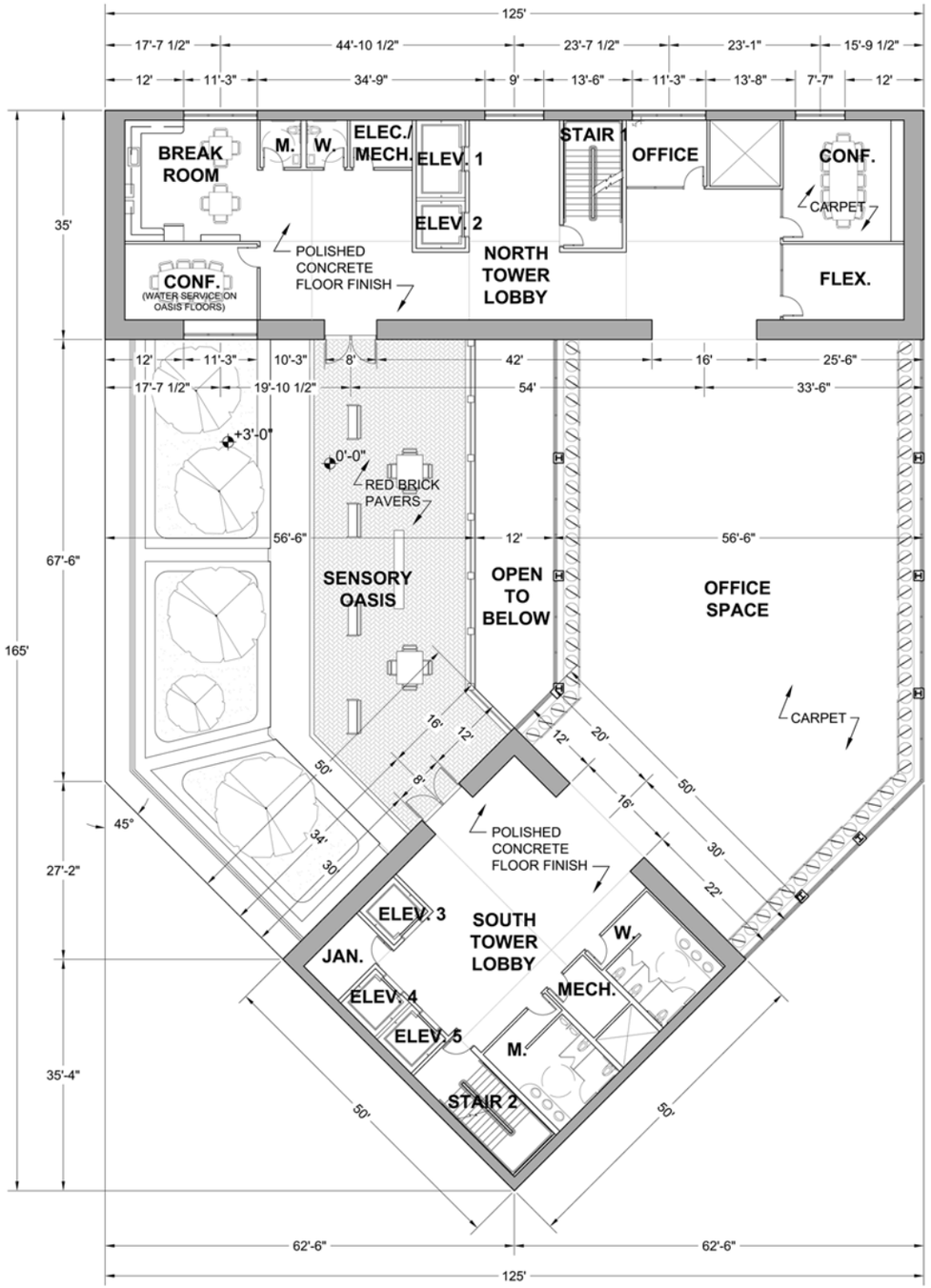


Fig 2.8 Building Section



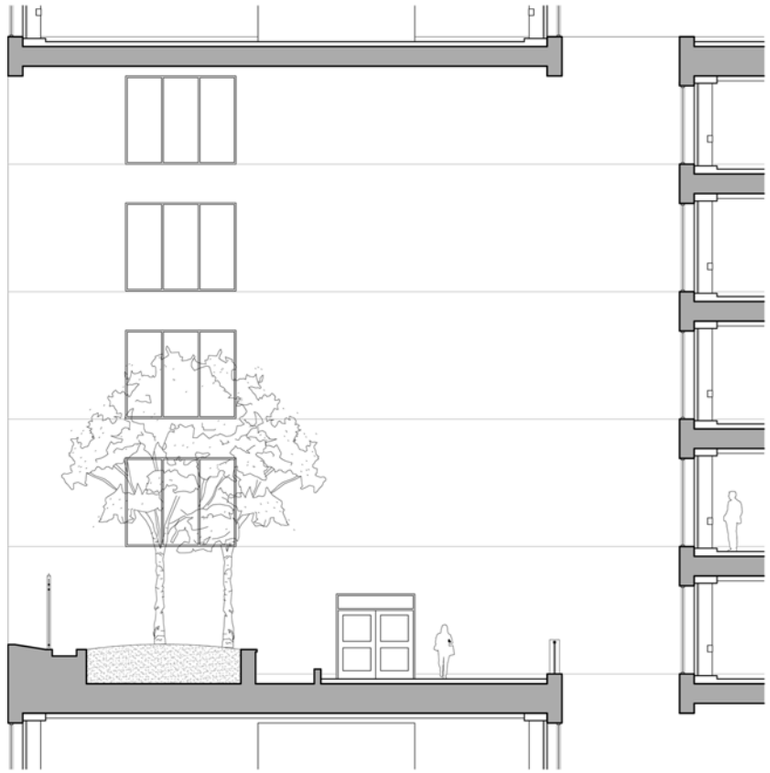


Fig 2.10 This partial section shows the typical relationship between the office spaces and the sensory oases. Office space occupants on every floor enjoy a humanized view of an outdoor scene and can find comfort in having fresh air only a few floors away. Occupants of the sensory oasis may feel as if they are on a ground floor plaza even though they may be as high as 320' from the ground.

Fig 2.9 The typical floor plan contains approx. 4500sf of open office space that overlooks the sensory oasis. All enclosed spaces are contained in the towers in order to maintain outdoor visibility in the open office spaces.

Fig 2.11 South Elevation

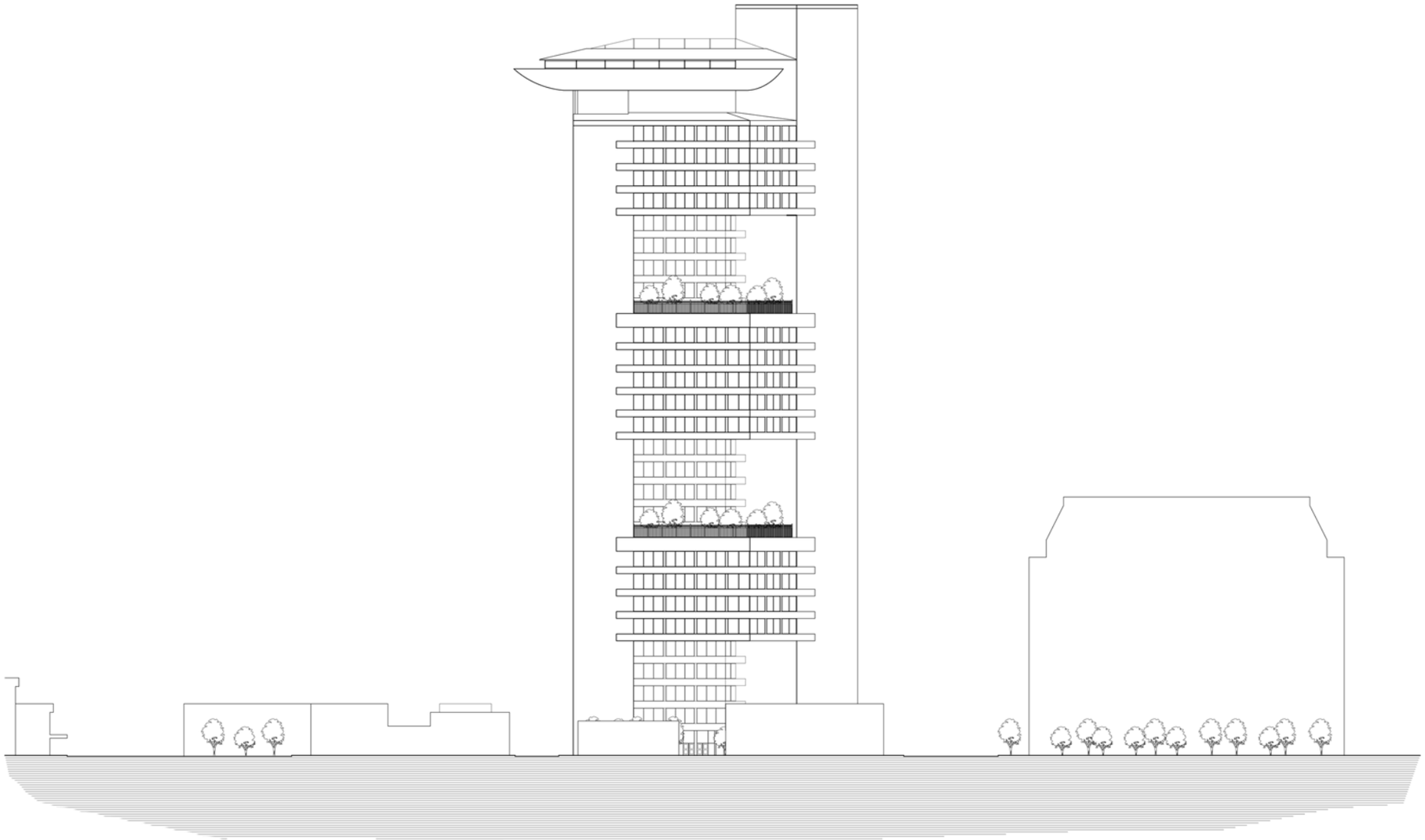


Fig 2.12 West Elevation

The Design Demonstration

“The brain is a wonderful organ; it starts working the moment you get up in the morning and does not stop until you get into the office.” -Robert Frost, American Poet [5]

I chose to design an office building because I believe the modern workplace is typically an environment where separation from nature is the norm and our senses are most deprived. Considering the amount of time we spend at work, our workplace environment has a tremendous effect on our health, our well being and even our productivity and profitability. Besetting ourselves for forty hours or more a week with inanimate, lifeless surroundings has a draining effect on our well-being and morale, which inevitably affects the quality of work that we do, the speed at which we do it, and our motivation to continue doing it. In many ways, productivity incentives may soon become the major driver behind the adoption of many green strategies. Successful companies in the future will be those that realize that their people are their most valuable and expensive resource and will be willing to spend money to protect their investment.[6]

I decided to design a skyscraper because they have always been an interest of mine and I think they will become more even prevalent in the future because of their spatial qualities. A skyscraper is spatially an intensification of large areas of built space concentrated over small building footprints. The skyscraper enables more usable floor space to be placed over a small plot of land by simply going higher.[7] I think the sustainable movement will continue to push for the reduction in footprint sizes and for higher building efficiency, and the result will be more vertical construction in our future.

