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A greener vertical habitat: Creating a naturally cohesive sense of community in a vertical multi-family housing structure

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A Greener Vertical Habitat:

Creating a Naturally Cohesive Sense of Community in a Vertical Multi-Family Housing Structure

by

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of the requirements for the degree of
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I would like to dedicate this to my parents, Gary and Sandy Onorati for their support and love in all of my studies. Without their encouragement and allowing me to follow my dreams, this all would not have been possible. Thank you for everything!

Dedication

Acknowledgements

I would like to thank my family and friends for all their love and support. Without them none of this would have been possible. I would also like to thank my chair Dan Powers for all his expectations and encouragement throughout my years here in graduate school. Also to my committee members Trent Green and Chaddy Hanwisai, for sitting on my reviews and giving constructive criticism that would only improve my project. I would also like to thank my closest friends for their help and support throughout thesis, Shane Ross, Kartrina Korte, John Stinson, and Javier Valencia. Thank you to all!

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ABSTRACT

Throughout multiple dense, tropical, urban contexts, high rise residential environments have created a sense of social detachment, where public and private green spaces do not often exist. It is through these varieties of green spaces that social interaction is encouraged, and without these social activities taking place, this vertical community becomes almost a meaningless entity within the urban realm.

The issue being addressed within this thesis is the scarcity of public and private green spaces within our high density tropical urban fabrics that help to create a sense of community. The majority of dense urban settings that we inhabit today do not include the resources of easily accessible public and private green spaces for the majority of their dwellers. According to the Trust for Public Land organization, the average dense urban setting contains less than ten percent green space for every seventy thousand acres of land use.

The goal of this project is to architecturally create an innovative residential high rise design by incorporating public and private green spaces throughout its structure, circulation, and tropical design elements. The design will begin to encourage interaction and promote a more cohesive living environment amongst its users. The design project will incorporate and deal with topical/ecological issues as well as sociological matters throughout the design process.

Through this approach, by answering some of the imperative questions such as, how will community life be encouraged, how can we incorporate natural vegetation within a vertical context and how can we implement sustainable

systems, the possibility of multiple, properly proportioned public and private green spaces will begin to push forward the ideas that are being addressed throughout this thesis. The constructive effects of such an articulated architectural contribution to a dense tropical urban setting will include improvements to physical and psychological health, social communal advancement, ecosystem development, as well as biodiversity systems. The important outcome of this architectural advancement in residential high rise design will be to improve the vertical community through the variety of incorporated communal and private green spaces as it begins to set precedence for future existing context in communal growth.

Introduction

This is an introduction that explains and defines the six major topics that will be discussed throughout this thesis. These topics directly correlate to each other from both a theoretical and design aspects of this thesis project. the six main topics that will be discussed throughout this thesis include, tropical climates, tropical architectural forms and their effect from the climate, sustainable and bioclimatic architectural systems, density within a tropical urban environment, green spaces that in clude; pocket parks, courtyards, gardents, and yards, and also community.

Tropical Climate

Tropical climate can be defined as a widely recognized scheme of climate classification that defines it as a non-arid climate in which all twelve months have mean temperatures above 77° Fahrenheit. Tropical climates are classified as type A climates covering the largest area of earth. The average rainfall is 130 inches per year and may exceed 150 inches per year in varying altitudes.

The equatorial belt within the tropical climate zone experiences hot and humid weather. There is abundant rainfall due to the active vertical uplift or convection of air that takes place there, and during certain periods, thunderstorms can occur every day. Greatest rainfall occurs when the Sun is overhead. This occurs twice a year in March and September, and results in two seasons, wet and dry. In the Northern Hemisphere, the wet season occurs from May to July, in the Southern Hemisphere from November to February. Nevertheless, this belt still receives considerable sunshine, and with the excessive rainfall, provides ideal growing conditions for luxuriant vegetation.

It is because of a substantial part of the sun's heat is used up in evaporation and rain formation, that temperatures in the tropics rarely exceed 95°F; a maximum of 89°F is more common. At night the abundant cloud cover restricts heat loss. This high level of temperature is maintained with little variation throughout the year. The seasons are distinguished not as warm and cold periods but by variation of rainfall and cloudiness. Open air green spaces can be used all year round within tropical climates.

Tropical Architectural Forms:
Effect of Climate on Architectural Form

Tropical climates can produces certain effects on architectural forms. For example, "the proportion of window area to wall area becomes less as one moves towards the equator. In warm areas, people shun the glare and heat of the sun, as demonstrated by the decreasing size of the windows."[1] In these tropical zones, architectural forms can be even more distinct due to the extreme heat. In these zones, projecting balconies and elongated overhangs are used to help cast shadows that are used for shading other areas of the structure. Trellises are also used to shade openings, all while allowing breezes to pass through to the interior space. These architectural systems are distinct characteristics of architecture design forms located within tropical environments, as they allow for thermal comfort as well as being aesthetically appealing.

Devices such as trellises have been added to the list of architectural features in the tropic zones. Due to the long rain season that these areas receive, the roofs are overly steep to provide protection from the torrential downpours of the region. Also, the natives of humid tropical regions built their huts with reeds and grass. This allowed for air to pass through the walls and allowed for cross ventilation through the materials. This design is what allowed for the steep pitched roofs to work so well. It wasn't until the locals began to experiment with other materials, such as cement and metal roofing sheets, which houses became sealed up and became unbearably uncomfortable to live in. The traditional roofs and shading devices combined with their original materials of recent tropical architecture, is what architects today should be imitating, but with a contemporary approach.

The problem today is the designer forgets the environment that they are building within and fails to realize that form has meaning only within the context of its environment. Many site specific systems from the past need to be implemented into tropical structures through form and function. This thesis will address specific climatic issues to develop a tropical residential structure based on function and form.

Bioclimatic /Sustainable Architecture: Tropical Systems

Sustainable architecture or bioclimatic architecture can be defined as a way of designing buildings and to manipulating the environment within buildings by working with the surrounding natural forces rather than against them. This is a general description of environmentally conscious design techniques in the field of architecture. "In the broad context, sustainable architecture seeks to minimize the negative environmental impact of buildings by enhancing efficiency and moderation in the use of materials, energy, and development of space. Most simply, the idea of sustainability, or bioclimatic design, is to ensure that our actions and decisions today do not inhibit the opportunities of future generations." [2]

"A bioclimatic building is an outcome of a design which focuses on increasing the efficiency of resource use energy, water, and materials, while reducing building impacts on human health and the environment during the building's lifecycle, through better design, construction, operation, maintenance, and waste removal." [3]

A bioclimatic building uses an array of different systems and techniques to help reduce the harm the building may eventually have on the environment. The ability to use natural resources such as sun, rain, and wind to help with the functioning and life of the building can make all the difference. There are many design strategies that can me implemented, such as using natural vegetation through green roofs, private gardens, and for reduction of rainwater run-off. Other techniques, such as using gravel instead of concrete or asphalt paving can be used to absorb and recycle rain water. "Effective green buildings are more than just a random collection of environmental friendly technologies.

They require careful, systemic attention to the full life cycle impacts of the resources embodied in the building and to the resource consumption and pollution emissions over the buildings complete life cycle." [4]

The impact that a bioclimatic building can have on the environment is tremendous. Buildings that are designed today all need to implement some type of sustainable technique to help with the impact they make within their communities. As cities become more and more crowded every year, the opportunity is there to design a bioclimatic vertical structure.

Density/Urban Environment: Urban/Tropical

Urban density can be defined as the number of people inhabiting a given urbanized area. Understanding how a city functions begins with the understanding of the concept of urban density and the amount of people that inhabit a given area. "Research that is related to urban density includes economics, health, innovation, psychology, geography, and sustainability." [5]

Density is relevant to "environmental quality, transportation systems, physical infrastructure and urban form, social factors, and economic factors." [6] Urban density can be measured by dividing a given population by a given area. Vertical design approach begins to take place when a suburban area runs out of land to accommodate its growing population.

As demand increases and land costs increase vertical construction is the normal result. The scarcity of green space within a dense urban area is the primary concern that this thesis will be addressing. It is through the location of the dense urban setting that climatic issues will also begin to factor in. Cities located in the northern hemisphere take on different climatic elements and design challenges than those in tropical areas. The environmental quality, physical infrastructure, urban form, and social factors are all main issues pertaining to density. This thesis will discuss how these elements will correspond with the green spaces that are much needed in these urban settings. The sustainability and tropical climates are what differentiate the focus on tropical urbanism from that of non-tropical urban settings.

Green Space: Pocket Parks, Courtyards, Gardens, Yards

Green space involves the investigation and designed response to the landscape. These green spaces include any vegetated land or water within an urban area. All can occur at varying scales.

Green space in the form of parks, yards, courtyards, and gardens should be an integral part of everyday urban city life. These numerous types of exterior spaces can offer multiple opportunities for activities, such as recreation, reflection, and relaxation. Larger scale public parks can improve community health and positively effect the interaction among users. They also help to provide habitat for numerous species of plants and animals. The vegetation even helps to cool down city air through transpiration and evaporation.

In a public realm, communal parks and gardens are places for interaction and can help to form a stronger sense of community. "Parks are valued more by people who do not have gardens or personal landscaped spaces. These public spaces are places to appreciate nature and reduce the "enclosed" feeling perceived to be present in cities." [7] The accessibility of parks, courtyards, gardens, and yards is what is needed to help allow for a community create its own identity.

Private green spaces are needed as well to help with the functioning of a multi-family residential building. A private vegetated space can include that of a garden or private courtyard. These more secluded spaces can be vital to their users by providing a place to allow for ones personal self expression to occur. The abundance and diverse array of plant life is how dwellers can distinguished their private green space and themselves from the other dwellers. Easy access and having control over a space allows for a unique relationship with the user and their private space.

It can be said that public and private green spaces should be accessible for everyday use. It is through these various types of parks, yards, courtyards, and gardens that communal growth will begin to occur as a result from the various opportunities that lie within.

Community: Sociology

The word "community" is derived from the Old French communité which is derived from the Latin communitas, a broad term for fellowship or organized society. Community can be defined in biological terms as "a group of interacting organisms sharing an environment." In human communities, intent, belief, resources, preferences, needs, risks, and a number of other conditions may be present and common, affecting the identity of the participants and their degree of cohesiveness. In sociology, a "community" has been defined as "a group of interacting people living in a common location." The word is often used to refer to a group that is organized around common values and social cohesion within a shared geographical location, generally in social units larger than a household. The word can also refer to the national community or global community.[8]

German sociologist Ferdinand Tönnies distinguished between two types of human association: Gemeinschaft (usually translated as "community") and Gesellschaft ("society" or "association"). In his 1887 work, "Gemeinschaft" and "Gesellschaft", Tönnies argued that Gemeinschaft is perceived to be a tighter and more cohesive social entity, due to the presence of a "unity of will." He added that family and kinship were the perfect expressions of Gemeinschaft, but that other shared characteristics, such as place or belief, could also result in Gemeinschaft. Gesellschaft, on the other hand, is a group in which the individuals who make up that group are motivated to take part in the group purely by self-interest. He also proposed that in the real world, no group was either pure Gemeinschaft or pure Gesellschaft, but, rather, a mixture of the two.[9]

Therefore, the goal of this thesis is to further advance these six main topics into an articulated architectural design. Spatial configurations and the addition of public and private green spaces will help to aid in the function of this vertical community that is being proposed. Morgan Scott Peck, an American psychiatrist and best-selling author, expresses community in the following way: "There can be no vulnerability without risk; there can be no community without vulnerability; there can be no peace, and ultimately no life, without community." [10]

Problem Statement

In the late nineteenth century a wave of innovations in the building industry led to the development of the first high rises in Chicago and New York City.[11] According to Ken Yeang, the elevator, the steel frame, and later the curtain wall, along with the demand for new office space on expensive and limited land, made the development of high rises possible and necessary. High rises can be categorized according to their function, structural system type, and environmental control strategies. From a functional standpoint, there are four building types: residential, commercial, hospitality, and mixed-use. Most high rises perform poorly in terms of lifecycle cost, environmental impact and social benefit. In a 50-year lifecycle of a high rise, energy costs contribute 34% of the total cost.[12] Close to 50% of energy use in high rises comes from artificial illumination.[13] Kaplan indicates that a typical high rise building is made of poor quality materials and is aesthetically mundane.[14] Successful high rise designs need to use a minimum of nonrenewable energy, produce limited pollution, and minimize their carbon footprint, without diminishing the comfort, health, and safety of the people who inhabit them. This thesis will begin to discuss and solve the issues that contend with the advancement in residential high rise designs within a tropical environment.[15]

The idea of community located within a vertical context, can be simply looked at as the interaction that occurs between the building's users. Community can then be translated through the concern and need of public and private green spaces within a high density urban fabric and how these spaces can begin to create a sense of community within a vertical system. Through multiple green spaces is where community can begin to take place and develop.

Without these spaces, there is a diminishing chance for interaction amongst the residences, and thus creating a disconnection from society.

The dilemma with today's multi-family high rise designs starts with the lack of response to the local climate. The typical residential, high rise building type that is located within a tropical environment is often seen as a sealed box. For the purpose of this thesis, the use of tropical sustainable architecture design such as passive cooling, solar reduction, grey water systems, and passive systems, seems to be nonexistent when it comes to residential high rises in tropical locales. "Typically they consist of concrete structures with masonry infill or precast concrete panels for the walls without insulation. Many of these buildings are clumped together and, for the most part, seem to have very little variety in form or heights." [16]

It is through "tropical architecture", a response to climate through passive sustainable strategies, that the design will begin to incorporate sustainable systems throughout the high rise structure. When observing the natural environment of a tropical region, the climatic characteristics consist of high temperatures, rainy seasons, dry seasons, winds and tropical vegetation. These site specific issues should be looked at before the design process begins. If these environmental issues are not addressed, the residential high rise becomes less dynamic and less responsive to the site, and resulting in that of a sealed box. Tropical site specific issues will be addressed at the earliest stages of design to incorporate sustainable systems and public and private communal green spaces. By creating a vertical residential structure that incorporates these features, this design will begin to encourage interaction amongst its users and thus create a more pleasant and friendlier urban environment. A spatially greener residential high rise design will begin to help promote a more sociable setting for dwelling, as well as creating a more cohesive residential community within the larger urban context.

Project Goals and Description

By 2010 the world's urban population for the first time will surpass its rural population. Across the globe, low-density urban sprawl will continue to be the primary solution to population growth. There is mounting consensus among the scientific community that urban sprawl has significant negative social, economic and environmental implications. Four billion additional people will need housing and work places in just a few decades. An immediate way to address population growth is for cities to support high-density residential buildings. Over the past century, high-rises have successfully and increasingly responded to this need. It has been calculated that housing for 4 billion people will require constructing close to four million forty-story buildings (each with 1,050 occupants in 350 units).[17]

The major goal within this thesis is to create an interacting community by incorporating public and private green spaces, breaking the "sealed box". The meaning of this "break is to allow for the development of green space and bioclimatic systems to occur. The constructive effects of such an articulated architectural contribution to a dense tropical urban fabric will include such improvements of physical and psychological health, social communal advancement, ecosystem provision, as well as biodiversity systems.

The positive implications of incorporating the correct proportions of green spaces to a dense residential community will have multiple results. By providing a variety of green spaces for dwellers to utilize throughout their everyday living, "it will improve elements in individual place-making as well as enhance the legibility of place." [18] As this variety of uses become more apparent, anywhere from biotic support to the public amenity, they will adapt into being apart of the private and public realm within the vertical community. Interaction and networking will be unintentionally provoked and possibly help to create a more sociable residential culture. These are the goals that will be reached through the design phase of the thesis and brought forth through observation of successful and unsuccessful communal green spaces.

The ability to create mixed use spaces and allowing those spaces to be flexible will aid in creating a successful project. Ideas and concepts used from the book titled "Front to Back, a Design Agenda for Urban Housing" by Sally Lewis, begins to discuss how users of private and public spaces would like to be able to interact and develop the space into their own and not be forced into conformity. Through research, it has been shown that users forced to adapt to a specific space will eventually transform that space into their own if possible or eventually just neglect the spaces all together. To design with flexibility in mind, "residential communities should be designed for future adaptability, offering occupiers the opportunity to modify and personalize their homes as the family structure changes, or when the user wants to accommodate workspaces or other activities." [19]

"Our perception of the shape, size, scale, proportion, and visual weight of a plane is influenced by its surface properties as well as its visual context." [20] One of the major design intents this thesis will focus on, is to propose a flexible modular living system that will proportionally relate to that of the green spaces that begin to shape the residential vertical community. Proportions, the relation between elements as a whole, came to be utilized throughout architecture and its design centuries ago. "While scale alludes to the size of something compared to a reference standard or to the size of something else, proportion refers to the proper or harmonious relation of one part to another or to the whole. While designers usually have a range of choices when determining the proportions of things, some are already given to us by the nature of materials, by how building elements respond to forces, and by how things are made." [21]

It is through this thesis that the ability to create such an architecturally tropical urban building type, such as a residential high rise community is being achieved. This residential building structure will include the right programmatic environment, as well as a variety of communal and private green spaces throughout its structure. If done properly, the design will begin to resolve the issues of scarcity of green space throughout the dense urban city. Such a building will have a tremendous impact within the community. It will begin to push forward the ideas of vertical green communities as well as help develop sustainability within a dense urban context.

Project Location & Scope

Fig. 1. Map of Punta Paitilla, Panama

The main points of interest start with the selection of the site. Research began by looking at locations that would best be suitable for a modern tropical residential tower design. The main aspects looked for included: the city was to be located within a tropical climate, incorporate a dense urban city with room to expand, and have the need for communal improvement. For the design to be tropical in nature and attain sustainable features, as well as have public and private communal spaces that can be activated all year round, it was crucial for the site location to have these demands. It was after much research that the city of Punta Paitilla, located within Panama City, Panama, was found to have an appropriate site to house the proposed project.

The city of Punta Paitilla (Pa-Ti-Ja), Panama is located in the Pacific coast of Panama, east of the Panama Canal. Punta Paitilla is a peninsula of land that is connected with fifty five multi-family residential towers, which reach as high as sixty-five stories tall. These towers offer views back into Panama City as well as to the Panama Bay. In this location, there are roughly 750 people per acre of land and still room to grow. Hospitals, shops, groceries, and other commercial spaces are located adjacent. Punta Paitilla has a wet season that stretches from May to December, and a dry season from January to April. The annual temperatures range between 70° F to 95° Fahrenheit.

The site that was chosen is located at the northwest corner of the peninsula. The proposed design that will best fit this site is a thirty-five-to-forty-story residential high rise building with the addition of commercial space and landscaped space. The idea of the project is to reconnect to the recently finished coastal park that will be attached to the projects site. The site is 65,000 square feet and is large enough for the thesis project to take place. A major advantage of this site is that it sits just across from the city's business district and is just feet from the recent redeveloped ocean boardwalk that stretches around the bay on the south side of the city. Located within the residential district of Panama City, the site is ideal for the design of this project.

