

# The Union of Aerial and Terrestrial Forces



Melissa Brown

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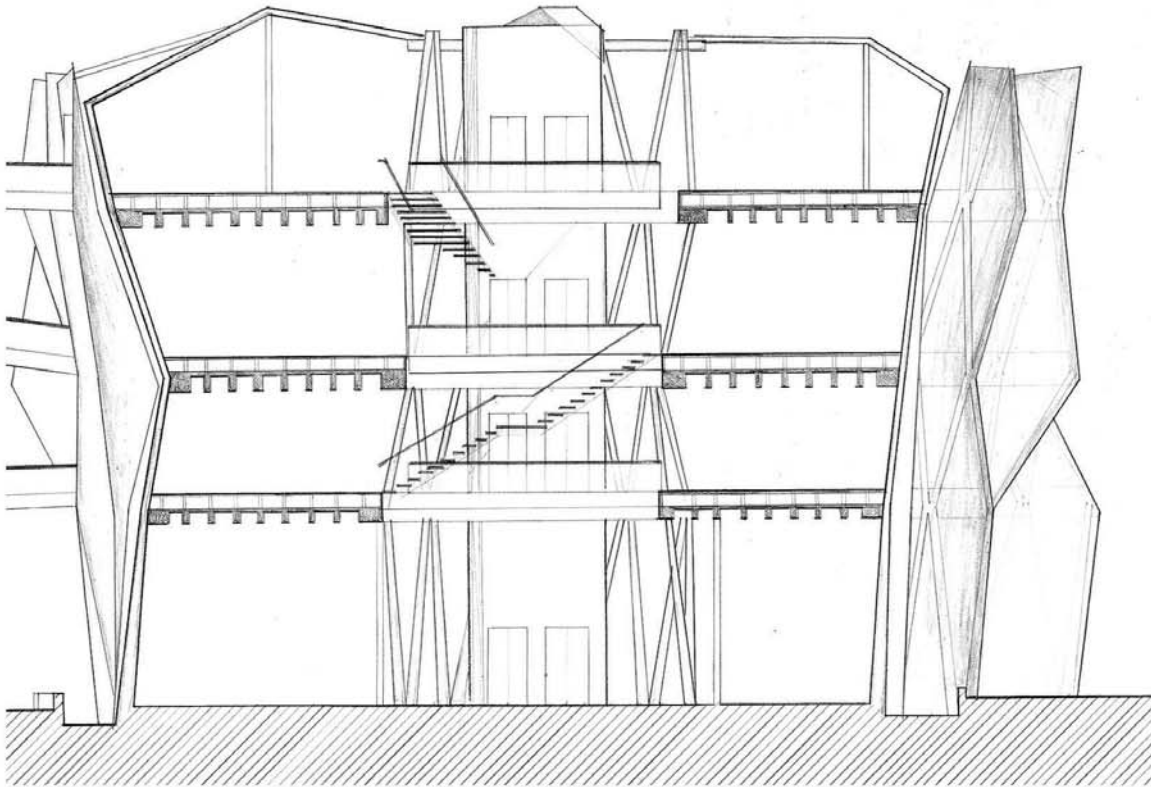
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# Abstract

Environmentally sensitive architecture is rapidly staking its claim on the building community. The structures that are being constructed to fulfill the increasing public demand for “green buildings” are not currently utilizing their unique potential to physically portray their inherent characteristics to be naturally and technologically advanced. Environmentally sensitive architecture has the potential and arguable responsibility to physically react to and portray the natural factors that they are programmatically and technically adapting to.

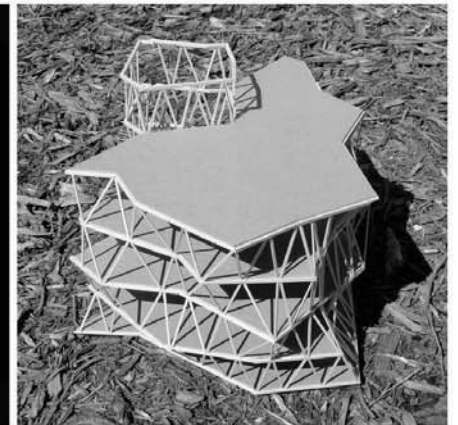
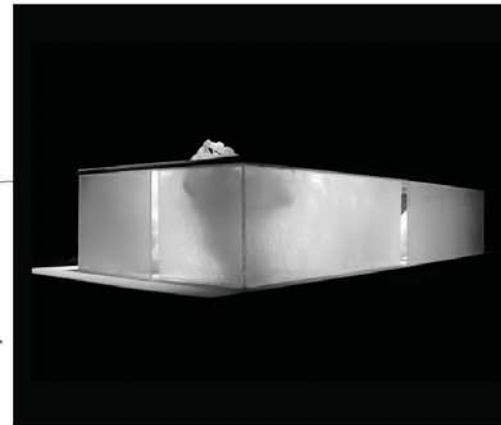
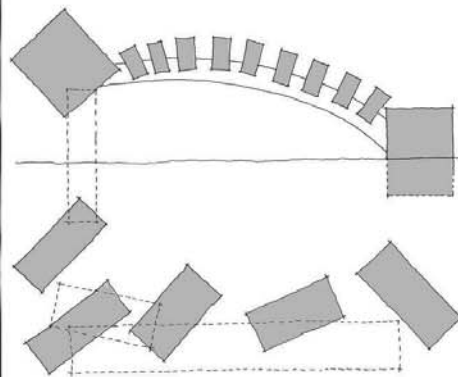
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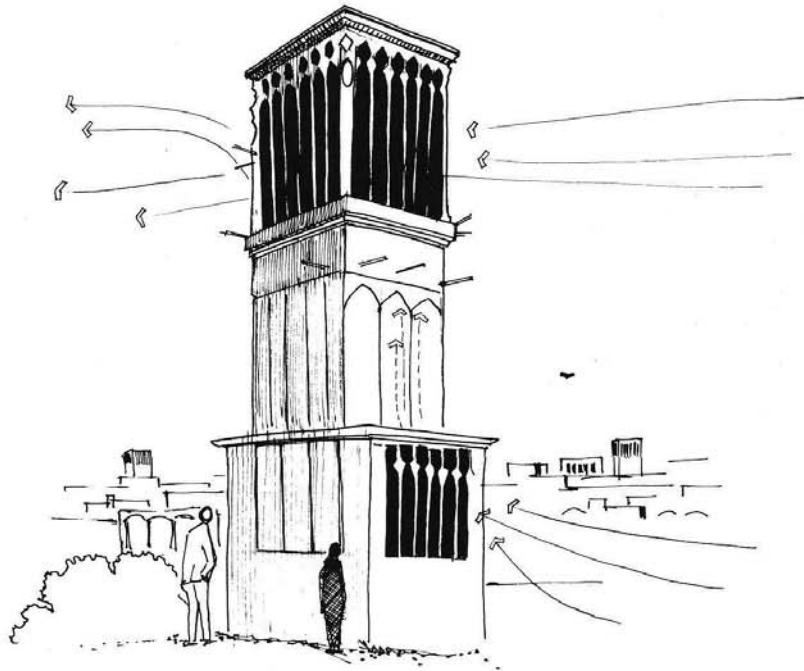


# Introduction

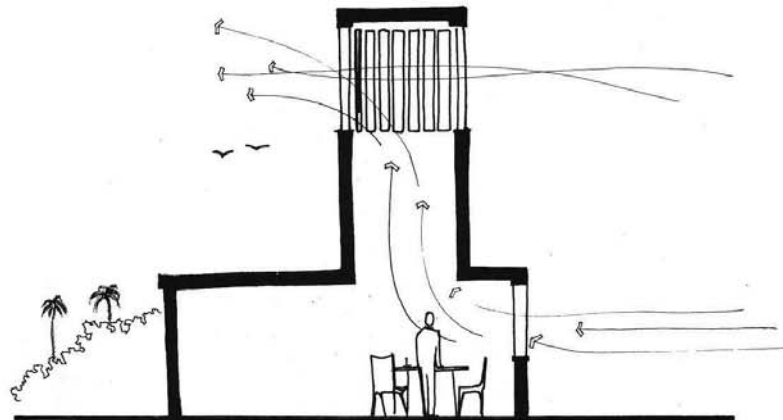
Environmentally sensitive architecture is quickly staking its claim on the building community. Environmentally sensitive buildings nicknamed “green buildings” are attractive to today’s clients and are therefore being sought after by public and private agencies alike. These green buildings are being built in a variety of places and have been designed in a broad spectrum of sizes and forms. One unifying characteristic is their inherent nature of programmatically and technically responding to environmental factors. However, for the most part, they also unfortunately share the descriptive characteristic of complete disassociation between their programmatically sensitive intentions and their physically designed realities. Environmentally sensitive architecture has the unfulfilled potential, and arguable responsibility, to physically react to and visibly reflect the natural factors to which it is programmatically and technically adapting. The challenge is therefore to design a green building in an urban setting that is inspired by and organized in response to a force of nature. This proposal will suggest a method by which a multi-use facility could be inspired and designed through studies of the wind, its behavior and a few of its historical representations.



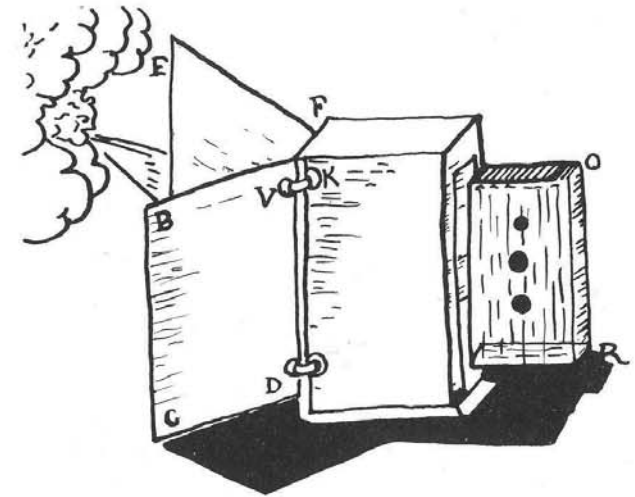
# Precedents



Iranian Passive Ventilation Housing



Iranian Passive Ventilation Housing



The Aeolian Harp

I approached this study by researching historical examples of environmental architecture, since cultures have consistently designed buildings based on the affects of nature or the influences of their religions throughout history. It has only been recently that new technologies have led to the creation of buildings dependant upon mechanical means of heating and cooling, which are fully enclosed to the environment and subsequently challenging to climactically control. As more problems arise with buildings which are poorly ventilated and improperly lit, architects and engineers are coming forth with new designs to construct structures that create pleasant working environments. It is no coincidence that these working environments feature natural ventilation, natural light and materials that are constructed from natural elements.



Chinese Symbol for Universalism



Structural Grid By Luigi Nervi



Tjibaou Cultural Center



Sendai Mediatheque



A few of the architects whom I feel are designing influential green buildings today are, Norman Foster, Renzo Piano and Toyo Ito. Throughout my design process as my own ideas began to change, I studied the works of these architects to inspire my design. Specifically, both the Swiss Re Headquarter in London, England and particularly the Sendai Mediatheque in Japan inspired my structure. Both buildings feature a structure utilizing crossing columns that are exposed as primary design elements and used not only as structural columns, but also as doorways, windows and light shafts. I also studied the structures designed by Luigi Nervi to inspire my concrete waffle slabs. The Tjibaou Cultural Center, by Renzo Piano is an excellent example of a design which was guided and determined by local wind patterns. It is an open structure which creates programmatic spaces that are functional and comfortable due to its environmentally sensitive nature. These projects in particular helped me to answer many of my technical questions that arouse throughout the exploration of my thesis.



Swiss Re Headquarters



# Initial Approach

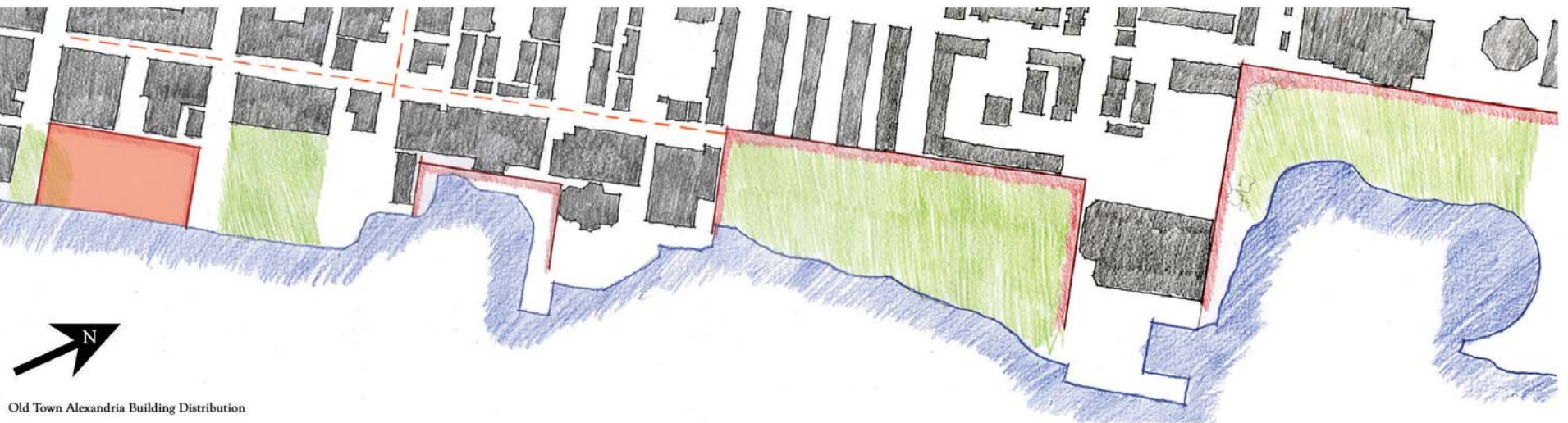


Existing Site Conditions

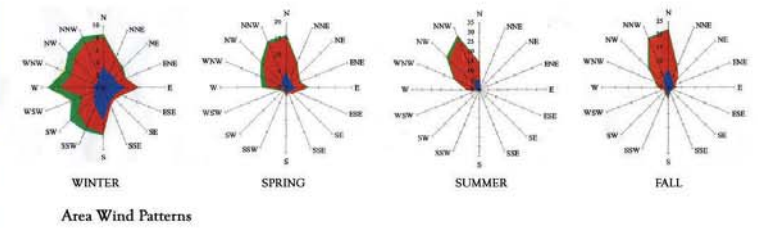


Existing Circulation Routes

Proposed Circulation Routes

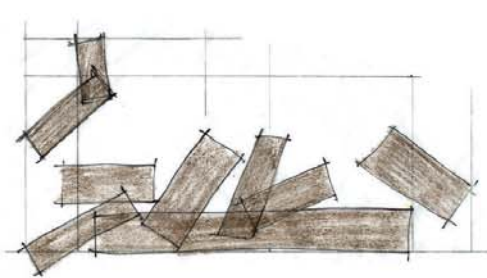


Old Town Alexandria Building Distribution

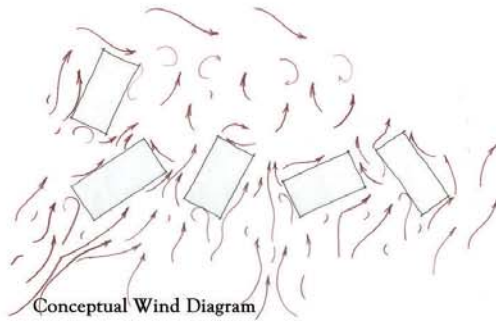


The site identified for this exploration is located along the shores of the Potomac River in Old Town Alexandria, Virginia, between Prince and Duke Streets. This site possesses several attractive features for a future office and residential development, including high commercial potential due to its proximity to the established stores and restaurants on King Street and its location on valuable waterfront property. The refreshed area will attract public traffic from the King Street shops both along the river and up through the surrounding streets, subsequently causing the main entrances to the complex to best be positioned in these locations.

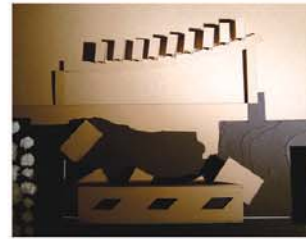
Upon further investigations the site proved to attract pedestrian and vehicular traffic along the same paths that the area's wind gusts traveled. This similarity required that the site of the complex, the positioning of the buildings and their associated circulation paths all be positioned according to these routes.



Conceptual layout sketch

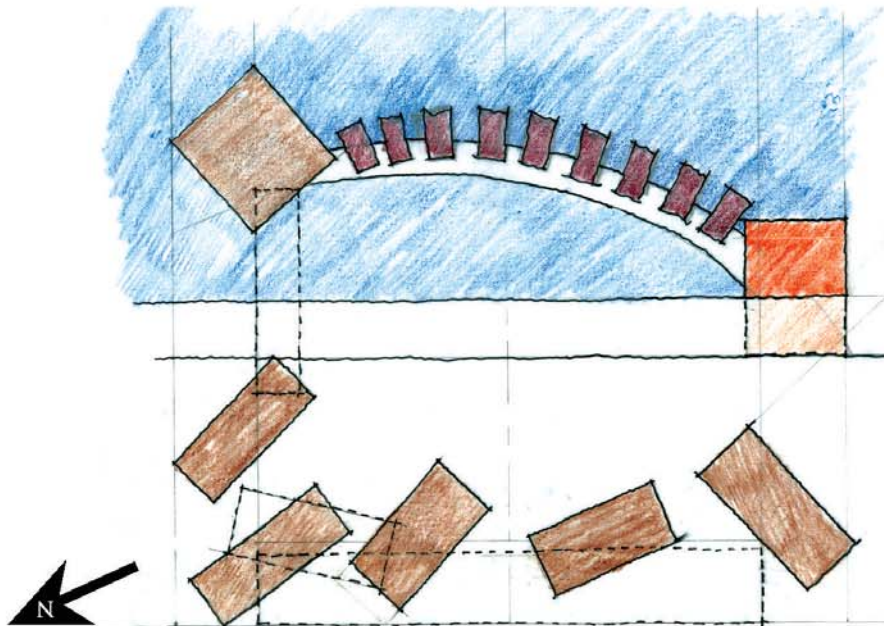


Conceptual Wind Diagram

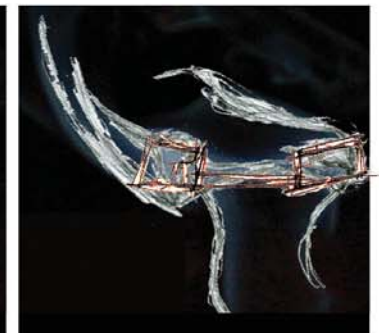
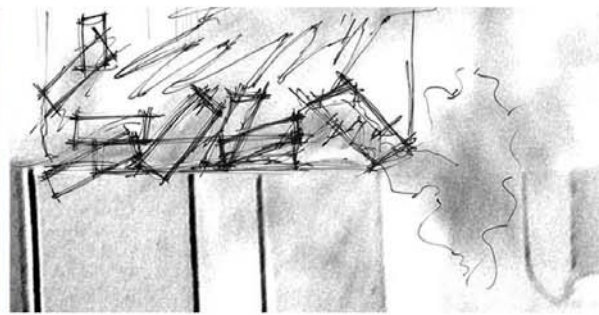


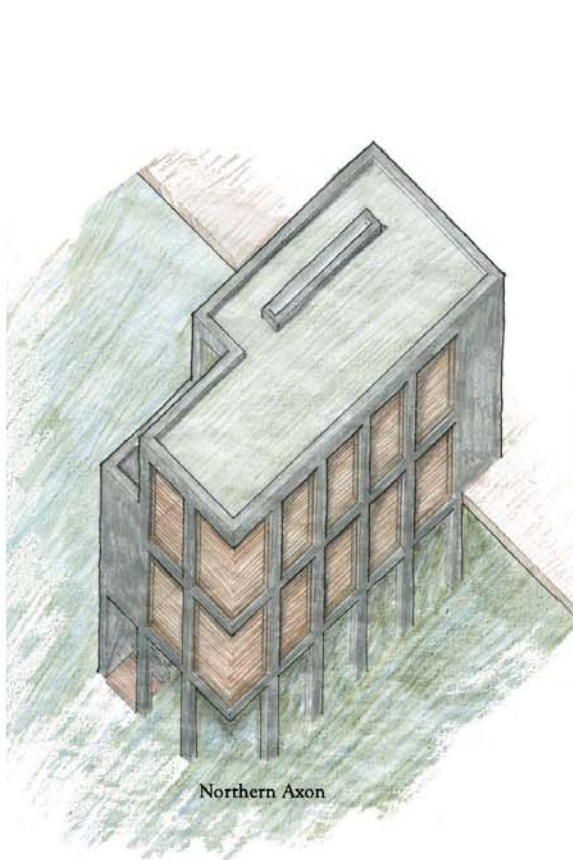
These routes were mapped out based upon smoke studies performed on a black model of the site and adjacent buildings created to track the paths of the wind around existing structures and across the area. Smoke was blown across the site model and photographed from different angles and levels in an attempt to visually record the behavior of winds on the site. The photographs of the smoke were studied and used to create the initial conceptual design sketches.

The smoke test sketches suggested the formation of two primary building groupings. One grouping featured a long, orthogonal structure, which was supported above ground level structures by a series of columns. The ground level structures were intended to be the restaurants and commercial properties, while the long, orthogonal structure would contain offices. As pedestrians entered the complex, they would be enclosed by a series of wood slats held against 40-foot columns on one side and shops on the other. The shops and restaurants were initially laid out as orthogonal position markers and were to be later designed to physically reflect the effects of the wind.