The driving force behind my thesis project is the design of the sensory oases, which are conceptually intended to be vertical extensions of the ground that contain features intended to stimulate the senses, reduce stress and encourage creativity. The sensory oases are situated across from clusters of four to five floors of office spaces, giving each office space a humanized view of an emulated ground level to minimize the negative feelings of remoteness from the actual ground plane.

Fig 3.1

The initial design process involved the exploration of potential floor plate shapes through sketches and mass modeling. I wanted to place multiple sensory oases vertically throughout the building in a pattern such that one was visible on every floor, so I determined that I needed a floor shape that created rhythmic voids as it stacked.

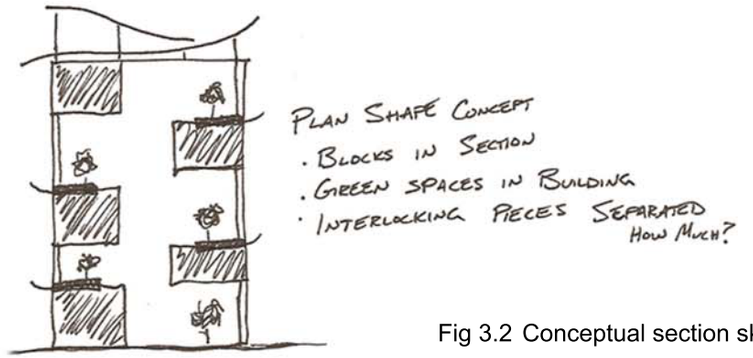


Fig 3.2 Conceptual section sketch

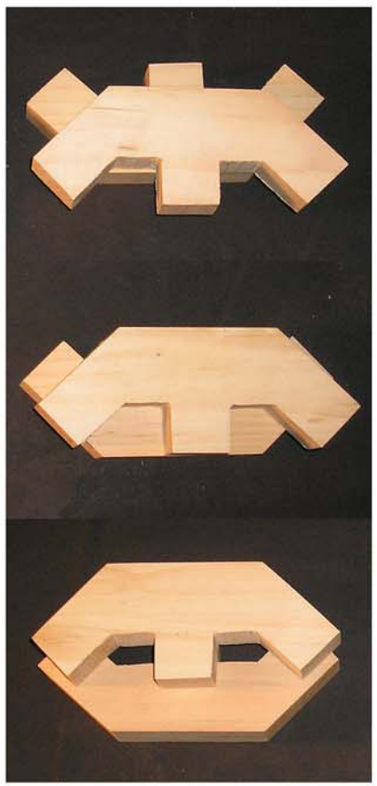


Fig 3.3 Floorplate stacking model

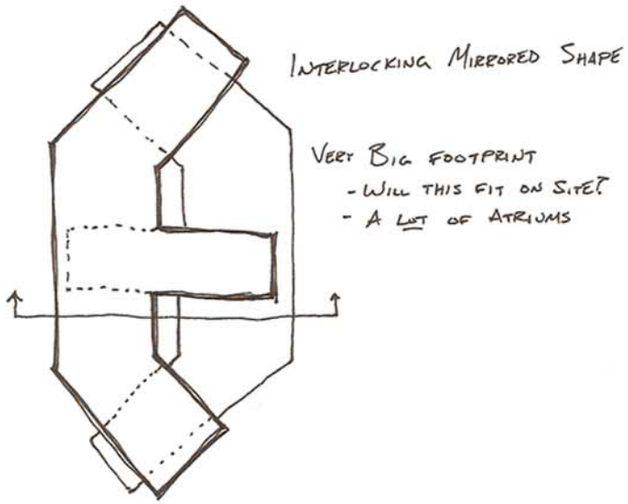


Fig 3.4 Early conceptual plan sketch

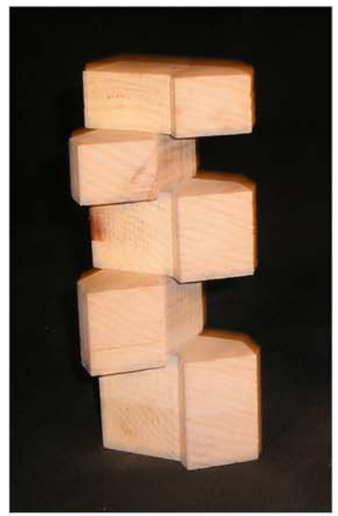


Fig 3.5 Section model

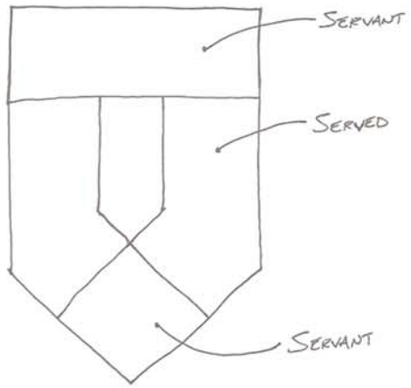


Fig 3.6 Conceptual plan sketch

The product of this study was a floor plate design that stacks and then mirrors to create voids opposite solids separated by a central cavity. I envisioned the solids as office spaces that would overlook the sensory oases in the voids. The overlapping portions of the floor plate would become structural masses containing vertical circulation and service areas.

