I, Luis E Sabater Musa, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture.

It is entitled:
Thermal Delight in Santo Domingo

Student's name: Luis E Sabater Musa

This work and its defense approved by:

Committee chair: Elizabeth Riorden, M.Arch.

Committee member: Christoph Klemmt, A.A. Dipl.
THERMAL DELIGHT IN SANTO DOMINGO

A thesis submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements for the degree of Master of Architecture

In the Department of Architecture Of the College of Design, Architecture, Arts, and Planning

by

Luis Sabater Musa B. Arch. Pontificia Universidad Católica Madre y Maestra Campus Santo Tomás de Aquino, 2013

Committee Chair: Elizabeth H. Riorden Committee Member: Christoph Klemmt
Global warming and climate change are inevitable issues\(^1\). In Santo Domingo, average temperatures have increased and escalated to year round uncomfortably hot and humid conditions in just the last twenty years\(^2\). Regardless, the current design and construction concepts have not adapted to this phenomena yet.

The construction is oriented almost solely around concrete and its derived components despite its poor thermal performance in the hot humid climate. Although this happens in big part due to availability and low labor costs, the strongest reason is cultural; people see the concrete as a symbol of safety and progress\(^3\).

In view of this, the following research intends to contribute a first step into a possible guideline to thermal comfort in Santo Domingo by understanding the climate and materials response to it. Ultimately, the project is meant to challenge the current design paradigm of what the dwelling building in the region is and what should it be.

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To Santo Domingo
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Imagine yourself planning your long awaited Christmas vacation, going somewhere warm to indulge the winter. In search of your paradise, you made Santo Domingo your destination, the first city in the Americas —Because you want more than just the all-inclusive experience… right? —

Upon arriving you head to the first plaza of America while playing an unusual but compelling game with your steps while chasing shadows. There you walked through the old arcades, under the evergreens, under the projected balconies above the sidewalks, right next to the edge of that building that casted the perfect blue tone to its west, and all that just for that lower temperature that shaped your way. Once at the plaza, the quiet steps of a small group of people walking on the stone pavement took you to a time five hundred years ago. You watched the faithful ones coming in and out the first Cathedral as the recurring sounds of its bells marked the passing of time. You breathed, the morning air still fresh under the shaded areas; the colonial square got filled with pidgeons as the elderly under the umbrellas tossed out raw corn for them to eat. —This was it, what else could you ask for? —

But as the biggest celestial body crossed over the top of everything, it became your craving to hide from its presence, to shelter from its harsh rays. The unavoidable and unceasing sweat started describing the geometry of your back, yet your body wouldn’t cool down because it was already too humid for that. The ease of the bottled cold water became as ephemeral as the breezes within the dense city. Humidity and heat were so overwhelming that it became hard to enjoy all the anticipated excitement you thought of. But the day was coming to an end; the sky was painted by an innocent pink tone, and with that same innocence you thought the night would cool you off. But the night didn’t plan for the longed temperature variance you were hoping for. At your Air b-n-b room, the heavy concrete walls started to let the stored heat of the day into the space. The single-vented façade was not inviting in the pacified winds of the night, and the ceiling fan was just moving the hot water vapor from one side to the other. —Well, who would have thought so? Next time make sure you get a room with an air conditioning unit. —
Fig. 1 Alcázar de Colón
BACKGROUND

You may say I over romanticized the previous tale — and maybe I did — but in fact one of the most frequent topics in Santo Domingo is the climate. It would be typical to hear anyone complaining about how overwhelmed they feel because of the heat and humidity at their own homes. To give you an idea, in Santo Domingo there is no actual Winter and not quite a Spring, nor Fall to ease the heat season, it is just Summer year round, one that goes from mild to harsh. Regardless, the architecture and the construction industry are merely starting to address this condition. Concepts like insulation or heat flow are not part of our vocabulary yet. I could argue in our behalf that the uncomfortable conditions are actually a recent phenomena; according to data registered by ONAMET, local meteorology office in Santo Domingo, temperature has increased over 5°C in the last twenty years. Therefore, our building industry was not necessarily mistaken before, since temperatures were usually comfortable, but things have changed, and so should the architectural response.

In view of this, I had to ask: Why do we conceptualize architecture around this poorly performing construction system, the concrete? The research revealed that the strong attachment to the concrete material and the little diversification of the practiced construction systems in Santo Domingo has its roots in historical and cultural misconceptions. It was the morning of September 3rd, 1930; the city of Santo Domingo was struck by the devastating hurricane “San Zenon”. The outline of the city at the time was comprised by colonial structures and arguably properly built wooden houses. Most of the city collapsed. Thereafter, official recommendations and regulations established the use of concrete as the primary construction system. Part of it also had to do with Rafael Trujillo, who was a dictator in the country and owned the concrete factories at that time, hence the regulations implied buying these products from his industries. Regardless, the new concrete structures withstood future coming hurricanes, and standard practice swiftly shifted away from its vernacular roots and traditional conception. Along with the international style influences, the concrete was adopted as an ideal of modernity and security, entering the collective subconscious of the Dominican people as “a symbol of progress”.