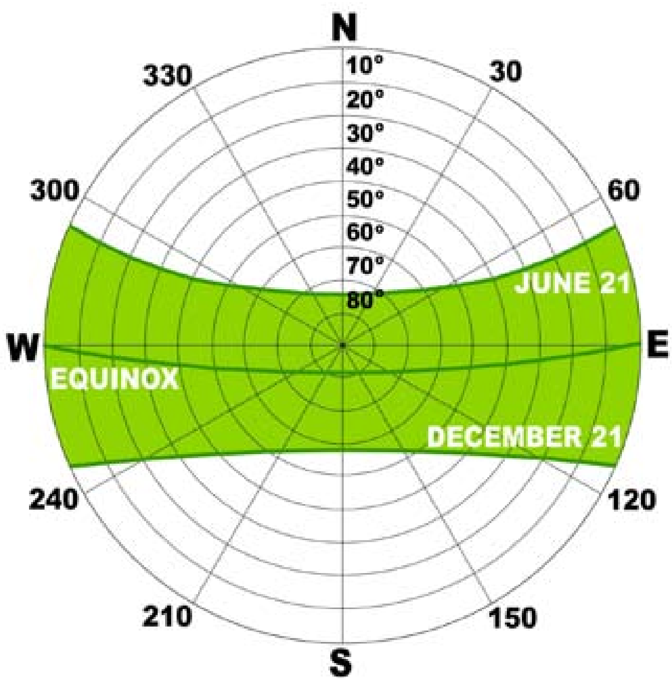


Fig. 2. Punta Paitill Sun Diagram

Project Concept

The main driver behind this thesis design began with the research of residential high rises and how these building types respond to their tropical environment. Understanding that the majority of high rise designs can be essentially viewed as sealed vertical boxes that do not use sustainable systems to help with the function or community of their design, the idea of "breaking the box" is the concept that will be carried throughout the design phase of this thesis.

The concept of "breaking the box" refers to separating or breaking apart the residential structure to allow for the development of green space, public and private, and bioclimatic systems to occur. Several conceptual models have been made to show the development and special configurations that can be possible to help construct this vertical community. A study model of grouping green spaces together along with the residential units was used in comparison to another model that used a linear configuration and the separation of communal green spaces to that of the residential units.

From these explorations, it was decided that the communal green spaces will be incorporated throughout the circulation of the vertical structure, and that the residential units will be spatially configured to work within these exterior elements.

The second conceptual driver will be a design that is in direct response to the site and its location within Punta Paitilla's tropical ecosystem. Responding to rain, wind, sun, natural vegetation, and existing context are the main site specific issues that will aid in the design process. After visiting Punta Paitilla and analyzing the scale of existing residential units, it was understood that there is a need for more square feet per living unit to accommodate the large amount of multi-families that live together in one location. As the selection is located on the Pacific coast and near a newly constructed boardwalk, the opportunity is there to reconnect Panama City to the north and to Punta Paitilla to the south by incorporating commercial spaces, landscaped areas, and community venues into the design.

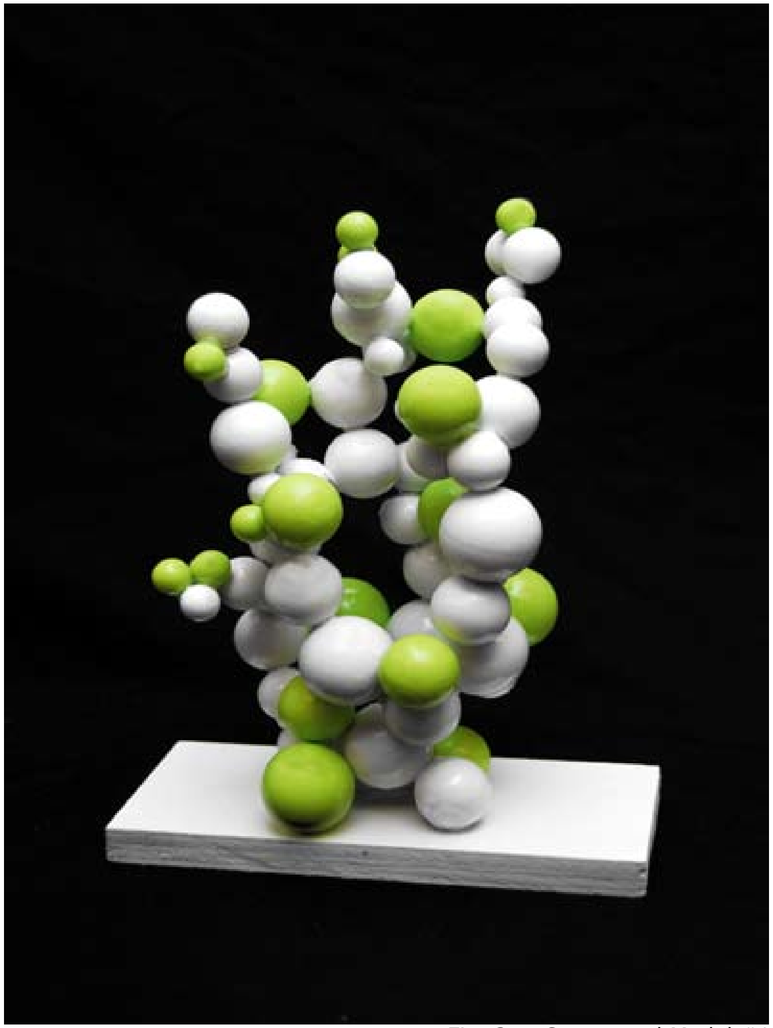


Fig. 3. Conceptual Model #1

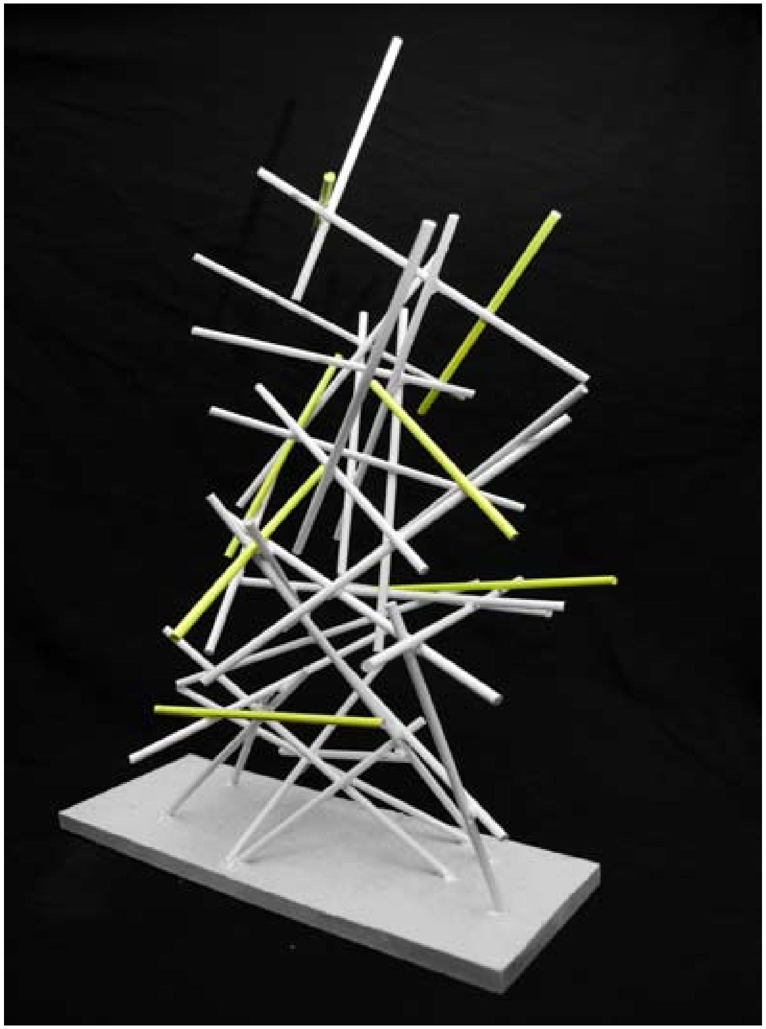


Fig. 4. Conceptual Model #4

Fig. 5. Conceptual Model #5

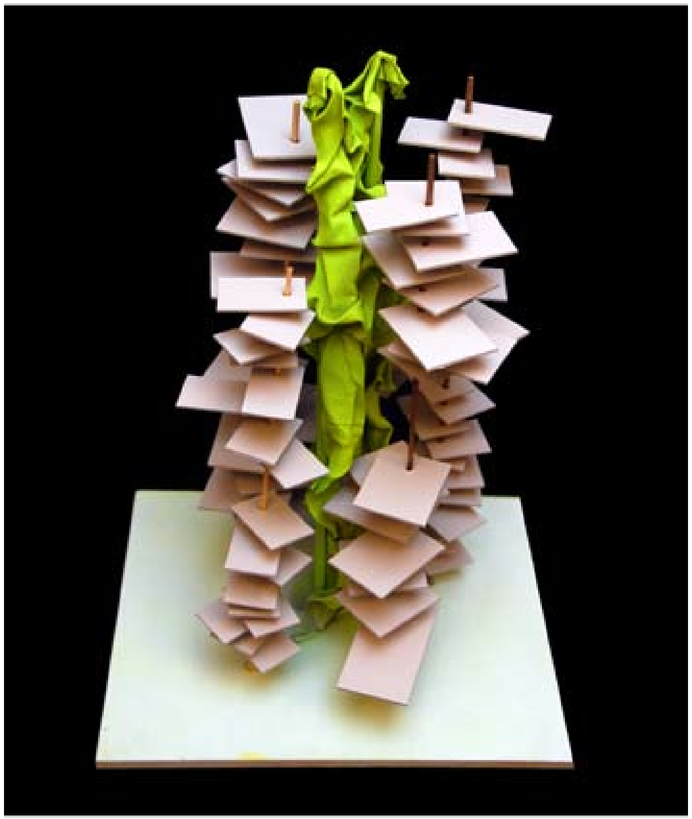


Fig. 6. Conceptual Model #6

Research Methods

In order to solve the problems presented throughout the thesis, researching urban city fabrics and the quantity of green spaces that are presented within those cities will be done. The variables throughout this thesis will be further answered through multiple surveys, interviews, observations, and topographical mapping studies. These methods of research will best begin to reinforce the concepts and theories, as well as help to differentiate between the multiple scales and functions of green spaces that will be incorporated in the design. Interviews and surveys that have been collected will be looked at from various researchers as well as current urban dwellers. Their personal outlook on inner city green space and communal living situations will help with the design and need of communal spaces. Interviews and surveys were chosen because they "can cover an extensive amount of information from demographic characteristics, to behavioral habits, to opinions or attitudes on variety of topics, across a large number of people in a limited amount of time." [22]

In juxtaposition with these interviews and surveys pertaining to inner city community living and public and private green spaces, a separate analysis will be constructed to determine how a multi-story residential tower building type that incorporates sustainable systems and begins to "break the box" can improve the quality and future of a vertical residential tropical community. Case study research will be conducted to understand existing residential towers that have already implemented some, but not all the urban and residential design issues that are being addressed in this thesis.

Case Studies

These case studies were chosen to research multi-family residential living units that are located in dense tropical locations. A residential condominium, an ecological tower design, and a green residential high-rise were studied to help understand the components needed to construct a vertical structure. A residential high rise begins with circulation and its structure as the main elements. From there, sustainable systems and social spaces can be implemented to help create a cohesive community and an ecological design. These case studies were looked at to begin to view a determined program of spaces that will work within a tropical residential environment. The site of each structure was also identified and studied as it needed to relate to the site that was chosen for this thesis. Site specific structures and surrounding context are an important aspect to this project.

Case Study 1

Fig. 7. Bedok Court Condominiums in Singapore

Bedok Court Condominiums, Location: Singapore, Date of Project: 1985, Architect: Cheng Fenn of Design Link Architects.

"Tropical Sustainable Architecture" written by J.H. Bay, includes one of today's most successful residential urban communities, located in Singapore, and designed by Cheng Fenn of Design Link Architects. Bedok Court Condominiums was completed in 1985 and consists of 280 apartments. Fenn stated that "he wanted to re-create the relaxed friendly atmosphere and strong sense of community and security found in this setting. He suggested that the high degree of visual connectivity of residents in their entrance porch spaces contributed to high levels of social interaction and familiarity, resulting in a strong sense of identity and security." [23]

Fenn used three dimensional multi layered streets within a high density context combined with "smart growth" and sustainability to create a vertical garden community. Open garden terraces were used to enhance communal activity and awareness as well as allowing for an increase in thermal comfort conditions within the residential units through shade, vegetation, and natural ventilation. These main sustainable qualities of the design are what allowed these residential towers to be so successful for everyday communal activities to occur. Fenn also mentioned that "he had been very much influenced by the writings of Jane Jacobs (1962) and her assertion that the modern city needs a vital street life. However, he went on to admit that some degree of privacy would have to be sacrificed in order to gain the necessary familiarity and trust." [24]

Fig. 8. Bedok Court Condos green space

Fig. 9. Section Circulation

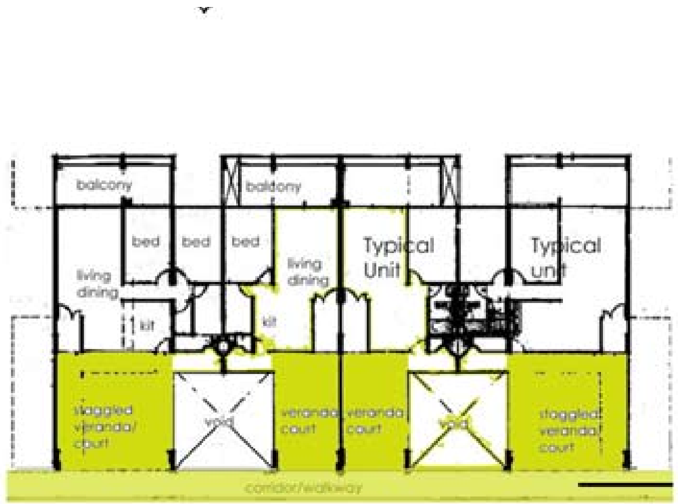


Fig. 10. Floor Plan Circulation

Fig. 11. Site Plan

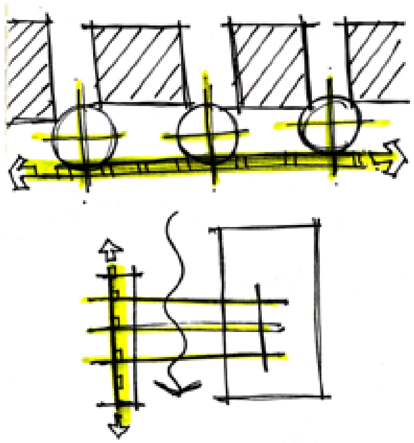


Fig. 12. Circulation Diagrams

In his text, Bay conducted multiple surveys that began to show the quality of community life and the environment of the forecourt in Bedok Court.

1. Preference of the forecourt over other spaces: A high percentage of interviewed residents (86%) nominated the forecourt/veranda as the most desirable space compared to the interior of the apartments, the balconies, the lift, the lobby, the playground, the swimming pool, and the car parking areas.

2. High frequency of social activities in forecourts: Most residents (86%) used this space for social activities, receiving guests, gardening, hobbies, children's play, study group activities and parties, more than once per week.

3. Thermal comfort condition: Most residents (80%) felt slightly warm, comfortable, or slightly cool for the three periods of the day, morning, just after noon and evening before dark, for the warmest month of the year.

4. Day lighting levels: The majority of the respondents (80%) found the day lighting slightly too bright, comfortable, to slightly dim, and therefore reasonably acceptable.

5. Acoustic levels Most of the respondents reported that they felt comfortable with the overall acoustic levels at the forecourts (most recorded levels were below 65 dBA). Noise was not a problem in the case of Bedok Court. This could be due, in part, to a high level of neighborliness and tolerance for a certain level of ambient background noise.

6. Privacy issue: Majority of residents reported not feeling a lack of privacy (90%). Although there will always be some people who demand total privacy, there seemed to be a large number of people who are willing to trade off reduced "privacy" for increased social contact. In any case, they could still enjoy the usual privacy of the interior of their apartment units, just as in any other apartments.

7. Sense of belonging, ownership and security: Almost all the residents interviewed felt a strong sense of belonging, ownership and security. [25]

Fig. 13. Open Courtyard Infront of to Individual Unit

It is the ideas and intuitions of Fenn's design that are the most influential in helping to formulate the architectural solutions throughout this thesis project. Fenn successfully places green spaces throughout the structure that directly relate to the residential units to help create a better internal community, as well as a stronger interconnected sustainable design. The residential structures contain multiple air wells that allow for air circulation to occur through the multiple green spaces. This was a good example of how to create a passive cooling system in a tropical climate. Although some sacrifices dealing with privacy will have to be made in order to achieve the goals of communal interaction, it is through precise design and organization that privacy and individualization can be achieved.

EDITT Tower, Location: Junction of Waterloo Road and Victoria Street, Singapore, Date of Project: 1998, Architect: Dr. Kenneth Yeang.

The inspiration behind this thesis and designing an eco-friendly residential high rise community that incorporates a variety of green space came from the ideas and theories of Dr. Kenneth Yeang. Yeang's research and theories on the ecological factors in the design and planning of his buildings, begins with the explorations of environmentally friendly design strategies for a "greener" communal high rise within a dense urban fabric. Yeang addresses the major issues of sustainable high rise design through five design strategies; "variability in facade and building performance in response to climate and location, alignment of building along the solar path, flexibility to adjust to different climatic needs throughout the year, use of entirely passive means of lighting and ventilation whenever possible, and material selection based on ecologically sound principles." [26] It is through Yeang's views that this thesis begins to use and understand rules and specific strategies are needed to help with the process of designing with sustainability and ideas of how to keep the integrity of green spaces within our cities. These ideas will be addressed throughout the thesis research and the design.

Ken Yeang's EDITT tower is set out to demonstrate an ecological approach towards tower design. The twenty six story high rise uses photovoltaic panels, natural ventilation, and a biogas generation plant within its structure. Two of the buildings facades are wrapped with an insulating living wall. This allows for a passive cooling system to be integrated

Case Study 2

Fig. 14. EDITT Tower Rendering

with the structure. The tower was designed to increase the site's bio-diversity and help rehabilitate the local ecosystem within the city.