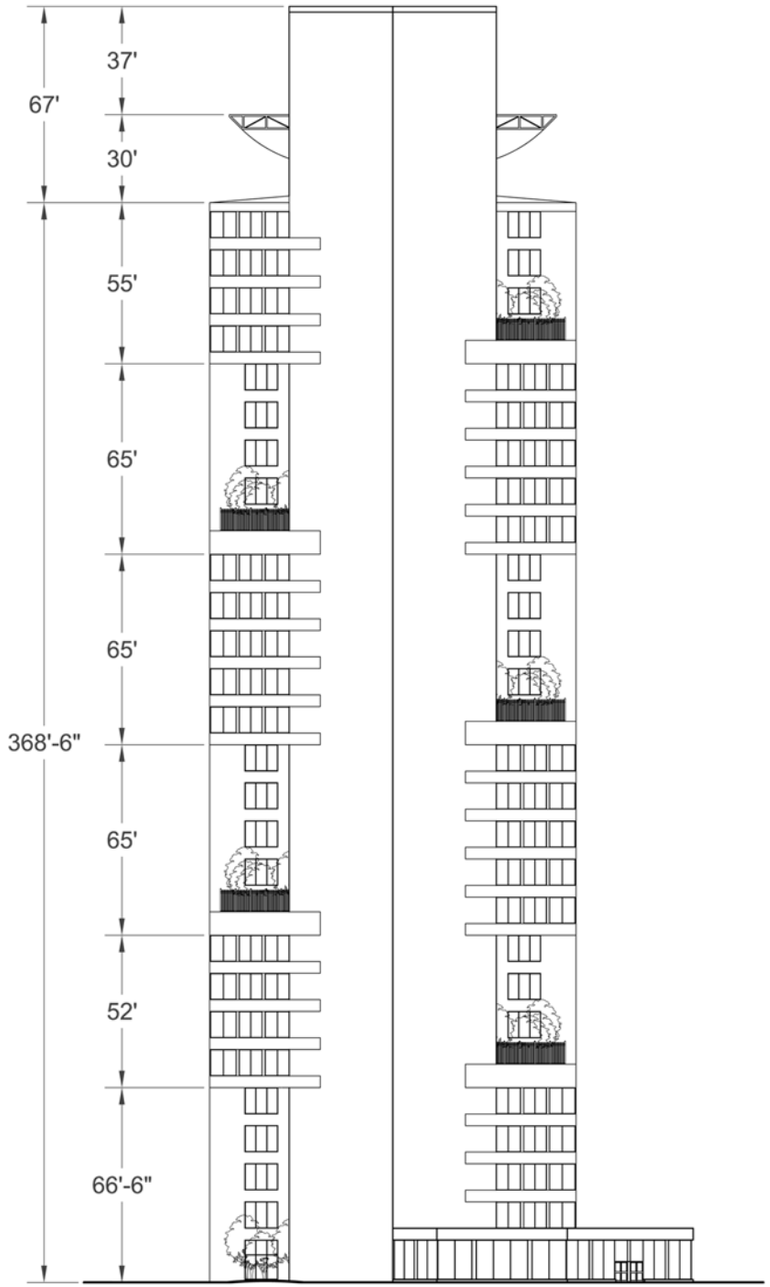


Fig 3.7 South Elevation

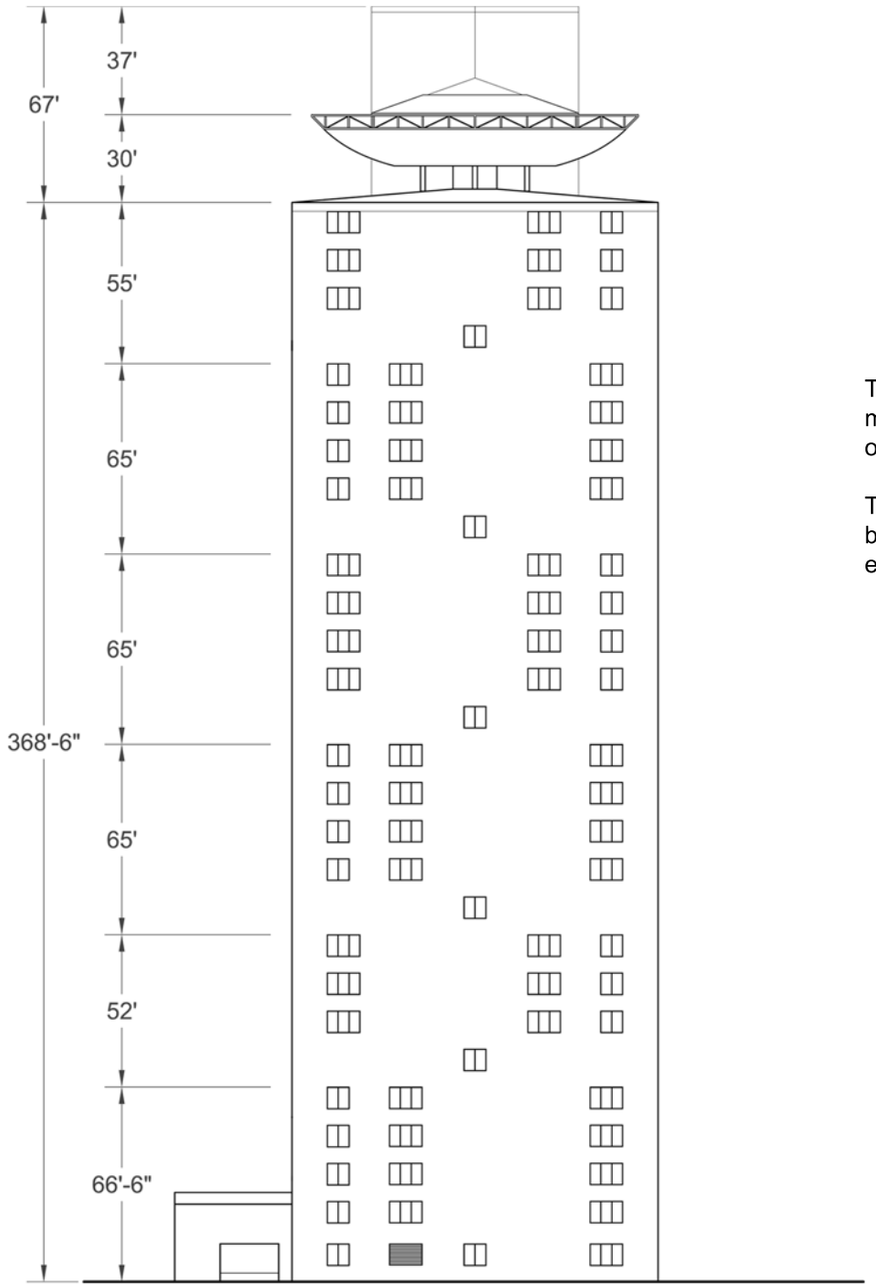


Fig 3.8 North Elevation

The South Elevation explicitly shows the mirroring solids and voids created by the office clusters and the sensory oases.

The North Elevation has window openings to bring natural light into the core spaces and to ease the appearance of the North tower.

The East and West Elevations showcase the sensory oases, five of which appear to be suspended parks over the city. The West elevation shows the ground floor oasis opening to the sidewalk, creating a covered plaza environment to encourage passersby to stop and engage their senses.

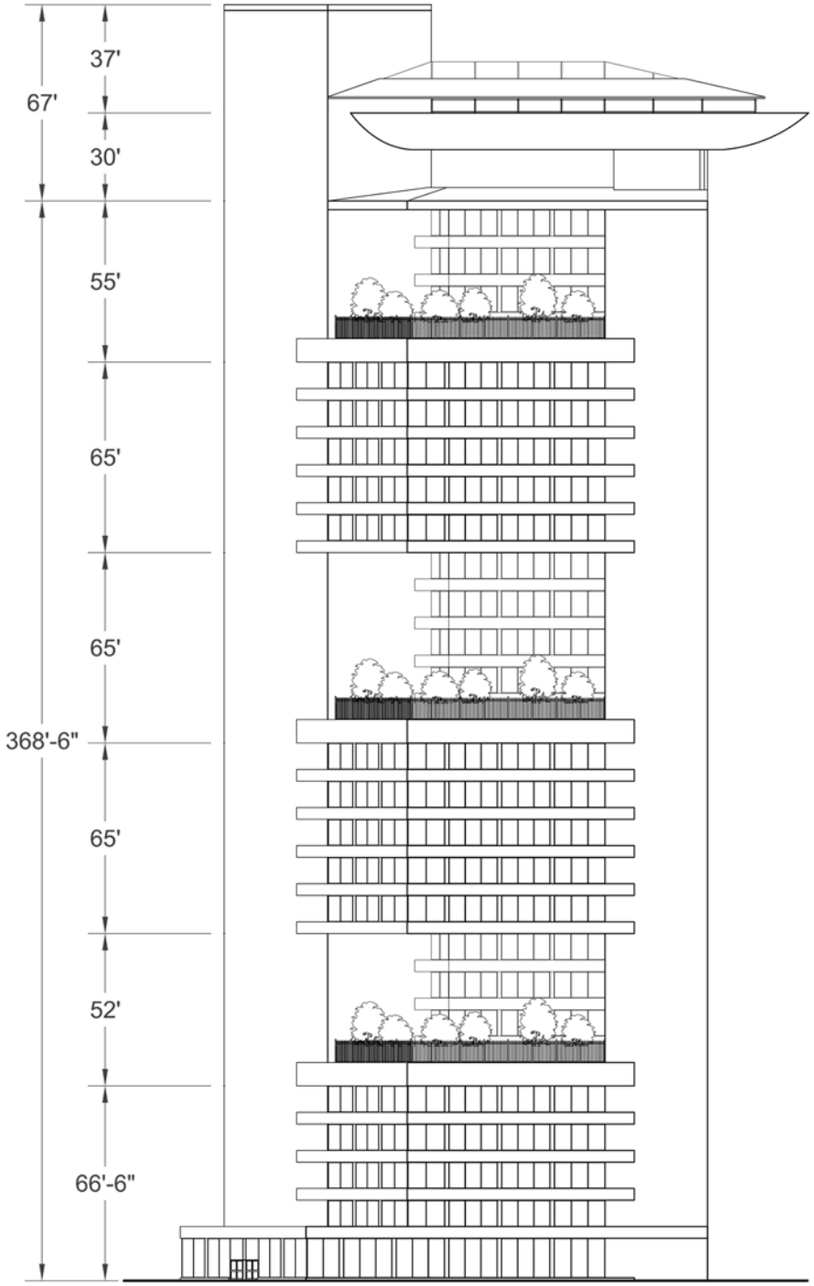


Fig 3.9 East Elevation

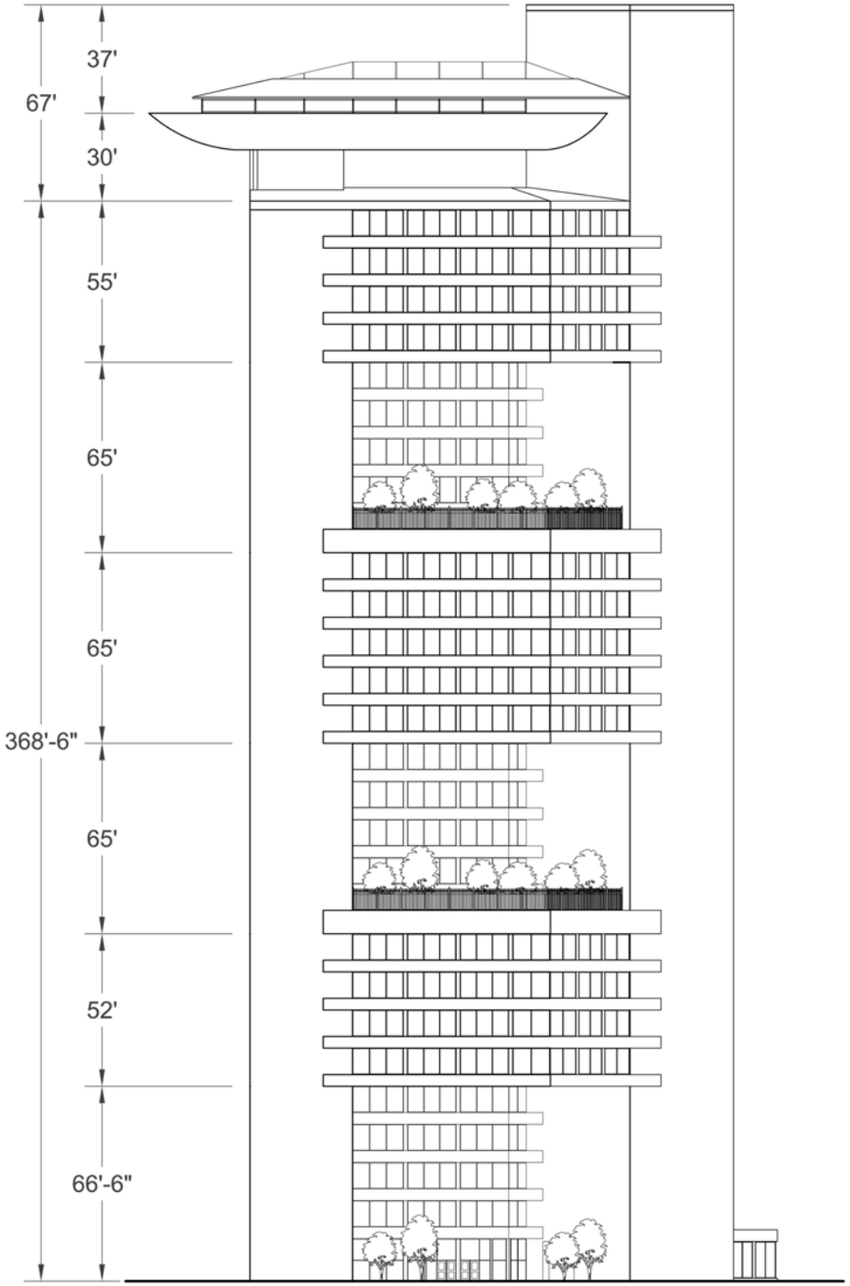


Fig 3.10 West Elevation

The voids that are the sensory oases require a structural system that allows for a column free space. The solution lies in the design of the structure for the office clusters; if the clusters can be structurally independent of each other and suspended by the towers, voids in between them can be formed. With research of similar building configurations, I discovered that vierendeel trusses are often used to achieve such a column free space.