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Since then, construction practice has not evolved much, energy codes and regulations have not picked up the international trends, and even architecture schools have not integrated this body of knowledge to their curriculum. But still, despite novel technologies, despite scientific studies, facts, lecturers, and mostly, despite the poorly bioclimatic performance of this technology that affects us in our day to day life, it is a challenging idea for the people to believe in a different construction alternative. There then stood my following question: What should we be doing instead, if not using concrete? This research intends to shed light upon this debate, and additionally, it intends to propose a more appropriate idea of what a bioclimatic design might be in Santo Domingo.

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First, what is the Hot-Humid Climate? The Hot-Humid climate happens near the Equator. It is the antithesis of the temperate climate; lacking seasonal variation in temperature, and holding year round high levels of humidity and relatively high temperatures, though no extremes. The seasonal variance is mostly dominated by periods of high rainfall and a cyclonic season.

Then, what is Thermal Comfort? It is the state of mind that happens when a person is satisfied with the thermal environment. Comfort standards are related to temperature and humidity levels at which a person would feel comfortable, hence the importance of understanding these two climatic conditions. In hot thermal conditions, the human body has mainly four ways of lowering its temperature: convection, conduction, radiation, and evaporation.

Based on this, it would be a very good starting point for conceptualizing architecture to ask ourselves: How is my building helping the occupant’s bodies loose heat through each one of these categories? How could the air be cooler so we can lose heat by convection? How could thermal mass be cooler than air temperature so the body can lose heat to it by radiation? Consequently, we could deduct based on the previous notions that in the realm of thermal comfort, the hot-humid climate presents two major problems: excessive solar radiation and high moisture content in the air. Thereafter, we can further deduct that searching for thermal comfort in these zones would be equivalent to cooling and dehumidifying, which architecturally would translate as Shading from Solar Radiation and Natural Ventilation for dehumidifying.

Also, keeping in mind the little annual variation, the minor day to night temperature drop, and the constant high humidity; we could rule out typical misplaced strategies like evaporative cooling and thermal mass. Evaporative cooling would add moisture to the already humid air. And thermal mass can cause unwanted re-radiation to the interior spaces at night from the stored and unwanted heat of the day. Although, if a space is meant to be used just during day-time, like an office building, the time-lag property of thermal mass could be a desired thing, since it might resist the outside temperature reaching inside until the end of the working hours.

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THE CASE OF SANTO DOMINGO

Santo Domingo is the capital and largest city of the Dominican Republic, it is also the largest city in the Caribbean by population. Its coordinates are 18°26’ N and 69°53’ W with a tropical climate that has little annual variation. Average temperatures range from 78°F to 83°F and relative humidity from 80% to 85%². It is worth observing that temperatures are not terrible, it is the high humidity that makes these temperatures unbearable. High humidity in the air will prevent the body sweat from vaporizing, hence reducing our capacity to tolerate higher temperatures, the same temperatures could be comfortable in a lower humidity³.

A rapid evaluation would suggest that dehumidifying should be the top priority, hence strategies like crossed ventilation are likely to be desired. The problem in the suburban context though, is that providing airflow for ventilation can be difficult due to high density of buildings. In addition, the orientation of plots provides problems where buildings face the street but not necessarily the optimum sol-air orientation⁷. The heat island effect also happens in dense urban areas, that is, the nocturnal elevation in temperature as compared to rural temperatures. In view of this, it would be acceptable to question the data provided by ONAMET, since the weather station collecting the information is located outside the city, at the airport. Likewise, it would be reasonable not to solely rely on ventilation strategies, but to try cooling the building through the envelope, which will likely be the most manageable element.

Nevertheless, in order to properly implement desired passive strategies, several concepts that shape these shall be understood: building shape, orientation, solar geometry, air flow dynamics, materials properties, and heat flow dynamics. The following chapters will frame these main concepts under the designation of Bioclimatic Design.

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Fig. 5 "Yun-yun"
02 | BIOCLIMATIC DESIGN
BIOCLIMATIC DESIGN

Olgyay was the first to suggest a scientific approach for assessing harmful and beneficial features of climate. He began an analytical investigation of climate through a series of steps which he named “bioclimatic design”. Following his work, Givoni, Konya, Hyde, and other researchers have expanded and adapted Olgyay’s method for different climates. However, the original method is still an easy breakdown used for this research’s purpose and can be summarized as:

**STEP 1: COLLECTION OF INFORMATION**
Get to understand your site's climate. Inquire what is the Seasonal and Daily Climatic Data, these are the Macroclimate conditions. Important data being: humidity and dry-bulb temperature recorded for a typical year, complemented by Minimum and Maximum conditions on a monthly basis.

**STEP 2: THE BIOCLIMATIC CHART**
Map the climatic data on a chart and call out when the conditions are out of comfort zone. Analyze the cause of this, and predict strategies to help the specific issues.

