ARCHITECTURAL FLEXIBILITY

AN EVOLUTION TOWARDS A MORE FLEXIBLE ARCHITECTURE

By

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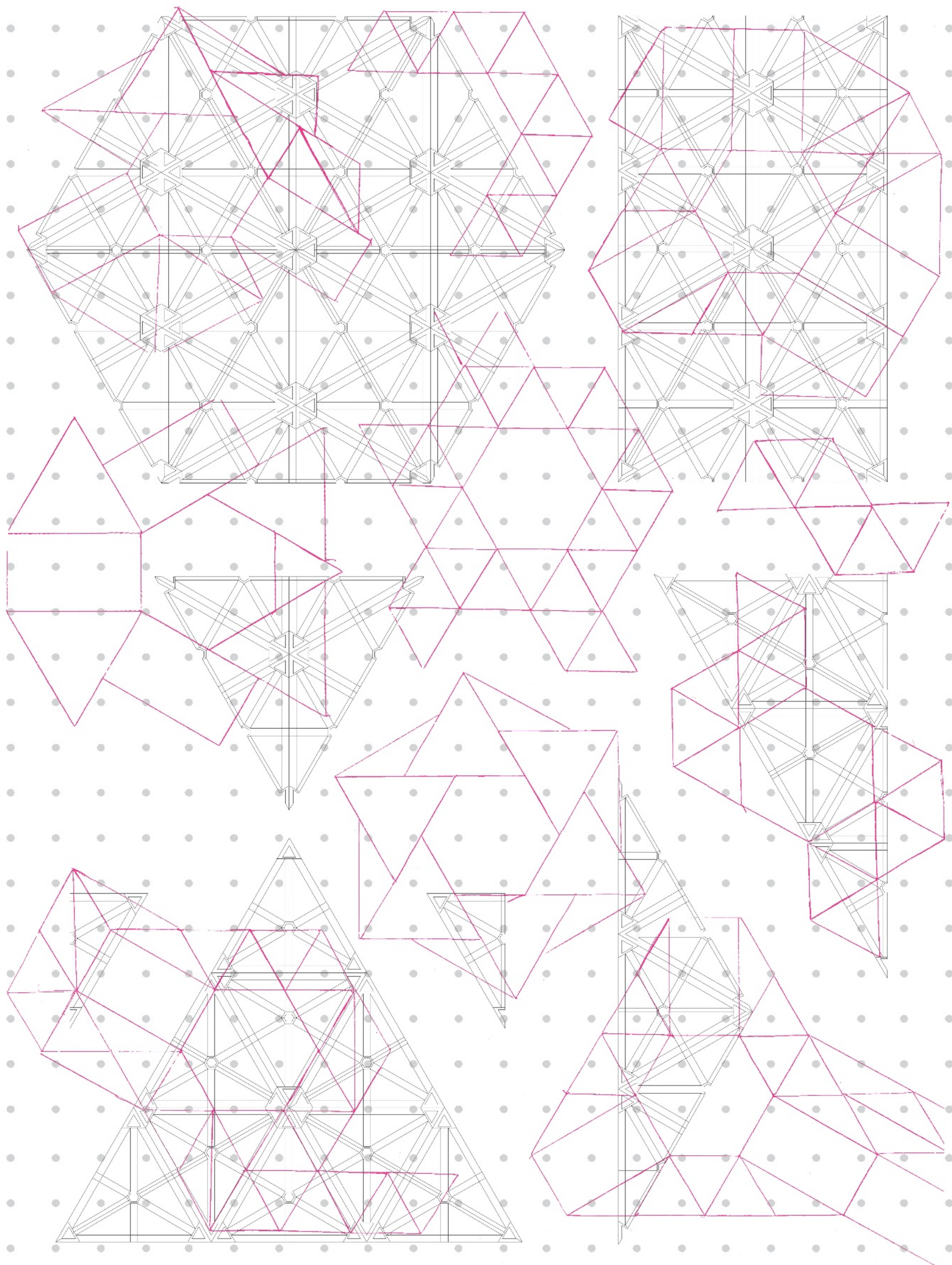

Abstract

How can architects redefine the way we design and construct buildings? Currently, buildings are too restrictive and do not allow for the ease of flexibility and/or change. The main reasons for the inflexibility of current construction methods are columns and structural walls, they prevent us from rearranging the spaces and buildings as needed. When it comes time to modify and remodel buildings and spaces architects and designers are constrained; These constrains do not allow for the liberty of creating new designs and spaces where many people could use, since they are predetermined by the existing architecture. The way designers can fix that is by asking themselves how can architects, engineers, and designers design a flexible building approach that supports the evolving needs of tenants, users and future change, and how can flexible building systems impact and change the environment we live in?

Exploring the ways architecture has evolved, will help architects and designers better understand the way we live, how construction and design changes over time have improved our lifestyles and how can we make them better. Through investigative research, design analysis, design, and manufacturing, architects can better understand how to design flexible buildings that will allow for changes to be made and permit accommodations for the future to come.

In this thesis we will explore a way to create buildings with a higher grade of flexibility, allowing for the adaptability of spaces depending on the user's needs. This thesis will not only talk about flexibility in the sense of adaptability, but also in the sense of reusability, and sustainability to encompass the needs of the future within architecture. To allow for that to happen I have come up with The Five Rules Towards A More Flexible Architecture. (1. External Structure 2. Fully Open/Flexible Interiors 3. Flexible Systems 4. Reusability 5. Sustainable/Environmentally Friendly) These rules will be further explained later in this thesis.