The design approach is to revitalize the community with an organic design that will hopefully lead the way in this modern greener building design, as it begins to balance the existing context of this urban site. The unique design feature of this scheme is in the vegetative facades and terraces. These vegetative spaces are integrated throughout most of the usable area of the building. The vegetation areas are designed to be continuous and to ramp upwards from the ground plane to the uppermost floor by way of a linked landscaped ramp. The landscaped areas encompass 41,098 square feet. Design began with a detailed mapping of the indigenous planting within a one mile radius vicinity of the site. This was to assure that the plant species be incorporated in the design that would compliment the indigenous species of the area.[27]

The purpose of this case study is to research the design strategies and the steps in designing a structure using sustainable systems within a tropical climate. It is from these site specific aspects, that he begins to design a high rise tower that will use natural vegetation as a screen system for sun, rain, and wind shelter. Open courtyards that are located throughout the structure, allow for wind loads to pass through and this helps to naturally ventilate and cool the building. The site is prone to an abundance of rainfall each year, so the building is equipped with a rainwater collector that is integrated with a grey-water system for both plant irrigation and waste water. All the sustainable systems that Yeang uses are a great approach to managing the local

Fig. 15. EDITT Tower Green Space

tropical climate of Singapore. The one disadvantage that Yeang does not discuss is the spatial qualities and how the circulation and core system is introduced. Although this is a commercial building, the climatic systems used are what pertains to this thesis. This research will be used as reference showing how to incorporate these sustainable systems and analyze the site throughout the design process.

Fig. 16. Circulation Diagram

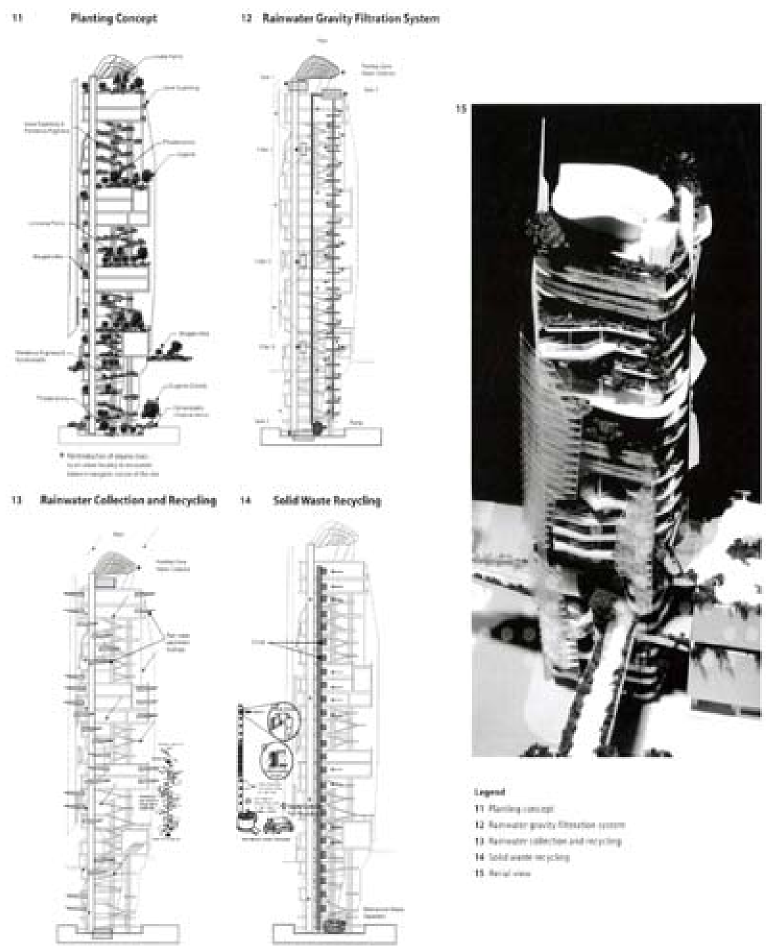


Fig. 17. Section Diagrams and Sustainable Systems

Newton Suites high-rise apartments, Location: Singapore, Date of Project: 2003-2007, Architect: WOHA Design firm.

One of the most recent green residential high-rises comes from WOHA Design firm. WOHA's Newton Suites high-rise apartments are located within Singapore's dense city. The thirty-six story tower incorporates 118 apartments with views towards the verdant Bukit Timah Nature Reserve and the city skyline.

"Attention to detail, proportions and scale, ensures that the building is a comfortable, efficient and elegant living space. A studied randomness adds a dimension of spontaneity and playfulness to the building's design and common areas that make them at once friendly and aesthetic. The architecture and landscape merge seamlessly, integrating living spaces into the flowing foliage of the sky gardens. The elegant profile of the building is a mature and stylish addition to the skyline."[28]

Case Study 3

Fig. 18. WOHA Design Firm: Newton Suites

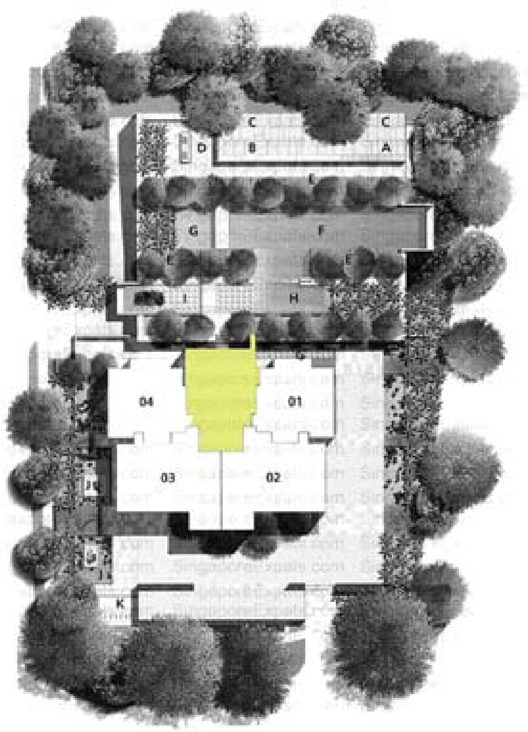


Fig. 20. Site Plan

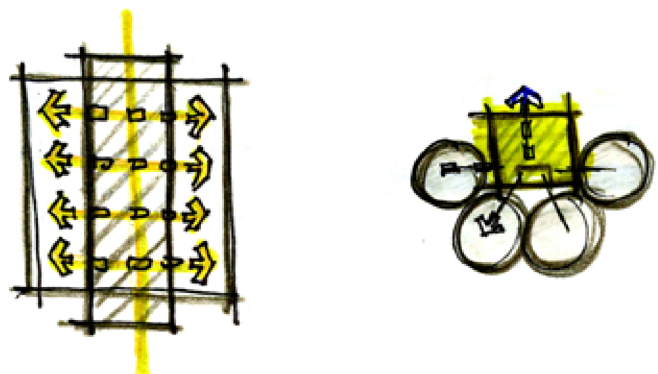


Fig. 19. Circulation Diagram

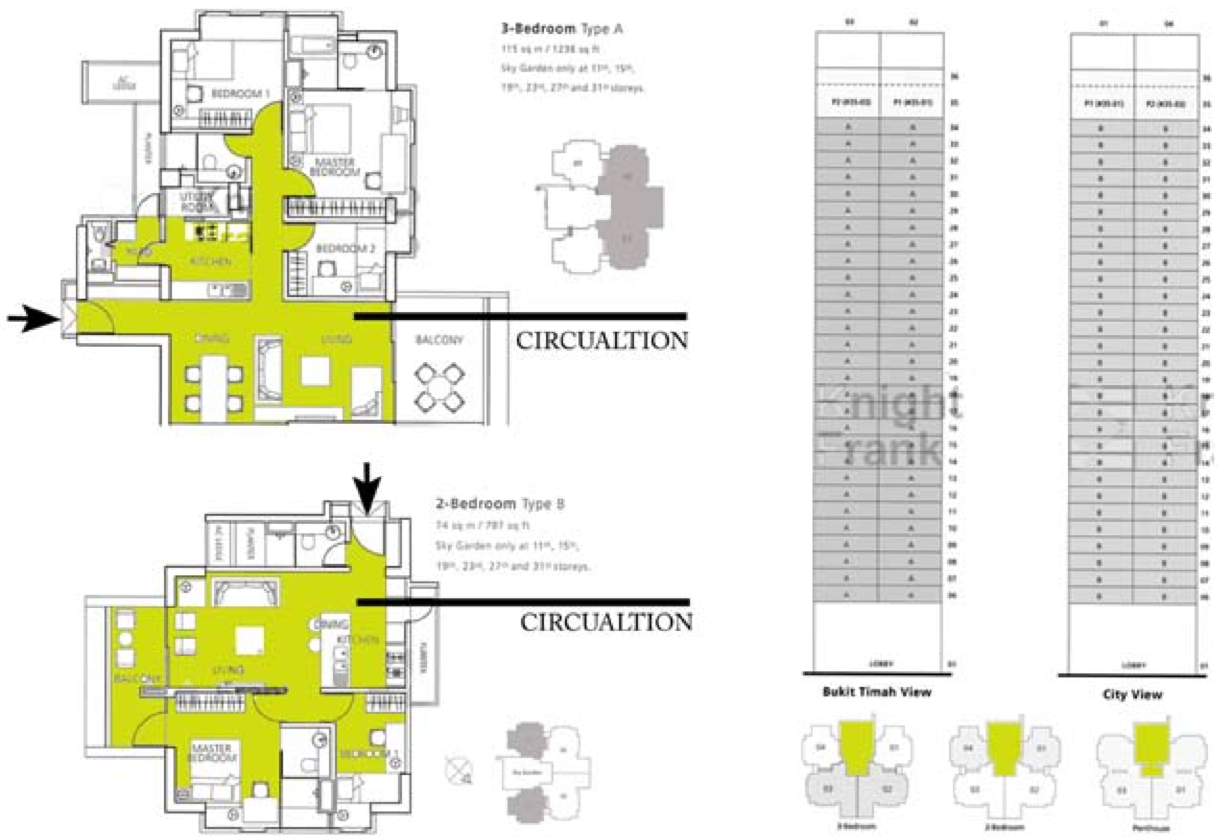


Fig. 21. Circulation and Floor Layout

The main goals behind the design of Newton Suites high rise, was to incorporate concepts such as orientation, maximizing views, solving environmental issues and including multiple scales of green space that begin to help answer the question of how one can design a modern and sustainable tropical high rise residential tower within a tropical climate.

The building form takes on a different approach to the common point block tower, in how the design layout begins to push and pull its floor plates and creates a multiple of scaled green spaces. As a result of the shifting of floor plates, the balconies begin to take on a distinct proportional pattern. The tower's design includes an angled mesh screen system to help prevent heat gain throughout the building. This system serves not only as a shading device, but also provides privacy for the residences. The dynamic facade is the main concept for this project as it is functional as well as aesthetically pleasing to the residences.

Newton Suites incorporates sustainable architectural systems by using a variety of landscaped open air spaces that becomes one of the primary design elements. At every four floors on the southeast facade there are covered communal green spaces which contain large scale vegetation. These vegetated spaces were designed to allow the users to use the spaces for multiple purposes. These spaces also allow air flow to passively cool the structure. Trellises covered with vegetation are used to help absorb sunlight as well as help filter air flow.

Fig. 22. Newton Suite Sky Court

The methods of integrating more green spaces within a residential high rise was done through various strategies and helped with the development of sustainable design systems for high rise residential buildings. It was through site specific conditions that WOHA Architects designed for and was able to use the buildings orientation, screen systems and open green spaces to help with the sustainable advancement of this residential high rise. Newton Suites design will begin to set precedence for residential vertical communities to come.

After researching many different types of tropical residential towers, it was found that the mixture of proportionally used green spaces throughout a residential community along with the combination of bioclimatic/ sustainable systems, can impact the users well being and promote interaction within a vertical realm. Such as a neighborhood or city park does.

Program: Residential High Rise and Commercial Space

The narrative of this project is constructed to create a vertical community that offers all amenities that are looked for throughout a dense urban setting. This residential high rise will include multiple residential units that will vary in scale. A variety of public and private green spaces will also be added throughout the design. These spaces will be accessible throughout the structure and circulation to allow for various activities, as well as communal interaction, to take place.

This residential high rise will also contain the necessary residential support spaces. This will include the main lobby, offices, mail room, gymnasium, loading dock, and waste collection and removal space. Residential high rise structures are complex and unique designs that begin with configuring the parking and structure, then address how the users will circulate through the structure. This project will be designed around the circulation system that will consist of green space and will help the building function as a whole.

There will also be an addition of numerous commercial spaces located at the base of the tower. These spaces, consisting of restaurants and large and small retail spaces will be available to the residents, as well as to the general public. The communal spaces will be an addition to an already existing river walk park.

Spaces	Area: Sq. Ft.	# of Spaces	Total Area: Sq. Ft.
Residential Space Allocations Residential High Rise:			
Residential Units:			
3 Bedroom Units	1500	20	30000
2 Story Units	1700	10	17000
2 Bedroom Units	1200	20	24000
2 Story Units	1400	10	14000
1 Bedroom Units	1000	20	20000
2 Story Units	1200	10	12000
Penthouses	4000	4	16000
Total Residential Area		94	133000
Additional Residential Support Spaces:			
Lobby	1500	1	1500
Offices	500	4	2000
Gym	1000	1	1000
Mail Room	300	1	300
Loading Dock/Waste	800	1	800
Total Residential Support Spaces		8	5600
Mixed-Use Space Allocations:			
Resturants	5000	2	10000
Large Retail	10000	2	20000
Small Retail	1500	10	15000
Exterior Green Space	Multiple Scales	1	Multiple Scales
Total Mixed-Use Space		15	45000
Net Total:			183600
Gross Total:		20%	220320

Fig. 23. Program

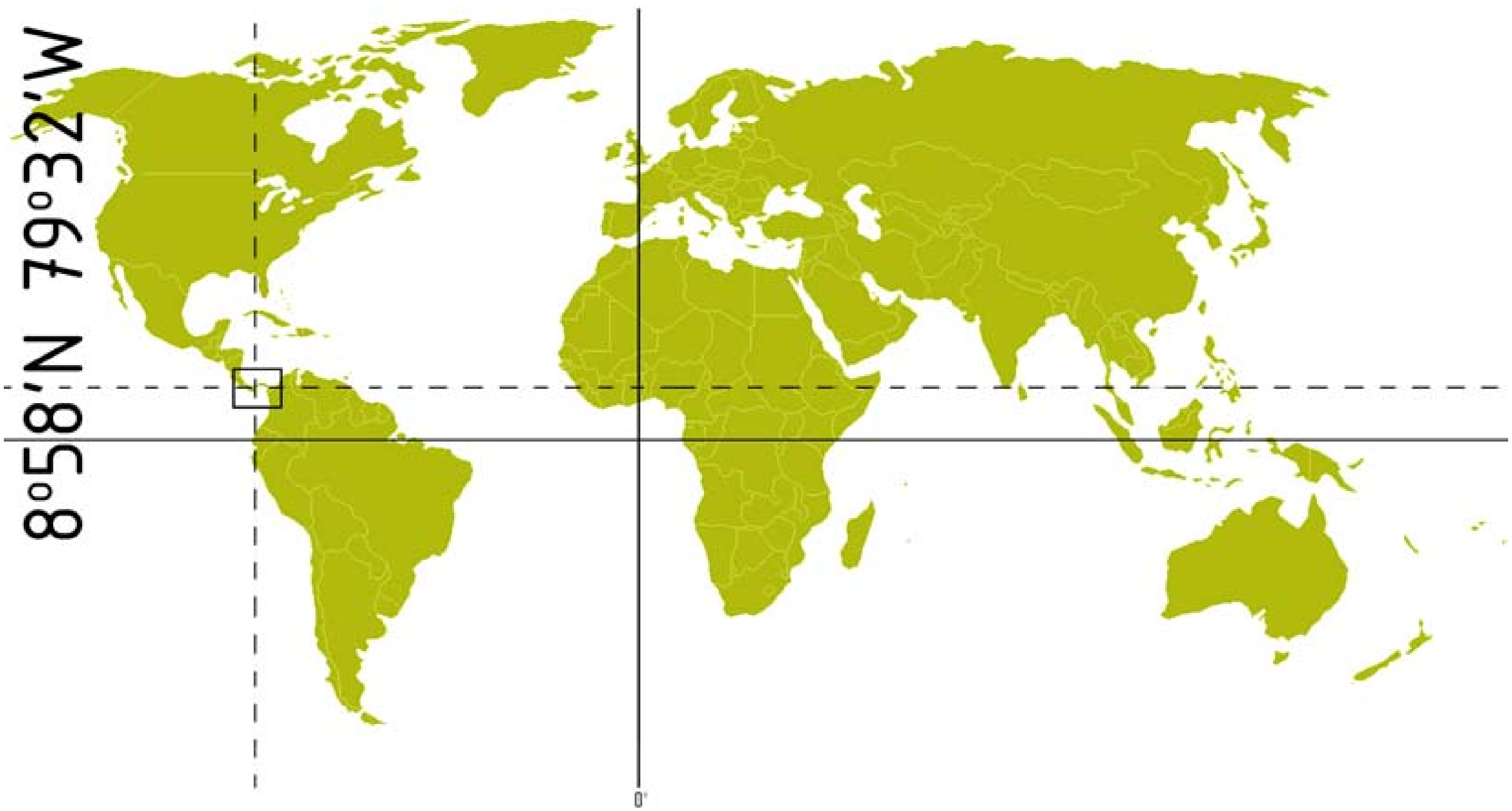


Fig. 24. World Map with Panama Located

The main objective of this thesis is to create a tropical residential high rise that incorporates public and private green space to promote cohesive communal living within a dense urban setting. This project is site specific in that it addresses specific tropical climatic conditions. Punta Paitilla was found to be the location that has the dense urban residential district that would support a modern sustainable residential high rise building. Four different sites were chosen within the residential neighborhood for future study. It was important to identify sites that would have the best views and accessibility for its residences.