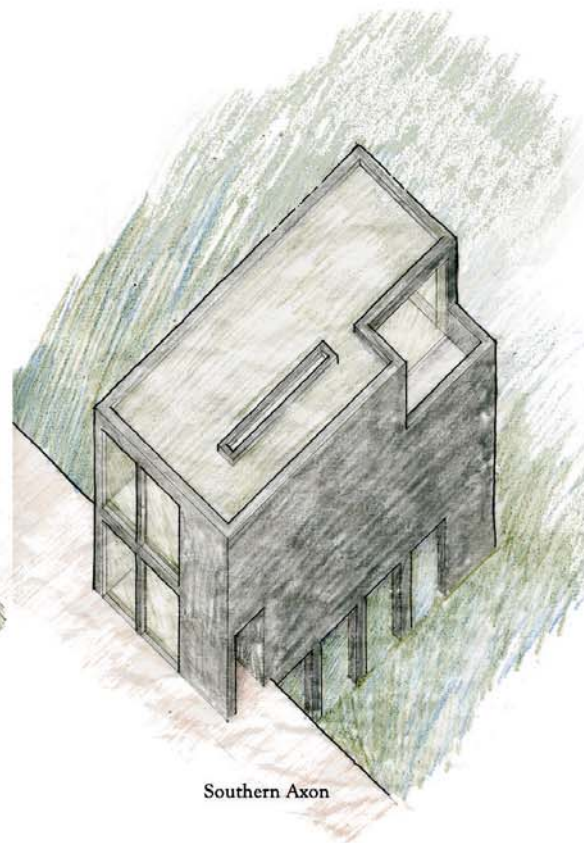


Conceptual Site Plan

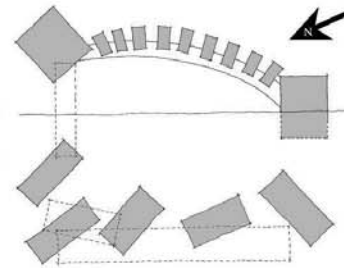




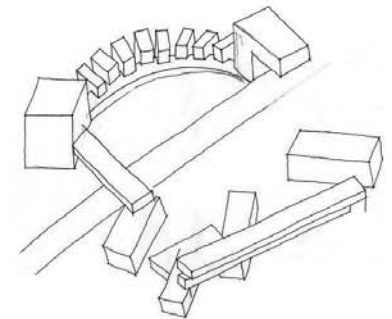
Northern Axon



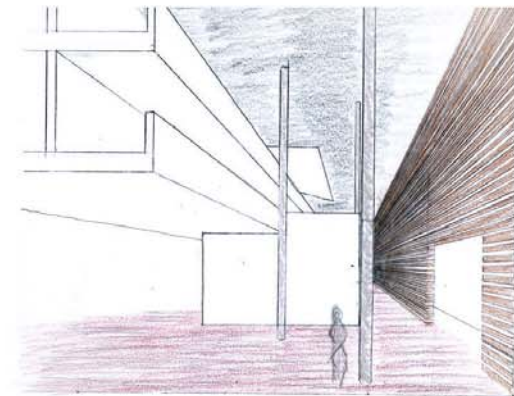
Southern Axon



Conceptual Massing Diagram

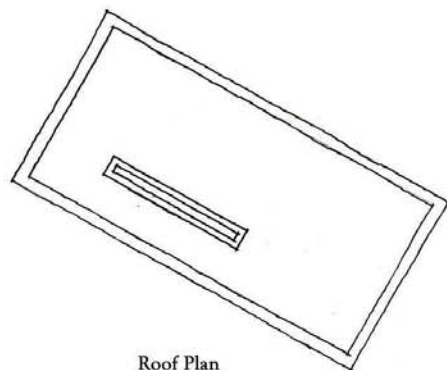


Conceptual Axonometric Massing Diagram

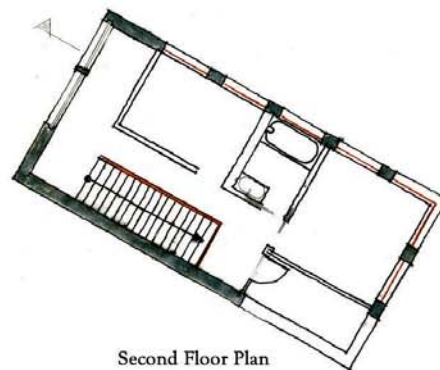


Interior Perspective

The second of the two groupings was situated off of the Alexandria shore and curved towards the shore to create an inlet for the boat, the Nina's Dandy. It was organized to provide a boardwalk along which were positioned condominiums, oriented to face the water. A rectangular mass held down the boardwalk and was also to be designed to reflect wind forces.



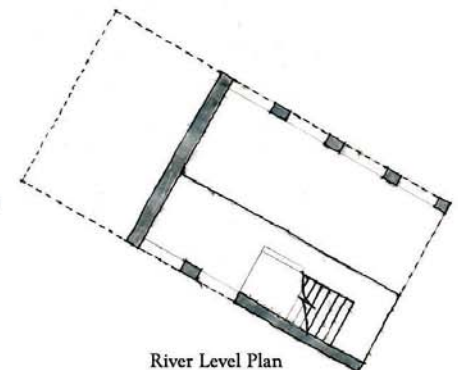
Roof Plan



Second Floor Plan



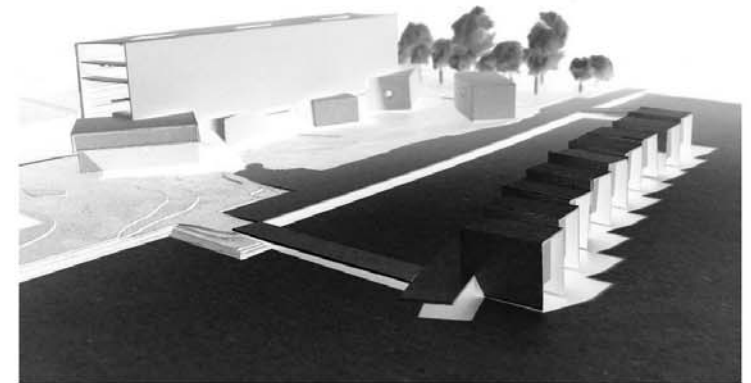
Ground Floor Plan



River Level Plan

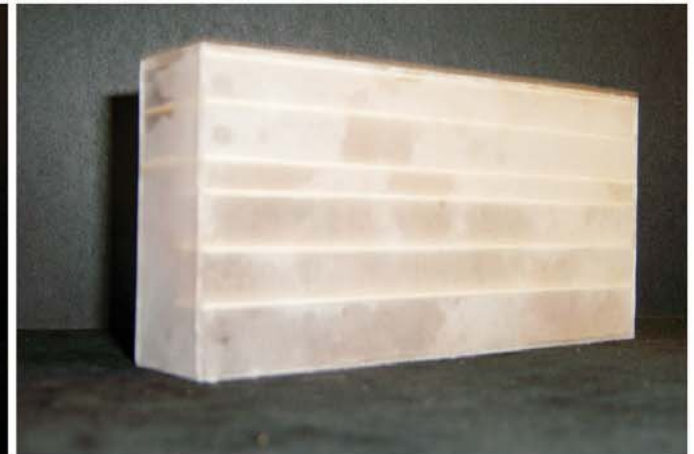
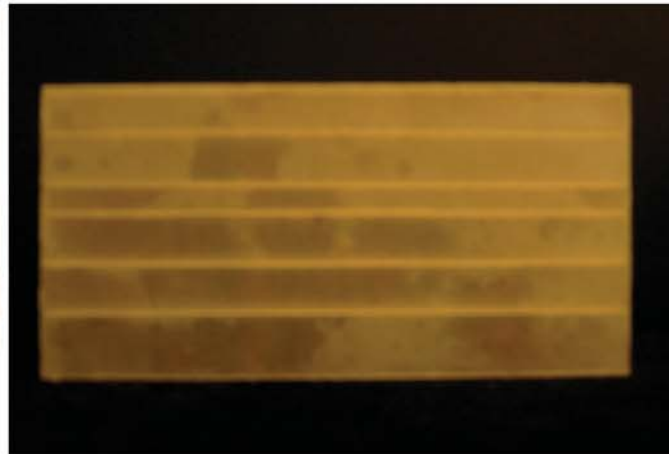
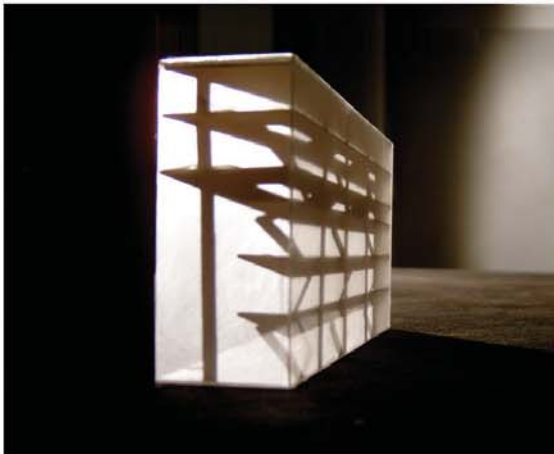


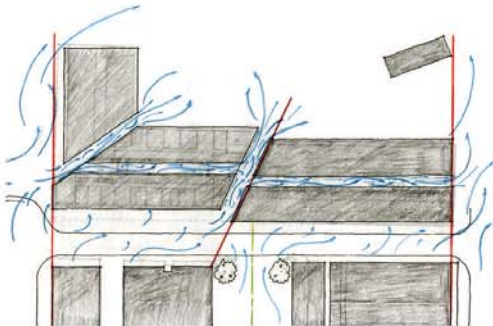
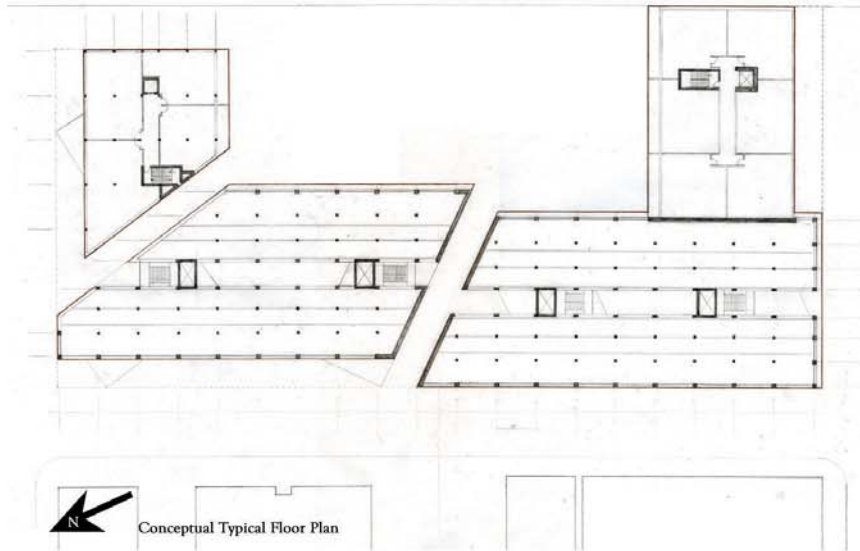
Transparency Model



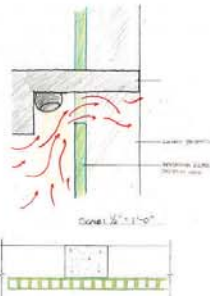
Conceptual Light Study

Material explorations for the primary building on the complex, led to the creation of this model, which was built to investigate the transition a building undergoes at night. During the day, the building would appear as a solid, rectangular mass. At night, however, the building would invert to become a sequence of floor plates, supported by the stairs and columns that ran vertically through the structure. Atriums positioned along the mass would bring light down into the structure and vent air up through the roof.

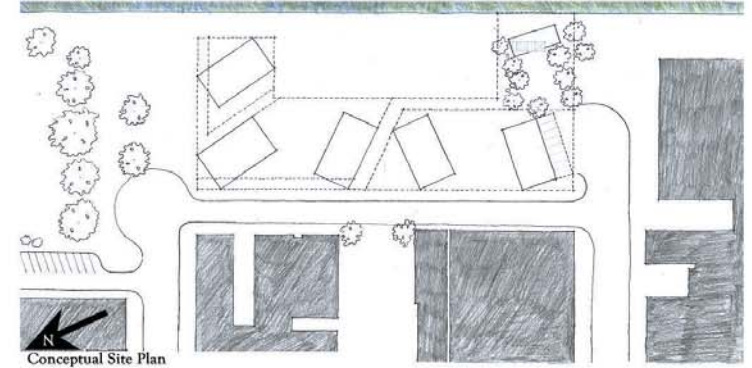




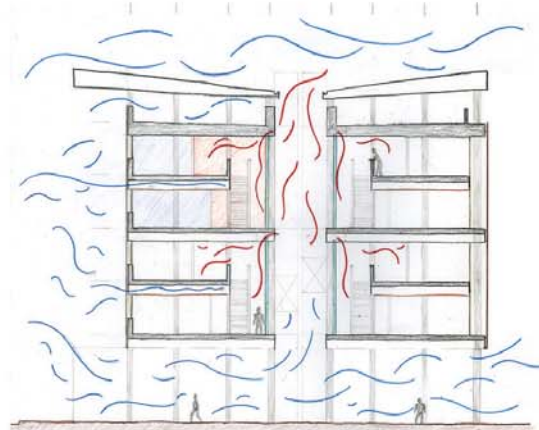
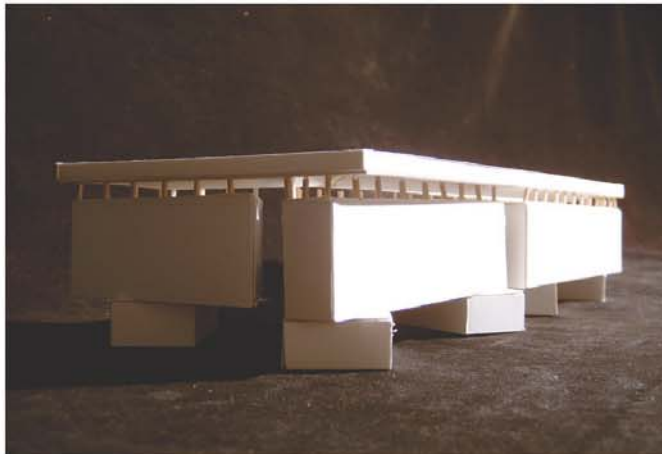
Conceptual Wind Diagram



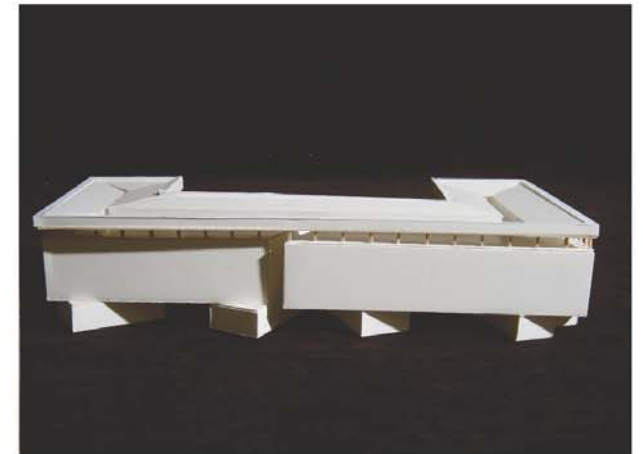
Conceptual Construction Details

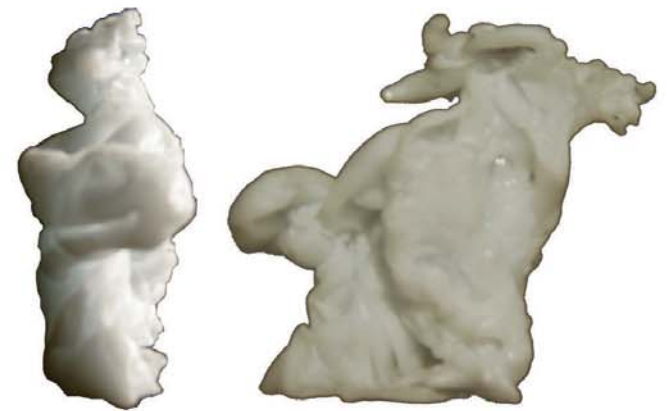


As the project developed, further explorations of area building developments revealed the need for the complex to become a horseshoe shape in order to relate to other complexes along the waterfront. The revised plan for the complex was composed of four main masses, divided by diagonal alleys that aligned with circulation paths and wind forces. The four buildings were supported above the ground level, where the restaurants and commercial properties (although still un-designed) were reoriented to bring people and breezes into the inner courtyard. Floors two and three of the buildings were programmed as office space, while the fourth floor was allocated for residential units. The roof of the complex was cantilevered out over the façade to visually pull the eye up off of the street and to unify the separate structures. The shape of the roof was angled inwards to bring water into the atrium space from the building's perimeter. Within the atrium space were the elevators and stairwells. The original intent was to clad these atriums with greenish glass that would transmit light into the offices, yet separate the interior space from the outdoor elements. The offices were designed as double story spaces, with individual stairwells connecting the floors.



Conceptual Building Section

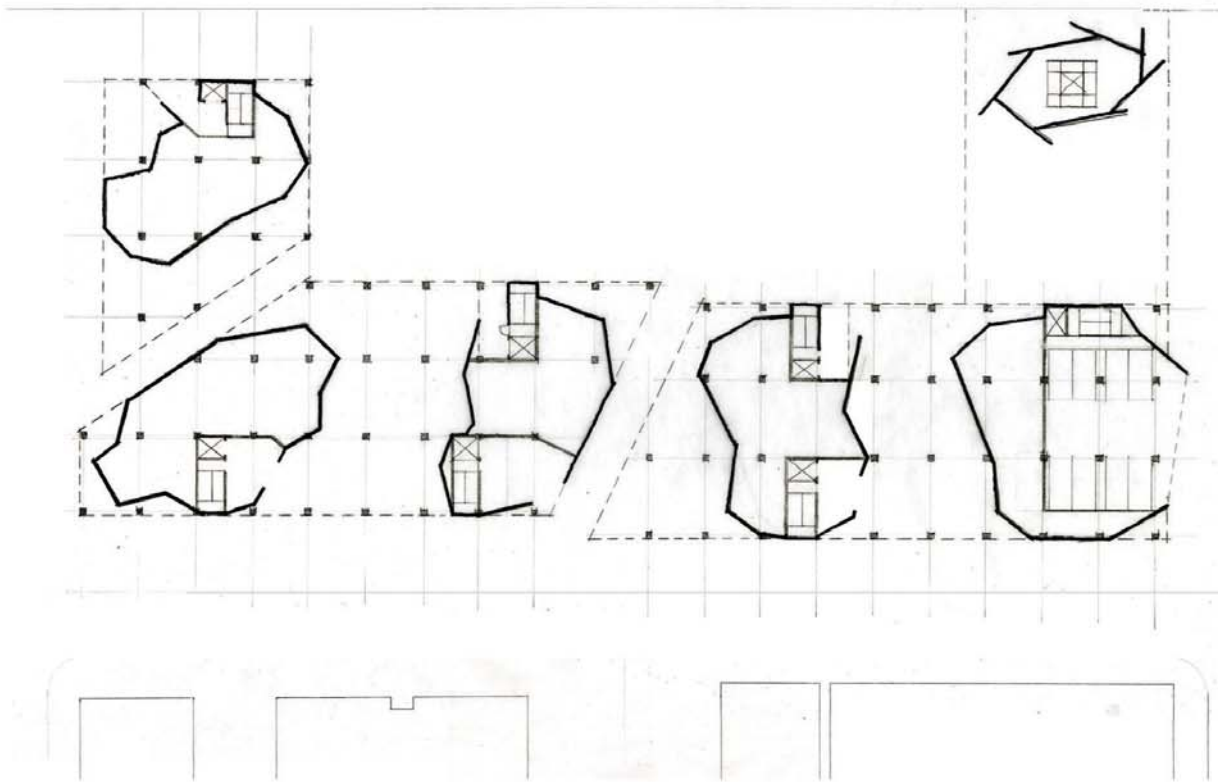




Wax Study Models

The shops and restaurants that occupied the ground floor of the complex were designed independently of the office structure above. The office above was originally designed to be an orthogonal framework that would contrast sharply with the organic ground floor structures. The commercial spaces were intended to physically react to the wind. In order to design these elements, a model was constructed using hot wax to physically mold the potential form of an organic mass. The wax was melted and poured into cold water to physically represent how a liquid force might affect a solid entity. These wax castings were then positioned within an orthogonal framework representing the office structure above the complex to better model the relationship of organic mass to the orthogonal framework.