**STEP 3: PLANNING THE STRATEGIES**
These are the strategies that in view of the analysis on step 2 would better respond to the conditions. These strategies can be divided in two levels; the first relates the building with its context, such as orientation, landscaping, and building form. The second relates the building and environmental control characteristics, such as shading strategies, materials, assemblies and sections design. A more in-depth review of the Contextual Approach and the Environmental Control in the Building Design will be reviewed next. This should satisfy our search for conceptually understanding the approach to designing in a Hot-Humid Climate.

Following these steps I analyzed Santo Domingo’s climate data provided by ONAMET from 1990 to 2016. I found out that the climate conditions go out of the comfort zone year round, but specially from April through November, and it is more due to humidity levels than to high temperature. A simple recommendation is to shade and ventilate. By shading and dehumidifying we can extend the comfort zone time to roughly a 60% of the year. Still, a considerable amount of time will have to rely on conventional air conditioning.

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IF

I can see this becoming that
(Vernacular Houses, Puebla, Mexico)

WHY?

But, I can’t see this becoming that
(Vernacular House, FL, USA)

WHY NOT THIS?
CONTEXTUAL APPROACH

Tan Hock Beng said: "Many architects working in the region today have forgotten how to design bearing in mind the climate and landscape. They have been caught in the homogenizing forces of mass media and are repeating the built mediocrities of international fashion." It is sad to admit that the failure of most buildings in Santo Domingo starts here. The design is mentally located in a different place with another climatic condition, hence abiding by a different set of rules that often do not work for the tropical context. Whereas in cooler regions, strategies are more related to the building, such as: the fire place, higher mass, higher insulation, reduction of windows sizes. This pattern should not be followed in warm climates, because it is more dependent on the relationship to the building context and its microclimate. Since the main passive cooling strategy is ventilation, building orientation and careful design of openings are a primary concern.

BUILDING ORIENTATION

Building Orientation refers to shaping and orienting the building in a way that some faces will receive the less heat gain and others will embrace desired winds. Normally for a Hot-Humid Climate, most of the solar gain comes from above and unwanted radiation from the west during afternoon hours, from the low solar angle when the heat of the day has already built up. This notion leads to minimizing the west façade of the building in order to reduce the unwanted afternoon radiation, and to pay special attention to the roof. Basically, forms elongated in the east-west directions are preferable. Although, the function and size of the building might change this priority.

OPENINGS DESIGN AND AIR FLOW

“In hot humid countries, a building layout which provides good potential for cross-ventilation is of primary importance.” Careful design of the openings of a building can guarantee successful ventilation. For hot weathers, it is more important the speed of the flow than the amount of air.

NATURAL VENTILATION COOLING

It is imperative to understand air-flow dynamics. A basic concept is to remember that if there is no outlet on the leeward face, no airflow will occur inside the building. Similarly, big openings placed opposite one to another, and positioned at the high and low pressure areas respectively, will provide the maximum air changes within the structure. Along the same lines, by using a small sized opening and a larger outlet, "Venturi Effect" occurs, provoking maximum air speeds within the building. Another key notion involves having the intake face of the building being perpendicular to the windward direction. Although this would grant better air intake, if it is not possible to orient the building like this, strategies like wing wall structures can help direct the air into the interiors.

LANDSCAPE AND IMMEDIATE CONTEXT

Finally, for the contextual approach, the surrounding landscape in warm weathers will have a profound impact on the thermal comfort of the building. Carefully selected trees are planned for shading where they are needed. Furthermore, planting should be designed to direct and accelerate beneficial air movements into the building and not to block them where desired. Having proper landscape and groundcover also will help to lower temperatures around the building due to plant cooling.

CONTEXTUAL APPROACH CONCLUSION

In a nutshell, the approach to bioclimatic design in the tropics starts with the context. The immediate context is the first buffer zone, hence it is a priority to carefully plan the immediate landscape and surrounding of the building in order to shade and direct air flow. The most climatically effective approach to building design in Hot-Humid Climates is to open to breezes while closing to direct sun. After analyzing this macro conditions, we can jump to a closer scale: the building approach.

Fig. 8 Conceptual Diagrams

1. Rethink the desired shape and desired orientation.

2. Let some air through, man!

3. Rethink the monolithic assembly; we won't need re-radiation at night coming from thermal mass.

4. Air tightness is not needed; inhabit the layers, man!

5. Rethink the proportions; open space vs enclosed space.

6. Shading and ventilation can get you free thermal comfort, leave enclosed space for privacy matters.

7. Can't cross-ventilate all spaces on a thin plan?

8. Then, rethink your section!

9. Rethink the architecture.
BUILDING APPROACH

SHADING

In the book “Solar control and shading devices” by the Olgyay brothers, we are given a very scientific method for approaching the shading necessity in a project. It is the “When, Where, and How” method. When? As a first rule of thumb, let’s say that a building needs to be shaded whenever it is in an overheated period. Santo Domingo, being overheated the entire year, should account for a precise shading calculations. Where? As a second step, knowing where the specific position of the sun is during overheated times can lead to knowing where to block it (one can use the sun diagram for this). How? By gathering data on “when” and “where” we can proceed to design the desired “Shading Device”. It can be said, that if your shading device covers at least 50% of the needed shading time, it will be effective.