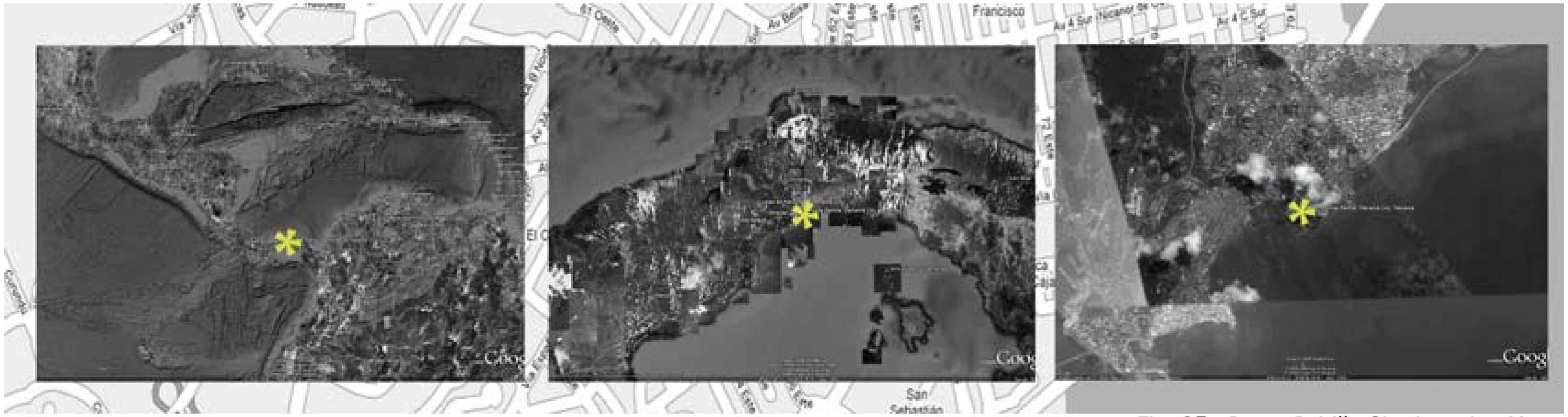
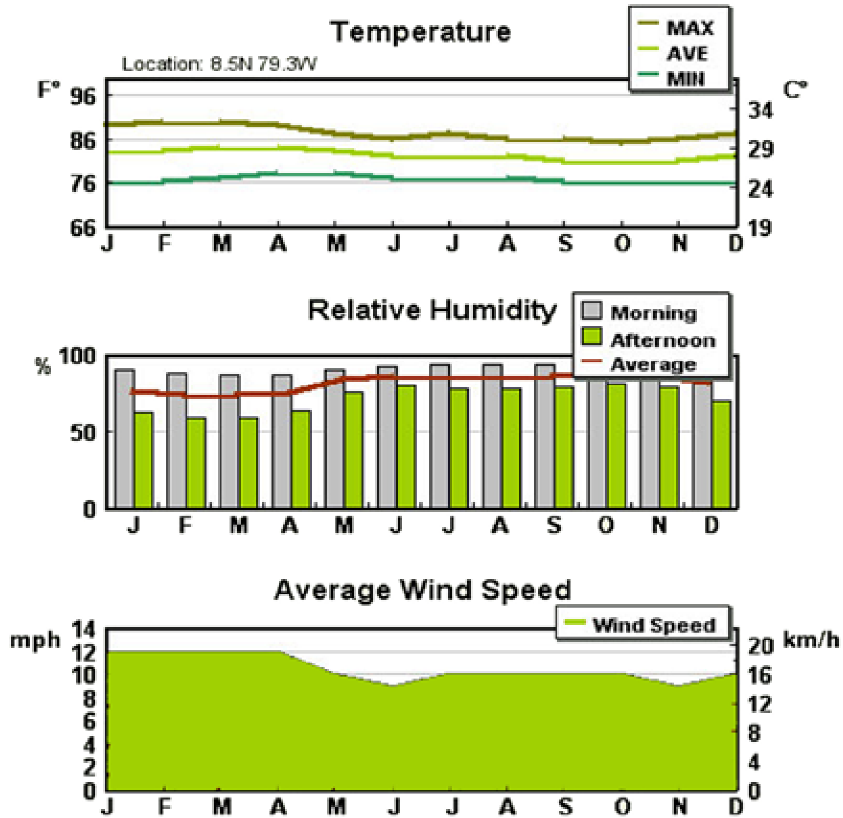


Fig. 25. Punta Paitilla Site Location Maps



VARIABLE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INSOLATION (kWh/m^2/day)	5.28	5.81	6.24	5.83	4.78	4.43	4.27	4.45	4.59	4.26	3.88	4.29
CLEARNESS (0-1)	0.59	0.60	0.61	0.56	0.46	0.44	0.42	0.43	0.45	0.44	0.43	0.49
TEMPERATURE (deg F)	78.01	77.99	78.46	78.75	79.02	78.96	78.64	78.64	78.53	78.48	78.53	78.53
WIND SPEED (mph)	12.82	13.09	12.39	9.26	7.38	6.87	7.34	7.29	7.52	7.87	8.72	12.15
PRECIPITATION (in)	1.14	0.57	0.52	2.00	7.85	7.33	6.06	6.71	7.44	10.95	10.12	4.87
WET DAYS (d)	10.70	8.20	7.50	9.70	19.40	20.50	22.30	23.10	19.50	22.30	23.40	17.50

Fig. 26. Climate Charts for Punta Paitilla

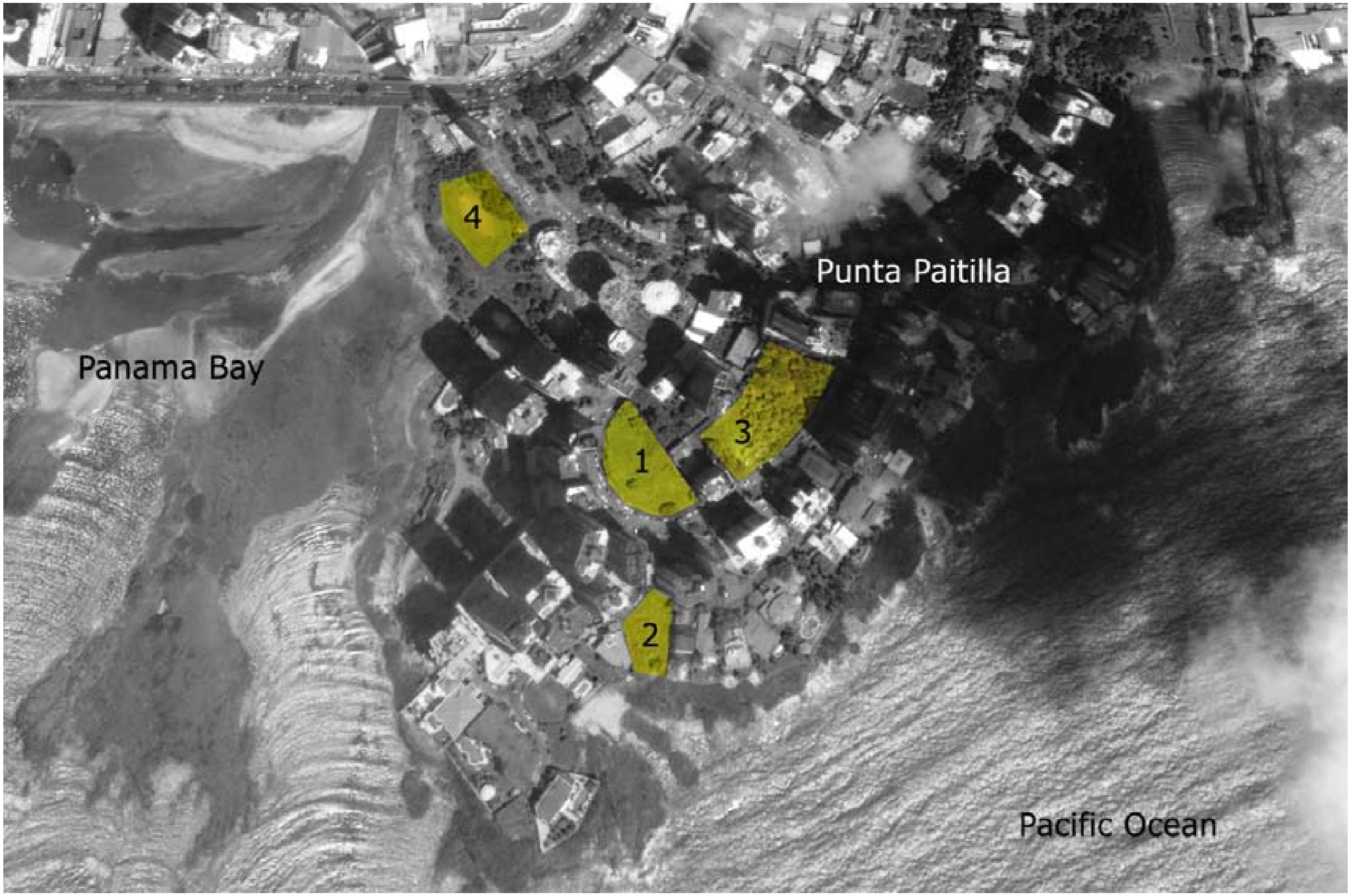


Fig. 27. Four Possible Site Selections in Punta Paitilla

Punta Paitilla has four possible site selections that are of interest based on availability and scope. The first site is a half circle shaped corner location located in the center of Punta Paitilla having a total area of 40,000 square feet (0.92 acres) and a height of seventy five feet above sea level. The site is located to the east of Via Italia. Via Italia is the main road that connects to Avenue Balboa, a major road to the north, and travels throughout the peninsula allowing for vehicular and pedestrian access within the city. It is surrounded by residential high rises and hotels. Vegetation on the site includes small local trees on the sites edge. The advantages of this site include its corner location and vehicular and pedestrian accessibility to the main road. It is also located just two blocks from commercial amenities. This site was not chosen because of the dense surrounding context and the lack of views that would be accessible to the users.

Site Number 1

Fig. 28. Site one with square footage

Fig. 29. Site one major and minor access roads

The second site is 27,000 square feet (0.62 acres). This site is located on the southern coast of Punta Paitilla in-between Calle Tomas Gabriel Duque and the Panama Bay. This site has a little vegetation due to its sloping terrain and poor vehicular accessibility. This wedged shaped site has potential due to its coastal location. The site allows for views back into the city to the north as well as out to the water to the south and east. The main downfall to this site is that it is the smallest of the three sites and thus fewer possibilities for design. The site is also the furthest away from major roads and accessibility to public transportation and attractions.

Site Number 2

Fig. 30. Site 2 and Square Footage

Fig. 31. Vehicular and Pedestrian Circulation

Site Number 3

The third site is 50,000 square feet (1.15 acres) with much plant life and is located off Via Italia, adjacent to site one and is considered an infill site. The typography is the same as site one as it is located at the highest point within the peninsula. The accessibility of this site allows for vehicular and pedestrian traffic to reconnect to Panama City's working district just several blocks to the north by way of travel on Via Italia. The benefit of this site is the large scale that will allow for a flexible design. Although it is located off the major road in the center of the peninsula, it lacks the potential of greatest accessibility and views to its users because of the dense surrounding context and infill location.

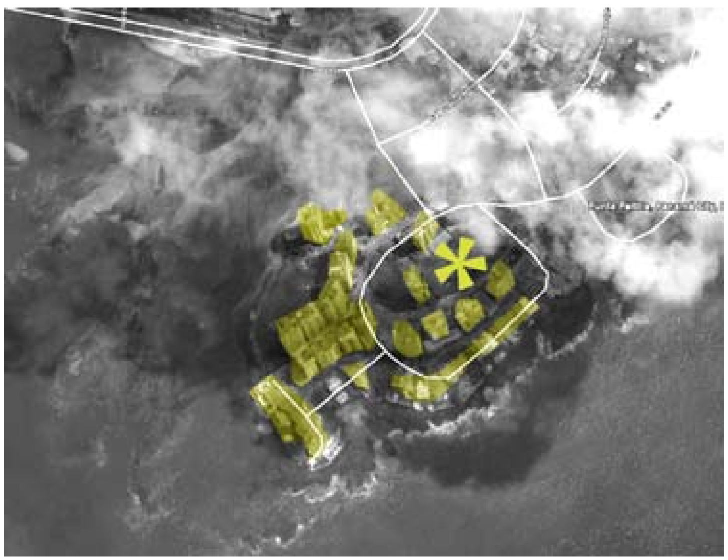


Fig. 32. Site 3 within Existing Site Context

Fig. 33. Views from Site

Fig. 34. Project Site

Site Number 4

Fig. 35. Views from site

The site selected for the project came after the site visit was completed. A fourth site was found that is located off Avenue Balboa to the North, Via Italia to the East, and the Panama Bay to the West. This rectangular, flat corner location has a total area of 65,000 square feet (1.49 acres) with a few trees scattered throughout. This corner site is adjacent to a major road to allow for greater vehicular and pedestrian accessibility as well as access from other major roads in and out of the city. It is located just a block from the Mall Multicentro Panamá and the commercial district. The site allows for maximum views to the north and east. These views look back into the city as well as towards the Panama Bay to the West. Located at the very North-West edge of the peninsula, the design will be surrounded by large scale buildings, which will help allow for shading to the South. Located at the north edge of Punta Paitilla, this site will act as the connecting point from Panama City, north, to Punta Paitilla, south. This site was chosen for the reasons of accessibility in and out of the city, views, surrounding context, and water front property. The scale of this site is ideal for the project of this thesis.

Fig. 36. Project Site and Context

Project Site Images

Fig. 37. Site Images

The purpose of these site models was to show the context as well as scale of the local infrastructure located within Punta Paitilla. They also show the vehicular and pedestrian circulation around the site.

Site Study Models

Fig. 38. Site Context Model

Fig. 39. Site Circulation Model

Conceptual Design

The idea behind this conceptual design is the notion of "braking the box" of a residential high rise. The intention is to create separation between living units to generate different scales of green space within the circulation of the tower. The positioning of these spaces will come from site specific features. Light, wind, and views will be the major factors. The new water front park is contributing to the idea of a large scaled green space that will continue from the existing park to the residential tower. A main objective is to allow for more natural vegetation to take place throughout the structure to allow for sustainable systems, such as passive cooling, and to help promote a better sense of community within Punta Paitilla's urban neighborhood.