Conceptual Ground Floor Plan



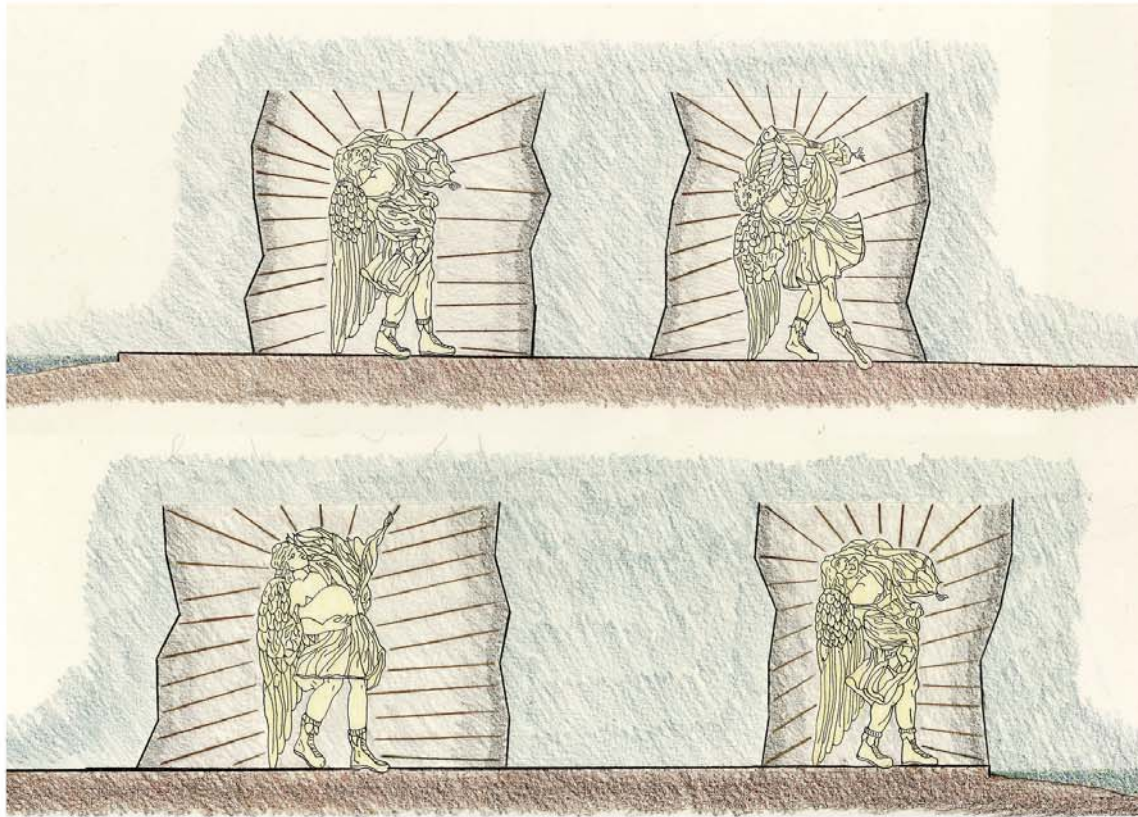
Figure / Ground Studies

After the wax castings were positioned within the orthogonal framework, which was modeled in Plexiglas, an exploration began to develop focusing upon the relationship of the organic forms to the orthogonal framework. Questions regarding solid versus void developed, which resulted in further wax models. Once again wax figurines were created, but this time the figures were imprisoned within a foam core box, and covered with plaster. After the plaster dried, the form was removed from the foam core and cut in half to reveal the wax form inside. The model was then submerged in boiling water, which melted the wax out of the plaster mold, leaving just the void behind. This new model showed the solid versus void relationship of the wax to the orthogonal structure, which led to the initial conceptual plan drawings.

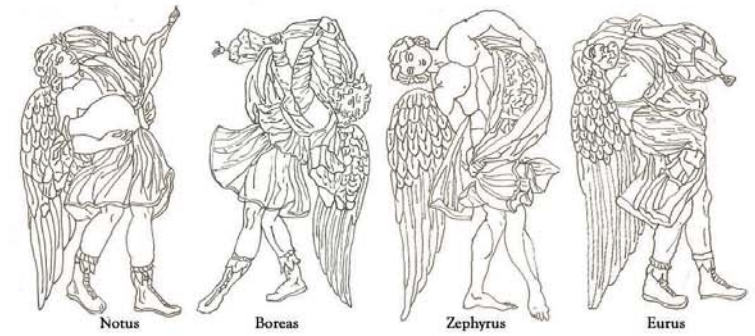
The drawings were created with the purpose of showing how the curves and angles of the plaster could be interpreted as structural spaces. Six masses were positioned on the site, along the footprint determined by the previous horseshoe plan and spaced to allow for breezes to pass between the masses. Each building was then laid out to move and twist as though its façade was being acted upon by the wind.

As the buildings on the site began to take form, a stronger conceptual basis for the unusual shapes of the structures was needed. Each building was positioned and oriented on the site to optimize wind exposure, yet they were lacking any direct correlation to the wind in either section or plan.



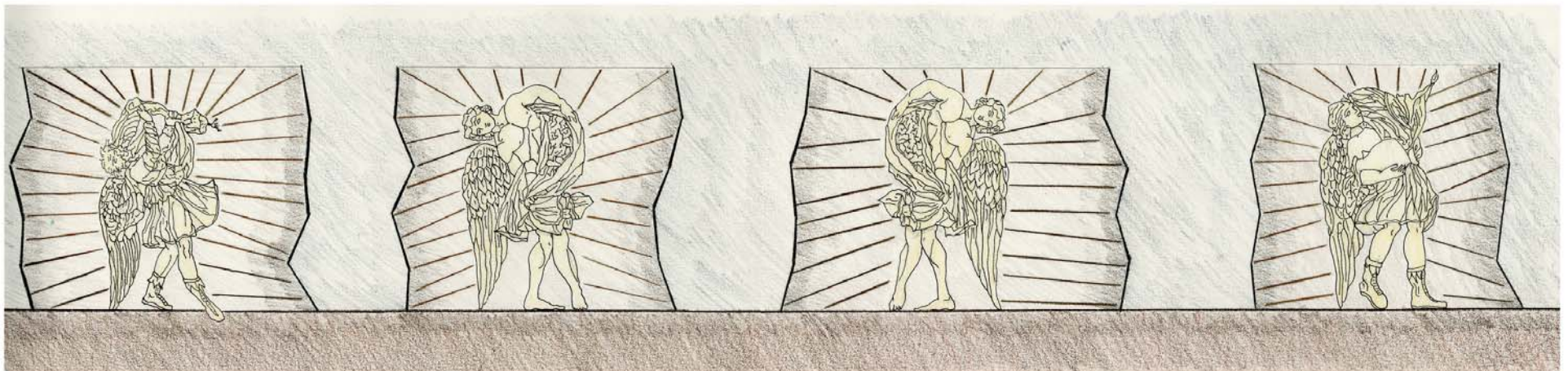


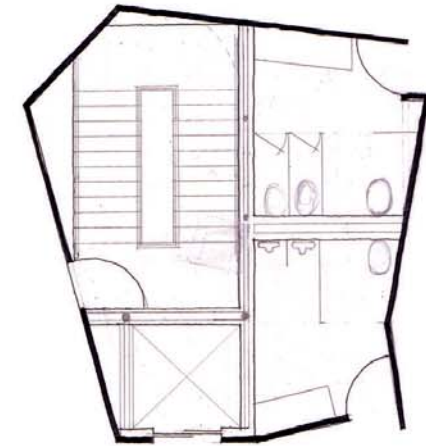
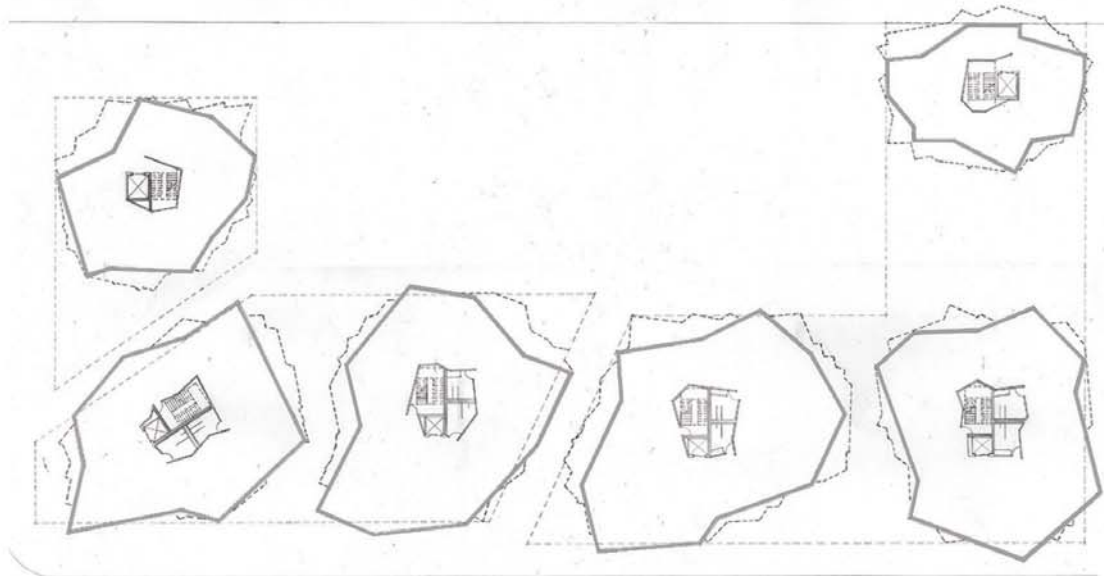
Initial Sectional Explorations



Greek Wind God Figures

Throughout history different cultures have used various figures to graphically represent the wind. The Greeks personified the four directions of the wind with four unique characters. The Northern wind became Boreas, the Eastern wind was Eurus, the Western wind was Zephyrus and the Southern wind was Notus. Although many renditions of these four characters exist, one particular set clearly displayed each god with it's own set of defining characteristics, which became the guiding images for the individual buildings. These graphics became inspirational guides behind each building, both in plan and in section.



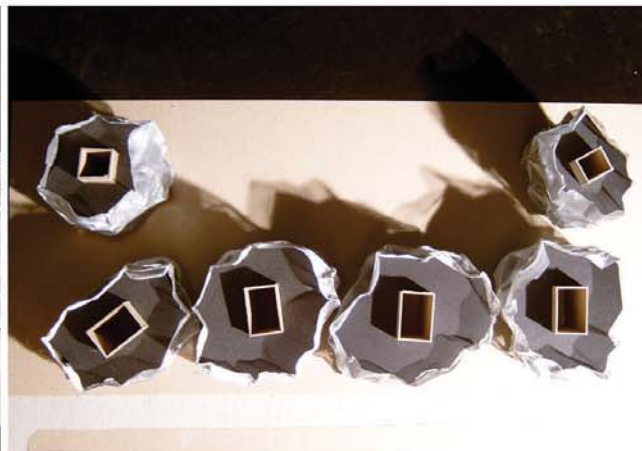


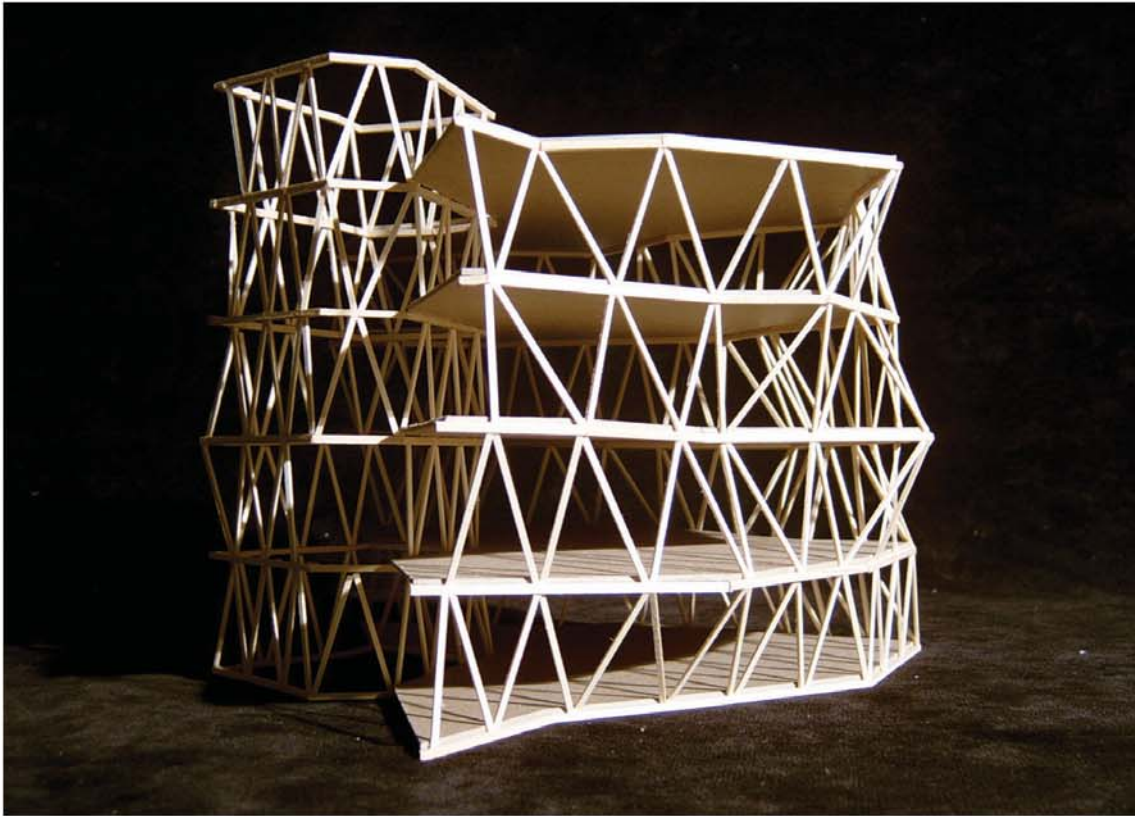
Initial Core Plan

The first version of the building plans inspired by the Wind gods featured six buildings set in a horseshoe plan, as determined by previous explorations. Each building was unique in plan and section, which required a 1/16" complex model be created. The model prominently featured the six buildings, each with an orthogonal core, which contained the stairs and elevators for the individual structures. The cores were constructed and the floors positioned at 12' height increments. The structures were then skinned in a perforated metal, which was envisioned to be stainless steel mesh.

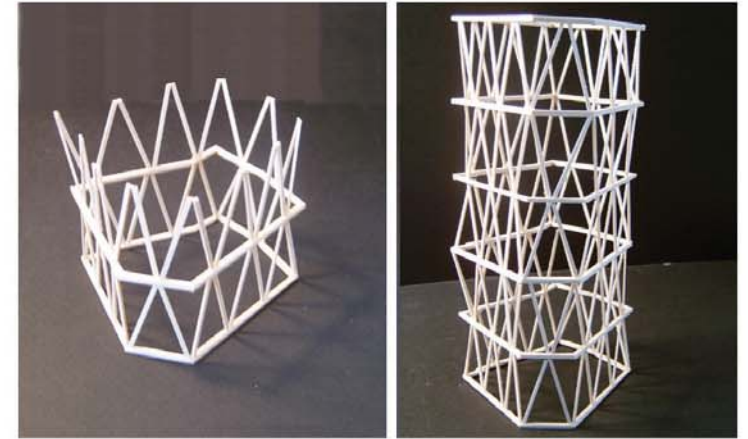


Initial Ground Floor Plan



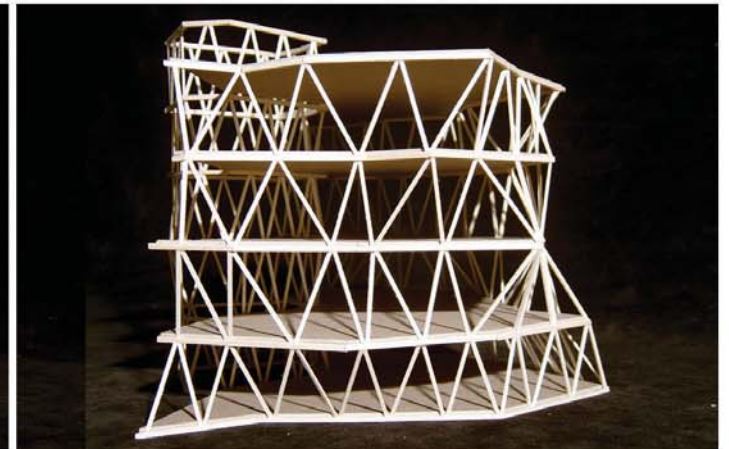
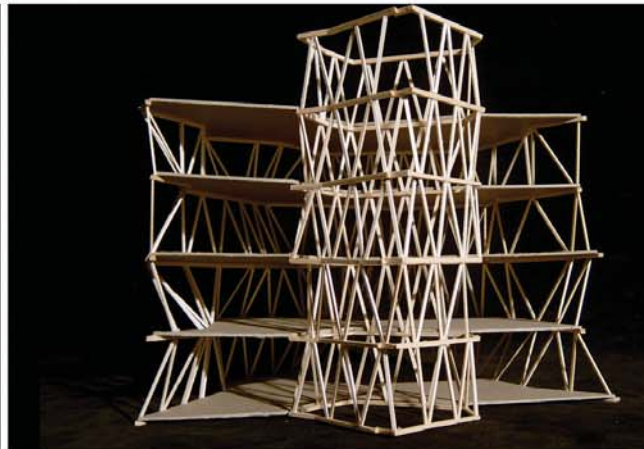
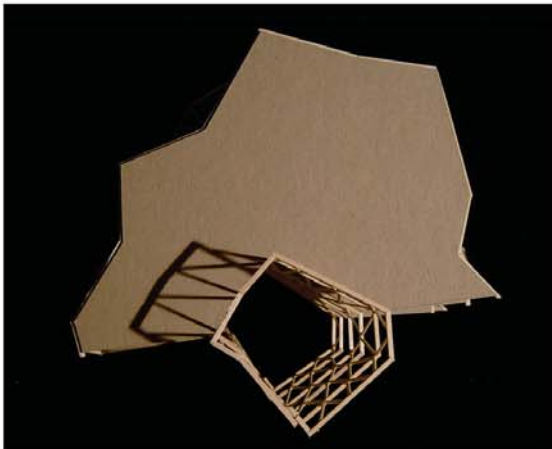


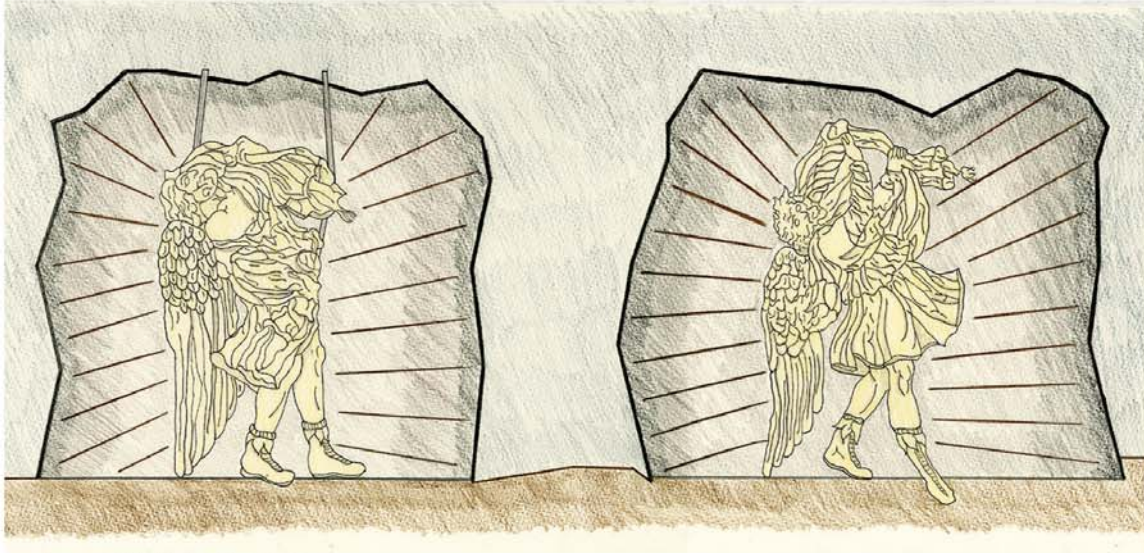
Conceptual Structural Exploration



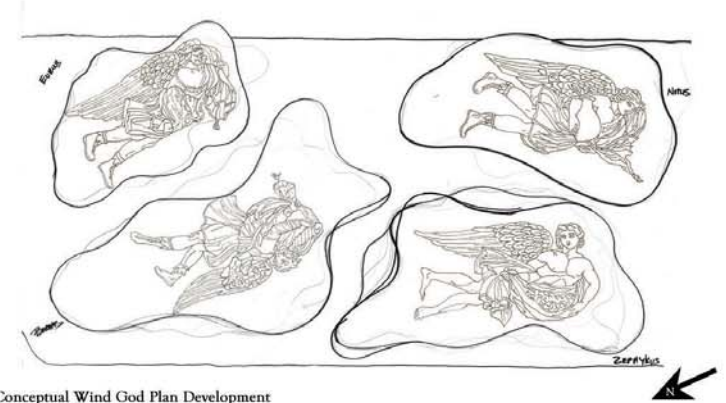
Conceptual Core Exploration

The proposal of a six uniquely figured complex required the development of a versatile structural system. In order to develop a successful structural solution, the works of Toyo Ito and Norman Foster were investigated. These investigations led to the development of a structural model at 1/8" scale, which demonstrated the strength and flexibility of a triangulated column structure around the perimeter of the building. A triangulated column structure allowed for the buildings to vary in section and plan while freeing the interior spaces of any columns.