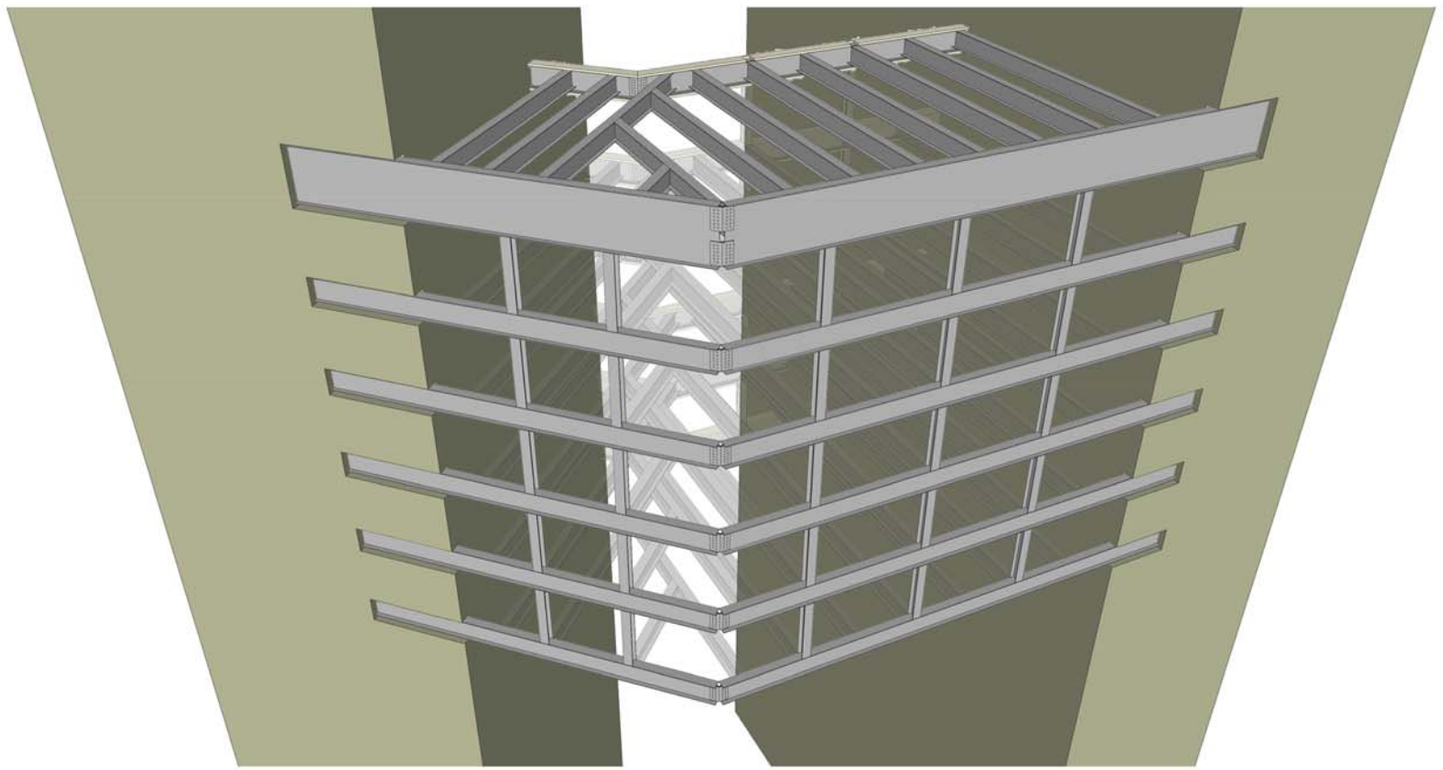


Fig 3.11 Structural design of office clusters

With this research in mind, I designed an assembly of steel beams and columns that essentially form a multiple story vierendeel truss that are the height of the office clusters. The three to five story trusses are cast into the structural towers, and the horizontal members become the girders for the floor slabs. There is a truss assembly on both the exterior façade and on the cavity façade of each cluster and the floors are supported by beams that span between them.

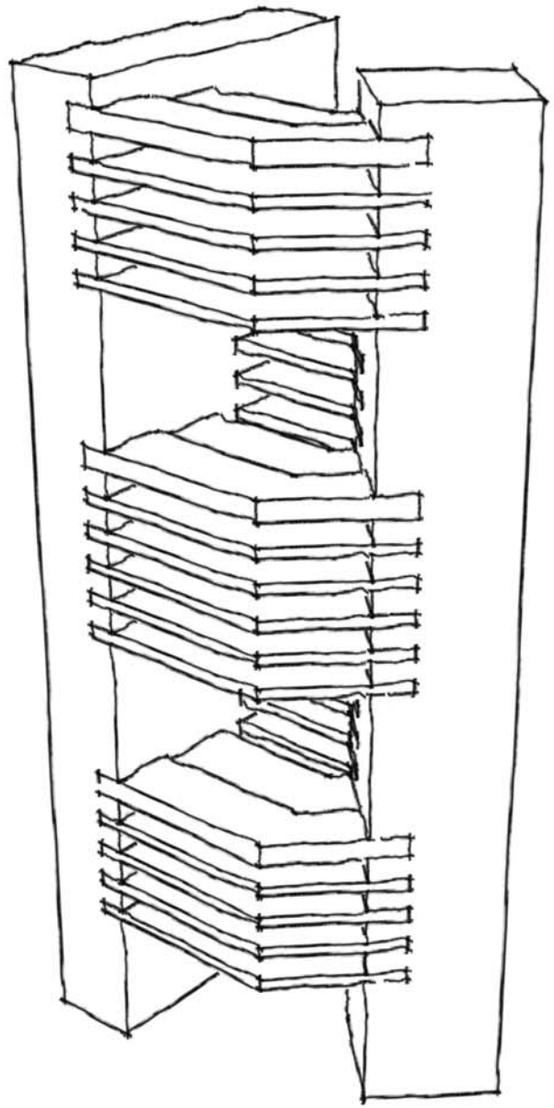


Fig 3.12 Conceptual diagram of the massive towers suspending the office cluster solids, creating voids for the Sensory Oases.

Fig 3.13 Exterior facade of office cluster

Initially, I intended to use precast concrete members for the trusses because I wanted the clusters to appear as solids suspended by masses to support my conceptual idea of solids and voids. With further research and design studies, however, I decided that it was more appropriate to use steel members for the trusses. In order to emphasize the solids as suspended by the towers, I decided to wrap the horizontal truss members with precast concrete.

The concrete wraps two sides of the beam and is exclusively ornamental with the intent to emphasize interlocking of the floorplates with the massive towers, and thus the suspension of solids by the masses to create voids. The vertical members of the truss are covered with metal panel to match the adjacent window system to make them less noticeable to viewers from the ground.