As general rules of thumb: for south oriented elevations, horizontal shading is more effective. For east and west, vertical fins are more effective, if they slant, they should open toward the north. For southeast or southwest orientations, egg crate types work more efficient. For north, vertical and horizontal devices perform well.

Traditionally, Ray Tracing diagrams were required to precisely mark the solar penetration at times when radiation is not desired, and based on that, designers would design the shading devices. These shading mask methods were complex, and it could take a great deal of time to figure them out. More experiential approaches like the Heliodons were designed to test shading devices on physical models. However, now we can digitally model our project with detailed shading devices under a specific set of coordinates, and simulate the real sun incidence on the model at any given time of year.

This precise concern for the location of the sun in relation to the building should be a major generator in the building design. The important technical significance of shading is that it not only frees the wall from heat gain, but also from rain. This gives the designer considerable flexibility in the design and construction of the wall, its function becomes reduced to providing ventilation, security and defining views.

SELECTIVE PROGRAMMING

Climate Responsive zoning is a simple but powerful concept. It means to plan the location of the spaces to the best convenience according to the temperature and sun position at the time that the space is meant to be used. For example, if an activity is meant to happen in the afternoon when the west sun is hard, it would make sense to place it to the east.

The same concept can also be used for deciding upon construction assemblies. Areas that would just be utilized during day-time, a thermal mass assembly could be of benefit, since the time-lag delay could shift the heat spikes until hours later when the space would not be in use. Similarly, for rooms which will be used at night for sleep, assemblies should be light enough to lose heat to the environment as the temperature drops, you do not want to have an interior space warmer than the outside temperature for resting purposes.

Following we’ll dive deeper into understanding heat flow through the building envelope. This will answer what should be the right approach to the envelope in the Hot-Humid climate.

---

HEAT FLOW & BUILDING ENVELOPE
HEAT FLOW AND BUILDING ENVELOPE

All external heat and humidity impacts must pass through the building shell before outdoor conditions affect indoor ones. This is a lot of responsibility on that edge, on that transition space. By understanding this we should be able to answer our questions: Why is the concrete a bad idea in Santo Domingo? And what is the edge of the building meant to be there?

HEAT FLOW

Understanding heat flow is fundamental to all aspects of climate control. In essence, heat flow always happens from hotter to colder, and the same from humid to dry. The heat flow can be measured in two forms; sensible heat flow (for temperature) and latent heat flow (for moisture content). Each material used in an envelope assembly has physical properties that determine how that material will interact with the sensible heat. This is known as Heat Transmission Properties, which include: Conductivity, Conductance, Resistance, Heat Capacity, and Emittance. Of these, the reduction of heat-flow is most efficiently achieved by the “Resistance-insulation” property.

The desired insulation is directly related to the difference between outside thermal conditions and interior comfort requirements. From the yearly maximum temperature range, a direct relationship can be established to the needed insulation values, this is called “insulation-index”. Typically, the design criteria would be established based on the hottest day of the year: July 21.

THE BUILDING ENVELOPE

From a construction perspective, the exterior enclosure consists of surfaces, numerous materials and components that are assembled on site or pre-fabricated to meet the intents of a design. Typically it includes materials like sheets, blocks, bulk products, membranes. From a thermal efficiency perspective the job of the envelope is to ensure that a proposed system will meet the design intent and criteria, which in this case would be based on desired temperature and humidity levels. This is typically thought of in terms of how many BTUs/h would the HVAC system need to supply in order to fulfill the cooling or heating loads.

INTERNATIONAL TRENDS AND SANTO DOMINGO

Current trends in envelope thermal performance can be followed since the early 1970’s, walls have progressed from using R-7 batts between typical 2 x 4 IN. studs, to use R-26 batts between 2 x 6 IN. studs plus insulating sheathing, thereby providing a threefold reduction in heat flow. Insulated SIP now approach R-25 per inch, future advances could produce yet another threefold reduction in heat flow without increasing the wall thickness.

This trend profoundly competes with the current panorama in Santo Domingo. Based on interviews, an average architecture student and practitioner in Santo Domingo thinks of the envelope as a synonym of a concrete product, whether it is a reinforced concrete structure or a CMU wall with or without mortar finishes. There is no concern nor notion for thermal properties and performance. The low diversity in our practice is also reinforced by the fact that Santo Domingo has no Energy Code, hence the lack of compliance rarely motivates the envelope to consider thermal performance qualities.

Fig. 11 Reflective Envelope
HEAVYWEIGHT VS LIGHTWEIGHT CONSTRUCTION

When we refer to the construction type as light, in terms of thermal behaviour it means that the heat fluctuation will be similar to outside conditions, generally overheating during daytime and cooling during night time. The heavy construction on the other hand, regulates temperature shifts, prolonging the time that outside temperature takes to affect interior conditions. This makes it better during daytime, but certainly would not let the building lose heat fast enough during night time.