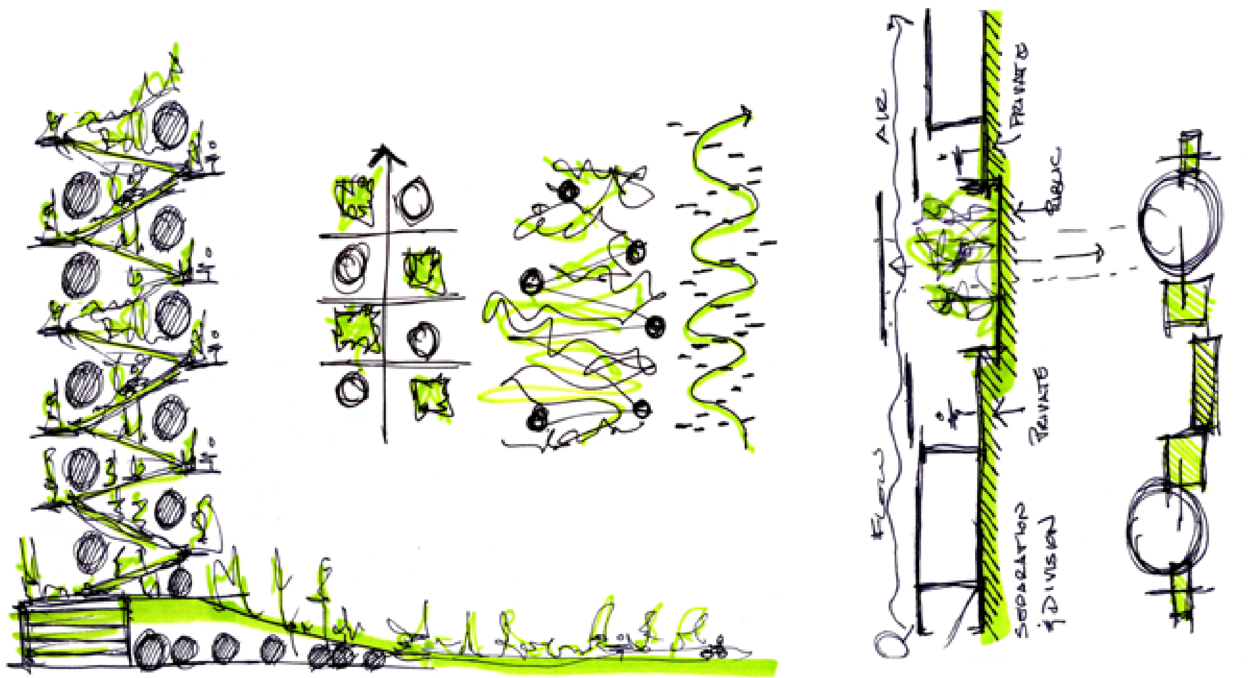


Fig. 40. Conceptual Design Sketches

Parti Models 1 & 2

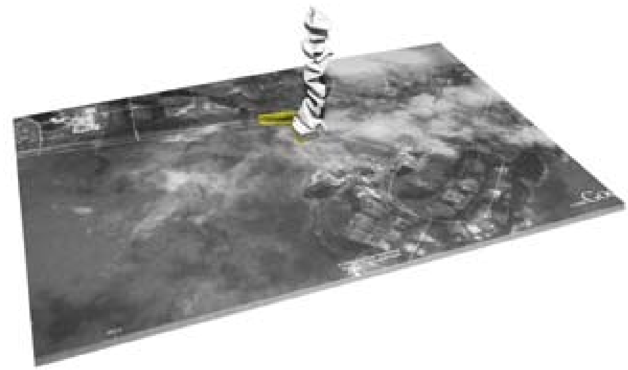


Fig. 41. Parti Model #1

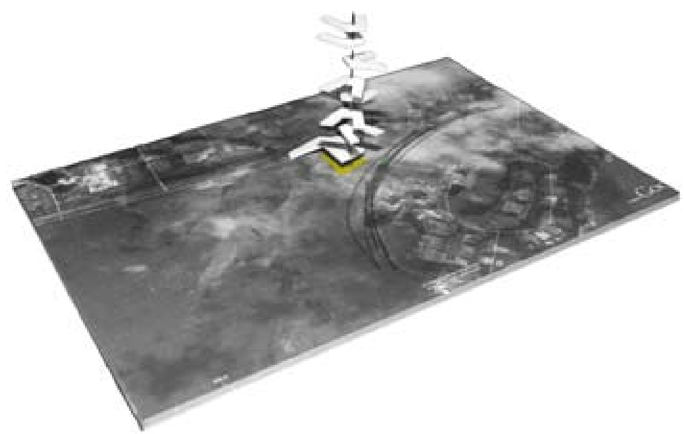


Fig. 42. Parti Model #2

Parti Models 3 & 4

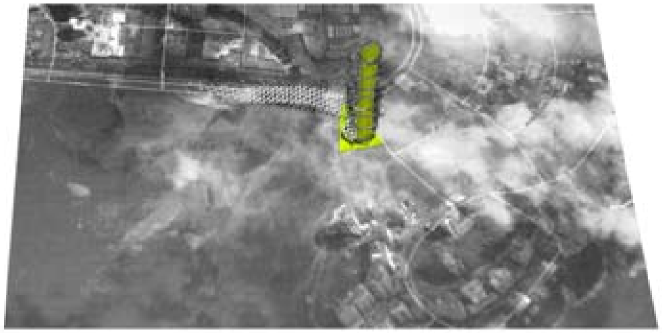


Fig. 43. Parti Model #3

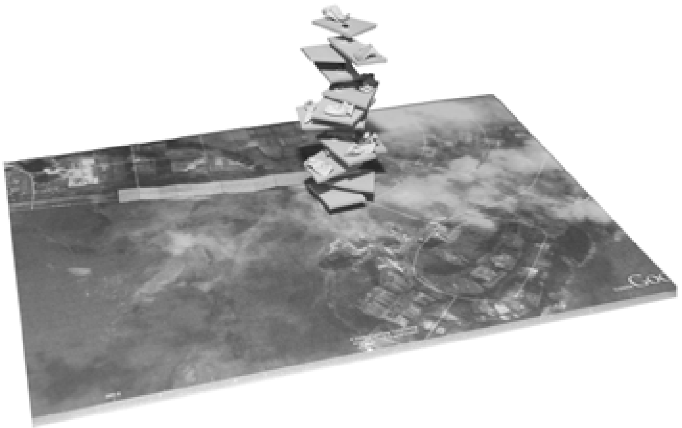


Fig. 44. Parti Model #4

Parti Models 5 & 6

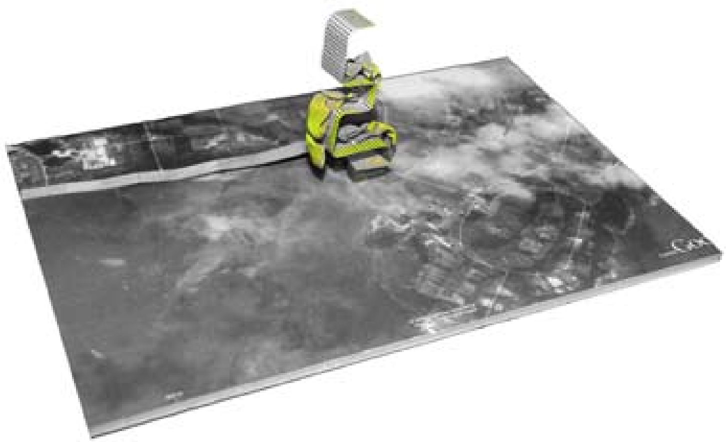


Fig. 45. Parti Model #5

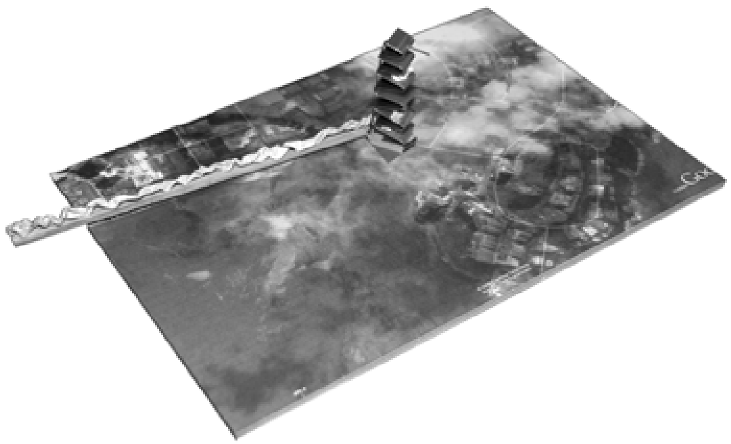


Fig. 46. Parti Model #6

Fig. 47. Circulation Watercolor Diagrams

This conceptual model begins to show the idea of separation. The base begins with the ideas for the commercial spaces as they would take the shape of the site and stretch across the bay to reconnect with the existing waterfront park. Parking would be located at the base, directly under the residential tower, to allow for direct access to the units. A large scaled green space would be located above these spaces to create a landscaped area for all to use. This will also help to provide shade for the commercial spaces below. From here, the residential tower would begin to take form as it vertically climbs to show separation of the communities that are formed from this abstract design.

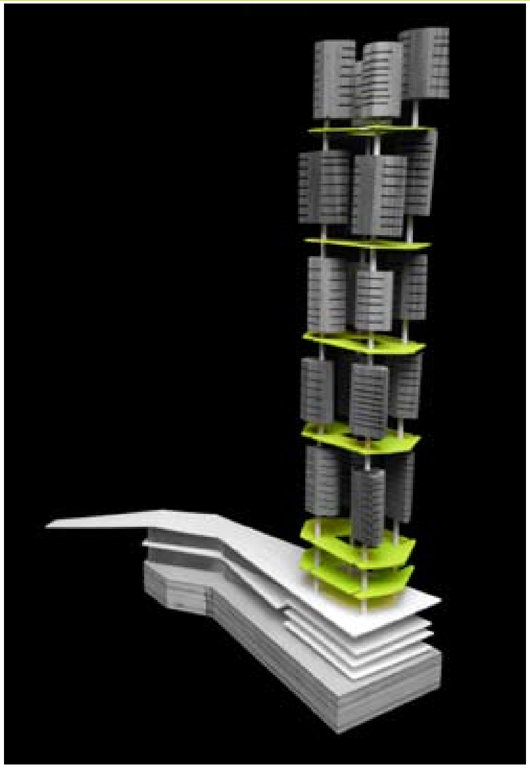


Fig. 48. Conceptual Building Design Model

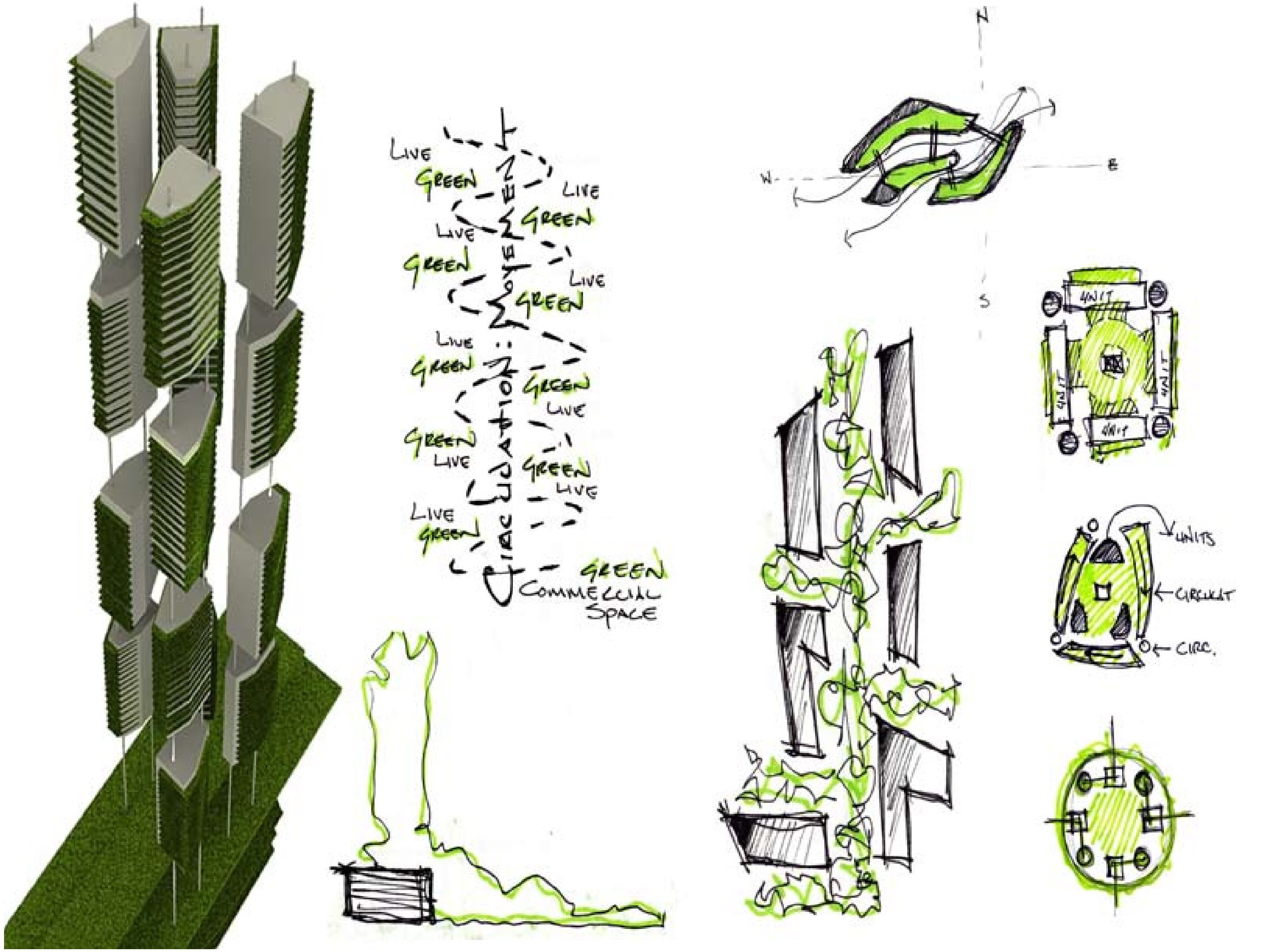


Fig. 49. Concept Drawings

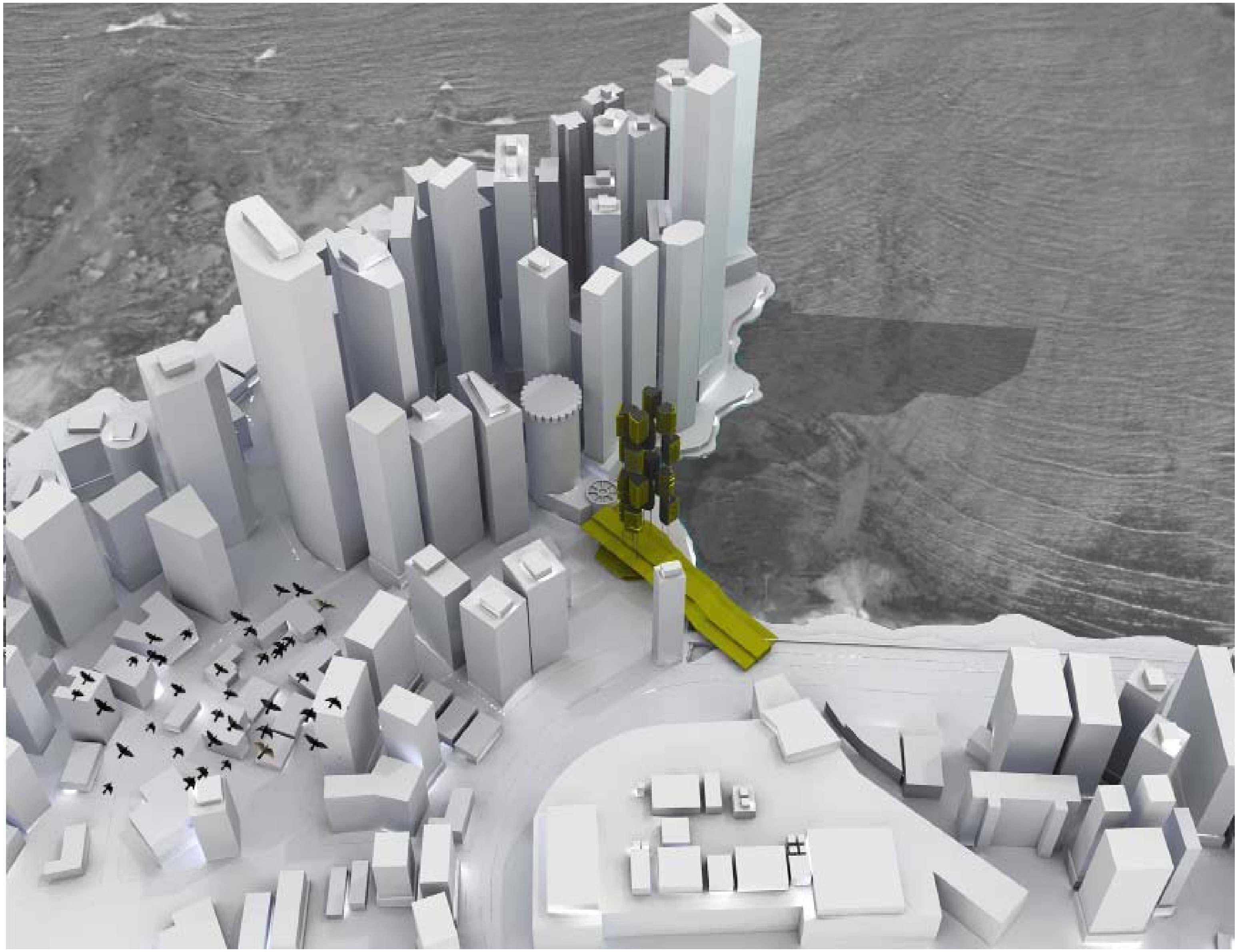


Fig. 50. Conceptual Design within Site Context

Fig. 51. Conceptual Design within Context #2

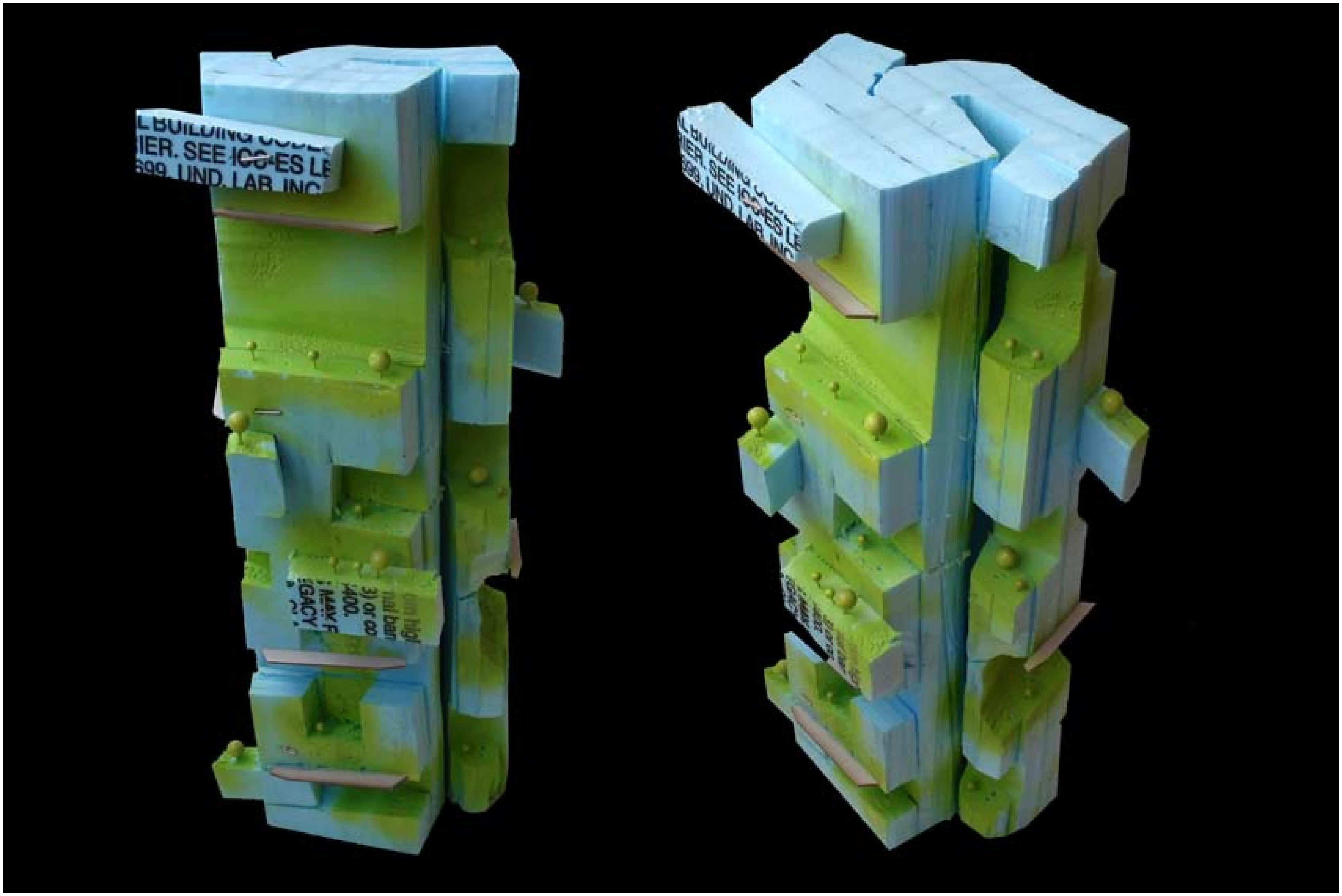


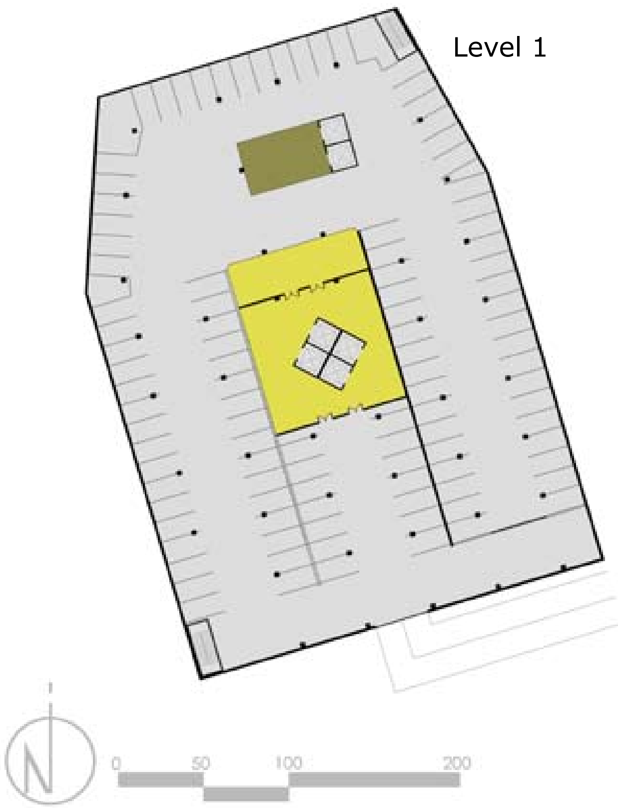
Fig. 52. Final Conceptual Model

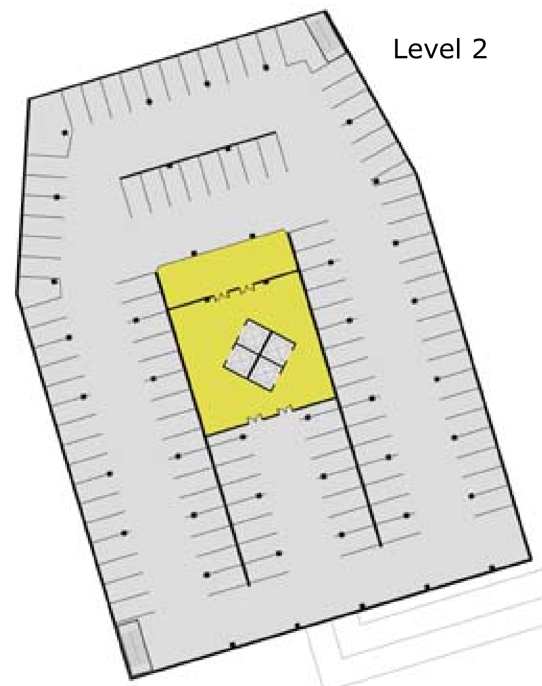
After having studied multiple design strategies, it was the concept model in Fig. 52 that became the main driver towards the final stages of design. With combining ideas from all previous conceptual models and research, the final form began to take shape. The S configuration floor plates were designed as a result of site specific conditions. Sun, rain, and wind were all determining factors that lead to the form of this residential tropical high rise.