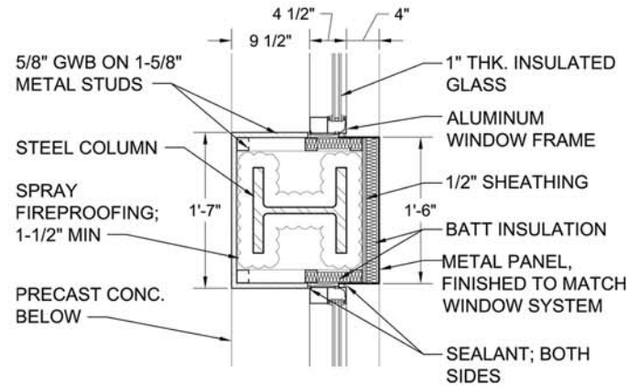


Fig 3.14 Plan detail at column wrap

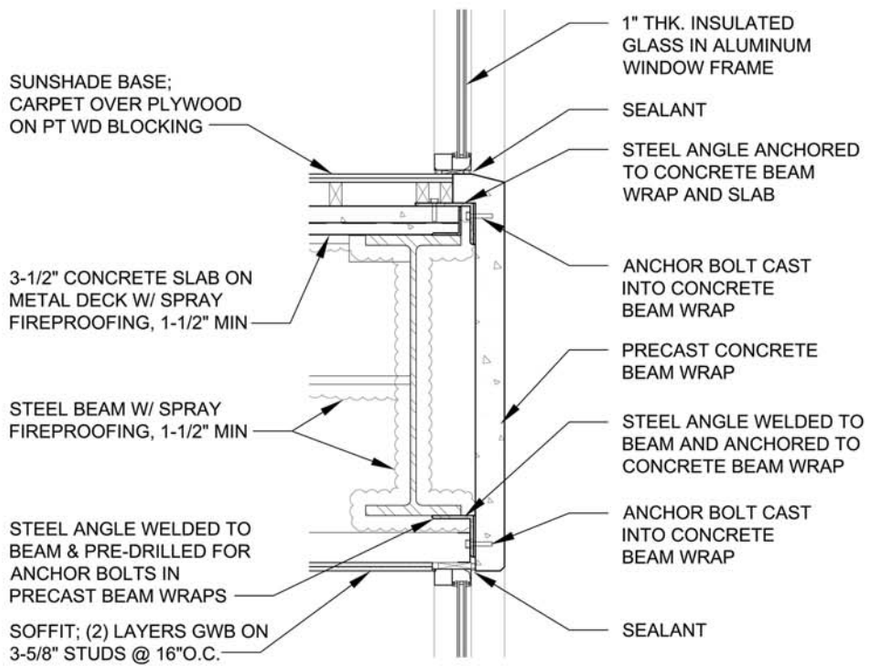


Fig 3.15 Section at girder with concrete wrap

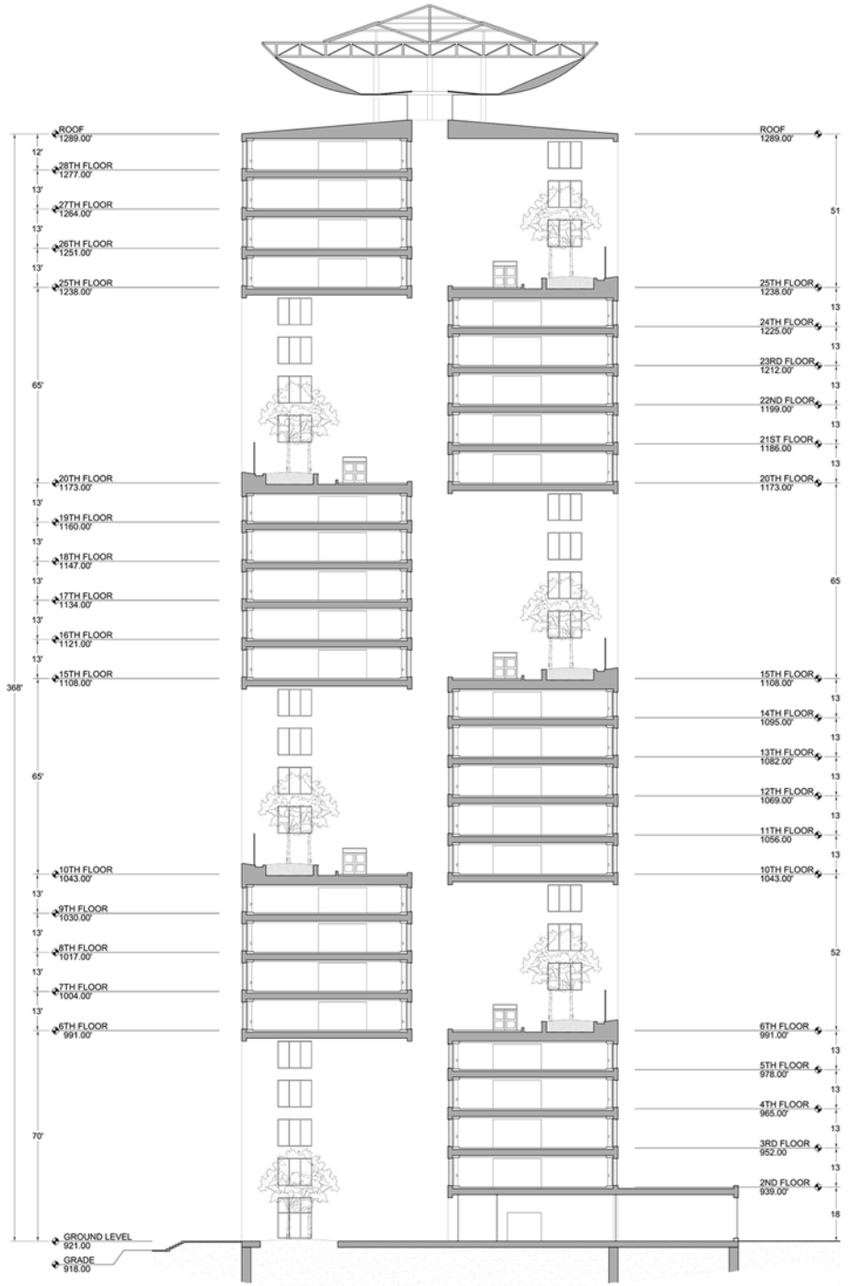


Fig 3.16 Building Section

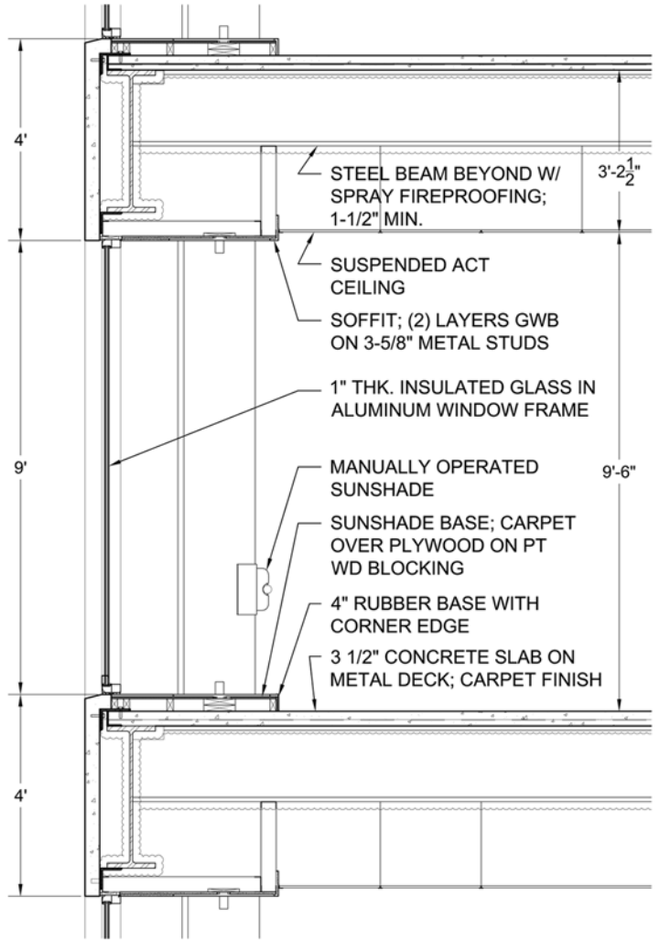


Fig 3.17 Typical wall section

The skyscraper is twenty-eight stories tall with a typical floor to floor height of thirteen feet. The office floors are grouped in clusters of four to five floors, which are separated by voids that become the sensory oases. The voids bring the outdoors into the building footprint, and are open to a central cavity, allowing air to freely pass through the building. This reduces the overall wind load on the skyscraper and creates a cross breeze in the sensory oases.

The typical exterior wall assembly in the office clusters consists of an aluminum window system with a soffit and a base to accommodate a manually operated sunshade system.

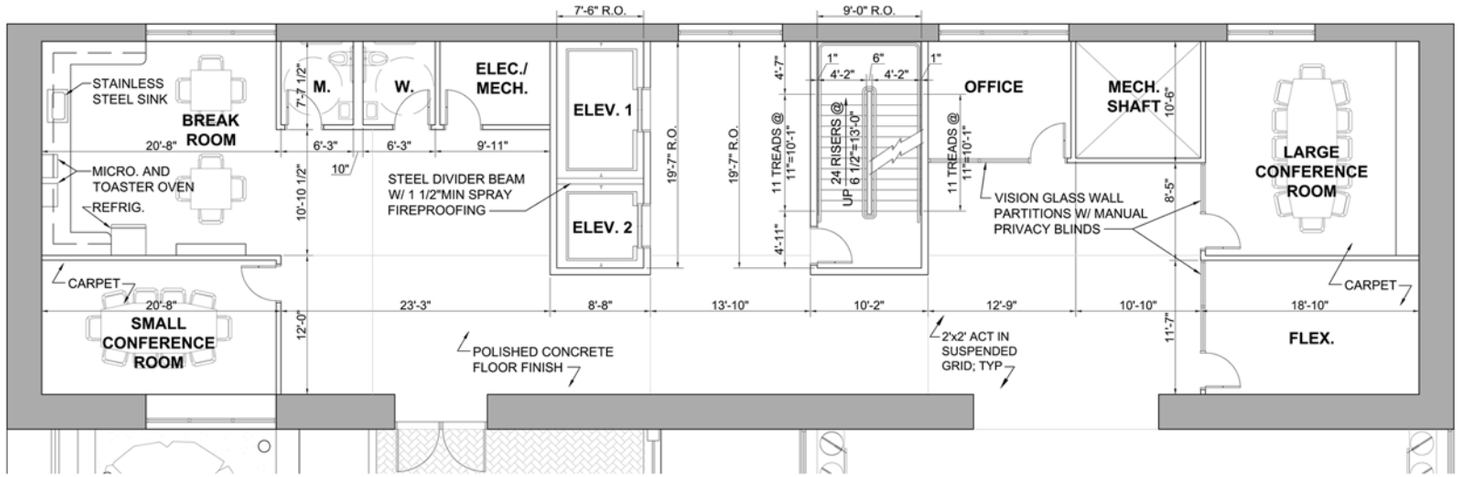


Fig 3.18 North Tower floor plan

In addition to serving as the primary structural elements, the towers are programmatically significant because they house all of the enclosed spaces so the open office occupants have a barrier-free view to the outdoors. Each tower contains an egress stair and passenger elevators.

The primary mechanical shaft is in the North Tower stacked above the main mechanical room on the first floor. There are also conference rooms, private offices, a break room and single person toilets for each sex in the North Tower.

The South Tower contains a secondary mechanical shaft, the janitor's closet and the floor's primary restrooms.