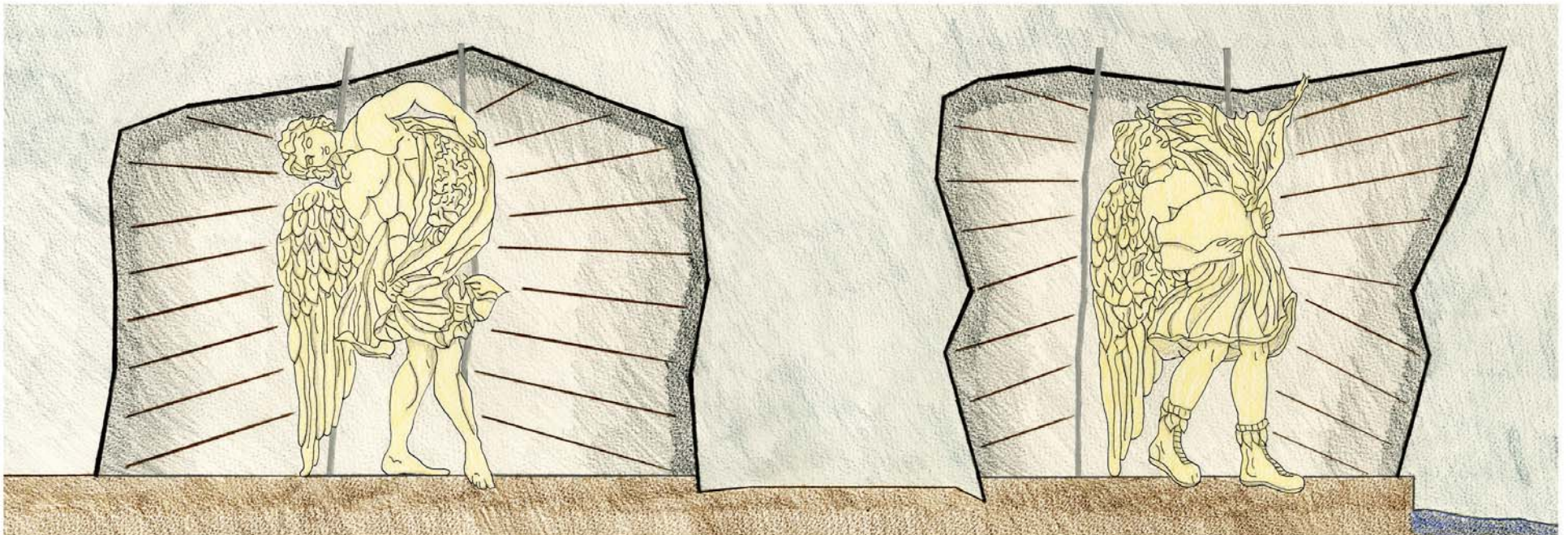


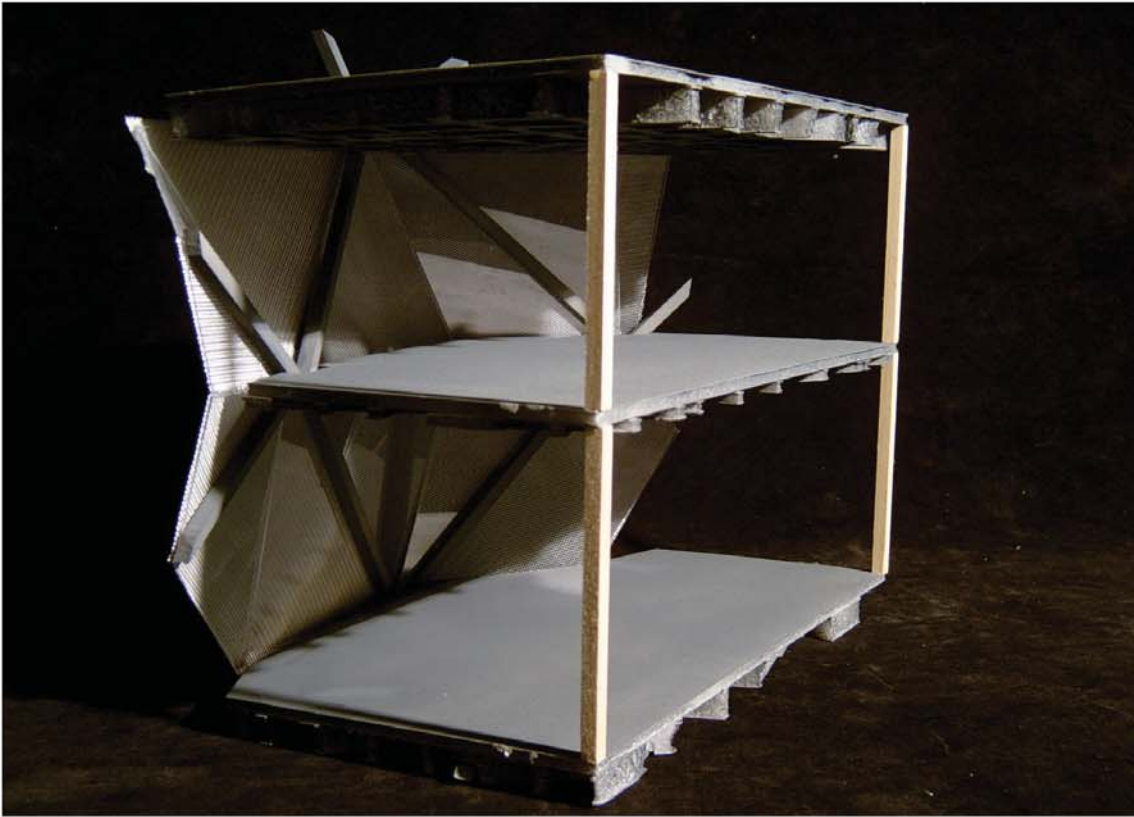
Conceptual Wind God Sectional Development



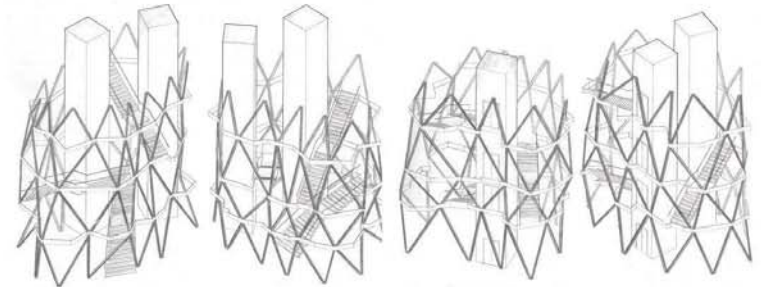
Conceptual Wind God Plan Development

Further investigations of the wind Gods and their potential to guide and determine the spatial organization of the development, produced the final forms of the buildings. Each wind god was studied as a figure standing up and as a figure lying down, and was then appointed to a specific building, so that each god correlated with its own building. Boreas inspired the building in the Northern corner of the site. Eurus Inspired the Eastern building, Zephyrus inspired the Western building and Notus was responsible for the Southern building.



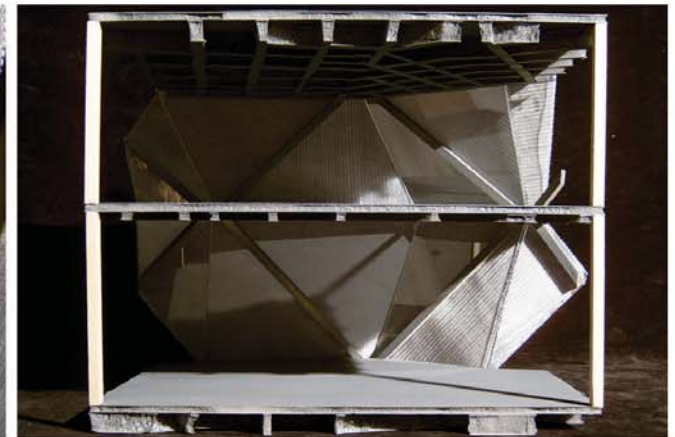
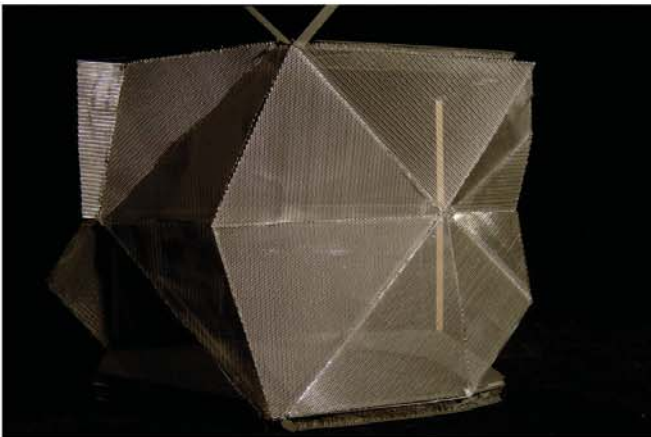


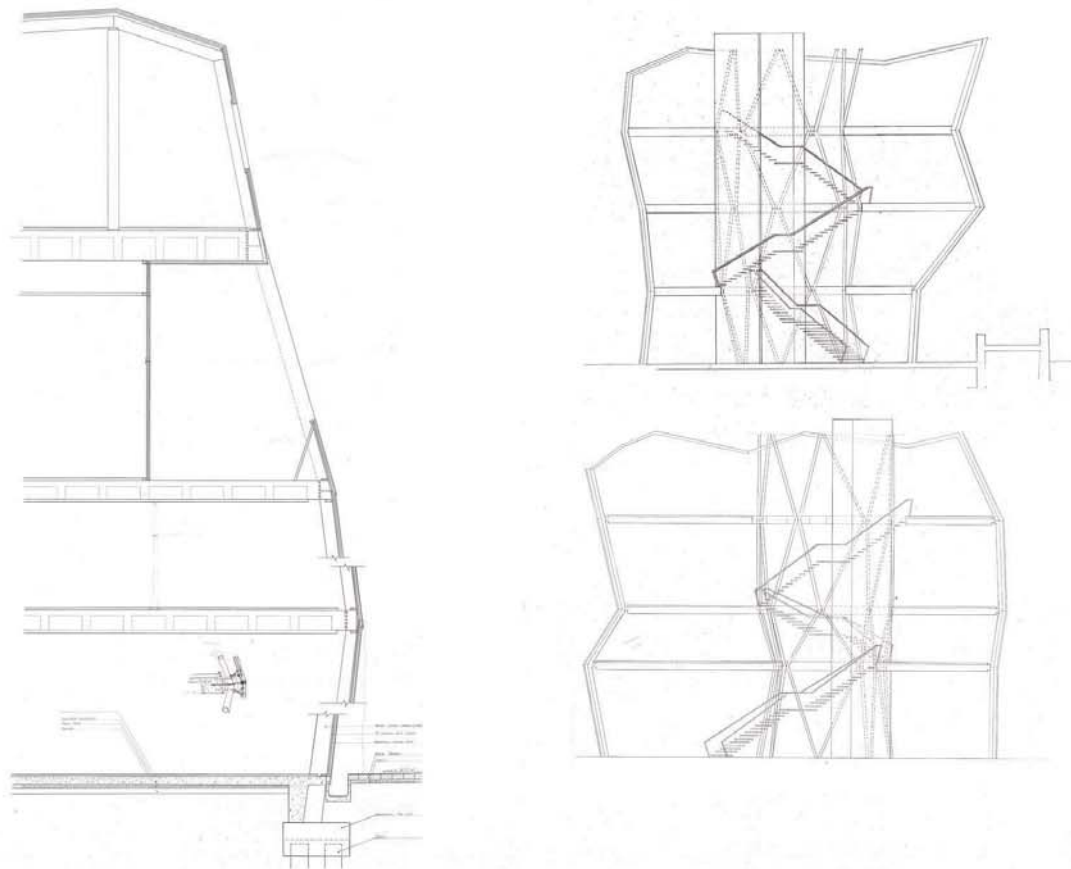
Wall Section Model



Initial Core Axonometric Drawings

Each building was individually planned and laid out, yet all of them were composed of the same materials. An enlarged sectional model helped to create the feel of the interior space. The model physically represented the concrete waffle slabs, suspended between the exterior and interior columns. The columns were visualized as ductal concrete, which incorporates strengthening fibers to create a highly resistant material with tremendous compressive and flexural strength, each attached at the junction of the concrete slabs, to strengthen the structural integrity of the building and free up the perimeter to allow for maximum light penetration. The exterior skin was composed of a combination of insulated glass and a perforated steel screen. The interior cores were visualized as open spaces for the stairs and elevators.

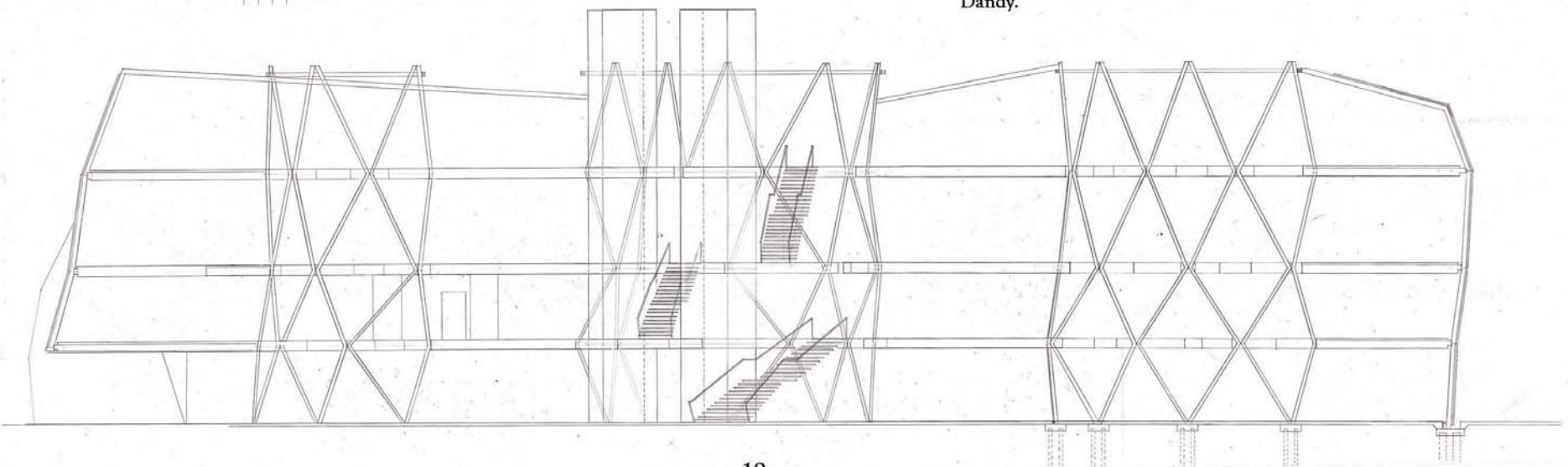




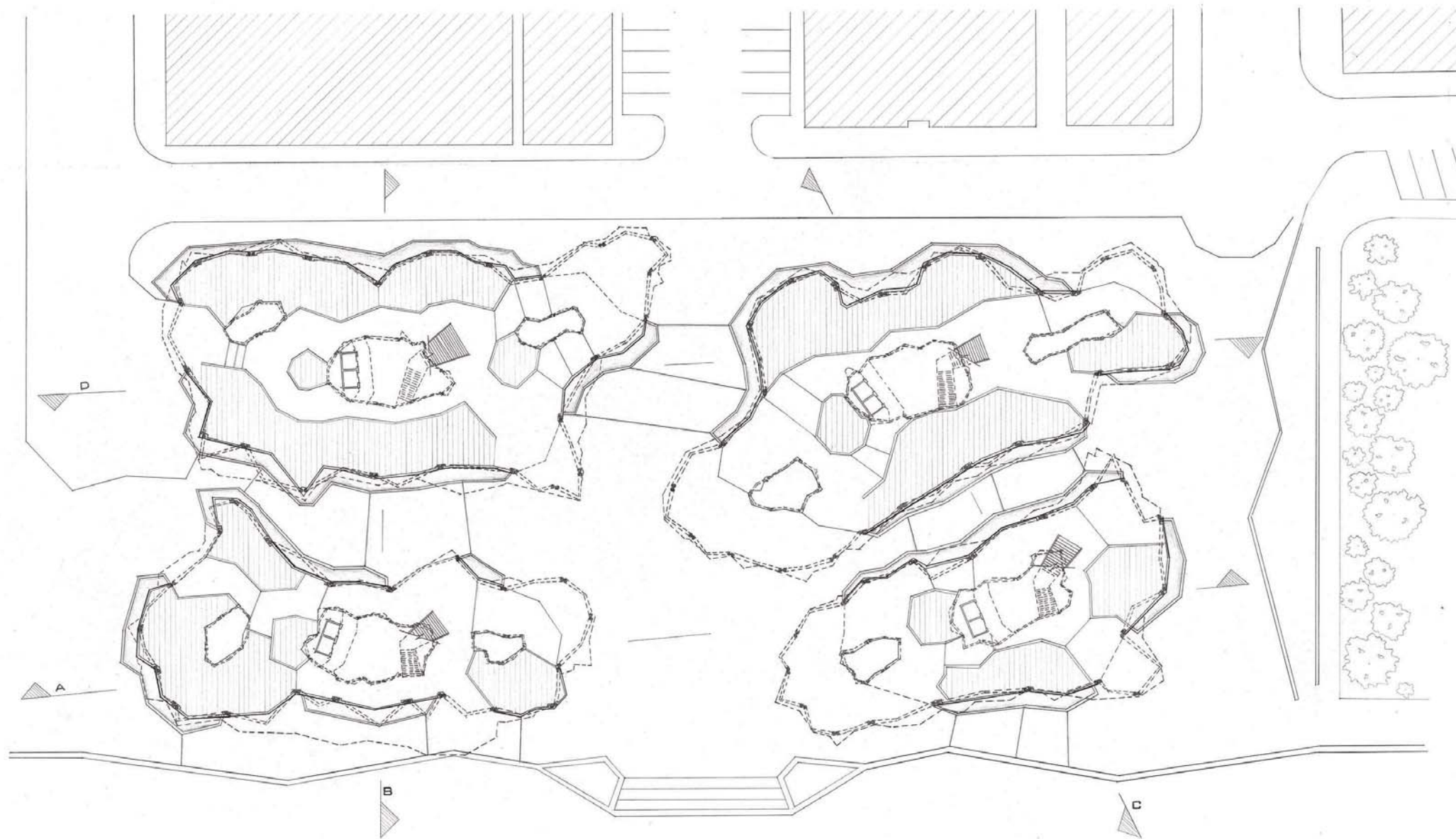
The original sections of the buildings revealed the design intention to alter the perimeter of each structure with gusts of wind and to alter the behavior of the wind with these façade modifications. The silhouette of each building's particular wind god inspired the sections, which reveal the four floors, with varying floor-to-floor height design. In addition to the structurally supportive core, light wells were added to the structures to decrease the concrete spans of the floor slabs and to increase the amount of light filtering into the structures.

An enlarged wall section highlighted the need for the skin of the building to become more interactive with the wind. The section showed how the floor slabs could be supported by the exterior columns and how the skin could be hung from these slabs, but it also showed how stagnant the assembly was. The stairs and perimeter silhouettes of each structure were beginning to visually move with the wind, but the wind was not entering the interior spaces. The final iteration of the proposal attempted to solve these particular issues.

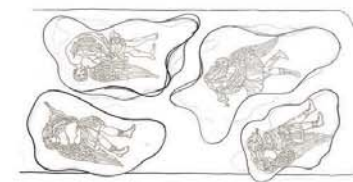
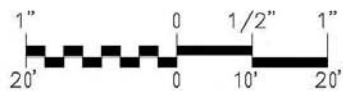
The site plan of the proposal was reinvestigated to situate the four structures further apart to create pathways for pedestrians and ventilation between the structures. Each building was planned in reference to the wind god graphics, then positioned on the site to allow the combination of the exterior walls, interior light wells and circulation cores to create spaces for commercial use. These ground spaces were opened to allow both the public and the wind to pass from the city through the buildings to the interior courtyard. Shallow steps between the structures slowly brought the public into the site and toward the primary gathering space. A smaller set of stairs against the river allowed people to access the Nina's Dandy.

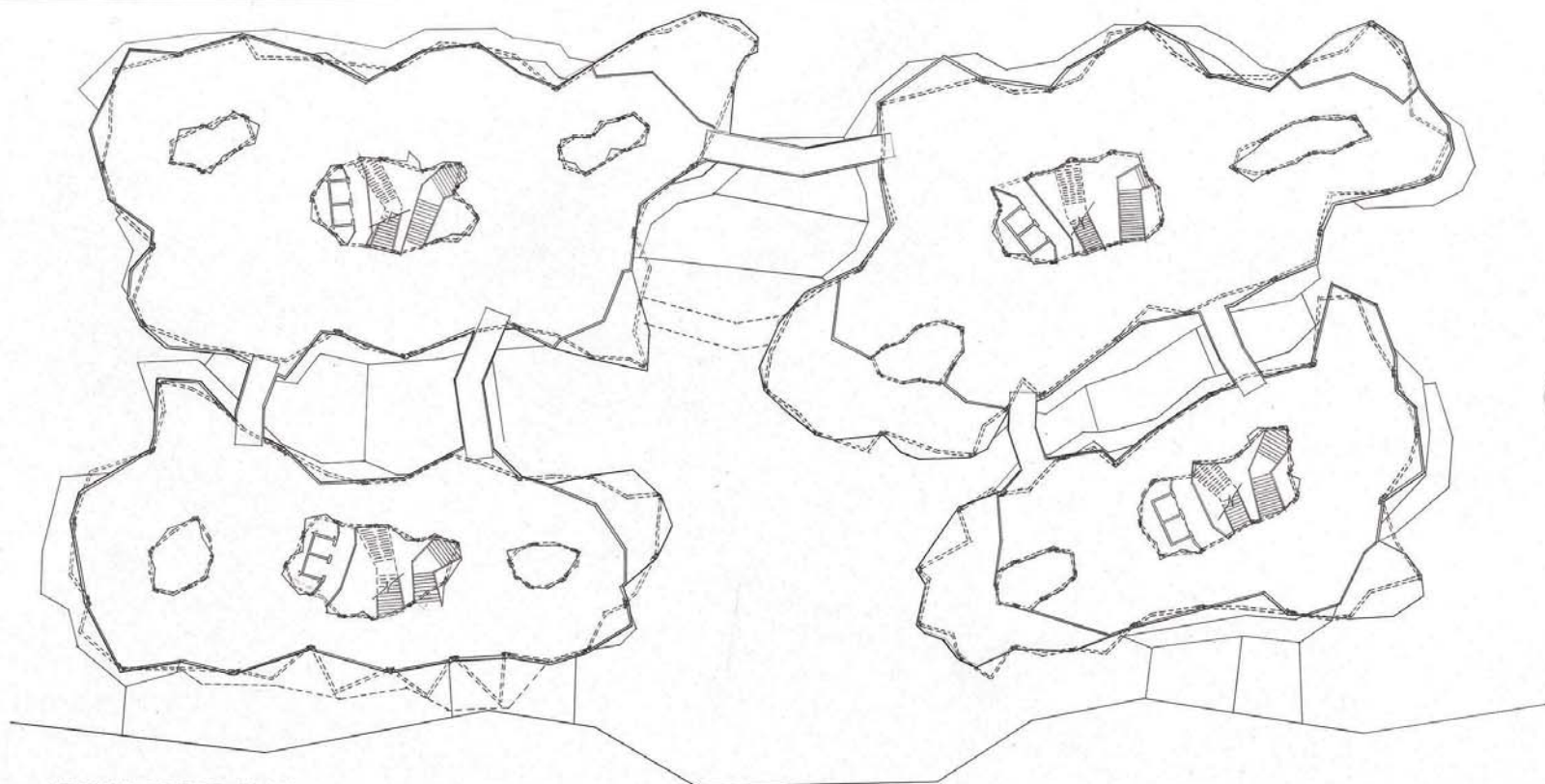


# Final Proposal

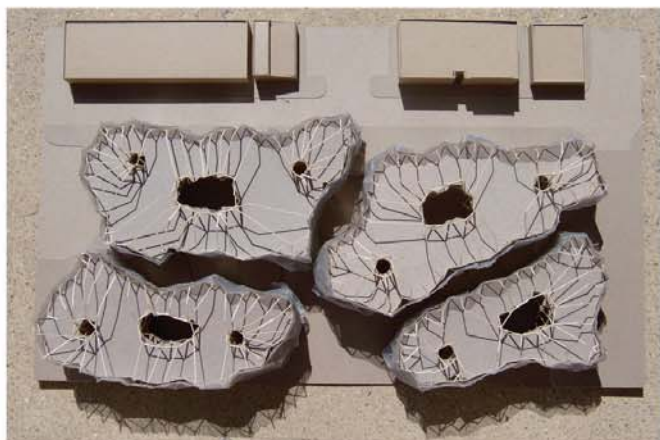
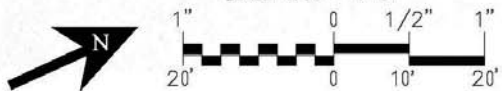