Schematic Design

Schematic Design: Plans

Fig. 53. Site Plan





Parking Garage

Fig. 54. Parking Garage Levels

Fig. 55. First Floor Plan

Fig. 56. Second and Third Floor Plans

Fig. 57. Various Floors Throughout the Tower

Circulation Diagrams

These three diagrams were constructed to show how the circulation patterns work throughout the residential high rise, as well as the different levels of space per floor. In Fig. 58, three shades of green were used to demonstrate the three different levels of green space. Public, intermediate, and private spaces are all located of each residential floor of the tower.

In Fig. 59, a section of the tower was taken to show the two different types of vertical circulation patterns. System one shows circulation patterns for the two story units located within the tower. System two demonstrates a skip stop circulation system. This allows for options and pedestrian circulation to occur throughout the communal green spaces.

With the available public, intermediate, and private green spaces within the two different vertical circulation systems, this began to break up space throughout the structure to allow for site specific sustainable systems to occur, as well as the advancement off community as a whole.

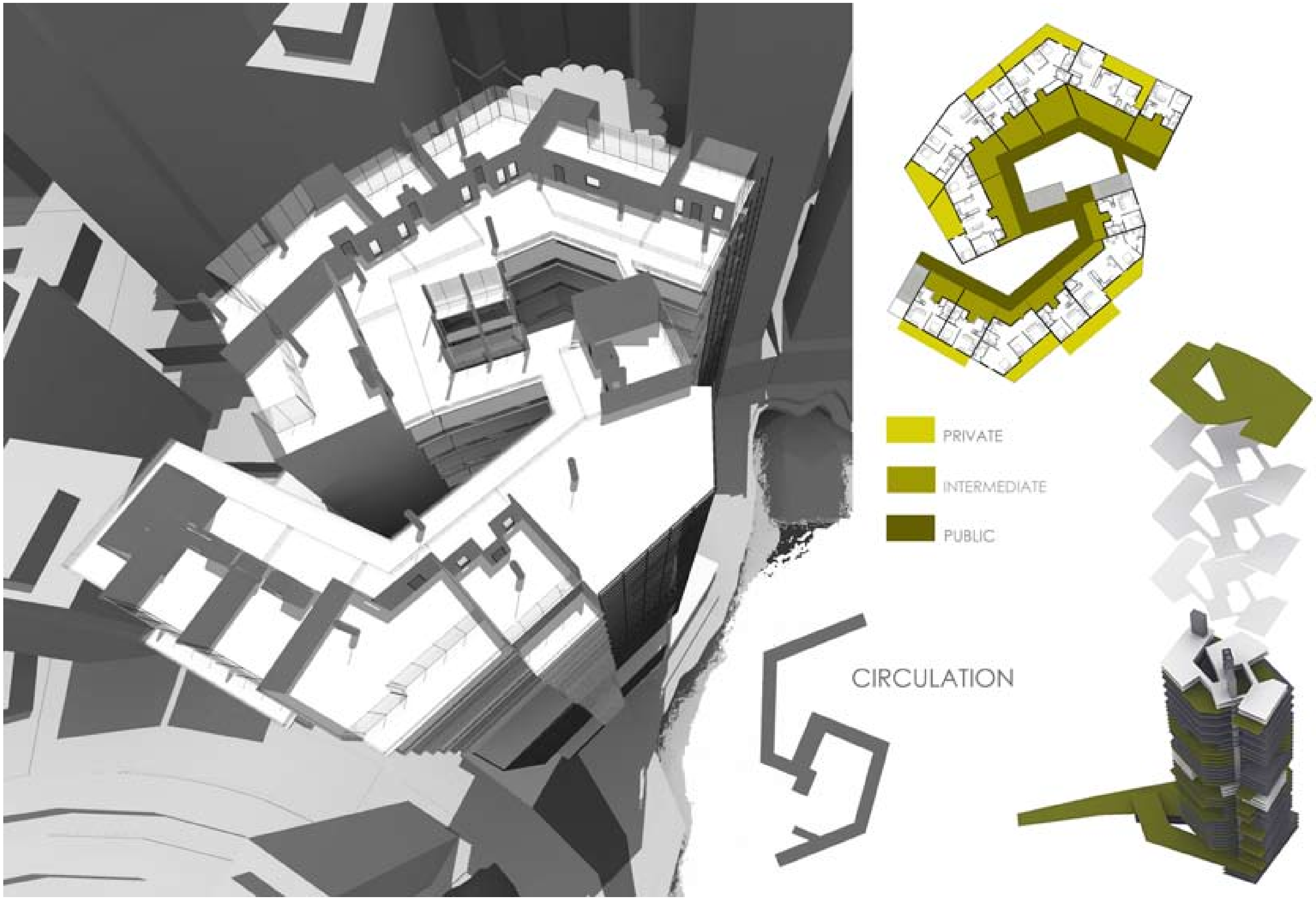


Fig. 58. Circulation and Distinction of Public and Private Space

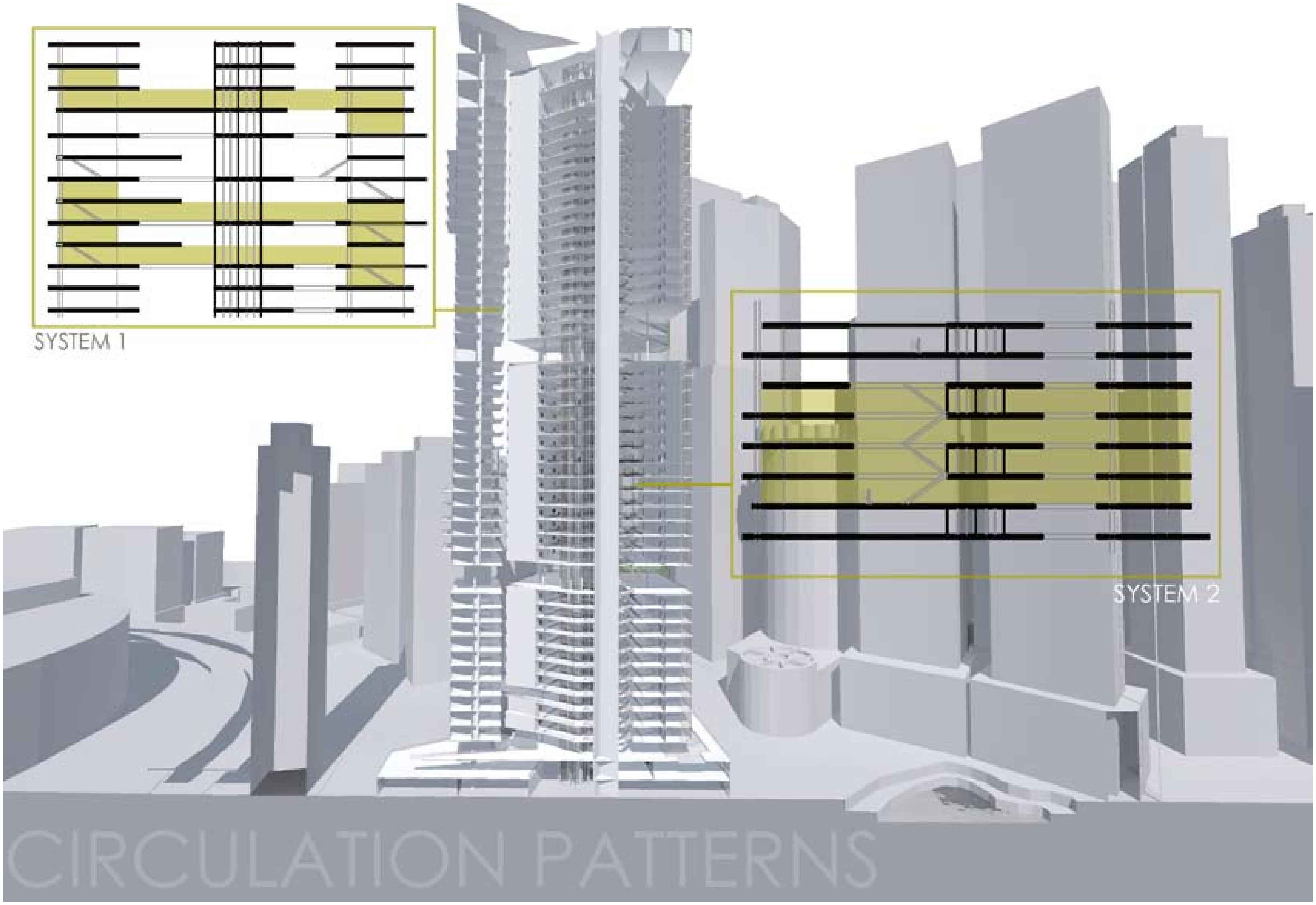


Fig. 59. Two Systems of Circulation

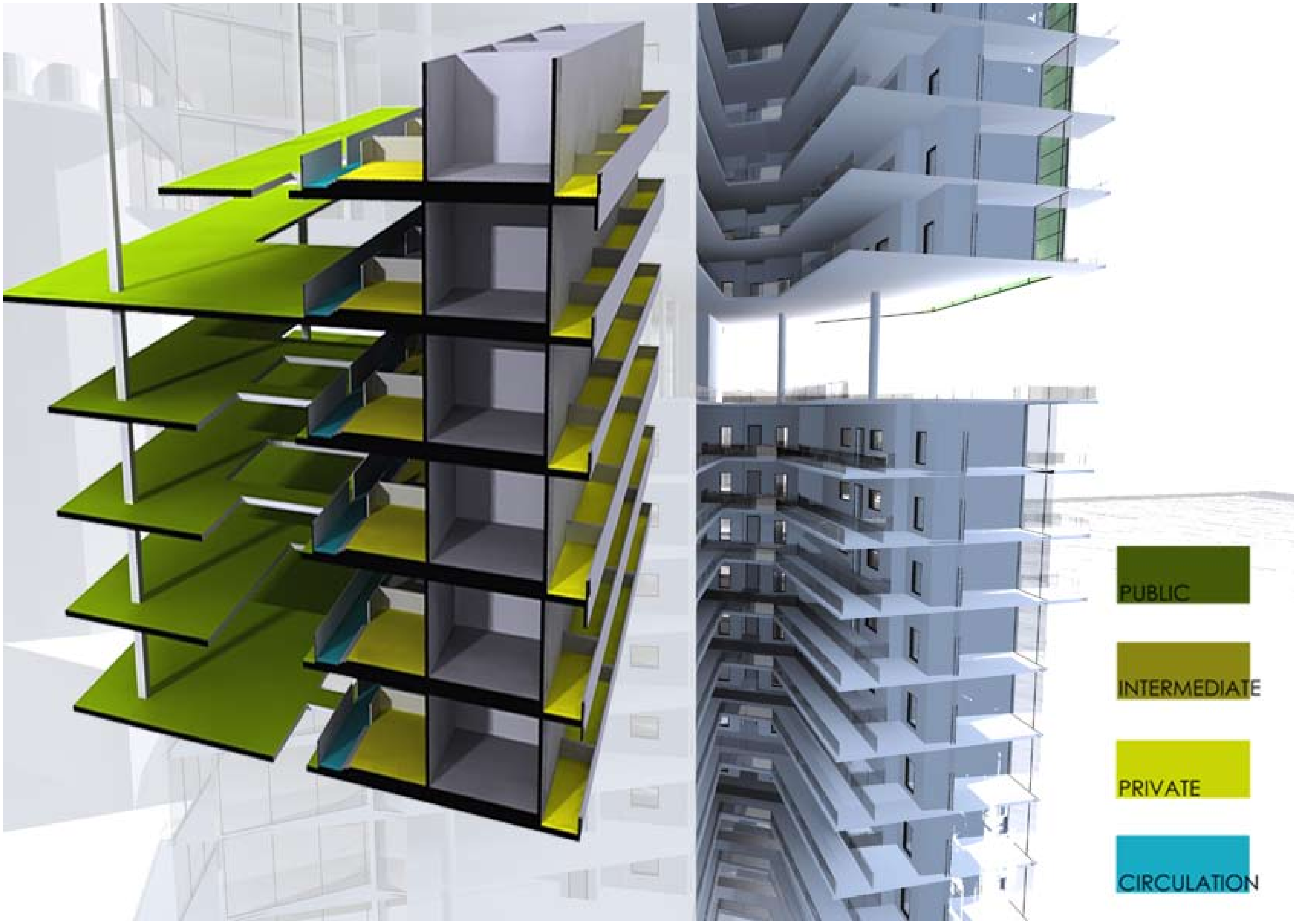


Fig. 60. Circulation Axo Diagram

Detail Section of Trellis System and Vegetation

One of the most important aspects of this project was to accurately construct each level to allow for the vegetation to be planted and grow. Studies were taken to calculate average size plant and root systems that would be used and the allotted size floor slabs that would be needed. Fig. 61 begins to show in section where green spaces occurs, the floor thickness needs to be four feet thick where vegetation takes place and then may recess to an eight inch slab where circualtion and dwelling units are located. This will allow enough space for average size tropical trees and plants to be grown within this residential high rise.

Another main element of the tower design was the use of a vegetative skin system. In Fig. 61, a detailed section shows the steel wire mesh trellis system used to suspend plant life from and help shade the residential balconies as well as the open green spaces. This trellis system helps block direct sun exposure, rain, and heavy gusts of wind. This sustainable trellis system also begins to define this residential high rise from the exterior view.

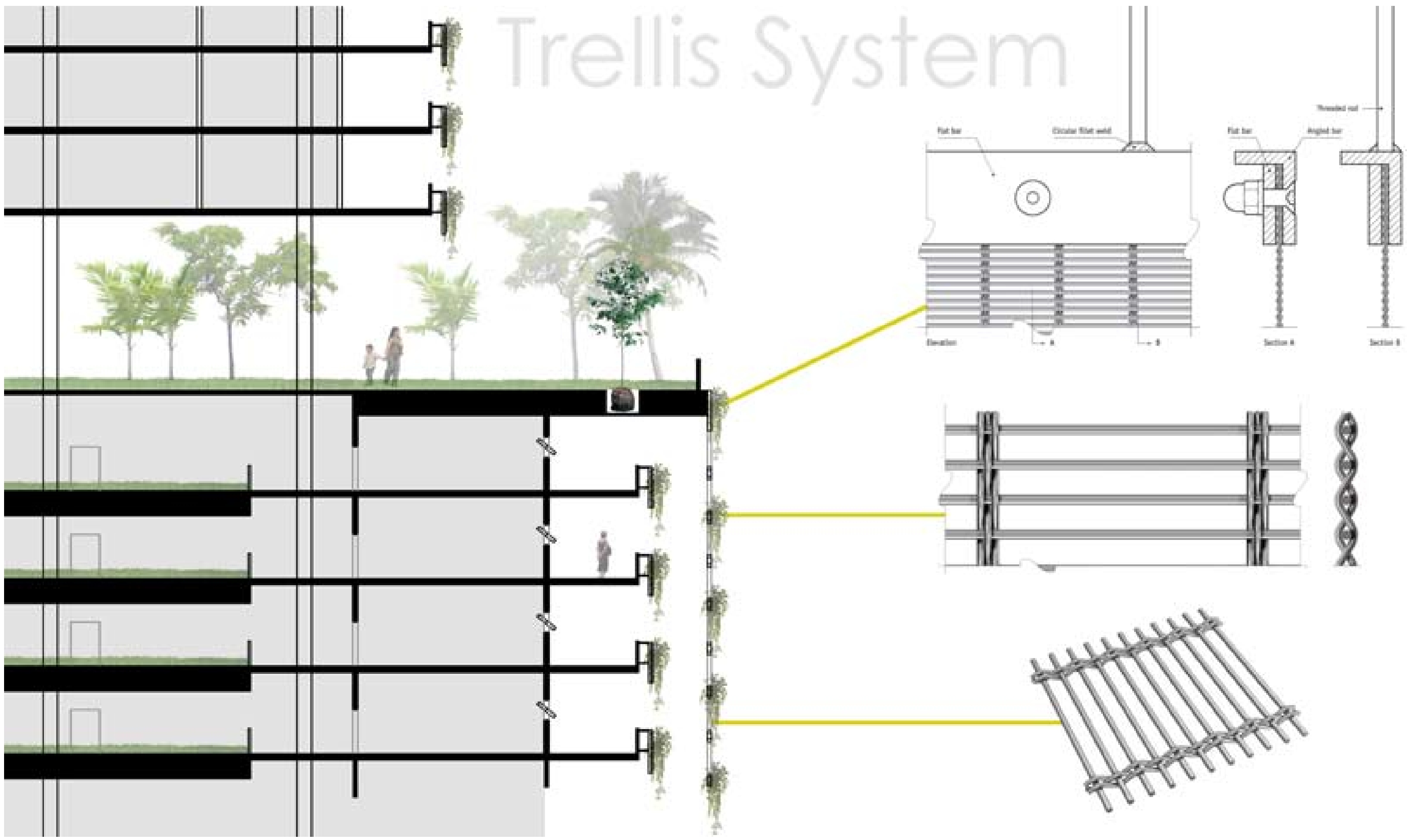


Fig. 61. Trellis System and Building Section

Cross ventilation was one of the main elements in this building design. The S shaped floor plan allowes for air circulation from the north west to flow throughout the structure and out the south west end. By creating a vertical neighborhood, this meant that each unit had a front and back yard that allowed for natural ventilation to take place, as showin in Fig. 62. The two main voids located at the north and south ends of the tower allowes for hot air to escape through the top of the tower, as shown in Fig. 63.