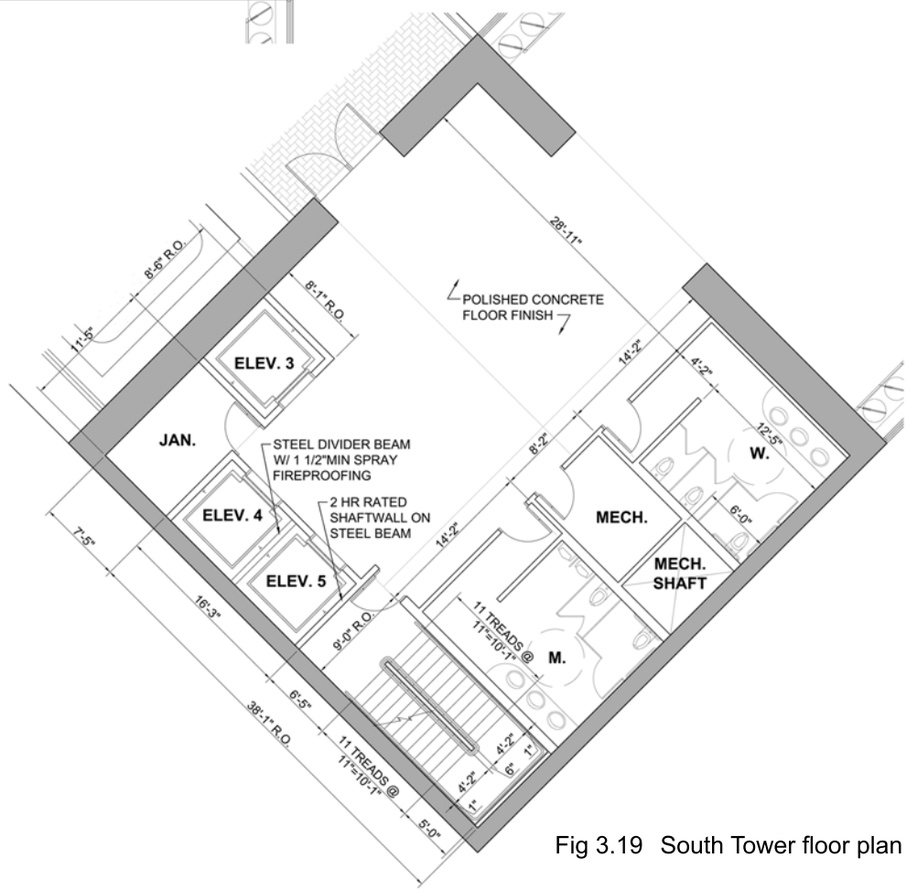


Fig 3.19 South Tower floor plan

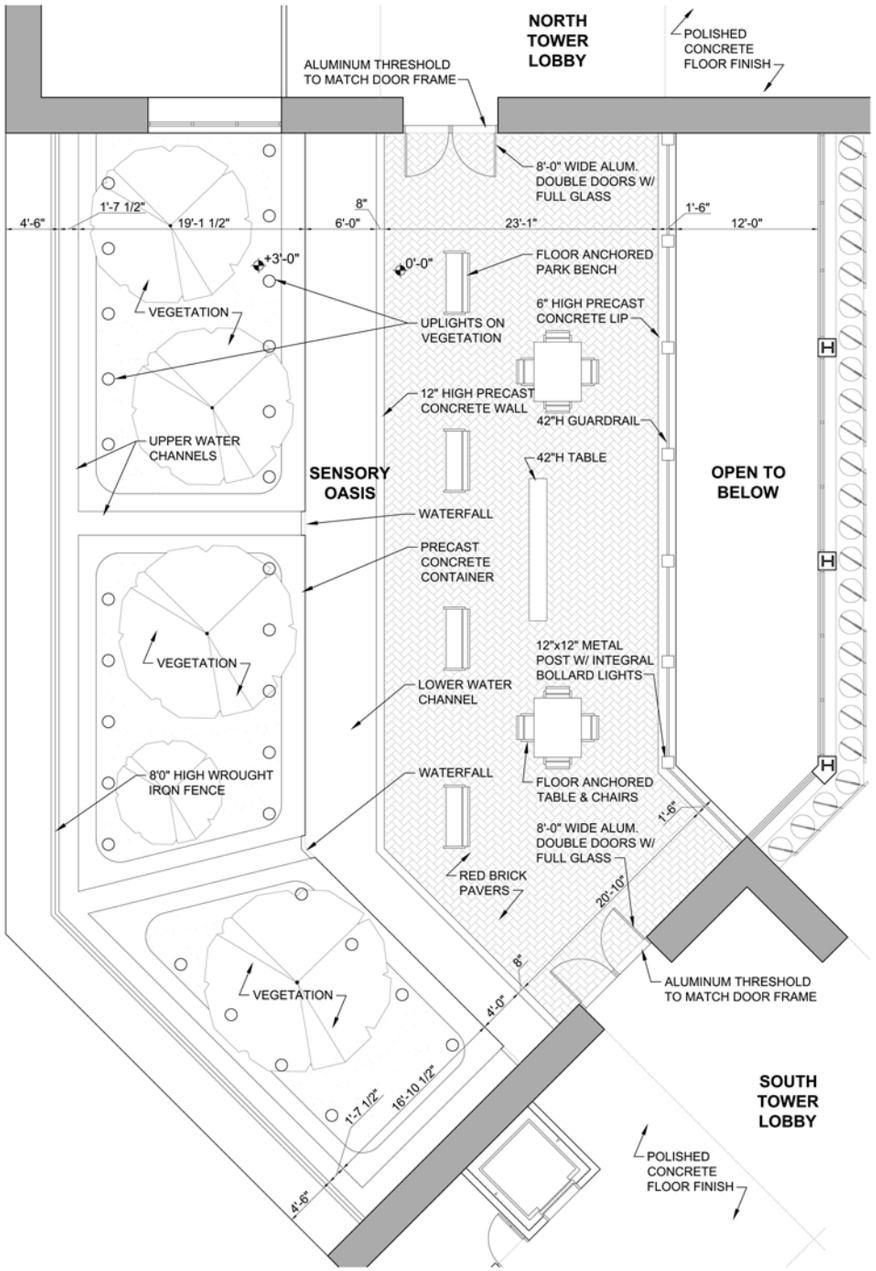


Fig 3.20 Enlarged Oasis Plan

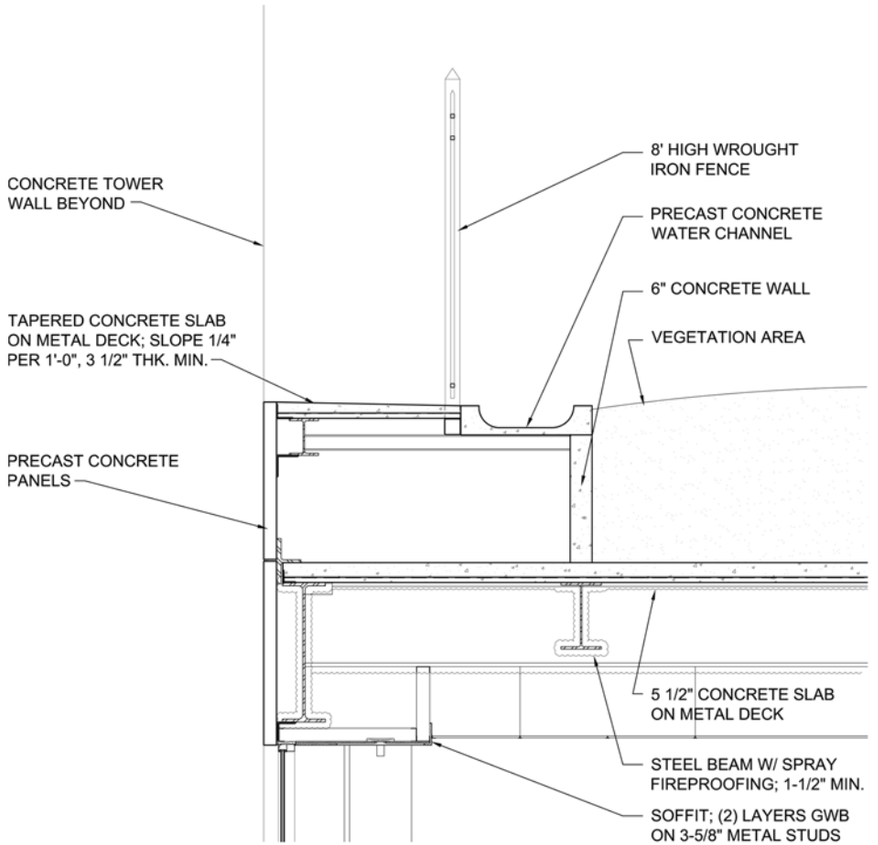


Fig 3.21 Typical Oasis Floor Section

The sensory oases are an easily accessible outdoor space for users on every level of the building. Programmatically, the sensory oases were intended to become nurturing spaces where employees could come to unwind, rest and find creative inspiration. The vegetation fills the space with vibrant colors and aromas, and the water creates movement and sound. Even for users high in the sky, there is fresh air to breath and plenty of places to sit end engage their senses.

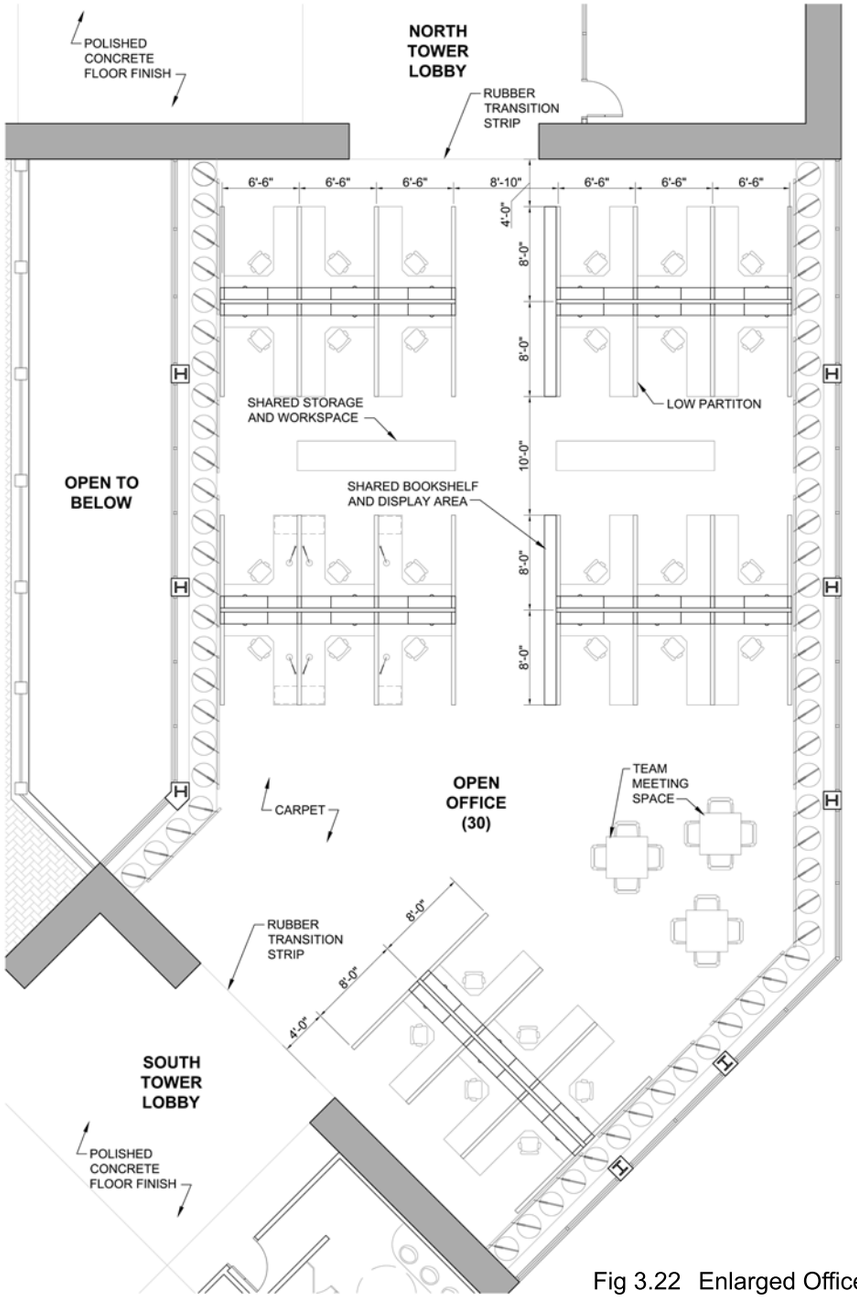


Fig 3.22 Enlarged Office floor plan

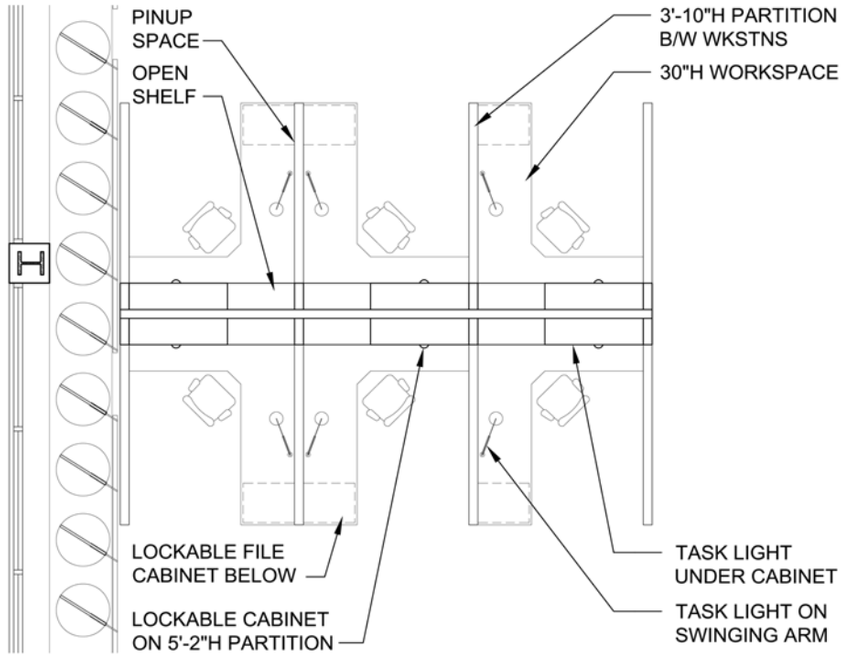


Fig 3.23 Typical Workstation

The typical open office is designed for thirty workstations and a team meeting area. There are no full height walls in the space, only low partitions that separate the workstations. This gives every seat a direct view of the outdoors in two directions. The low partitions are also intended to encourage collaboration among team members by creating an open “shared space” environment as opposed to enclosed cubicles.