We may think to find some contradictions when reading Givoni 13, who has said that on a cross-ventilated building thermal mass can perform better than lightweight construction if an exhaust fan that counteracts the re-radiation effect is provided for the night time. But, when Givoni talks of “High-mass”, he talks of 10cm thick concrete assembly with external insulation, which is still much lighter and thermal resistant than a typical 20cm thick concrete assembly without insulation used in Santo Domingo.

Being aware and smart about these notions leads into selective design, meaning, for daytime used areas is better to use heavy materials, while for nighttime used areas, the use of light materials would perform better. But in general, for our climate conditions in Santo Domingo, where temperature shifts within a day are not big, light construction is preferred. It is important to note that, while light heat capacity is better for the envelope, thermal mass located inside the structure can stabilize diurnal temperature conditions.

In conclusion, buildings in the Hot-Humid climate should be thermally lightweight, since night temperatures might not be enough to remove the stored heat of the day 9.

---


Fig. 12 Heavyweight Construction

Fig. 13 Lightweight Construction
RECOMMENDATIONS AND CONCLUSIONS

In summary, the main strategies for thermal comfort in the Hot Humid Climate are Shading and Ventilation:

**Cross Ventilation**
Most important strategy on this climate, to be used for dehumidification purposes. Fenestration should be highly minded for adequate ventilation and specially when the envelope is insulated, since it could prevent heat from coming out when desired.

**Highly reflective and light colored materials**
These are the most important characteristics of the envelope on this climate. These will reflect heat from the building and reduce surface temperatures.

**Resistance insulation**
This should be used as a sine qua non condition. In particular, the best practice might be the use of double-sided reflective foil in the interior of the assembly. Optimal R-values being 15 and 30 for walls and roofs respectively 15.

**East and West Faces**
These are to be specially treated, the use of bulk insulation to prevent peak heat gain from low-angle sun is recommended. Also, by avoiding windows one can cut the direct gain from the morning and afternoon solar gain.

**The Roof**
Here is where the highest thermal incidence happens has mainly two aspects; Reflecting Foil Layer and Color, and Insulation 7. The use of bulk insulation will cut the heat gain by convection, but it may also reduce the ability of the roof to lose heat at night unless ventilated. This is why other strategies like ventilated double roofs and attic spaces happen, where the upper roof if functioning mostly as sun protection, while the lower roof should be well insulated since it is the actual edge between interior and exterior. Ideally, a wide overhang should also protect from rain, which normally comes at 45°, and reduce sky glare.

**Humidity**
It can be controlled by cutting the admittance of water vapor inside. Through the envelope’s perspective, the less permeable a material is, the greater resistance to water vapor flow. These materials are usually named Vapor Retarders. These are very thin materials, which take virtually no space. These must located regarding the dew point of the assembly. A general rule of thumb would be to place it on the warmest side of the wall, which would be closer to the exterior face if working on the tropics. Other novel method is the use of solid desiccant salts; these can absorb very high quantities of water vapor in the air, thus lowering humidity levels.

**Economic Implications**
By the end of the conversation with Phd. Abrúña 15, I asked him how to convince a client to make this extra investment on properly insulating their construction. He made reference to his project “La casa ausente” in Puerto Rico, in which the cooling loads were cut to a quarter of what is expected out of a similar building using conventional assemblies. Abrúña stressed that the benefits of minding all these passive strategies are found in the life of the building rather than in any immediate measurable aspect other than the thermal comfort of the users.

**Envelope Conclusions**
To the right, a comparison chart was developed to contrast the energy performance of the standard construction practice in Santo Domingo to other assembly alternatives. The conclusion is that the optimal performance can be achieved by a well shaded lightweight construction, adding light insulation can get us to the best possible scenario.

---


**CONCEPT**

**BASELINE**
Typical System in Sto. Dgo,
CMU and Concrete
U- Factor for Glazing – 0.9
SHGC – 0.9
Walls R-Value – R20
Roofs R-Value – R30
Floor R-Value – R30

32,053 KBTU/YEAR

**LIGHTWEIGHT**
Lightweight Construction
Studwall and No Insulation
U- Factor for Glazing – 0.9
SHGC – 0.9
Walls R-Value – R5
Roofs R-Value – R5
Floor R-Value – R5

26,798 KBTU/YEAR

**HEAVYWEIGHT & SHADED**
Heavyweight Construction
Shaded Openings, No Openings on E/W Facades, CMU and Concrete
U- Factor for Glazing – 0.9
SHGC – 0.5
Walls R-Value – R5
Roofs R-Value – R5
Floor R-Value – R5

25,312 KBTU/YEAR

**LIGHTWEIGHT & SHADED**
Lightweight Construction
Shaded Openings, No Openings on E/W Facades, CMU and Concrete
U- Factor for Glazing – 0.9
SHGC – 0.5
Walls R-Value – R5
Roofs R-Value – R5
Floor R-Value – R5