Ventilation Diagrams

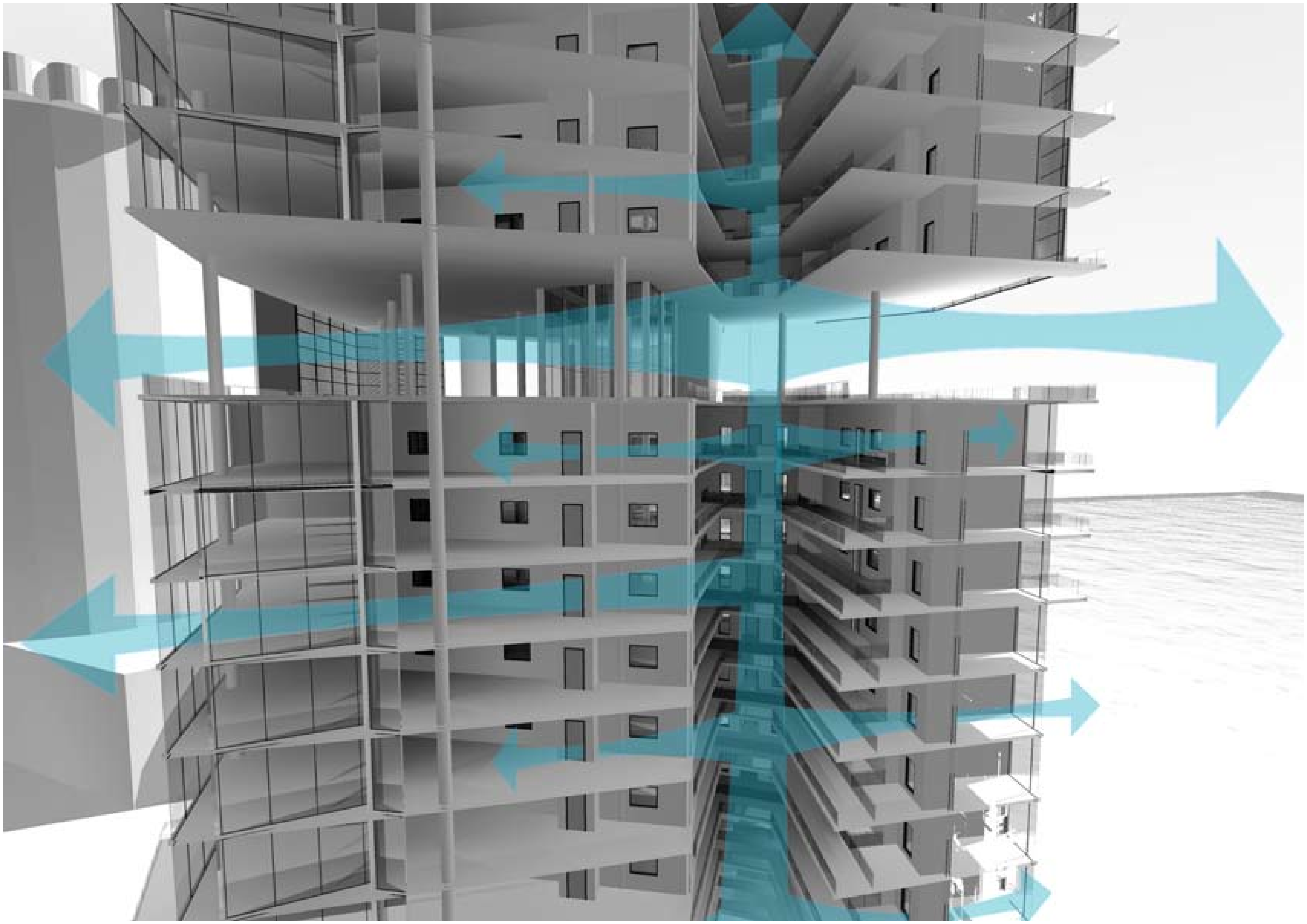


Fig. 62. Ventilation Diagram #1

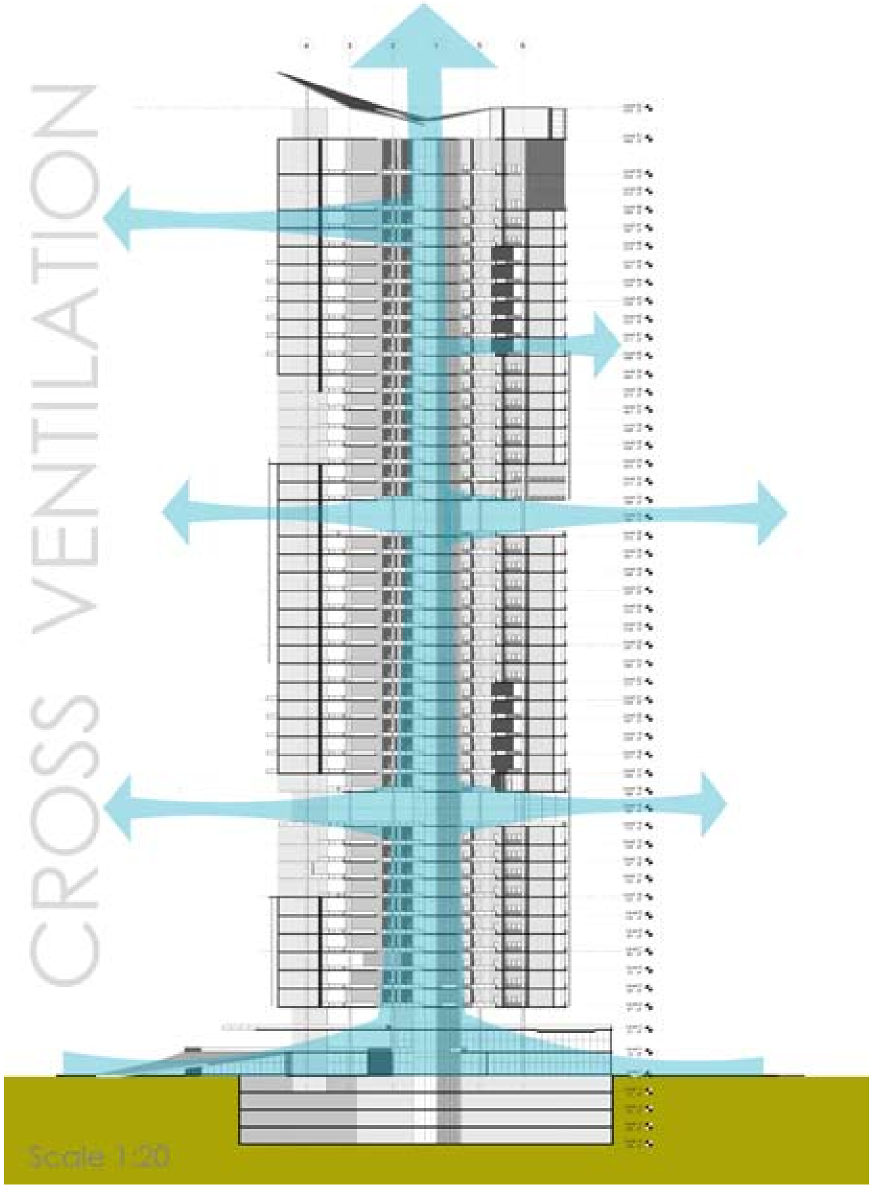


Fig. 63. Ventilation Diagram #2

Elevations

Fig. 64. East Elevation

Fig. 65. West Elevation

Sections

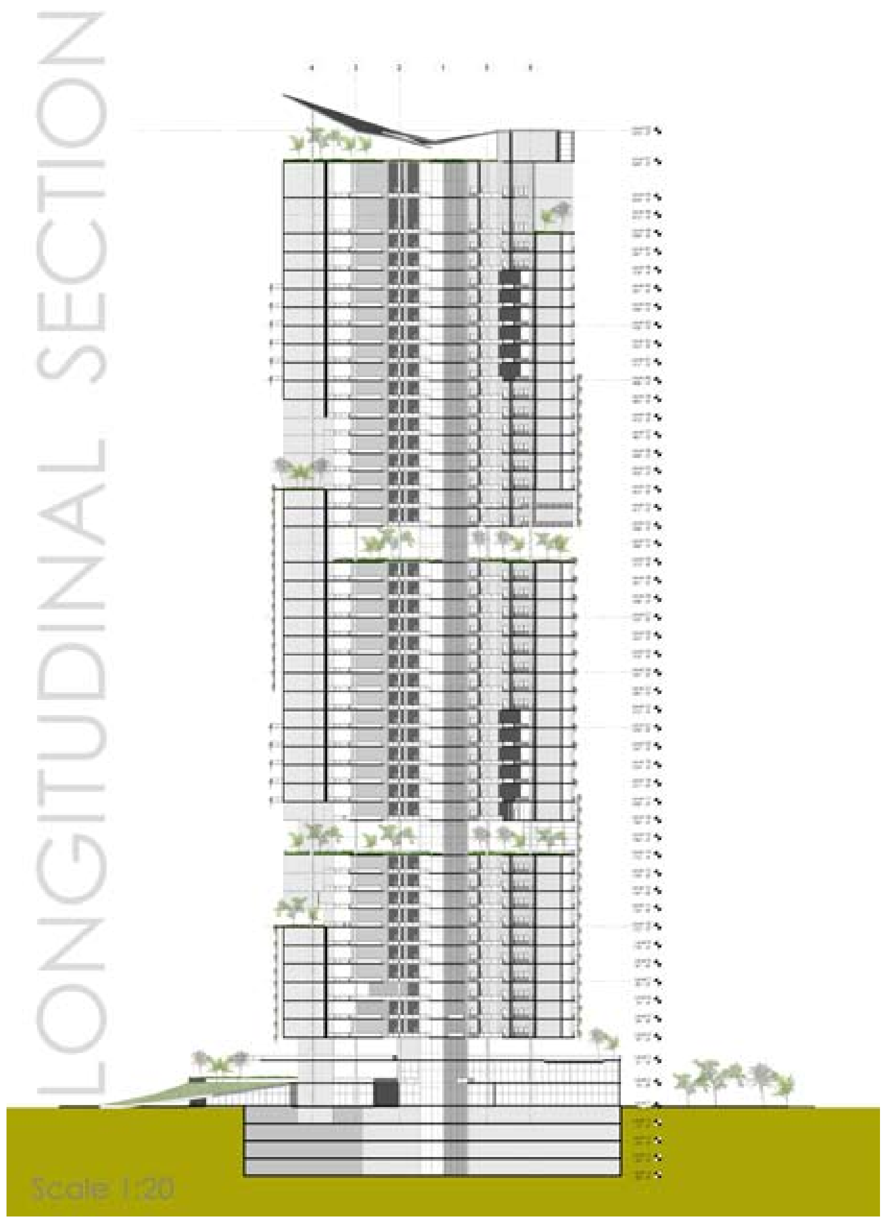


Fig. 66. Longitudinal Section

Fig. 67. Cross Section

Fig. 68. Cross Section

Perspective Renderings

Fig. 69. High Rise Design on Site in Punta Paitilla

Fig. 70. Bay Front View Towards High Rise

Fig. 71. Exterior Lobby Space

Fig. 72. Exterior Green Space within Tower

Fig. 73. Exterior Green Space and Trellis System

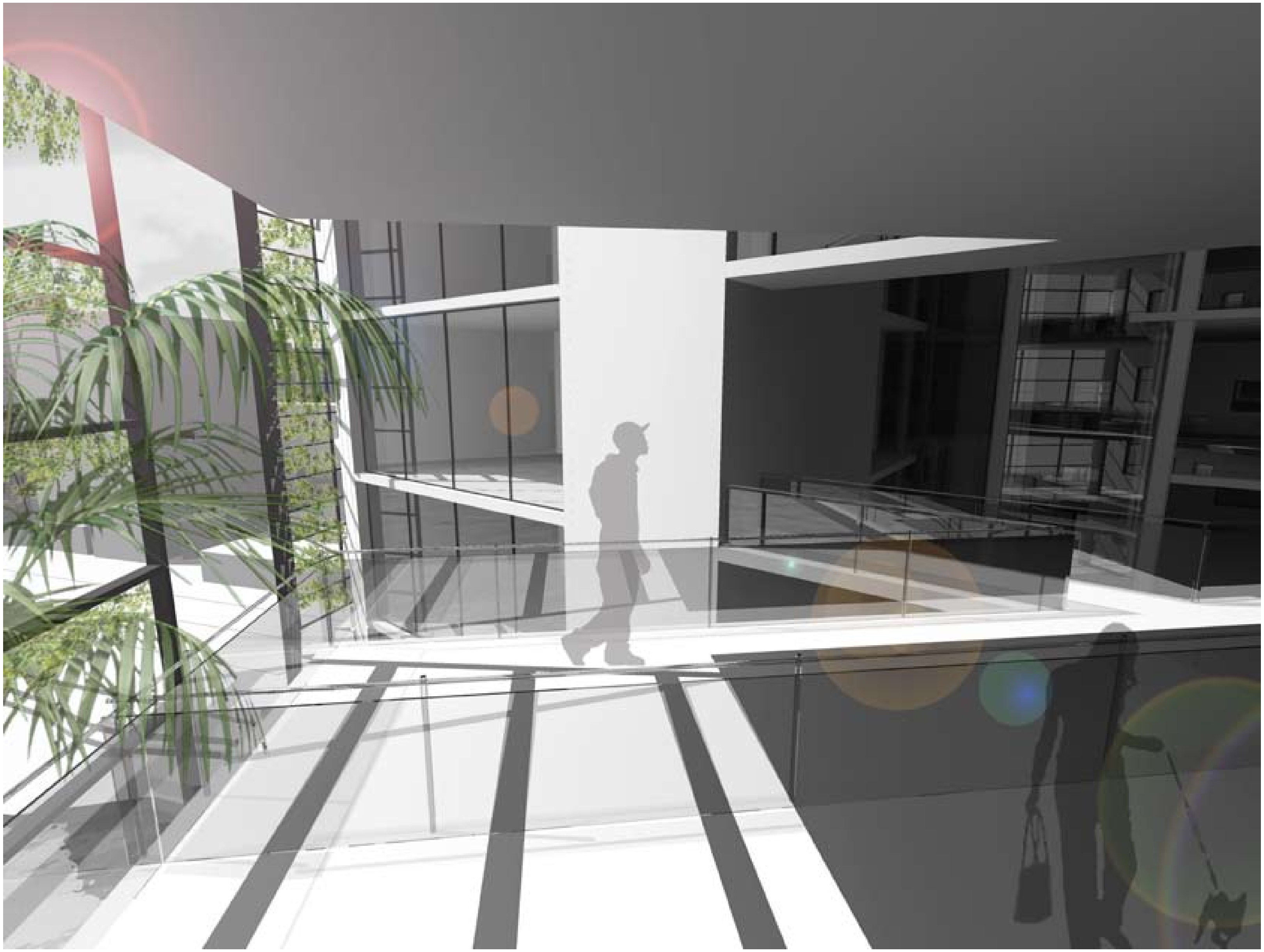


Fig. 74. Interior View of Intermidiate Space and Circulation

Fig. 75. View Looking Through Void

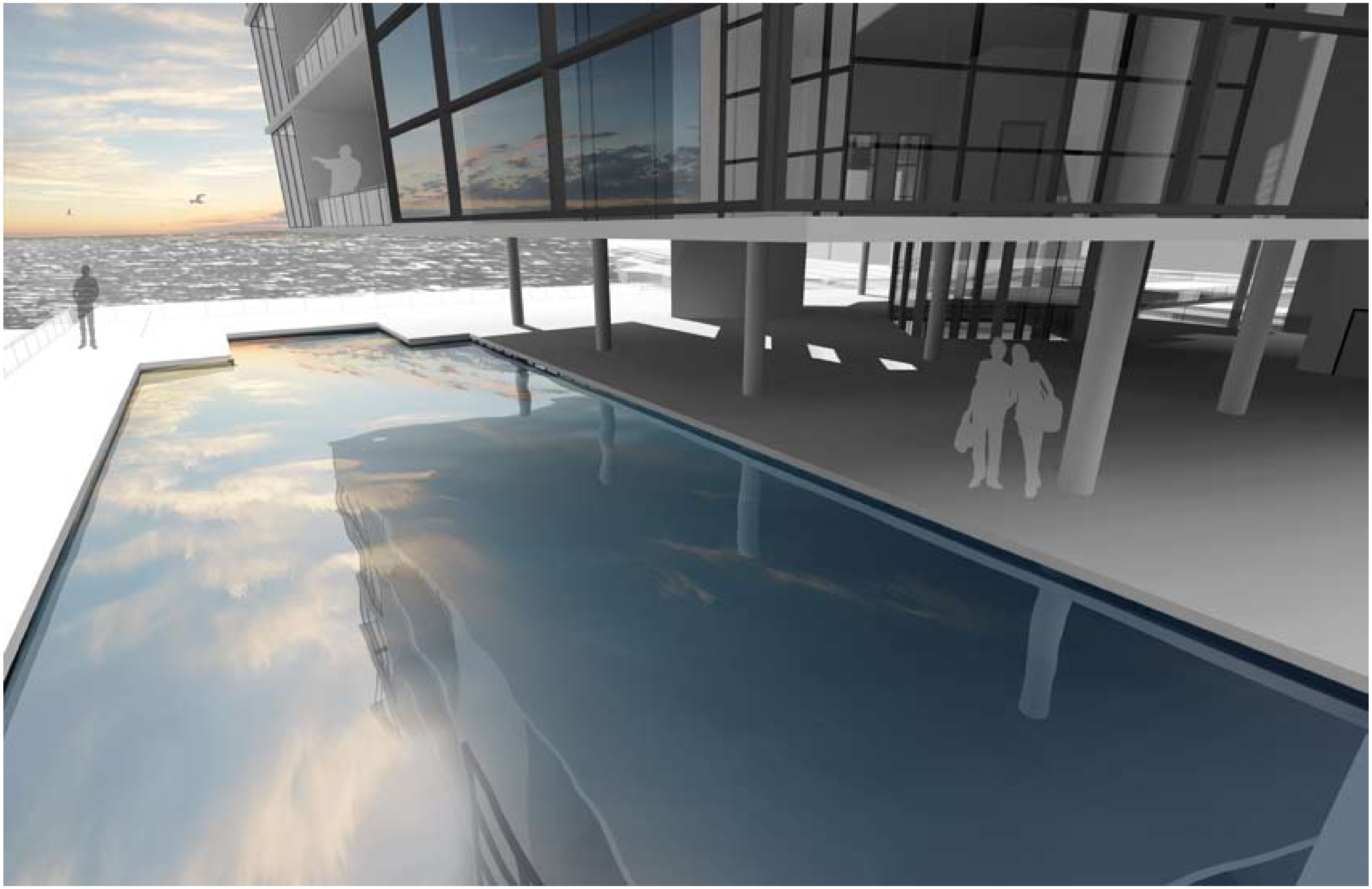


Fig. 76. View Looking West from Pool Deck

Fig. 77. Residential Communal Green Space and Circulation

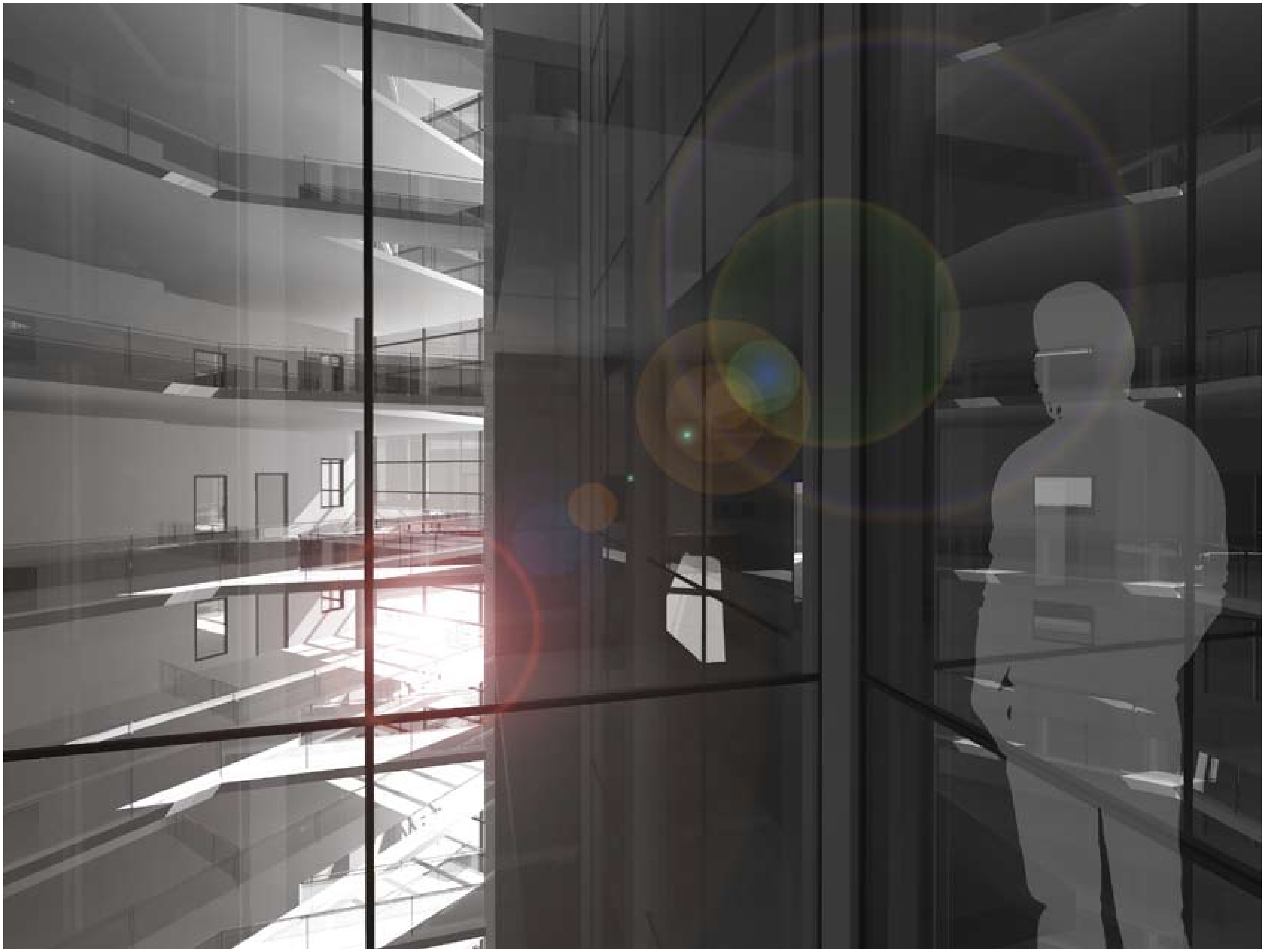


Fig. 78. View from Glass Elevator

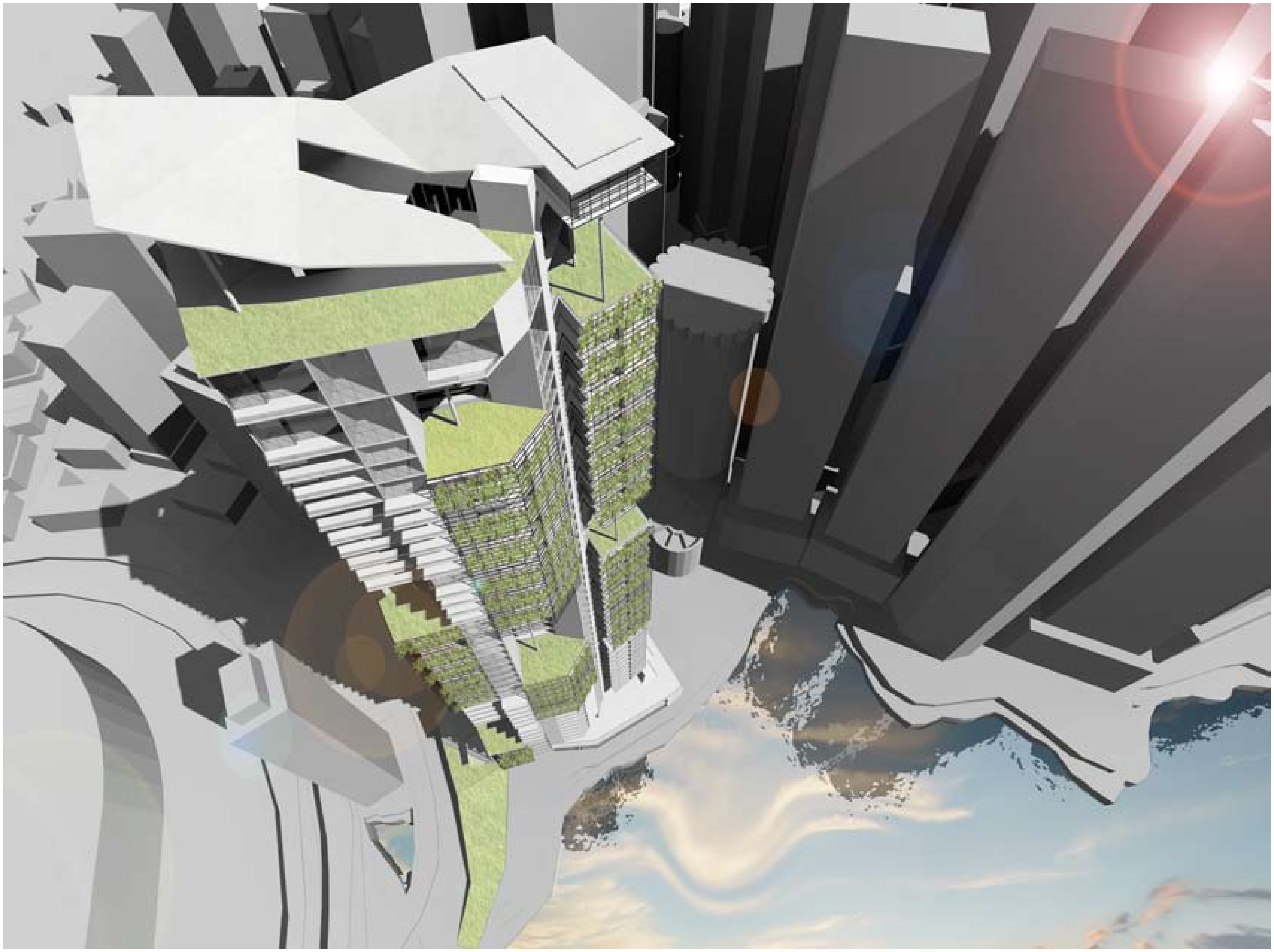


Fig. 79. One Point Perspective View of Tower on Site

Fig. 80. View Looking East at Tower within Main Plaza

Final Model

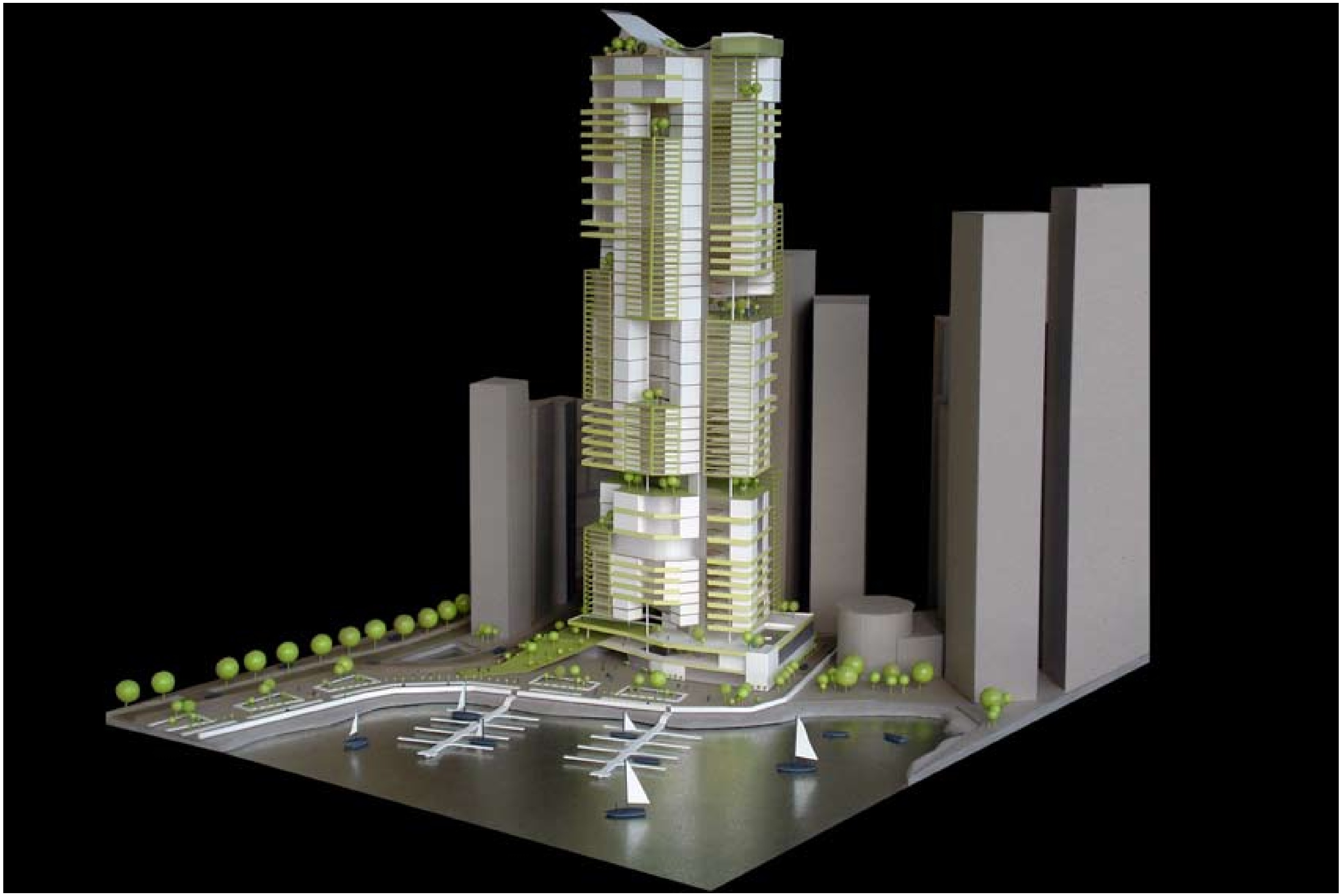


Fig. 81. North East View

Fig. 82. East View from the Bay Walk

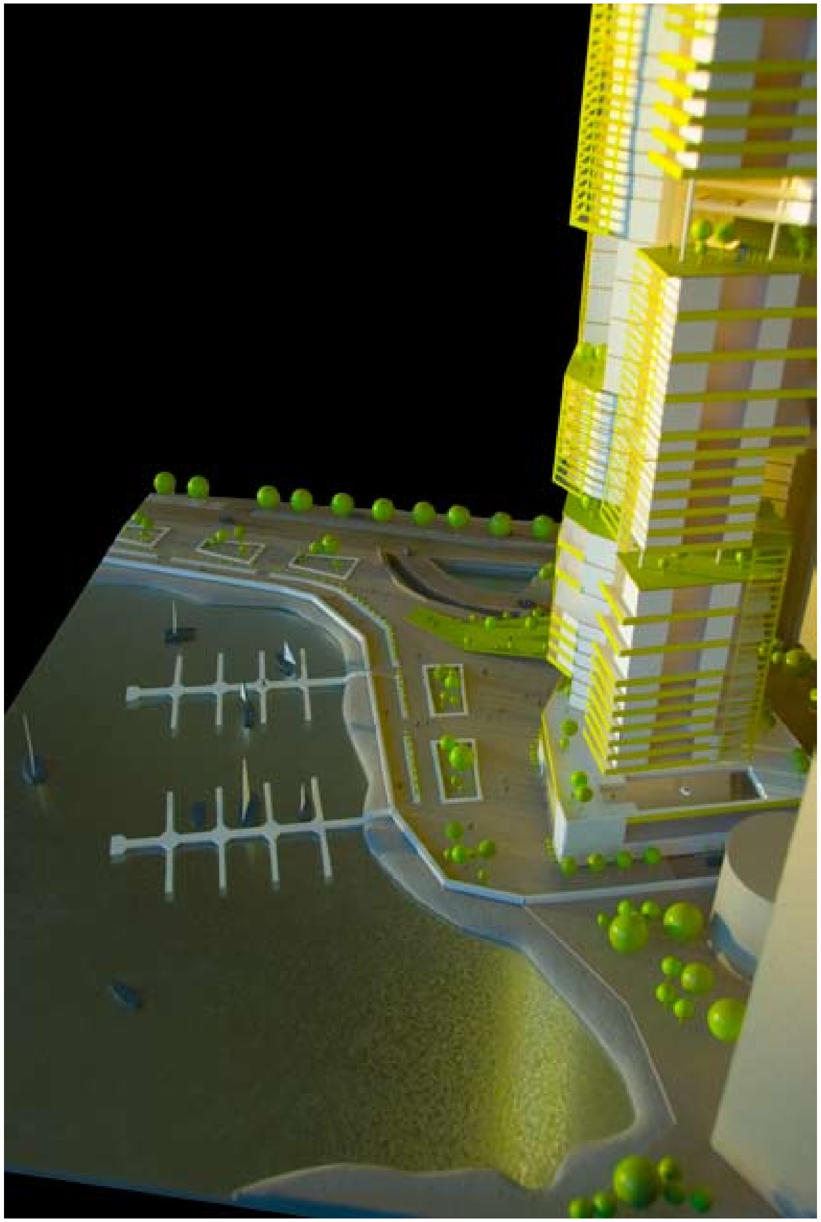


Fig. 83. North View

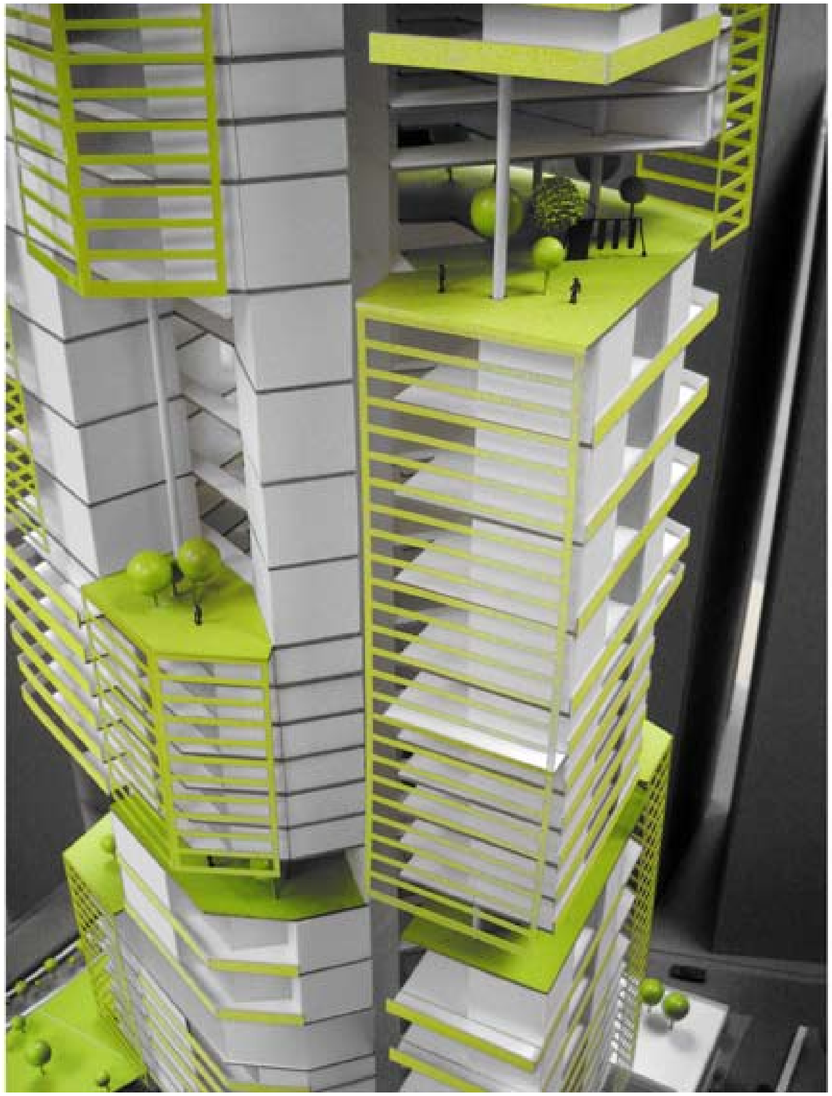


Fig. 84. Mid Tower View #1

Fig. 85. Mid Tower View #2

Fig. 86. North East View showing Rooftop

Fig. 87. Eastern View with Marina

Conclusion

This thesis was a collective arrangement of studies that began to look at the advancement of the residential high rise located within a dense tropical urban fabric. It was through much research in tropical climate, tropical architectural forms; effects of climate on architectural form, bioclimatic/ sustainable architecture; density/urban environment, green space; pocket parks, courtyards, gardens, yards, community, and sociology to understand the dynamics of the residential high rise located in a tropical environment.

The main idea of this thesis was to design a modern residential high rise building type that would be located within a dense tropical city, as it addresses the issues of context, community, sustainable systems, and public and private green spaces. The thesis began with viewing the existing context as a "sealed box" and beginning to break apart the infrastructure to see how it can be improved.