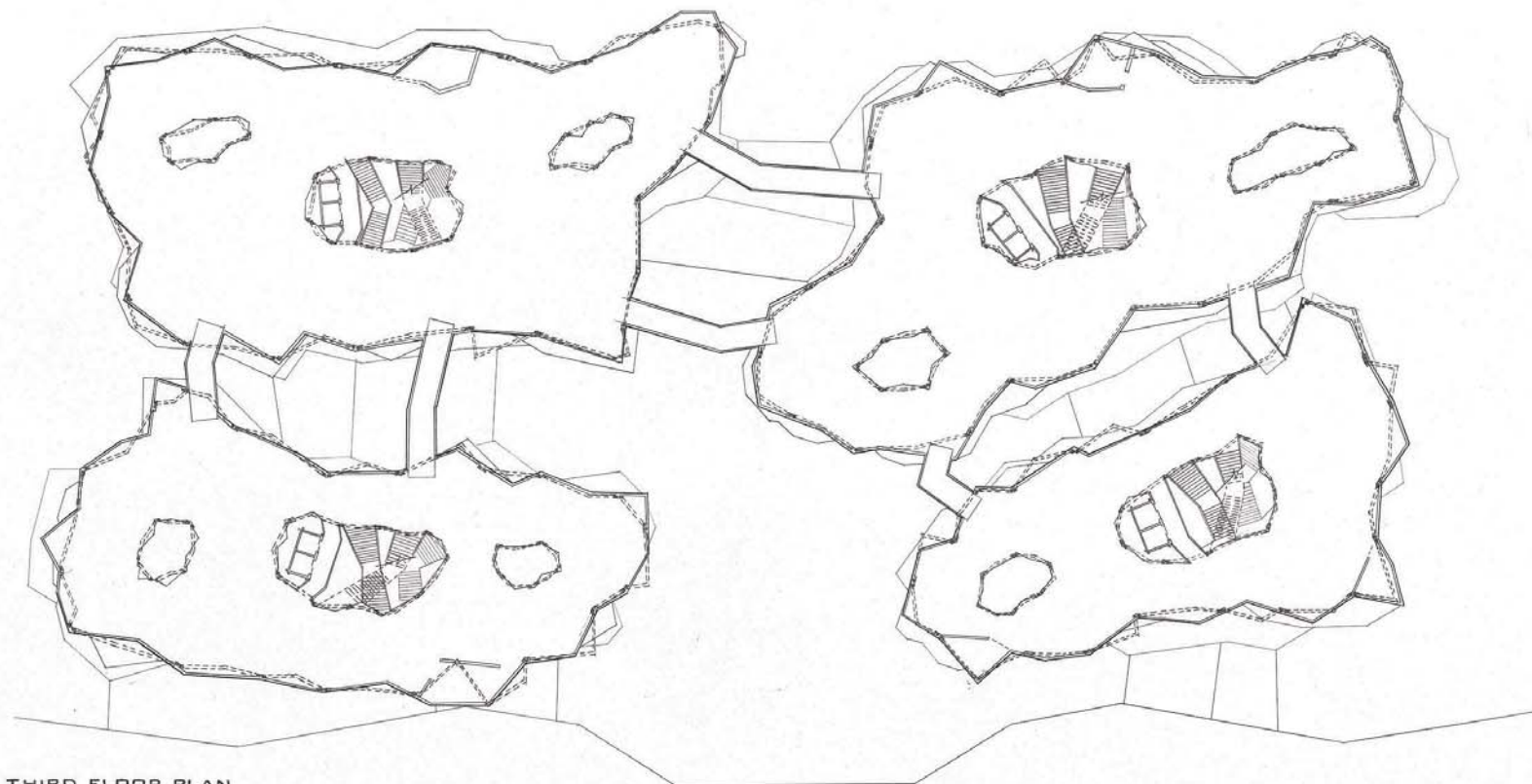
GROUND FLOOR PLAN



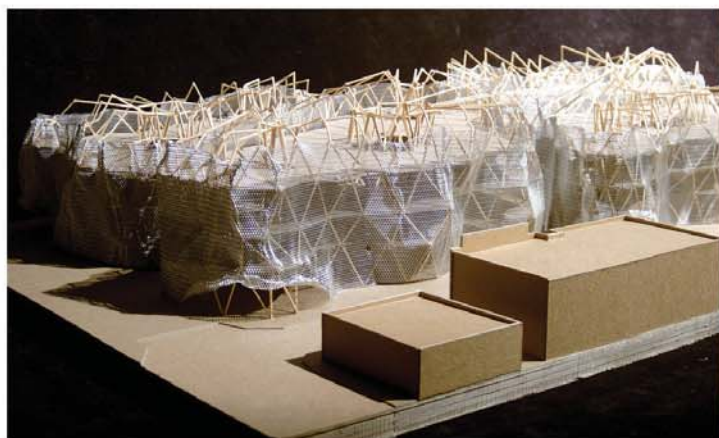
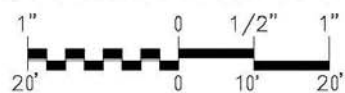


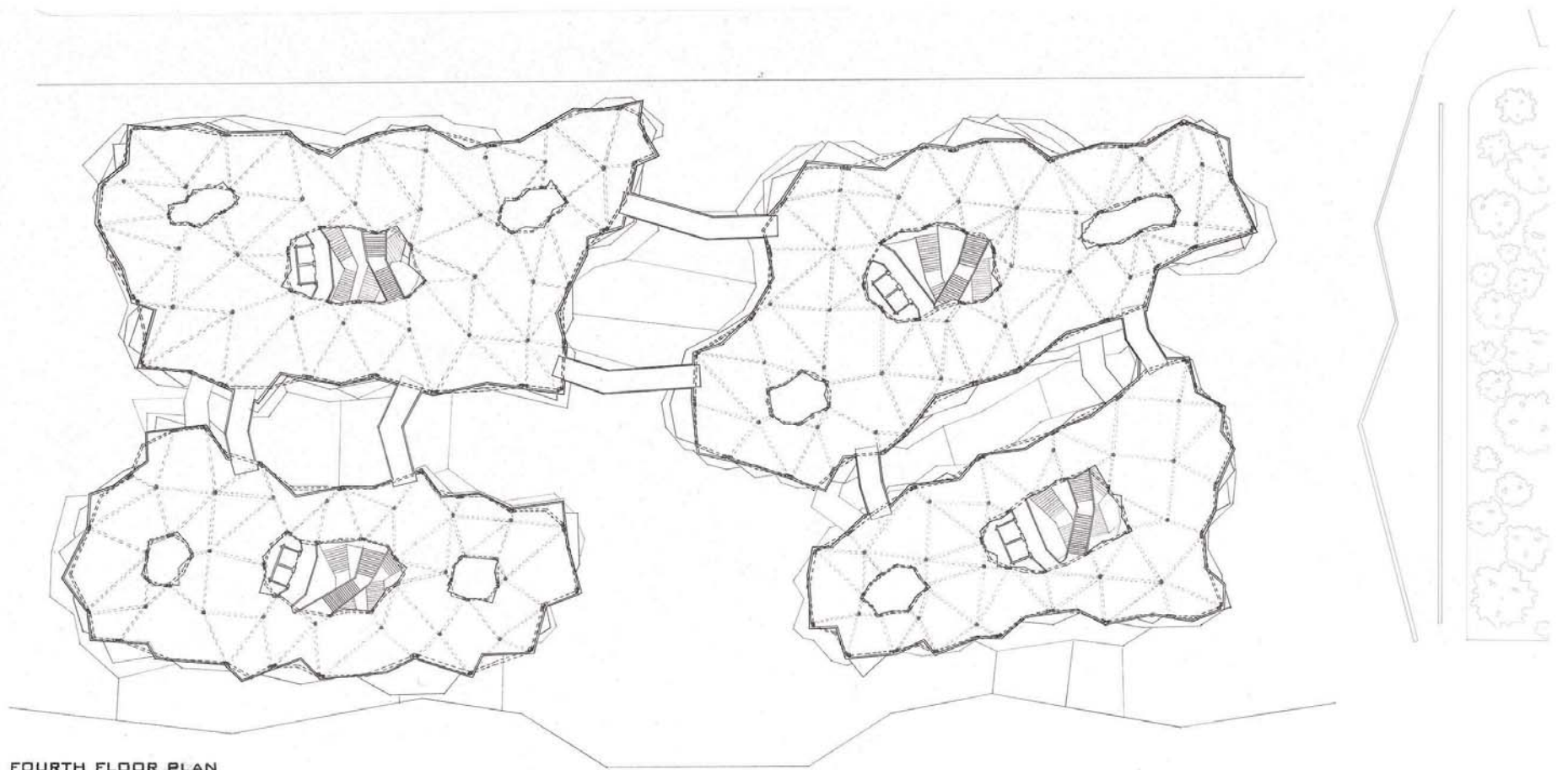
SECOND FLOOR PLAN  
SCALE: 1/16" = 1'-0"



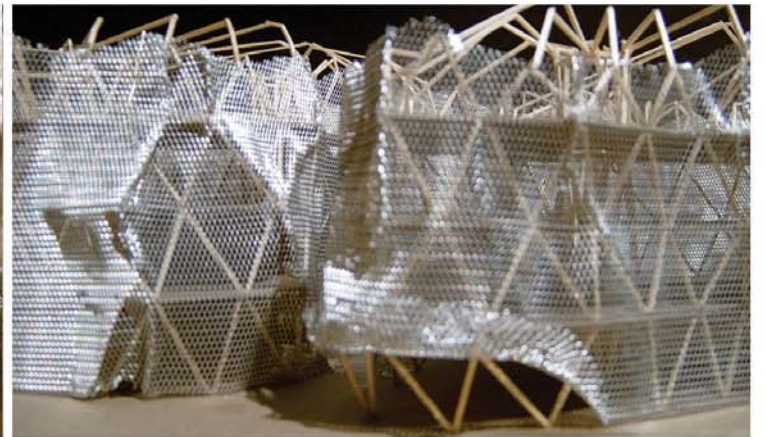
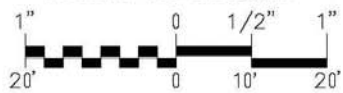


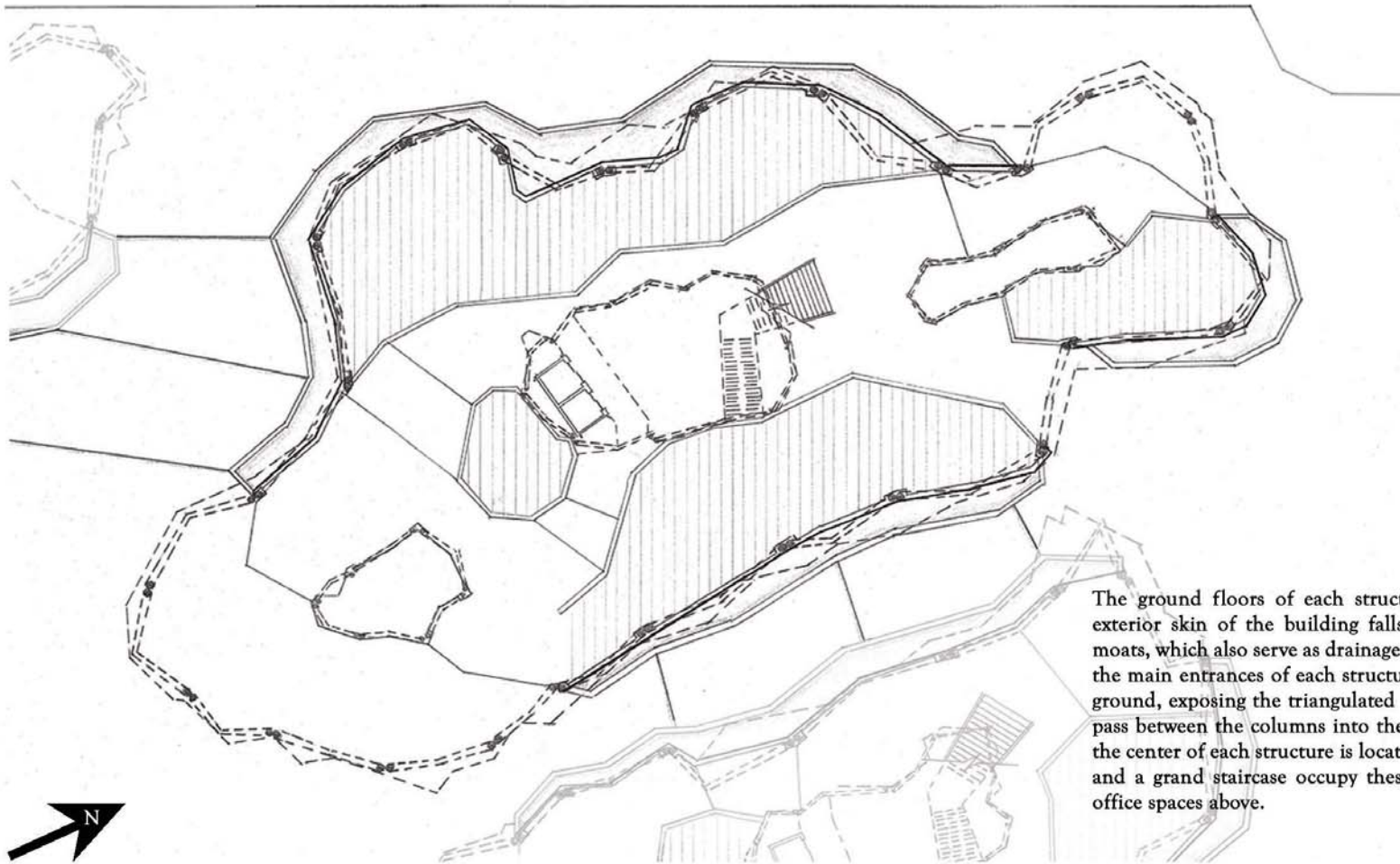
THIRD FLOOR PLAN  
SCALE: 1/16" = 1'-0"





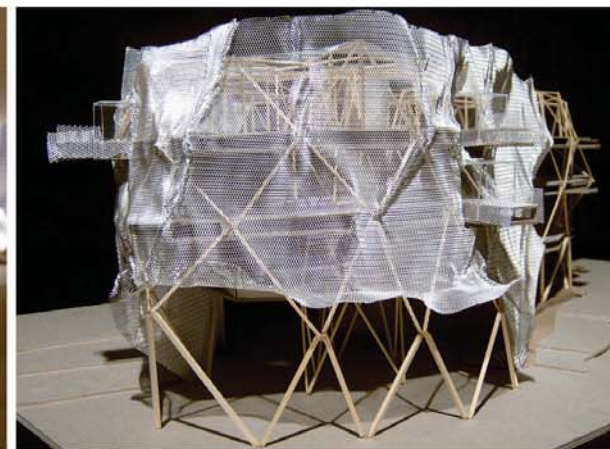
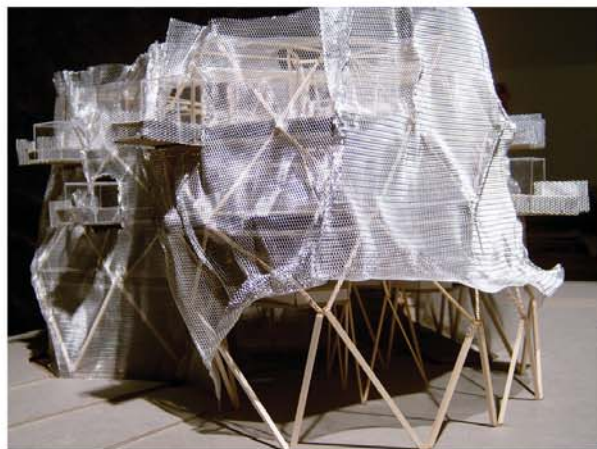
FOURTH FLOOR PLAN

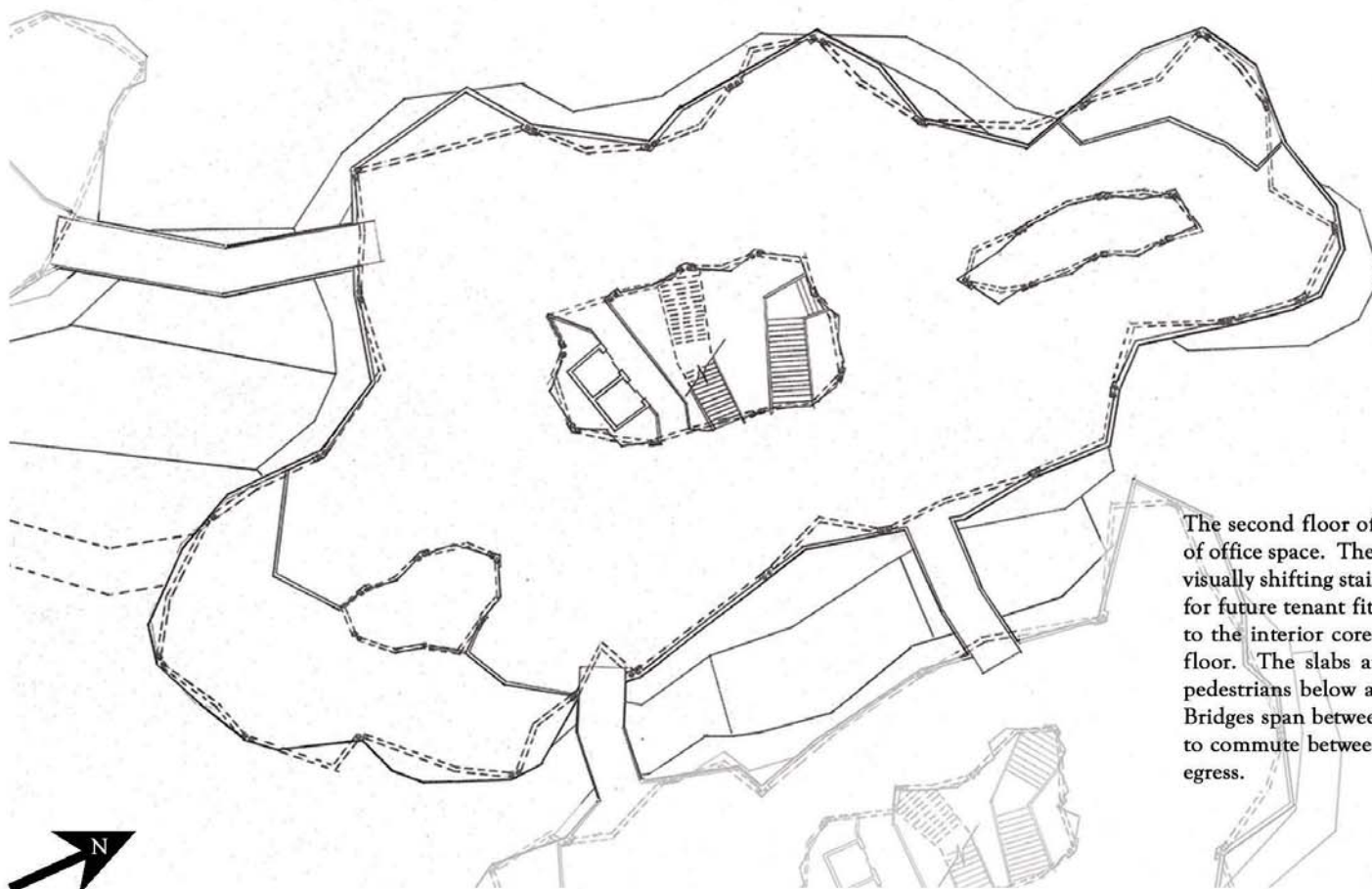




Boreas

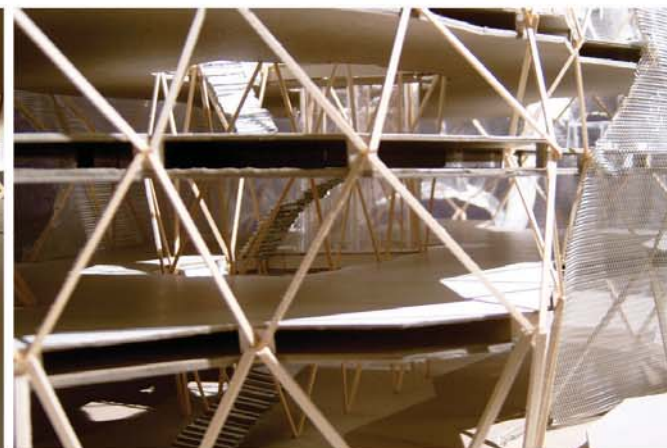
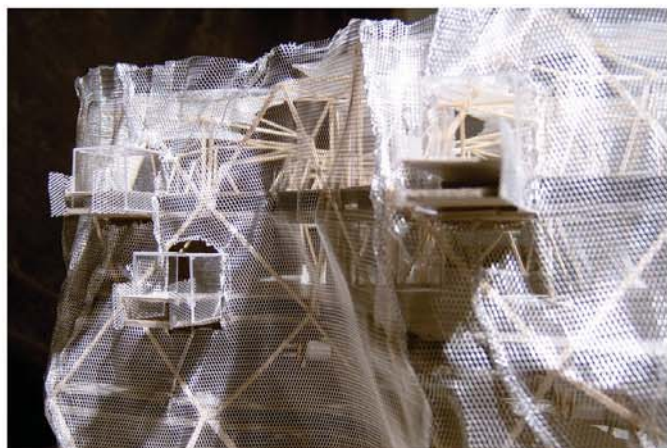
The ground floors of each structure are planned out similarly. The exterior skin of the building falls past the ground plane into shallow moats, which also serve as drainage channels and planters for bamboo. At the main entrances of each structure the exterior skin is lifted off of the ground, exposing the triangulated ductal concrete structure. Pedestrians pass between the columns into the structures, just as the wind does. At the center of each structure is located the circulation core. Two elevators and a grand staircase occupy these cores to bring personnel up to the office spaces above.