The typical workstation is 6’-6” x 8’-0” with 30” deep workspaces. Each user is to have a swinging arm computer monitor and a keyboard tray that they can adjust to their comfort.

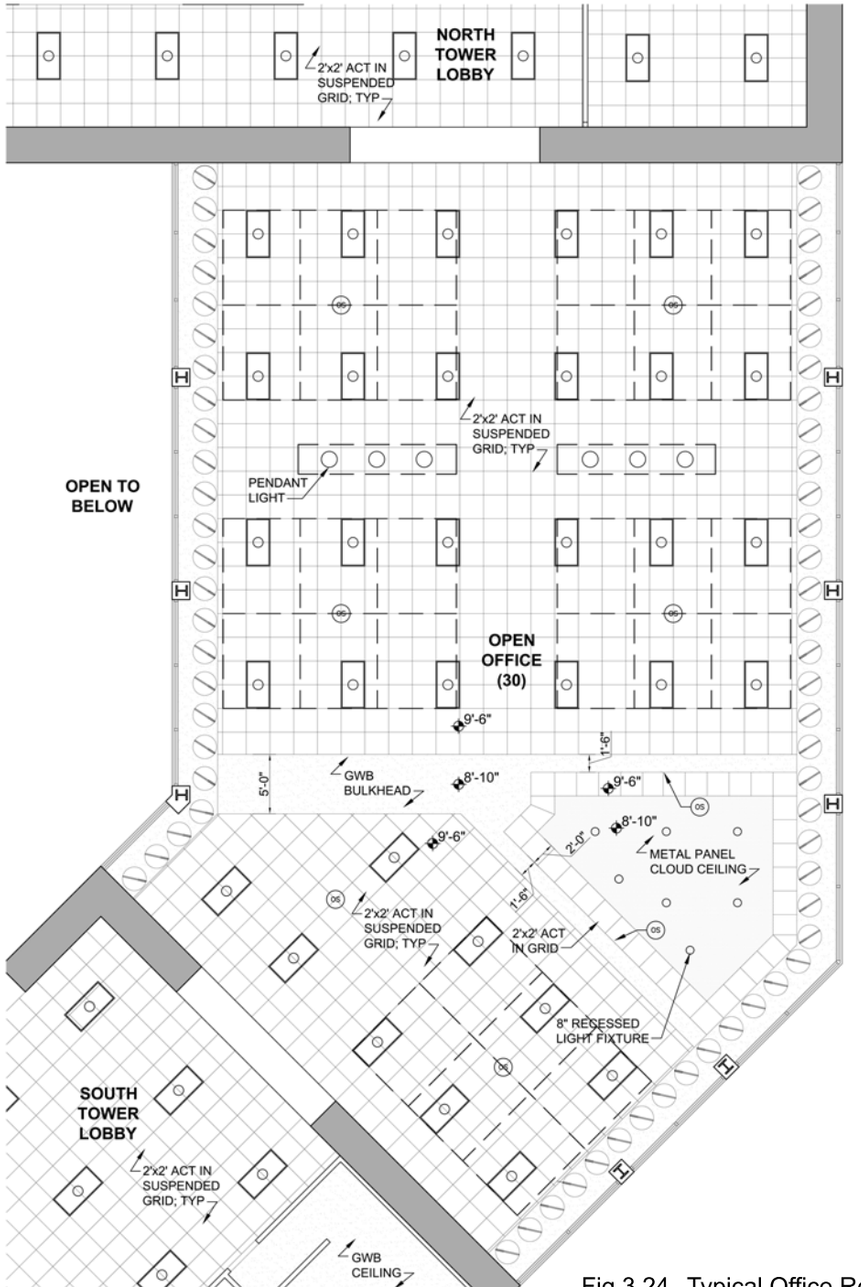


Fig 3.24 Typical Office Reflected Ceiling Plan

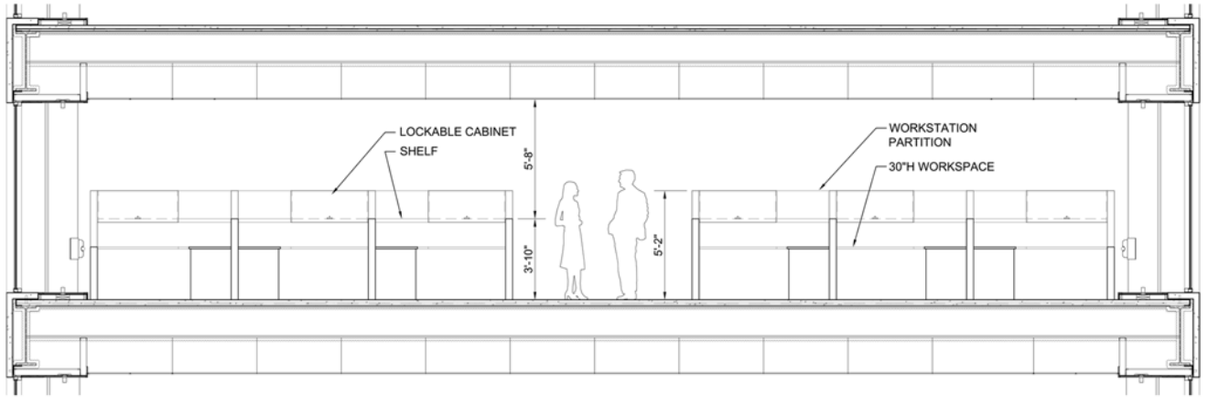


Fig 3.25 Section Through Office Floor

The lighting strategy in the open office is to use as much natural light as possible and to reduce wasted electricity. Occupancy sensors are located over each of the workstation bays to turn off the lights in unoccupied areas. The outside two rows of lights on both sides of the space have a dimming ballast that are controlled by photo sensors. The sensors detect the amount of natural light in the space and adjust the artificial light accordingly to maintain 40 footcandles. The users are able to control natural light with the manually operated sunshades and have several task light options at their workstations. All wires and cables are concealed above the ceiling of the level below and fed through A/V boxes located at the center of each of the workstation bays.

The section above shows the heights of the office partitions and the direct view of the outdoors from each workstation.

Humans are largely diurnal, relying on the daily rising and setting of the sun to satisfy physical, emotional and intellectual needs. The interaction of sunlight with the vegetation and water is critical to the biophilic design of the sensory oases, so I did not filter the light coming into the space.

Such direct sunlight is not necessarily desirable, however, for a workspace. While maximizing the use of daylight in the office spaces is advantageous, if it is unfiltered it can also create unwanted glare that compromises performance. With this in mind I determined that it was appropriate to design a manually operated sunshade for the offices. The sunshades are placed on both the oasis and the exterior facing perimeters of the open offices.

Fig 3.26 Sunlight in the sensory oasis

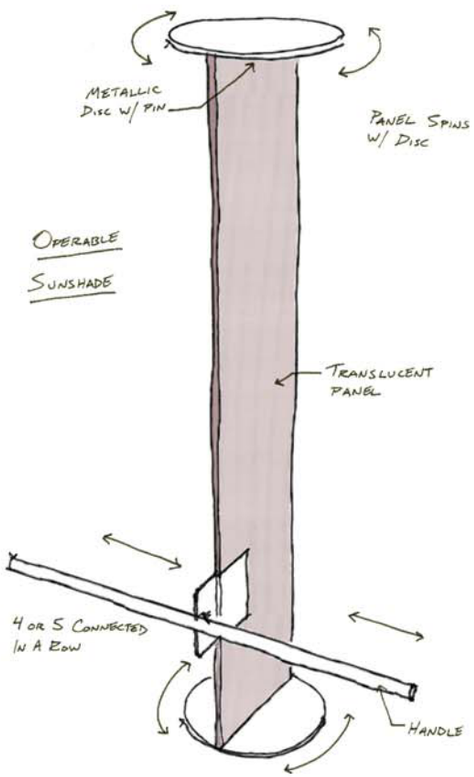


Fig 3.27 Conceptual sunshade sketch

The sunshade design is intended to give the user manual control over the amount of sunlight that enters their immediate work area. They consist of translucent panels that span the full height of the space and are fixed on metallic discs that rotate as the user desires. The panels are controlled in groups of three to five, allowing users to independently filter the light that affects their space.

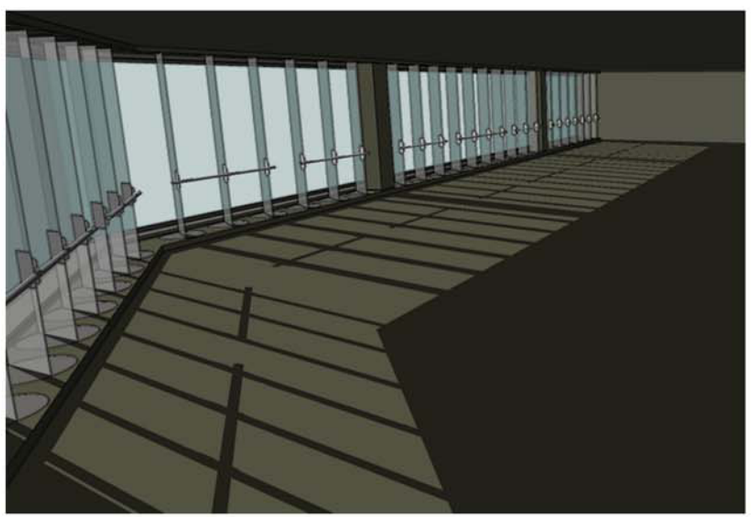


Fig 3.28 Sunshades open

Fig 3.29 Sunshades closed

I wanted to bring water into the sensory oasis because the sound and the vision of water in motion is often associated with relaxation and spiritual restoration. Waterfalls seem to have a universal appeal as flowing water in motion because they showcase both the visual and the acoustical qualities of water. When water interacts with sunlight, it becomes animated as the reflected sparkles dance across its surface.[8]

In the sensory oasis, collected water is directed through a series of sloped channels filled with river rocks. The texture of the river rocks is vividly enhanced by the water running across the surface, and their jagged edges disrupt the flow of water and intensify the natural sound in the sensory oasis. Vegetation impinges on the edges of the channel, emulating riparian plantings on a river bank. The channels ultimately lead to one of several waterfalls, and the water drops three feet into the main waterway.

The main waterway is gently sloped towards the water service room, where water is stored and re-circulated back out into the upper channel.