The idea of "breaking the box" refers to separating, or breaking apart the residential structure to allow for the development of public and private green spaces and other sustainable systems. The design began with a site specific tropical location within a dense urban city. After much research, the peninsula of Punta Paitilla located at the southern coast of Panama was selected. The site for this thesis is surrounded by an abundance of residential high rises to the south and a newly developed bay walk to the north-west. This provides the opportunity to reconnect the project back to the community as well as set precedence for a newly designed residential high rise.

The project begins with four levels of parking underground. The first level is public, followed by three levels of private parking for the residences. The ground floor includes large and small retail spaces, as well as a cafe and restaurant. The interior/exterior lobby spaces are main elements that transitions from the street access from the east to the water front to the west. It was important to design such amenities for the public and private, all while successfully separating the two.

The second level reconnects to the ground floor by a landscaped bridge that allows access to the retail space located above. The open green space provides for venders and other amenities to occur throughout the day. Overlapping, the third level is the pool deck for the residences. This overlapping design allows for a visual connection to the public spaces below, while allowing the residences to bask in the sun in privacy.

The remaining fifty-one levels include a variety of scaled residential units that incorporate multiple public and private green spaces throughout the structure. Two different vertical circulation systems were designed, allowing for options for the pedestrian circulation to occur throughout the floors and the communal green spaces.

The overall design was looked at being a success, as it incorporated multiple levels of green spaces that began to enhance a sense of community within this large vertical setting, as well as providing a multitude of options for the residents. This modern residential tropical high rise building type was seen to successfully address all these issues through orientation, materiality and sustainable systems. Although there is no definite way of concluding this thesis as being a true success, the hope for this project is that it can show that there are possibilities in tropical residential high rise developments in the near future.

End Notes

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