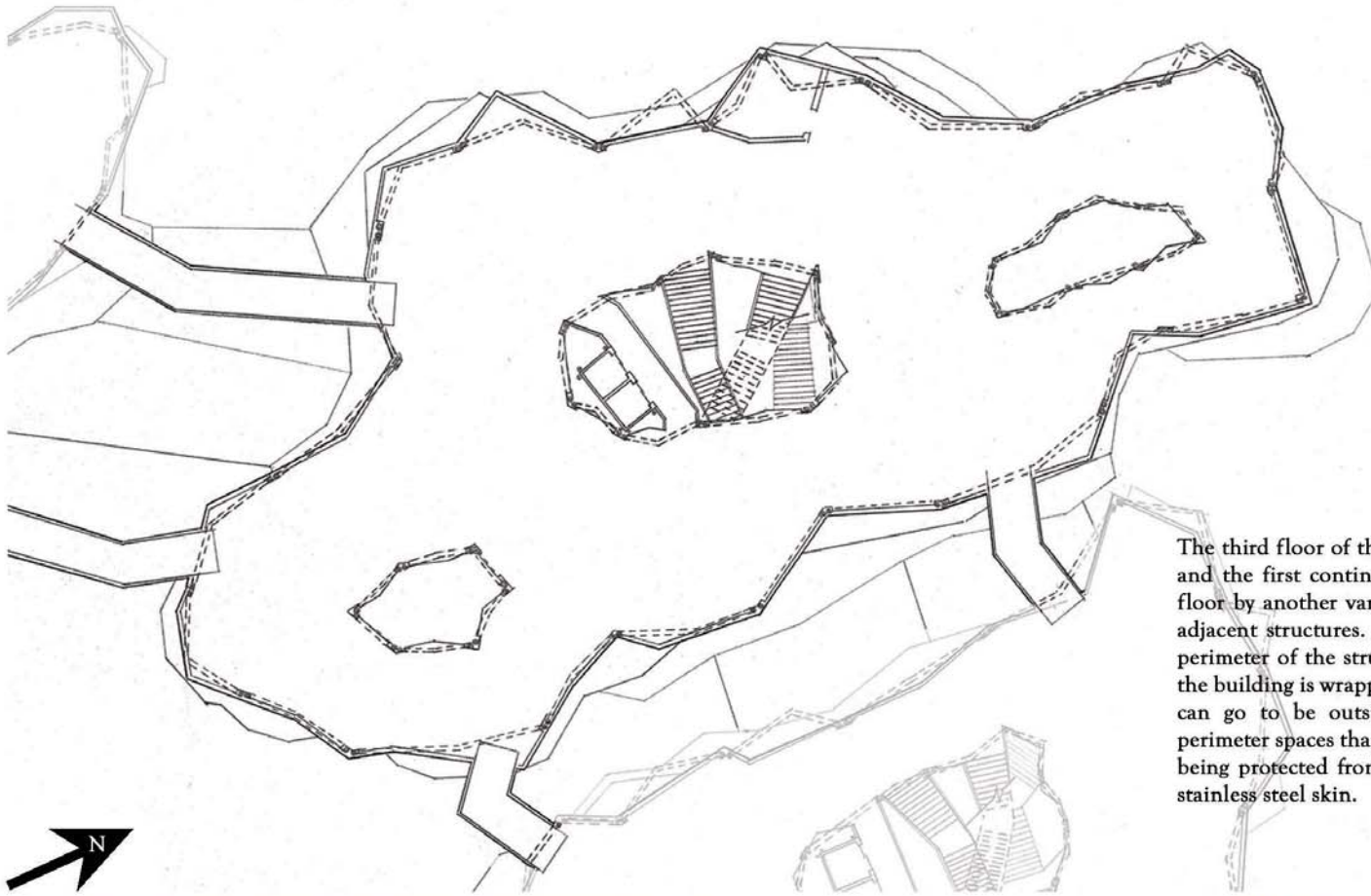




Boreas

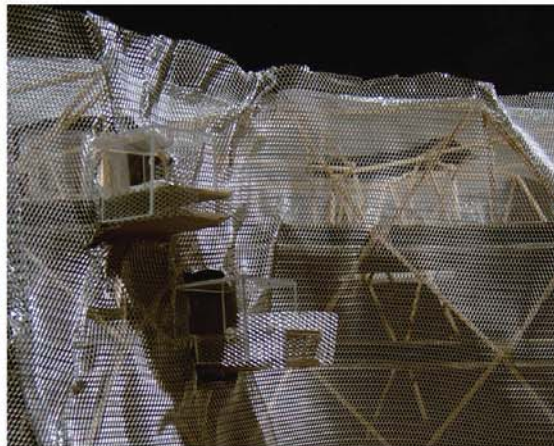
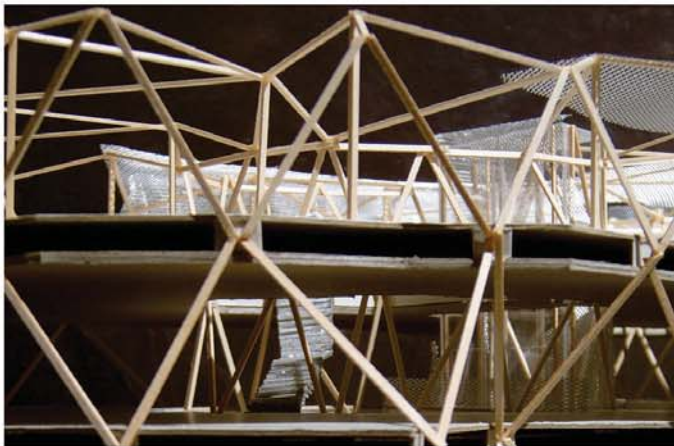
The second floor of each structure marks the beginning of the two levels of office space. These levels are accessible by either the elevators or by the visually shifting staircase. Once on the second level, the space is left open for future tenant fit-out. The floor slabs span from the exterior columns to the interior cores, yet are pulled back at the entrances to the ground floor. The slabs are pulled back to allow for office workers to watch pedestrians below and to create a double-storied space at the entrances. Bridges span between the second floors of each building to allow workers to commute between the individual structures and to provide emergency egress.

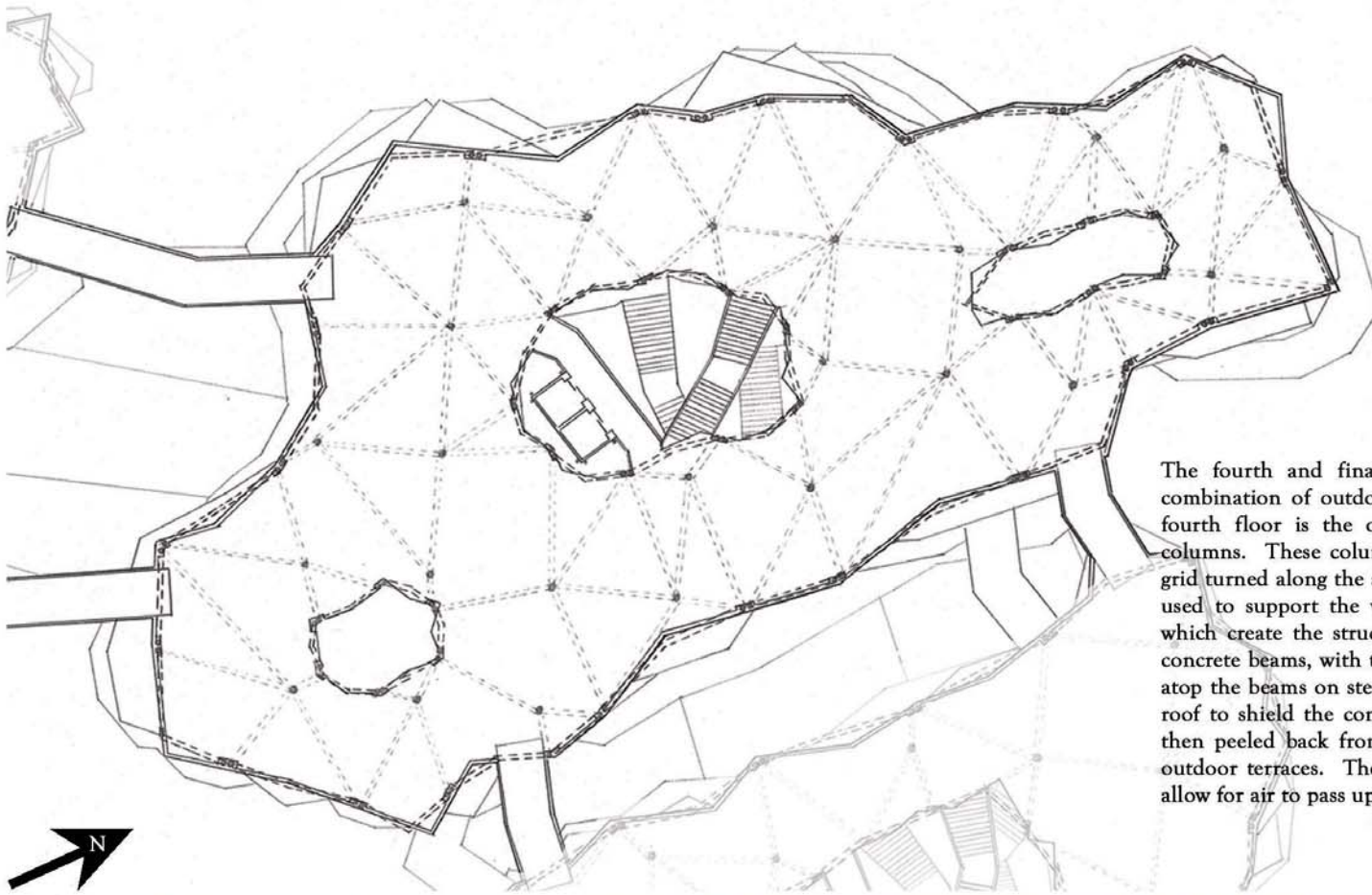




Boreas

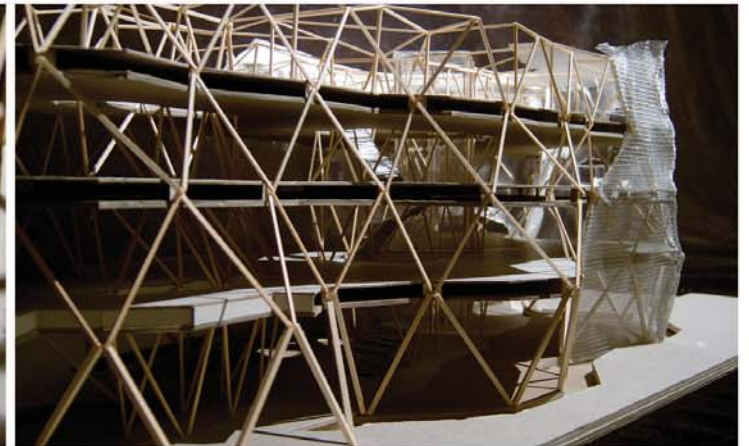
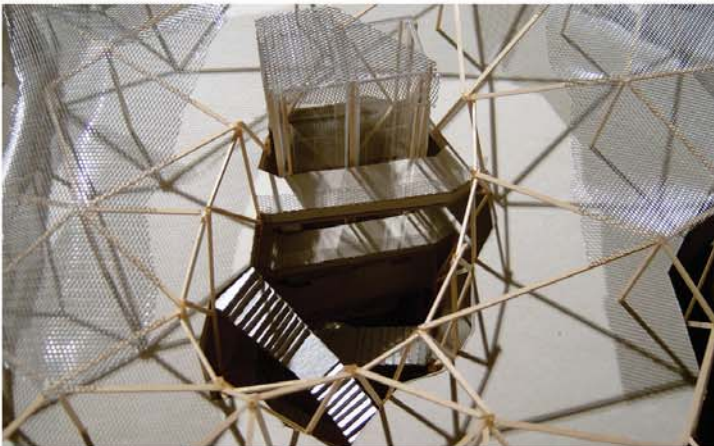
The third floor of the buildings provides the second floor of office space and the first continuous slab. The floor is accessible from the second floor by another varying staircase, the elevators or the bridges from the adjacent structures. The third floor also offers outdoor terraces at the perimeter of the structure. These terraces are formed where the skin of the building is wrapped into the structure to create pockets where workers can go to be outside without going downstairs. Each floor offers perimeter spaces that allow for light to penetrate the interior spaces, while being protected from glare or extreme heat generated by the perforated stainless steel skin.

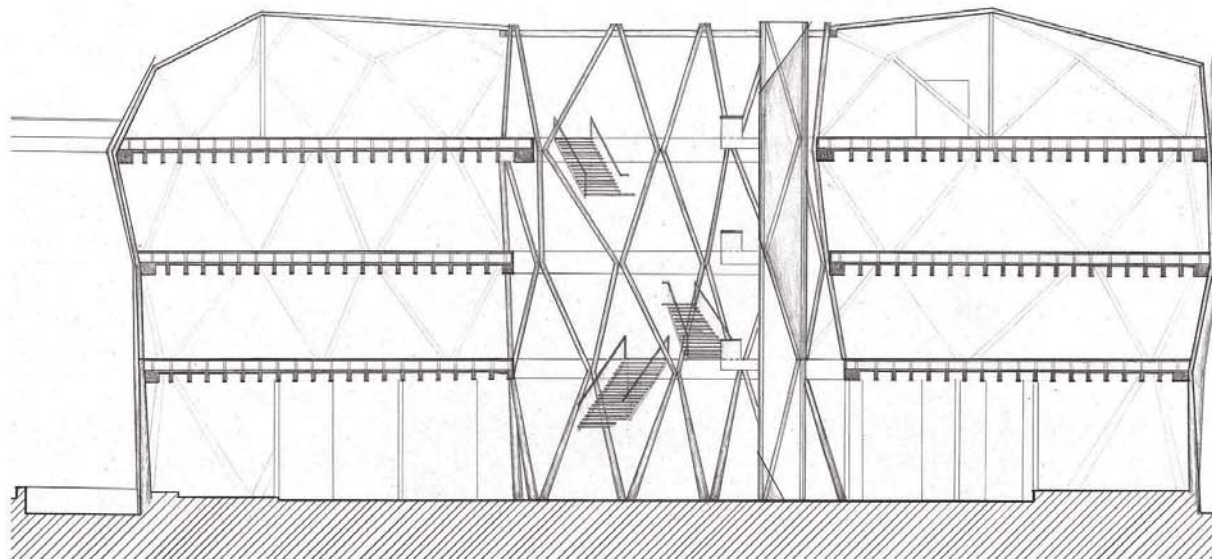




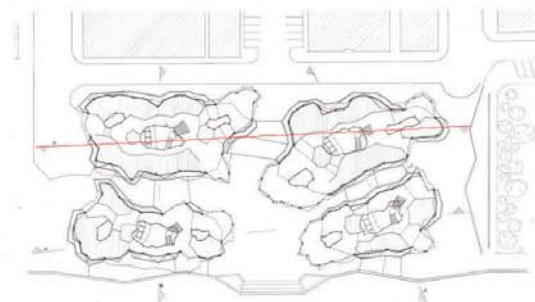
Boreas

The fourth and final floor of each structure is programmed as a combination of outdoor gathering spaces and conference rooms. The fourth floor is the only floor to contain an additional network of columns. These columns are situated along an orthogonal twenty-foot grid turned along the axis of the Alexandria streets. This column grid is used to support the web-like network of ductile columns and beams, which create the structure's roof. The roofs are composed of ductile-concrete beams, with triple insulated glass and stainless steel panels laid atop the beams on steel joists. The steel panels are situated around the roof to shield the conference rooms from direct sun exposure, but are then peeled back from the structure to delineate egress corridors and outdoor terraces. The circulation core and light wells are left open to allow for air to pass up through the building from the ground level.