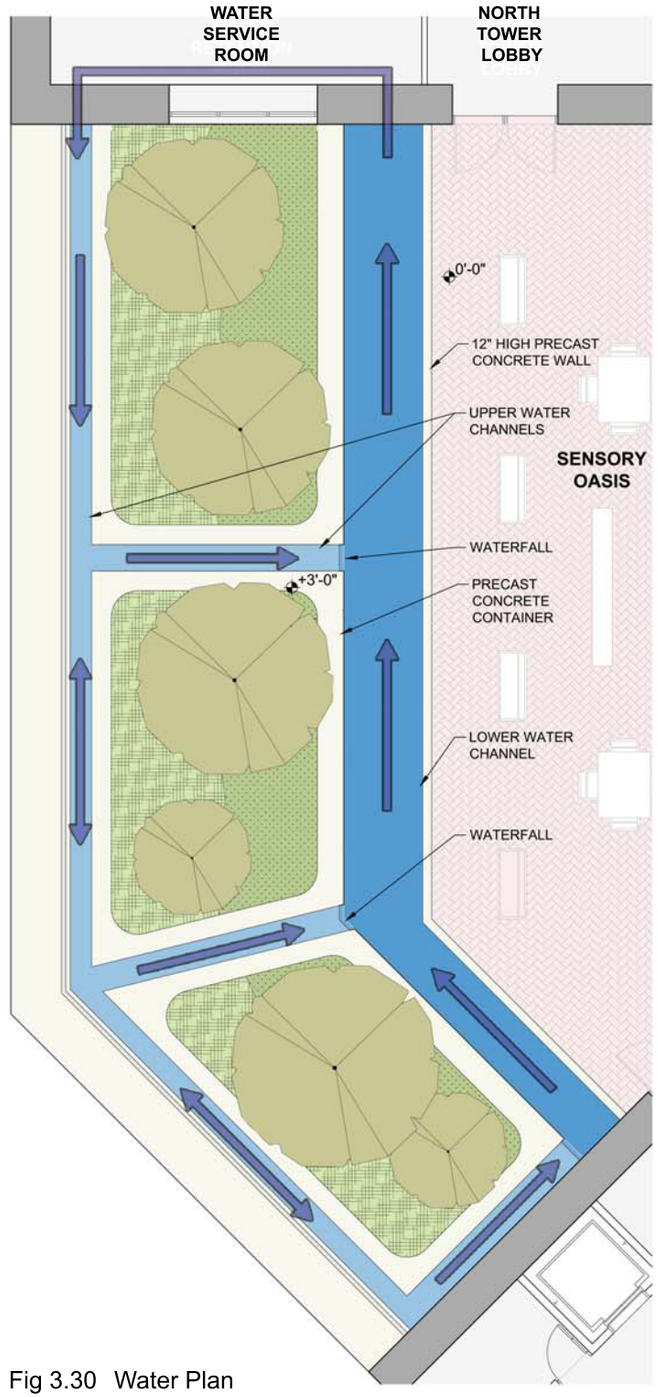


Fig 3.30 Water Plan

When I was choosing the types of vegetation to include in the Sensory Oases, I considered several particular qualities of the plants: the overall size, the leaf size, the aesthetic qualities (color, shape, beauty, etc.), and the aroma.[9] The plant selection and arrangement can be classified into three zones based on these qualities:

Plant Zone 1 consists of trees ranging from 15 to 18 feet in height; these are the largest plants in the space. The trees are speckled sparingly across the planting area, with their purpose primarily being to shade the space without overpowering the other plants. The species in this zone will be cultivars of Acer Palmatum maple trees. These plants are known for their colorful and delicate leaves and for growing well in containers.

Fig 3.31 Acer Palmatum tree

Plant Zone 2 is located near the exterior edge of the oasis, and will be made up of plants with bright yellow and green foliage to reflect sunlight into the space. These plants will range from 3 to 6 feet tall, and will bear large bold leaves as they will be furthest from the viewing area. Species will be variations of Hosta and Dicentra.

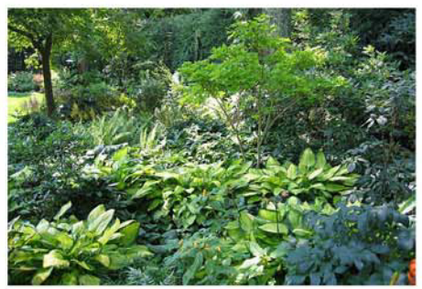


Fig 3.32 Hosta plants

Plant Zone 3 is made up of vividly colorful and aromatic flowers. The plants will range from 2 to 4 feet in height and is located closest to the viewers. Species include cultivars of Lilium, Lavandula, Daphne and Geranium. These plants will likely be the signature of the sensory oasis for many with their sensational fragrance filling the space and their colors so captivating.

Fig 3.33 Geranium flowers

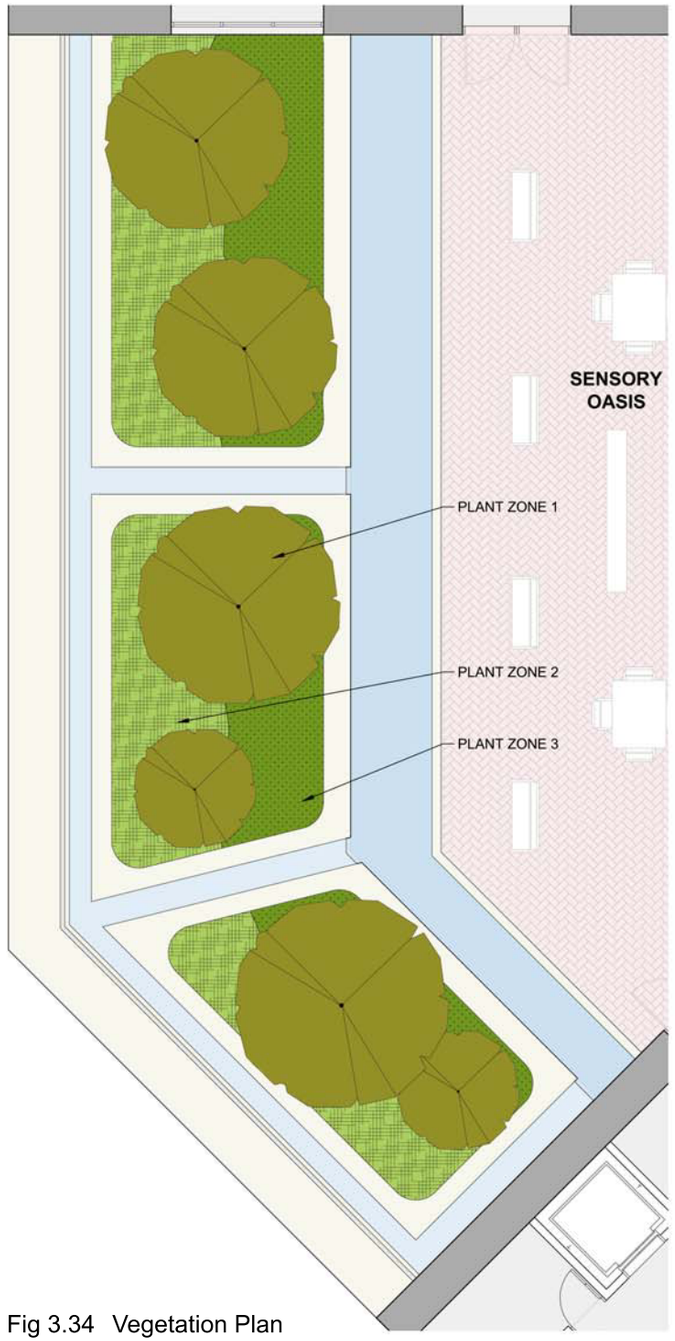


Fig 3.34 Vegetation Plan

Conclusion and Lessons Learned

Currently it seems that the prevailing approach to sustainable design is focused exclusively on low environmental impact objectives and not so much on enhancing the connection between people and the natural environment. Biophilic design attempts to place an emphasis on this human to nature relationship in the built environment under the ideology that we have an innate affinity for the natural world because of our evolutionary development.

Through my work on this thesis, I learned that “sustainable design” should not be merely about accruing credits, but rather about incorporating “sustainable techniques” into our buildings while staying true to our conceptual design ideas. People should enjoy the buildings in which they live, work and use and not simply exist and function in them with little impact to the natural environment. The application of biophilic design principles in conjunction with sustainable techniques is the solution to fulfilling both of these objectives. In order to properly apply biophilic design, it is necessary to study and understand what it is about specific elements in nature that creates a sense of pleasure and well being. Nature is rich with sensual features, and the expression of these biophilic traits in architectural design is really what “sustainable design” is all about.

End Notes

1 The definition and explanation of the terms “biophilia” and “biophilic design” were taken from the chapter *Dimensions, Elements and Attributes of Biophilic Design* written by Stephen Kellert in the book *Biophilic Design,* p3

2 Paraphrasing Jason F. McLennan in the book *The Philosophy of Sustainable Design*, p54

3 Quoting Stephen Kellert in the book *Biophilic Design,* p9

4 Conclusion interpreted by the author from the chapter *Transforming Building Practices Through Biophilic Design* written by Jenifer Seal Cramer and William Dee Browning in the book *Biophilic Design*.

5 This quote is by Robert Frost, a famous American Poet. Taken from *The Inspired Workspace*, p8

6 Paraphrasing Jason F. McLennan in the book *The Philosophy of Sustainable Design*, pp152-155

7 Quoting Ken Yeang in the book *The Skyscraper Biomatically Considered: A Design Primer*, p14

8 Description of water taken from the chapter *Water, Biophilic Design, and the Built Environment*, written by Martin L. Mador in the book *Biophilic Design*, p50

9 All plant information in this section was derived from the book *Foliage* and the book *Garden Plants and Flowers*.

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All images are original works of the author unless noted otherwise in this section:

The plant images in Fig 3.31, Fig 3.32, and Fig 3.33 were generously provided by the Hahn Horticulture Garden at Virginia Tech.

References

Catalogue Foster and Partners. (New York: Prestel, 2005)

Kellert, Stephen R., Judith H. Heerwagen and Martin L. Mador, eds. *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life* (Hoboken: John Wiley & Sons, 2008)

Kwok, Alison G., and Walter T. Grondzik, *Green Studio Handbook: Environmental Strategies for Schematic Design* (New York: Elsevier Inc, 2007)

McLennan, Jason E, *The Philosophy of Sustainable Design* (Kansas City: Ecotone LLC, 2004)

Ondra, Nancy J., *Foliage: Astonishing Color and Texture Beyond Flowers* (North Adams: Storey Publishing, 2007)

Spence, Ian and H. Marc Cathey, *Garden Plants and Flowers: An A-Z Guide to the Best Plants for Your Garden* (New York: DK Publishing, Inc., 2004)

Yeang, Ken, *The Skyscraper Bioclimatically Considered: A Design Primer* (London: Academy Editions, 1996)

Zelinsky, Marilyn, *The Inspired Workspace: Designs for Creativity and Productivity* (Glouchester: Rockport Publishers, 2004)