21,872 KBTU/YEAR

**INSULATED**
Lightweight Construction
Insulated Assemblies and Double Pane Windows
U- Factor for Glazing – 0.4
SHGC – 0.6
Walls R-Value – R15
Roofs R-Value – R30
Floor R-Value – R30

21,021 KBTU/YEAR

**INSULATED & SHADED**
Lightweight Construction
Insulated Assemblies and Double Pane Windows, Studwall Construction
U- Factor for Glazing – 0.4
Walls R-Value – R15
Roofs R-Value – R30
Floor R-Value – R30

19,059 KBTU/YEAR

Fig. 14 Envelopes Performance Comparison
SANTO DOMINGO, THE SITE AND THE PROJECT

The site in the city of Santo Domingo is located along the Anacaona Ave, across the Mirador Sur park. This street is planned to be a high-rise zone of high-end residential buildings that overlook the park, which itself overlooks the Caribbean Sea. Given the site's strong connection with the Park, it becomes important to understand the park itself, its use, and the current social dynamics that take place in it.

The major winds come from the south during daytime and from the north during night time. Responding this and to the existing park becomes a priority for this project. The park is the biggest public space extension in the city, being five kilometers long by almost a hundred meters wide. Commonly use for low intensity sports as walking, jogging, biking and roller-blading. And it is also a typical venue for a family Sunday, where kids would run freely, ride the inner street cart, fly kites, eat ice cream and enjoy a picnic time.

While most of the buildings being developed in the Anacaona Ave. are highly private with a controlled access, the idea of this project is to integrate the life park to the building dynamic while at the same time being really conscious and scientific about the climate response.
LEARNING FROM OTHERS

The precedent’s floorplan compilation to the right was drawn off of existing projects from around the world. This was helpful in many ways: to become familiar with what different architects around the world are thinking, to understand what a typical layout for an apartment unit is, what is the scale on a project like this, what is the program, the relationships, but more importantly, this exercise was helpful to see how these units are approaching climate responsive design and how it might perform in a tropical environment.

These projects are located in Hot-Humid zones: Dominican Republic, Italy, Australia, Malaysia and Singapore. If I could call out some things to notice, these would be: the proportion of balcony or “open” space versus “enclosed” space; the depth of the unit and how it helps cross ventilation; the amount of garden space being integrated to the units and how this brings plant cooling; shading devices protecting the unit; and organizational strategies around service versus served spaces.

The best bioclimatically responsive units tend to offer more balcony space, shallow sections for better cross ventilation, garden space as amenity and cooling strategy, and shading. All these talk about one thing: attention to context, to the edge of the building and to that buffer zone between outside and inside. Nevertheless, it becomes interesting to me how some of these units are pushing this idea of “living outside”, by giving major importance to the balconies.

With these notions in mind, the DNA of our proposed unit starts to emerge, and it shall shape the proposed building. Following, site plan studies on how to approach the selected site.
SITE PLAN STUDIES

The design process started on different scales at the same time: the scale of the unit, which was the clearest thought; the scale of the building that simulated the conditions of living in a canopy; but neither one could simply fit into the site, which is bigger than I was hoping. So I started to quickly iterate on site approach possibilities. In some of these, the mass is broken in two, or three, or subtracted by a courtyard like space. But mostly, I was just getting familiar with the scale of the project.

Then, having in mind the type of spaces I wished the project to have, the quality of the light according to the orientation of the masses, the solar impact and the wind direction for cross ventilation, I started thinking about many possible site configurations to shape the project. After multiple iterations, I chose the ones that worked the best, and proceeded to work on how to mass some of these.
Fig. 19 Site Diagrams
As usual, I went to my sketchbook and later on to built several working models. It took me a while to really understand the scale of the project. But the same ideas were shaping these iterations one way or another.

The project’s intention was driven from the particular unit experience. The priority was to make it so that it would cross ventilate entirely, offer as much outside space as possible, while keeping its closure easily customizable by the user. Hence a thin section for cross ventilation, high amount of balcony space, and a skin for shading and wind control. But all these dictate so little in the massing of such a large building.

Hence, for these form iterations something needed to speak more to the overall building. As part of the context of the project, another intention was to expand the public character of the park up into the building. These iterations explored this idea through a set of platforms that break the massing and offer a space to watch marathons or any other activities happening in the park below.

DESIGN PROCESS

Fig. 20 Working Models
Since it is out of the thesis scope to comprehensively design the entire project, I still felt necessary to give an idea of what different moments in the building outside the units should feel like.

Number one conveys the idea of approaching the building from the street. Different layers of green work to slowly detach you from the world happening outside the project. Glimpses of different activities and other public levels start to pop out to the view through the different green platforms.

Number two talks about perceiving the vertical aspect of the park. While the lovers enjoy a moment on a lower level, still a connection that permits the experience of higher grounds through glimpses of the private program is there.

Number three is about being on the park up there, behoding the street and the park at the ground level, and reading the different layers of Santo Domingo at that point: where you see the park, then the city, and then the Caribbean sea as the final background.