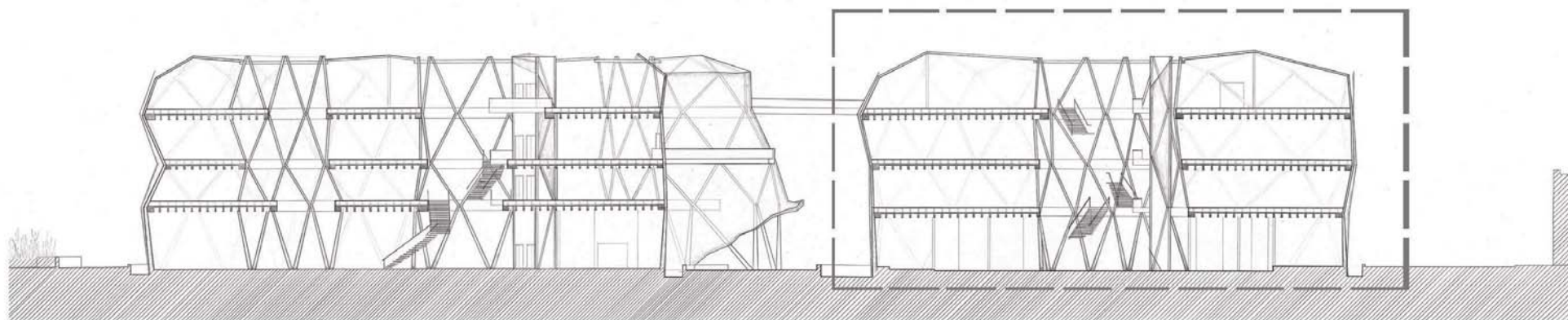


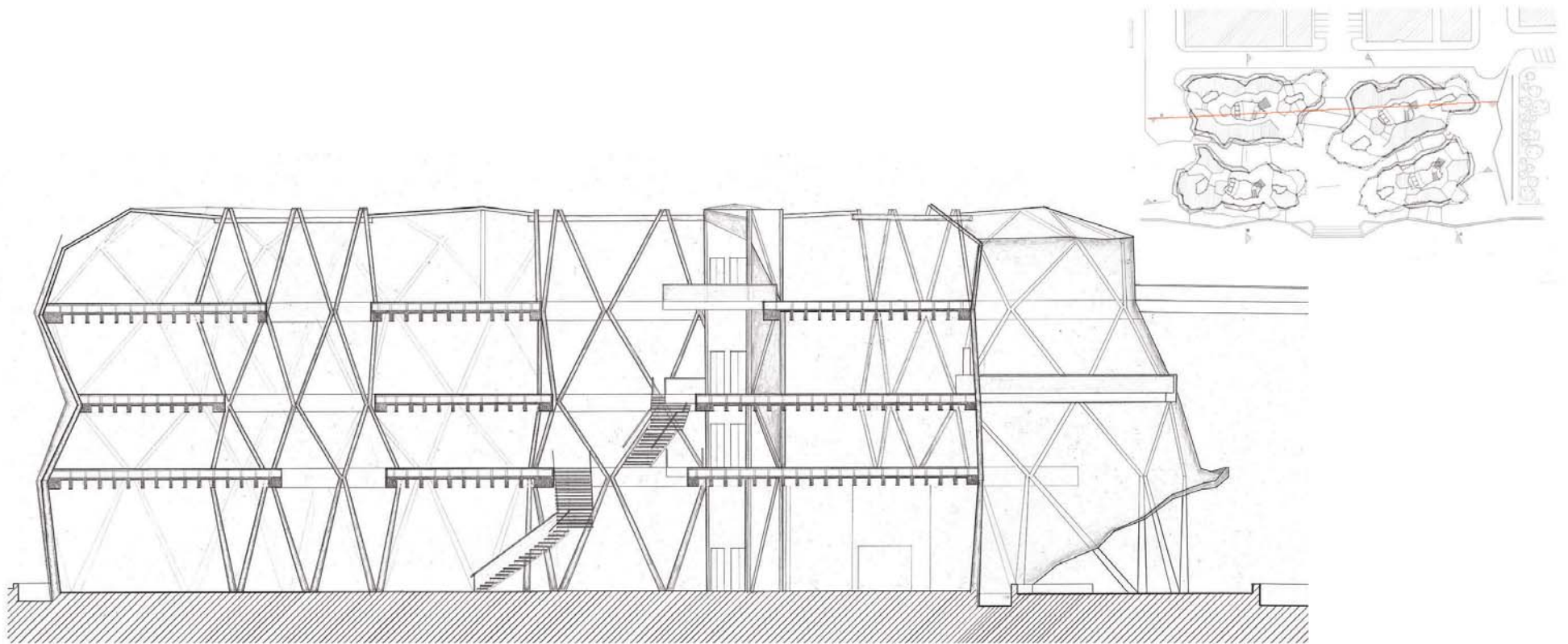
Enlarged East-West Section of Zephyrus



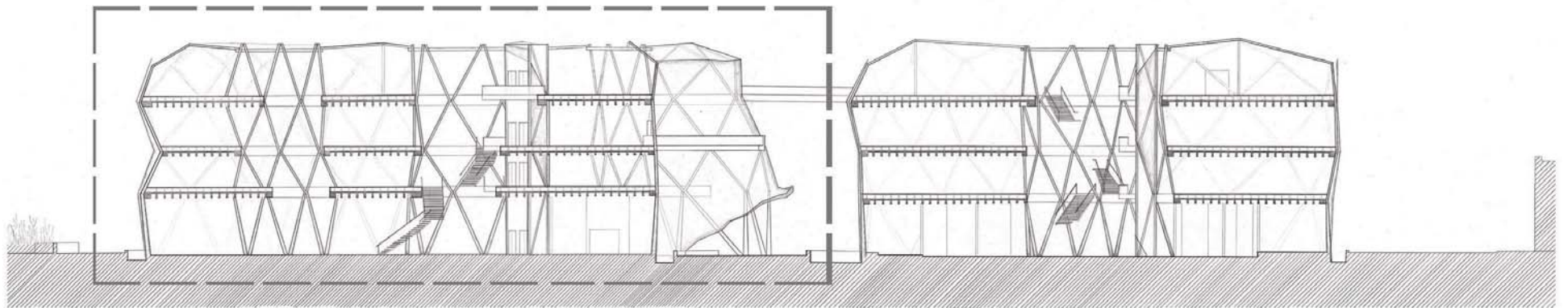
Key Plan

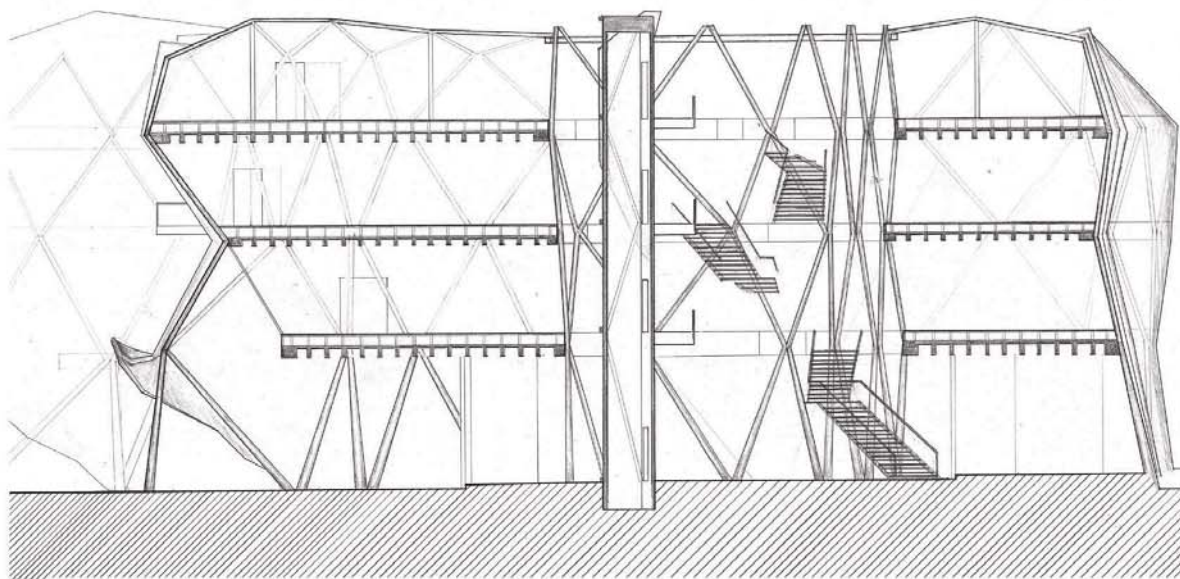
The final sections for the site were composed to illustrate not only each building's individual character, but also their relationships to one another. These particular sections are taken through the buildings inspired by Boreas and Zephyrus. The sections display the waffle slabs being suspended between the exterior and interior columns, and also introduce the idea of an above floor heating and cooling system, which is drawn in more detail on an enlarged wall section to follow. In the sections, the exterior skin is illustrated as a transparent entity that reveals the structural columns beyond. They also expose the circulation cores of the structures and how the stairs move back and forth beside the elevators.





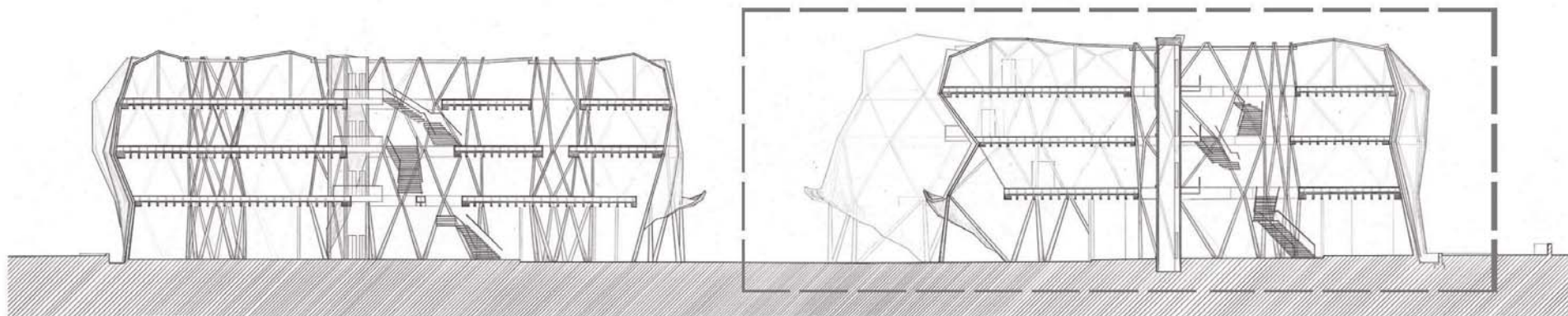
Enlarged East-West Section of Boreas

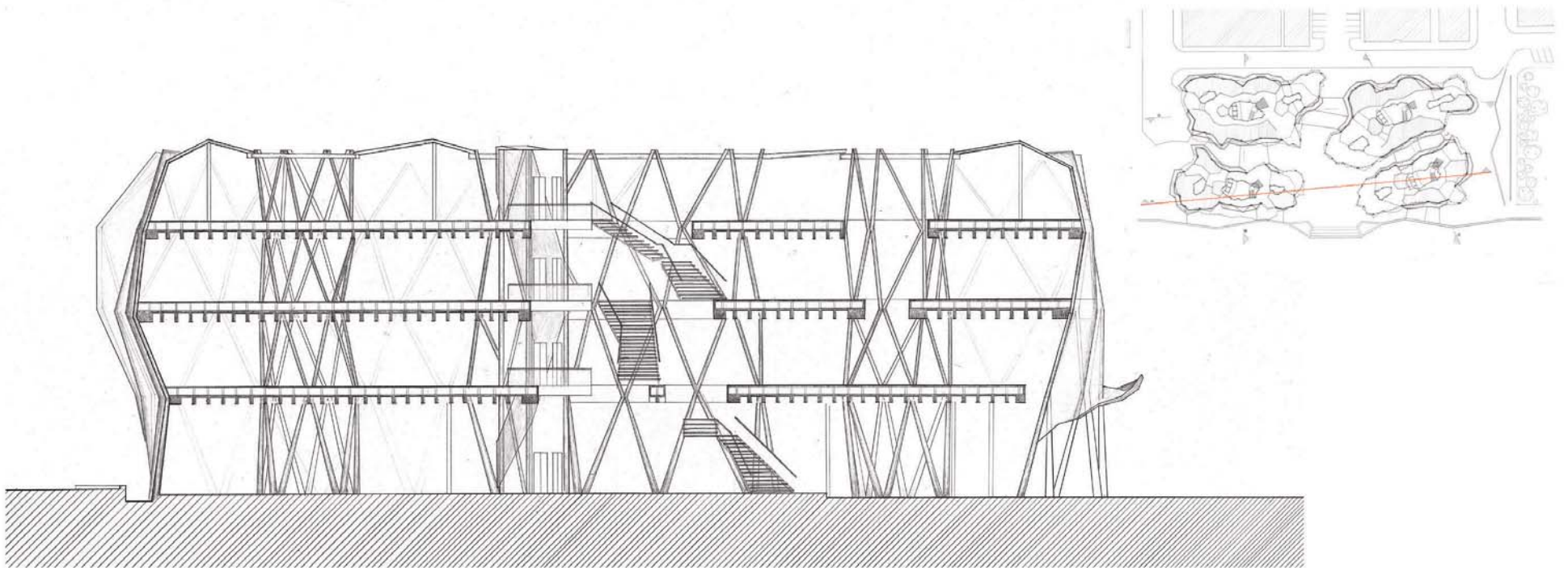




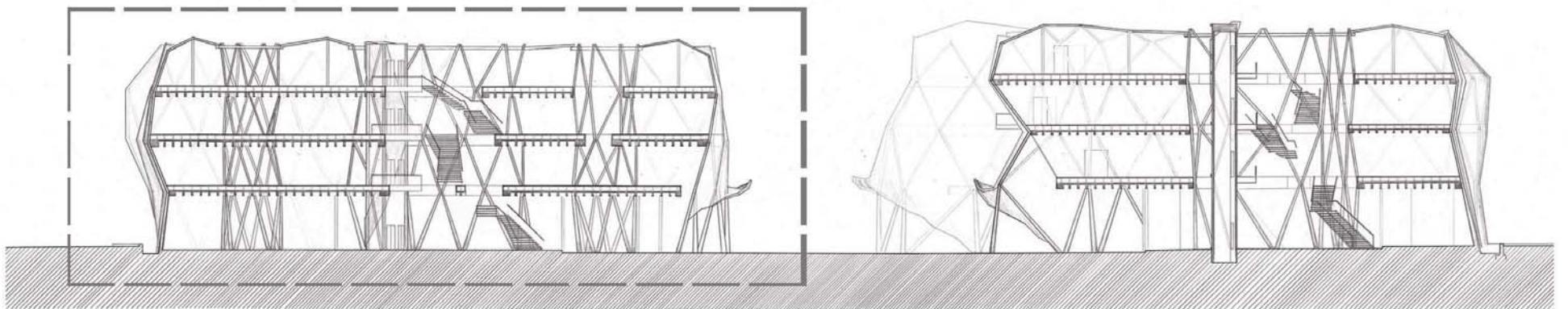
SECTION A

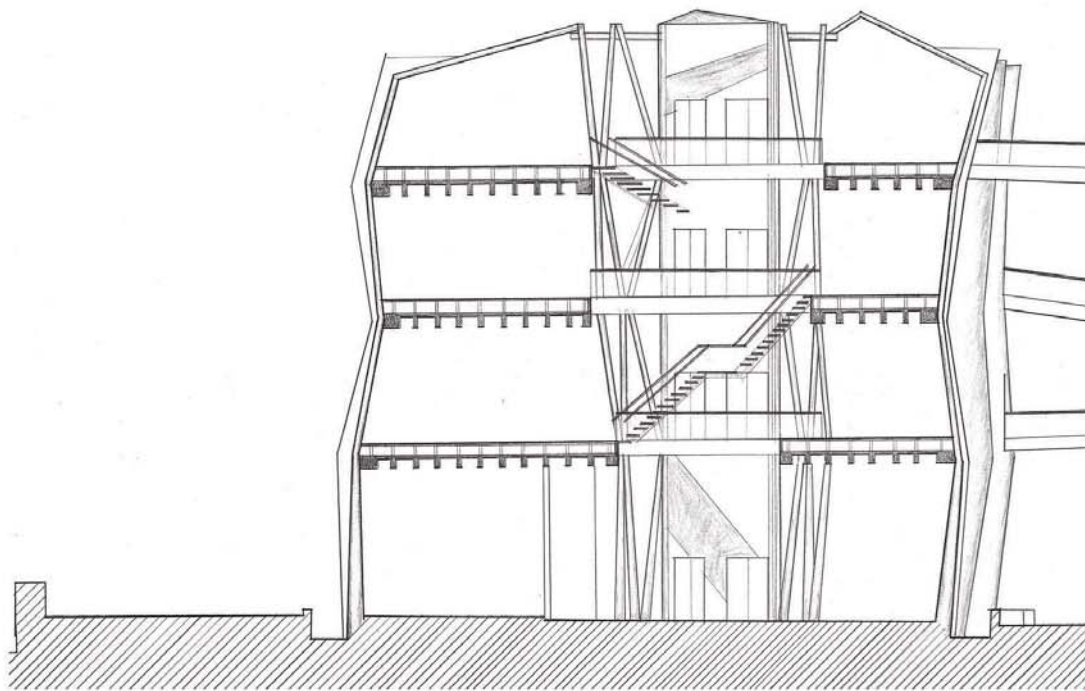
These sections illustrate the conditions found between the structures inspired by Notus and Eurus. They suggest the feeling of the exterior skin being lifted up at the primary entrances to the structures. The exterior columns continue past the skin to the ground plane, where the second story floor slab is pulled back away from the entrances to create the before mentioned double-storied entryway. The elevators are glass-enclosed shafts, which feature separate stainless steel perforated skins, which cross back and forth across structural beams. The sections also draw attention to the perimeter detail of the skin falling past the ground plane into the surrounding moats.





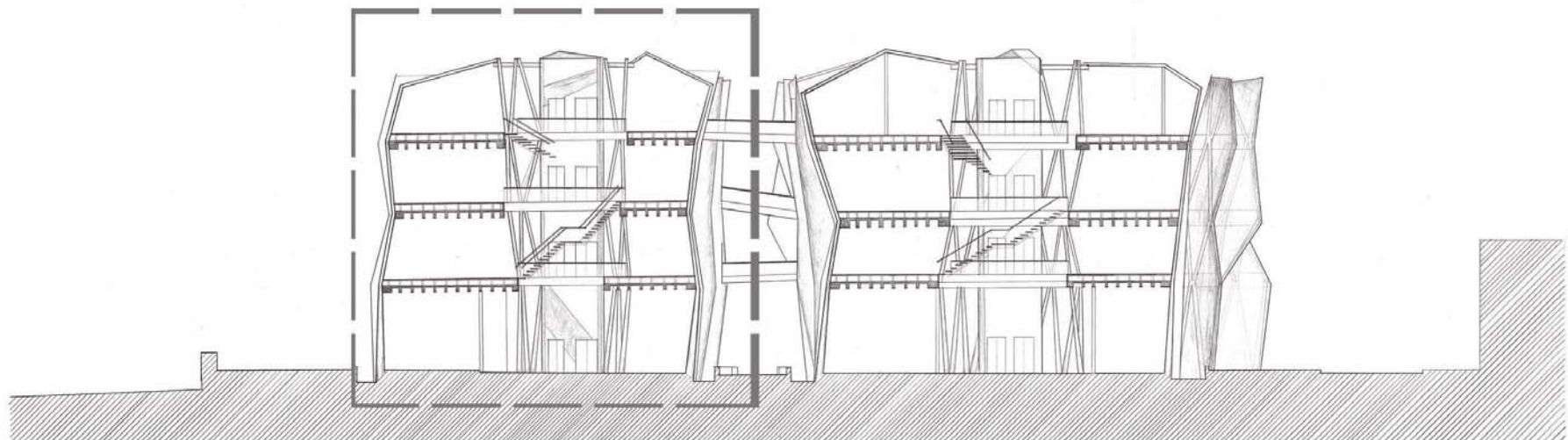
Enlarged East-West Section of Notus

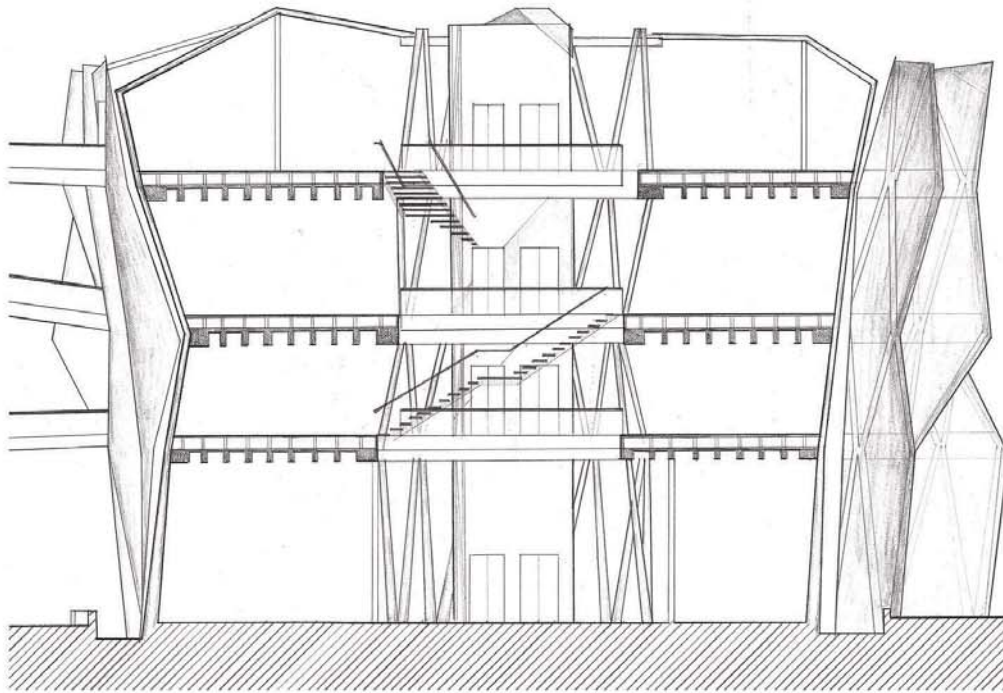




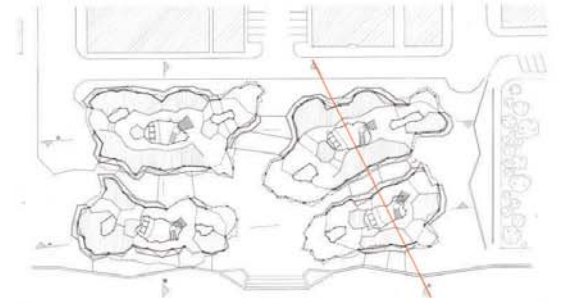
SECTION C

In the sections drawn between Eurus and Boreas, attention is drawn to the perimeter silhouettes of the adjacent structures and the bridges that span between the two. The bridges emerge from the buildings where cavities are carved out of the exterior skin by extruded glass cages. These cages catch the surrounding skin and allow the bridges to pass between the floor slabs. The floors of the bridges are concrete waffles slabs, like the floors of the main structures. The bridges feature perforated stainless steel railings, like the exterior skin. They span from structure to structure at different angles due to the varying floor heights of the adjacent structures and the varying distances between the structures.

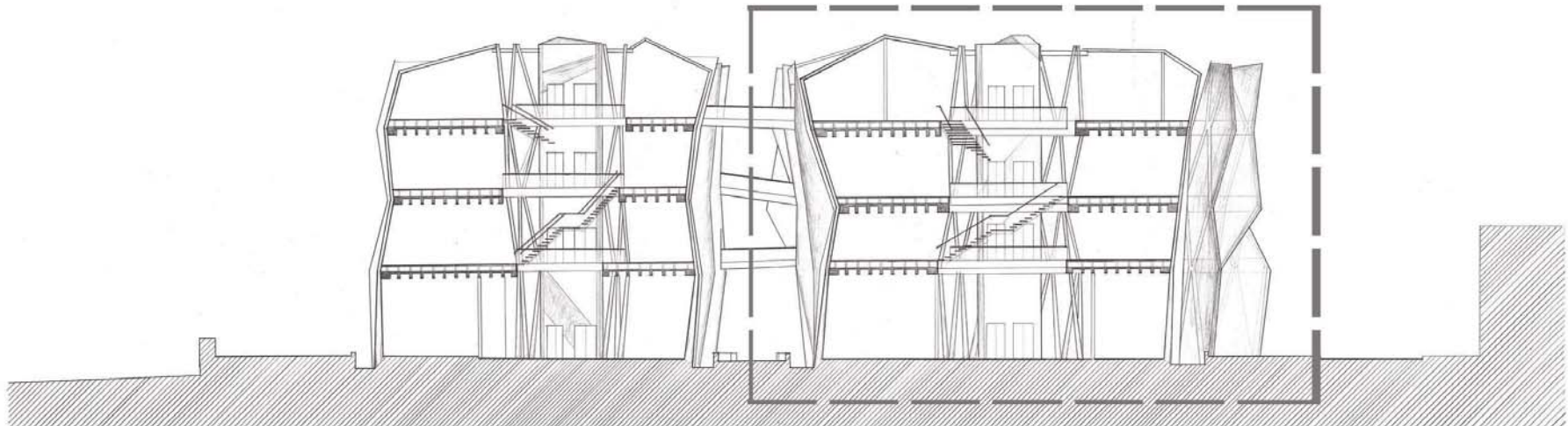


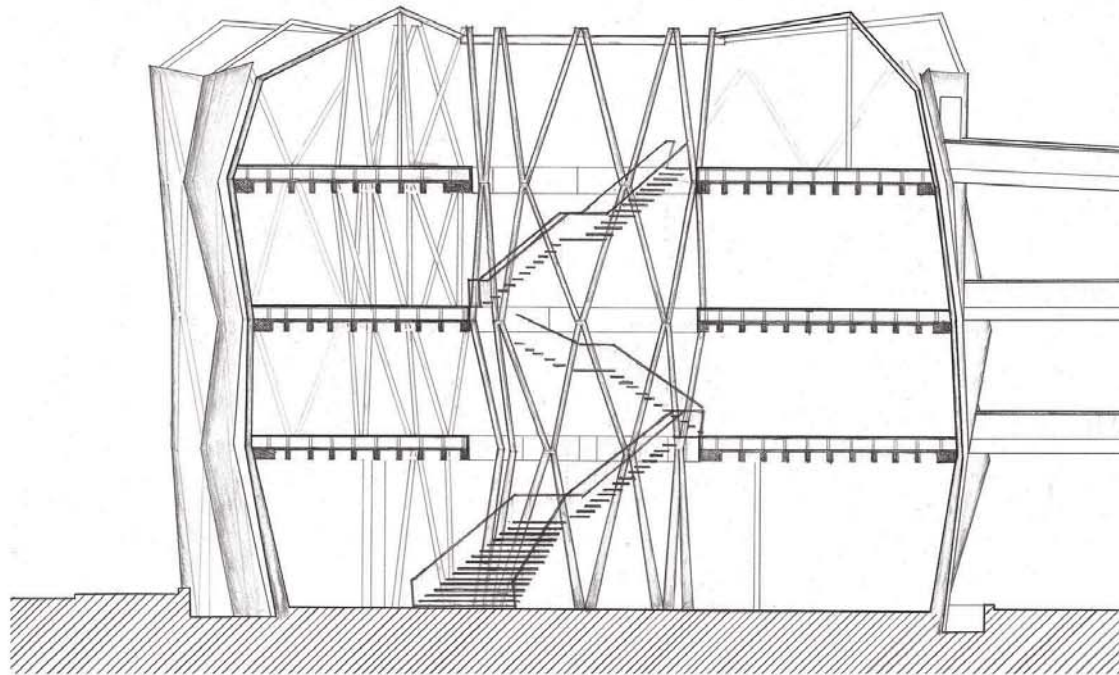


Enlarged North-South Section of Boreas

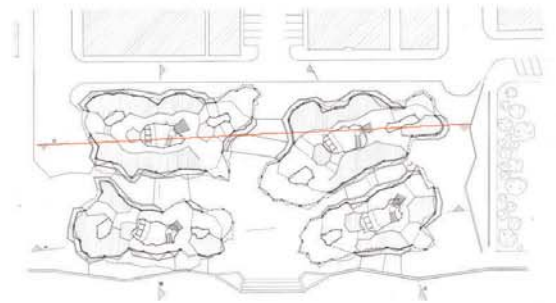


The sections drawn between the buildings inspired by Eurys and Boreas also help to illustrate the relationship between the stairs and the elevators. The stairs for each structure move between the floors at different locations and angles. They are designed to be sculptural and functional additions to the cores. The stairs move back and forth in front of the elevators, which are accessible by additional bridges that span over the circulation cores. From these bridges, workers can see down to the ground floor or up to the sky. In the sections, the stainless steel skin can be seen wrapping the elevator shafts, opening for the elevator doors and moving up and over the shafts.