Number four describes a moment in the unit. Where you can see that the edge between outside and inside is not clear. The green is still part of the unit as part of the buffer from exterior to interior. The scene describes the entry sequence by showing a woman and a child entering the unit from the balcony. Finally, the backdrop again is the park, the city, and the Caribbean Sea.
The project’s intention to connect to the Park in front is apparent in the Transversal Section. The idea is to bring the green of the park and its public character to higher grounds through a set of platforms that could also be used as a place to watch marathons or any other activities happening in the park below. The idea is translated into three public green platforms that split the massing of the building creating more opportunity for plant cooling, cooling by convection through the generated shaded spaces and opportunities for heat loss to the free flowing air bathing the project.

The three volumes also organize the different levels of privacy in the project. The bottom one is dedicated to the most public part of the program, embracing the semiopen courtyard that becomes the visual center for the gymnasium, conference rooms, administrative offices and cafe. The middle mass contains the bulk of the residential spaces. The co-living idea starts to generate different spaces and strengthen the idea of a bird’s nest or tree canopy kind of habitat. The units range from studios to single and two bedroom units. The third volume is the house of the high end condos and penthouses. The shallowness of depth provides the ability for cross-ventilating most of the spaces in the units.
05 | DESIGN DEVELOPMENT
ESSENCE
LIVING IN THE CANOPY

On the previous scheme I thought I reached a good schematic design, but the truth is that there were still some problems to be addressed, and more than that, there was the designer intuition telling me something better could happen. But rationally, there was a disconnection between the public domain and the other “public” platforms that actually felt more like private zones due to the clear architectural separation. Another issue, although a formal one, was that I felt I was still generating a form that could be easily built using the CMU or the Poured Concrete system, I thought that the project wasn't still making a statement of change, it still needed a different language that would shout out loud that something different was going on.

Then, I went back to that “living in a canopy idea”, I visited rural Ohio for inspiration, looked at the canopies of trees, looked at their density, how much covered space and exposed space existed in the view, and afterwards decided to take a stab at a silly graphic deconstruction of that view. The purpose of this exercise was just to get a new line, a new geometry that might help me break the massing and deal with the porosity of the building and maybe its shading device later on.
After grasping the new language from the previous graphic study, I was ready to try a new idea, driven by all the climate responsive concerns, but also by a stronger conceptual statement.

Again I sized the building, maximizing the space it could take in the lot. I proceeded to make its section thinner, so it would cross ventilate all the spaces. I split the massing into public and private. Then I shaped and split the massing with the extension of the park, in such a way that it would climb and reach higher grounds seamlessly from park to roof deck. Then the units needed to become double height to be able to house their entire program without taking away the privilege of cross ventilation from any space. Finally, the shading system covered the building, while remaining permeable enough to let the winds in and out.
SYSTEMS WITHIN THE BUILDING

The project can be analyzed and dissected into a number of different aspects: enclosed spaces, structure, program, public park system, vertical circulation, and shading elements.

The biggest contribution of the design is related to the amount of enclosed spaces vs open spaces within the unit. I managed to invert the typical ratio of the typical high-rise residential unit in Santo Domingo by offering mostly balcony space, a flex zone to be controlled by the user, and the most private settings which can be air conditioned.

The structure was a given and did not drive the design. It can be described as a metal structure comprised of beams and bracings along three structural cores that integrate the main vertical circulation within the project.

The program basically behaves like a tree, where the bigger and most public areas (exhibition spaces, auditorium, offices, and gymnasyum) are acting as the roots or plinth for the residential part elevated like the canopy.

The park system reaches higher grounds through a series of ramps and steps which connect platforms yet to be programmed. At the same time, the public gesture splits the private zone into two buildings and creates a dialogue between them.

The vertical circulation happens inside the main cores and the emergency stairs and the ones internal to the units happen to the East and West facades, acting also as a buffer zone for low altitude solar impact.

Finally, the skin of the building acts as a first protection layer against the solar radiation and hurricane scenarios. Still, very open and meant to let the winds through.
Fig. 26 Building Systems Diagrams
THE TREES AND SHRUBS PALETTE

The landscape design of the project is based and inspired on the conditions in the High Line project, NYC. There the deepest planters along the entire structure are three feet only, reserved for a few larger tree plantings. Most of the planting beds along the High Line are eighteen inches or a bit more. Although this shallow depth favors drought-tolerant grasses and other perennials, there are a number of shrubs and smaller trees that also grow in these planters. What is important is lateral room for the roots to spread out and anchor the plants, particularly when there is high wind potential.

Since the size of the tree becomes directly proportional to the space available for the roots to expand, the size can be controlled and dictated by the given spatial configuration. Hence, to limit the species to a twenty feet height, planters would not exceed four feet by four feet dimensions.

Furthermore, to make a stronger relationship between the project and the Park in front, the tree palette was selected among the existing endemic species existing in the park.