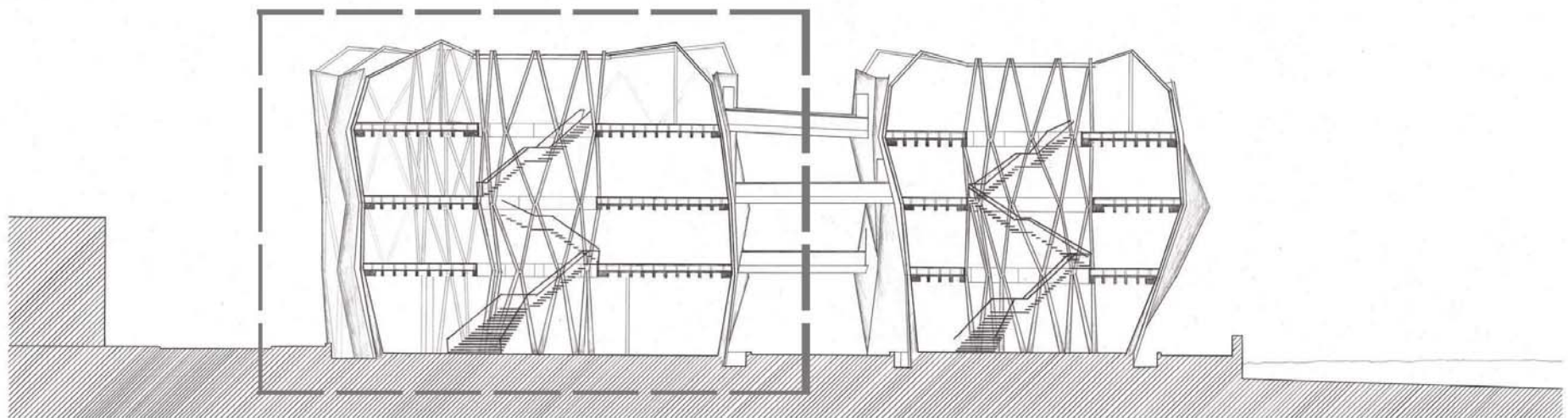


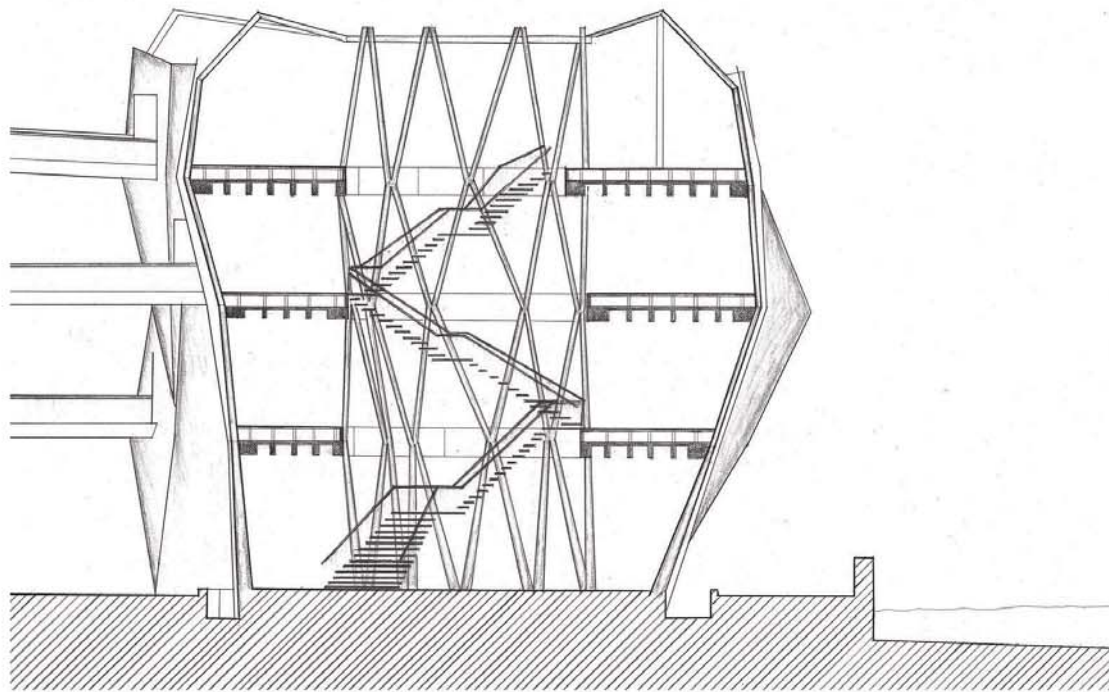


Enlarged North-South Section of Zephyrus

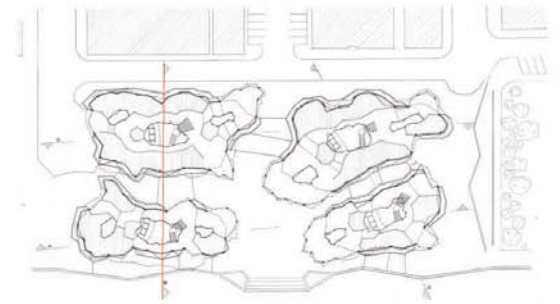


The sections cut between the buildings inspired by Zephyrus and Notus help to further illustrate the different angles and inclines of the sculptural stairs. These shorter sections draw attention to the perimeter columns that surround the structure and suggest how the skin comes up along the sides of the structure and then ends at an edge near the roof, allowing for the skin to visually continue up past the fourth floor. The relationship of the columns to the floor slabs and skin is more noticeable, highlighting the light feeling of the roof and the visually shifting concept of the exterior.

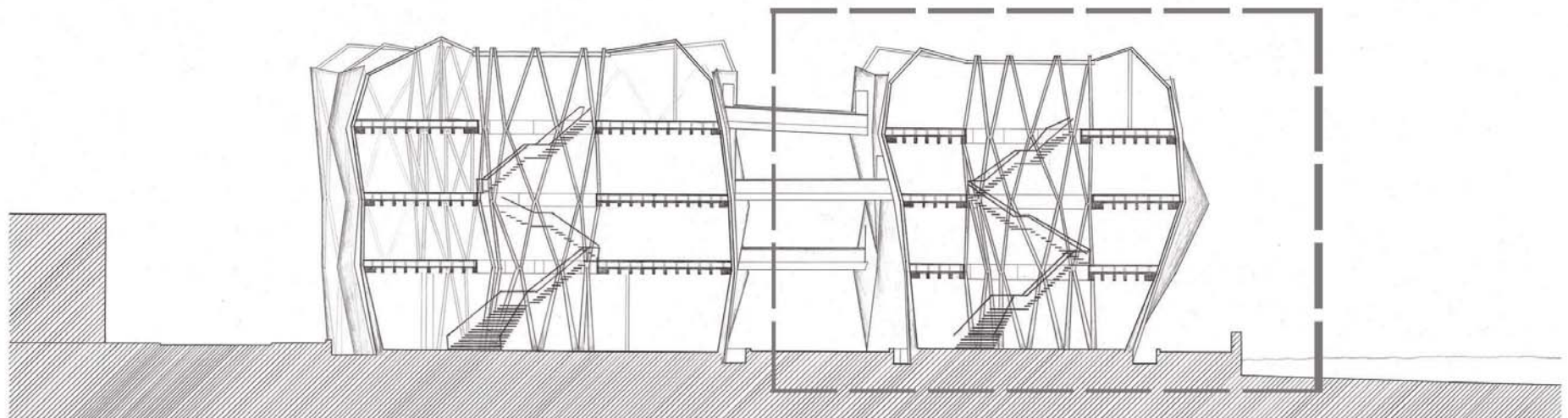




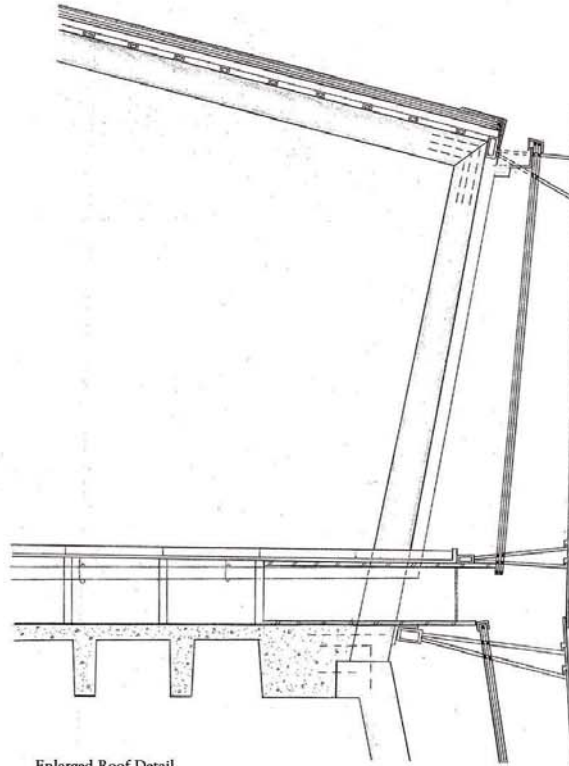
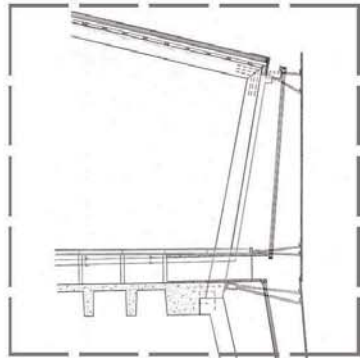
Enlarged North-South Section of Notus



All of the sections drawn through the complex were created to explain the relationship of the interior spaces to the exterior spaces and how the buildings sat on the site. The structures were situated between the existing buildings of Alexandria and the waterfront edge, which you can see along the perimeters of the buildings. Each of the structures was designed to visually move as though it was physically reacting to the forces of the wind. The graphic representations of the Greek wind gods were used to inspire and direct the sections and the plans of the buildings.



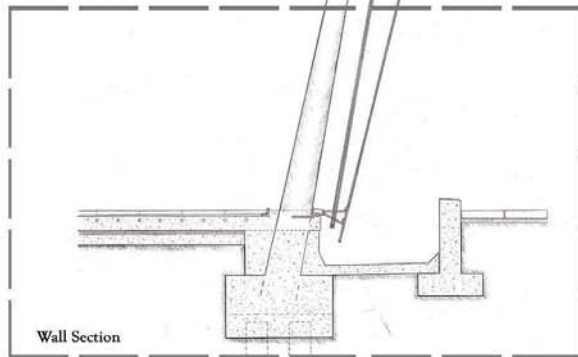
SECTION B



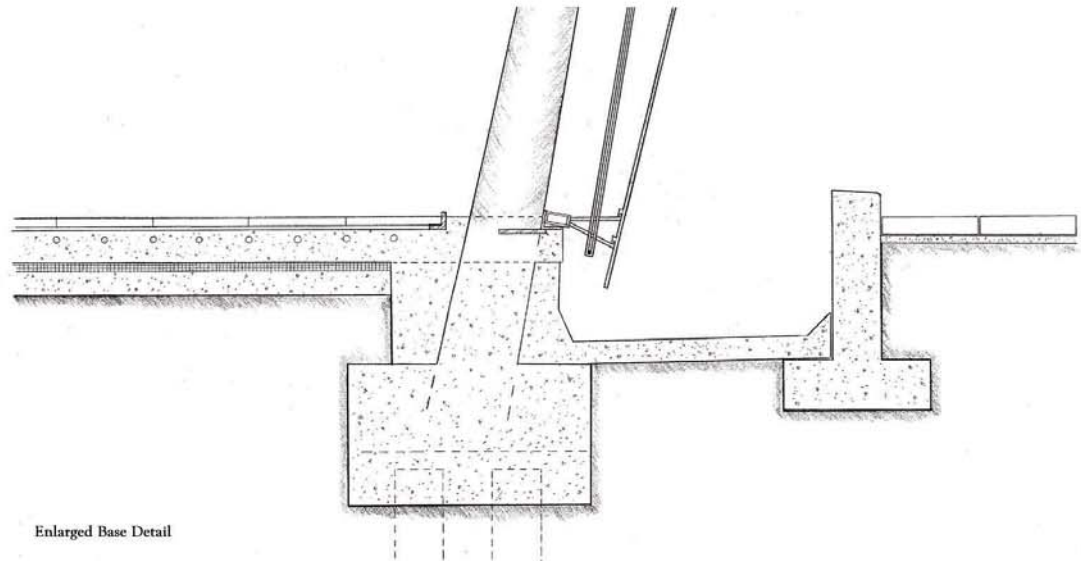
Enlarged Roof Detail

The detail wall sections of the building illustrate how the skin evolved to float away from the columns at varying levels to create spaces between the glass and the perforated stainless steel screen. The ductal concrete columns support the concrete waffle slabs, which wrap around the columns to extend out and attach to the skin components. An above floor heating and cooling system is utilized to free up the underside of the slabs, allowing for the waffle slabs to be visible throughout the office space. Cool air is allowed into the building between the column joints, where the glass is held apart and just the perforated stainless steel screen covers the floors. This detail will allow for the wind to physically penetrate the interior spaces of the structures.

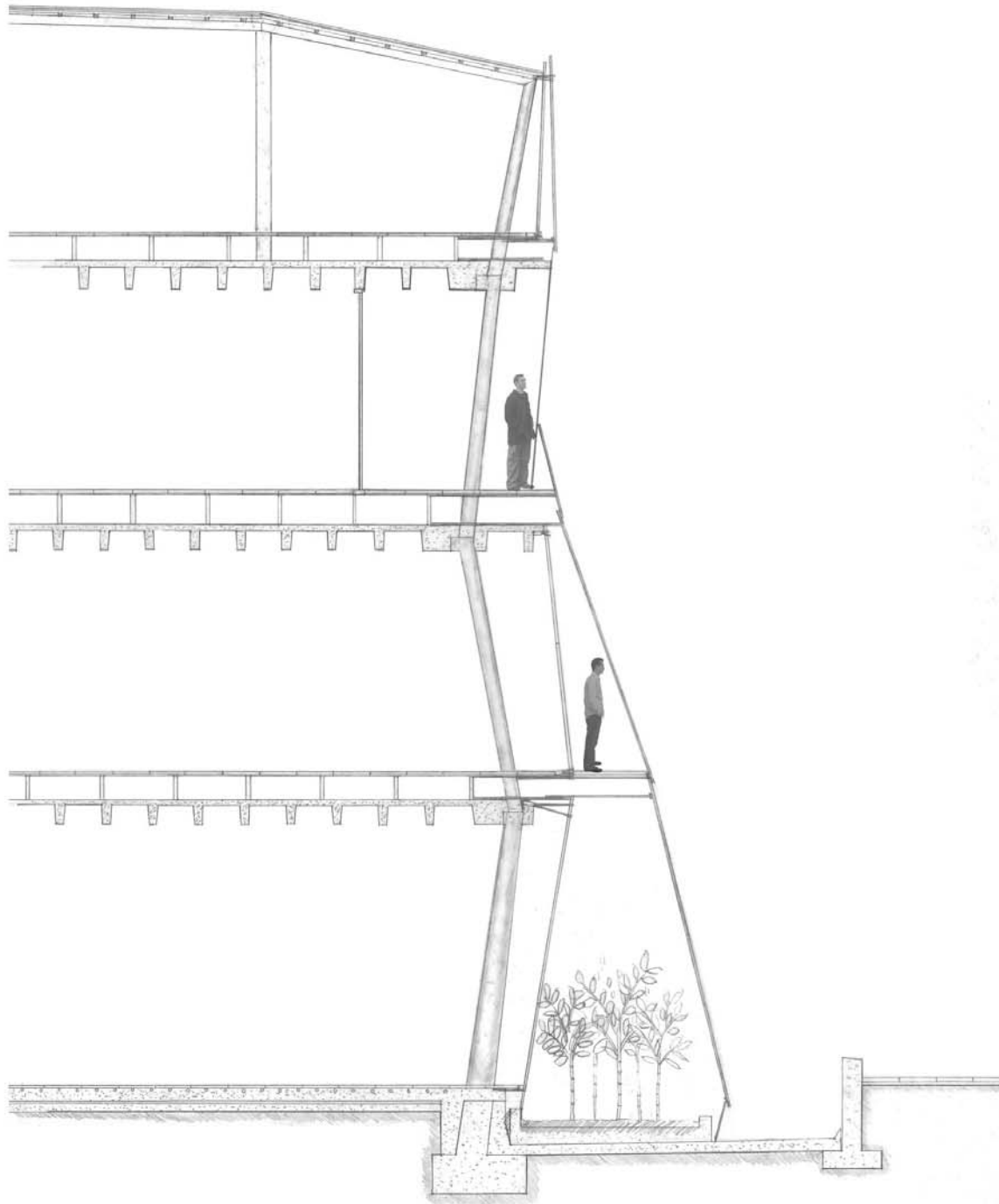
Steel plates are fastened to the concrete columns, and the glass is anchored to these steel plates. A glass system is utilized that allows for the anchors that support the glass to extend at different lengths to account for the varying angles and lengths of the columns. The steel screen is supported on anchors attached to the steel plates that also hold up the glass. At the base of the system, a shallow concrete gutter system rests between the footing of the building and the footing of the retaining walls wrapping around the perimeter of the structures. These gutters act to catch water falling off of the skin and as planters for bamboo around the site.



Wall Section



Enlarged Base Detail



The final wall section developed was able to embody the ideas that the project discovered. The critical features realized through previous explorations remain, such as the raised floor system supported upon waffle slabs, suspended between ductile concrete columns, yet small changes are also evident. Along the perimeter of the structure, the skin can be seen being pulled further away from the columns to create spaces between the glass and the stainless steel mesh where occupants can stand between the layers of the envelope. Along the ground level in particular, a large space is created between the glass and the mesh screen where pedestrians can walk in and around the bamboo plantings while remaining within the confines of the complex. At these locations, the bamboo gardens can become more of an interactive feature versus strictly an ornamental element on the grounds.

# Conclusion

A multiuse facility on the waterfront of Alexandria is a proposal that will probably be built within the next ten years. One of the sites of these eminent developments will most likely be between Prince and Duke streets, just like the site of this proposal. The project that is built on this site at this time in history will most likely be an environmentally friendly development in order to be sensitive to the demands of local authorities. This proposal studied how a project that might be viewed as a standard program could respond to the environmental forces with which it was forced to contend. Natural forces, such as wind, rain and sun have the capacity to inspire the spatial configurations of urban developments. This proposal produced a multi-use development structure that physically responded to the natural forces that acted upon it. Environmentally sensitive buildings are being built around the country, it is the responsibility of the architect to use the natural forces guiding the programmatic requirements of the building to guide and inspire the final design of each and every environmentally friendly project proposed.

# Bibliography / References

Unless otherwise noted, photos and work are by the author.

- Page 3     *Iranian Passive Ventilation Housing , The Aeolian Harp and Chinese Symbol for Universalism* Michele G. Melaragno Wind in Architectural and Environmental Design pages, 210, 19 & 21
- Page 4     *Structural Grid By Luigi Nervi* Ada Lousie Huxtable Masters of World Architecture: Pier Luigi Nervi pg. 57
- Tjibaou Cultural Center* <http://194.185.232.3/>
- Sendai Mediatheque* <http://www.galinsky.com/buildings/sendaimediatheque/>
- Swiss Re Headquarters* <http://www.fosterandpartners.com>
- Page 16     *Greek Wind Gods* [http://www.pantheon.org/articles/g/gods\\_of\\_the\\_winds.html](http://www.pantheon.org/articles/g/gods_of_the_winds.html)

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# Vita

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