The wind, the hurricanes, and the security will be addressed by reducing the density and size of the species according to major heights in the project. The biggest will belong to the first public levels, and then species will become Shrub types on upper levels. Palm trees will be specially considered given their outstanding performance during hurricanes and/or strong winds conditions.
Fig. 39 Longitudinal Section

SCL. 1:250
Fig. 40 Transversal Section

TRANSVERSAL SECTION

SCL. 1:250
After all that was built up, a clearer idea of the project was possible. Two towers rising from a public plinth, embracing the green system in between and merging into one unique residential structure.

The handicap of this image was the rendering of the skin, which is treated as a glazed surface, but is just a representation of an element yet to be designed. Still, the scale of the shading decive should be small enough that perceptually it would emulate a reflective solid surface.

The challenge to be taken next is that each unit becomes different given the morphing shape of the building every level. So, a strategy was needed, one that could inform every unit without having to design any of them, a DNA for the project.
Fig. 41 Design Development
The unit is the soul of the project; its DNA dictates the purpose of the thesis. Its diagram starts to address the set of rules that were thought throughout the investigation and conceptualization of the project. From outside to inside, the first element is the screen for shading, which design process began on the previous sketches. Then there is a buffer zone with trees, a bigger balcony that is now used as living space. Then there is an operable section, that can be air conditioned or open to the environment as the user wishes. On the upper levels bedrooms on each side of the core, independently accessed, one able to be cross ventilated since there is no access corridor in front of them to block the wind.

It is important to clarify that the representation is somewhat abstract. Hence, to properly read this image, the concept of operability is more important than the actual form it is taking.
The skin is important because it is the edge between inside and outside, which is particularly stressed in this thesis, but also, in the project it becomes the unifying element. While the east and west shading devices perform better by being vertical elements, the iterations for south and north facades had to be designed with horizontal elements that could break the given sun angles.

At first, a series of explorations with diagrids took place. But the diagrid itself is such a strong geometry, a tectonic language that by itself would compete with the already unconventional geometry of the building. Regardless, the break down in the scale of the louvers was carried in following iterations. Finally, a combination of fixed skin element and an operable part was the preferred solution.

FIGURING OUT THE SKIN
Fig. 45 Skin Working Models
THE POPULAR TRADITION AND THE BAY MODEL DESIGN IDEA

I felt that the skin of the building was an opportunity to learn from the tradition, not in the formal way, but looking at the ideas behind it. Hence, I observed the traditional houses, and those have a curious element: the French-style shuttered casement window, which is very typical in Dominican popular architecture. Its most interesting characteristic is the several layers that come into play for different purposes. A solid panel that swings to the outside becomes the first layer of protection and privacy. An inner panel is louvered and can also be swung open for full exposure to views, sun light, and ventilation. And above, the transom is a fixed grill that regulates ventilation and humidity levels.

The same way the traditional window is working, the layers of the bay model are conceptualized. The first fixed layer is for solar protection mostly from above and west sun rays, while still open to the breezes. A second layer of different sized louvers is controlled by the user, which also can slide away when more aperture is desired. These are followed by the balcony space with planters for plant cooling strategy. And then the private setting follows the same logic of multiplicity of control to offer privacy as weather proofing.
The unit is structured around a central vertical circulation core. The constantly shaded and hence cooled thermal mass keeps in balance the unit’s temperature swings. Something to note is the difference between east and west facades from the south and north ones. While both sides are operable, west and east are designed with vertical shading devices, whereas the north and south sides respond to horizontal configurations.

The unit is also elongated on the east/west direction to minimize the heat gain from east and west. This move also accounts for cross ventilation, which is kept in all spaces because no access corridor blocks the winds. While this could be done in a single floor, the double height space emphasized the experience of the outdoor living.

The bedrooms on the second level are also treated in the same direction as the whole unit, keeping east and west closed, and south and north operable faces. The bathroom space occupies the position next to the vertical core for plumbing pipes and HVAC ducts to travel through the building.
Fig. 47 Unit Exploded Axon
07 | CONCLUSIONS
CONCLUSIONS

It all begun with the question: What then if not concrete? Through a long research, I learned many things that helped answer this. It is somewhat funny that technology and modernism drove us away from more pertinent practices. The answer resided in our Native American vernacular tradition: a thick insulated roof and thin light walls. I understood the challenges in the hot-humid climate and the best ways to achieve thermal comfort when working within it. Finally, I was able to compare different systems with an energy analysis tool and prove my hypothesis: The best performing envelope condition for the Hot-Humid climate is a shaded, low insulated, and lightweight one.

But, after all that, it seems like the real journey had just begun, the one that would validate this thesis being worthy of an M. Arch. To understand the faults in the construction system and be able to give a better answer is one thing, but to challenge the idea of what a living unit in a high rise is, is a very different story, and it is indeed the most satisfactory one. The idea of living in a canopy rather than an elevated floor was the key. It not only guarantees the desired shade and wind for thermal comfort, but becomes a different poetry about the space. The double height balcony space, the floating rooms within that space, and the constant connection to the exterior through the shading skin at both ends of the unit, no matter where you stand, makes the idea a tangible reconfiguration of the expected highrise residential architecture.
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