Acknowledgment

I would like to thank all the people that have provided me with help and encouragement throughout the process of this thesis. There are certain people to whom I would like to express gratitude.

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John Blake: Chair
John Becker: Reader
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Kevin Hill: Consultant

For all the support and guidance, they have given me throughout the process and design decisions

Finally, to my family and colleagues who has supported me throughout my life and my studies

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The Five Rules Towards A More Flexible Architecture

External Structure

-All the main structure will be moved to the extremities of the envelope to allow for fully open Interiors.

-The secondary structure will go in the floor plates, eliminating structural columns and walls, allowing partitions to be moved freely, to maintain the flexibility of the buildings.

Fully Open/Flexible Interiors

-The interior of the building must be completely open, with no structural columns, wall or anything permanent that would prevent the interior from being flexible and adaptable.

-The open and flexible interior concept will allow all types of walls and systems to adapt depending to the needs and use within the building.

Flexible Systems

-All systems in the building must be flexible, and adaptable to the required needs. (Walls, Floors, Electrical, Mechanical, Plumbing, etc.).

-The size of the systems that will be used in buildings will have and essential impacts on the flexibility of the buildings, the systems must be smaller, and must be reusable, given possibilities to refit the needs of different functions and buildings.

-Systems must contain some sort of connect and disconnect joints to allow freedom of movement, expansion, ease disassembling and reassembling.

Reusability

-Everything if not most of the building needs to be made up of modular systems to allow reusability within the same or other buildings, preventing construction waste.

-Every system must be easily disassembled and reassembled to allow the ease of construction, remodeling, and swapping of parts, either within the same building or from one building to another.

Sustainable/Environmentally Friendly

-The building must use materials and systems that must be recycled, reused, and repurposed to minimize the construction and remodeling waste.

-Every Part of the building must be fully or almost fully reusable and recyclable.

Introduction

Architectural design is under the influence of construction practices that, while effective, do not allow room for much change and development in the ever-evolving field of architecture. Designers in the field of architecture are not adapting to new technologies and advancements in construction possibilities as fast as we could for the following reasons: the cost of new technologies, the lack of knowledge, the fear or moving forward, complaicancy or even the lack of trust in investors who fund the designs. But if architects and designers start thinking outside of the box and taking advantage of the new technologies, there could be endless design possibilities and advancements in the field of architecture.

Currently not all, but many architects, construction workers and professionals in the field, design and construct with antiquated processes. These antiquated processess and technologies dateing back to the period of architecture ealy modernism, which took place during the late 1800's to the mid to late 1900's. While some of the ideologies from the early modernist period are extraordinary and have revolutionized the world that we live in, some have kept us from advancing. It is time for architects and designers to start thinking differently about the future of design and construction practices, to accommodate for future needs.

While thinking of ideas and formulating concepts for our designs, most architects first and foremost think of what the building or space within the building will be used for in the present time. Must often than not, designers don't consider how buildings will be or may be used in the future. This is concerning because the purpose of buildings, and even their tenants' changes throughout time which will cause the buildings to be modified, remodeled and even adapted to the new use or requirements. But modifications lead to many problems: from the cost of modification, construction waste, and even restrictions created by the existing internal structure of the building. Which currentlly are columns and inner structural walls which restrict the flexibility of the space. These restrictions often force tenants to modify the way they will be utilizing the space. But this shouldn't be the case. How can designers start thinking further ahead and design for many or any possibility imaginable? Architects, engineers, and designers need to design a flexible building approach that supports the evolving needs of tenants and users, as well they need to think of how flexible buildings systems impact and change the environment, we live in. To design and provide buildings that allow for free flow of plans, with no restrictions to allow for adaptability to accommodate any use or tenant imaginable.

Designers need to take a look at the good ideologies and design approaches form the past and improve/modify them to the new technologies and ways of designing. Taking some ideas and rethink the way we can use them, making them work for the future while keeping flexibility in mind. The ideology of the "Free Plan"[1], which Le Corbusier presented in 1927 in *Five Points Towards a New Architecture* is a great place to start since it was the idea that revolutionized architecture to where we are today. Free Plan design is a concept in which Le Corbusier wanted to achieve a adaptability/free ground plan, but it still had internal column structure that restricted buildings from becoming fully adaptable and flexible. The goal is to take his idea for Free Plan even further by taking all the structural aspects of the buildings to the exterior to create an actual fully flexible plan, where the internal spaces can be fully adaptable, modified and customizable to the future needs.

Modifying the Free Plan ideology is not enough to create a fully flexible space, as there are many aspects that need to be examined to make buildings as flexible as possible. By exploring the past and how we have progressed to the present architects will have a better understanding of how lifestyles have evolved which will help us better understand what our needs are and will be in present and future times. To make a flexible building

[1] Free Plan: In the architecture world, refers to the ability to have a floor plan with non-load bearing walls and floors by creating a structural system that holds the weight of the building by ways of an interior skeleton of load bearing columns. The building system carries only its columns, or skeleton, and each corresponding ceiling. Free plan allows for the ability to create buildings without being limited by the placement of walls for structural support, and enables an architect to have the freedom to design the outside and inside façade without compromise.

approach possible we need consider the following topics: Past to Current Construction and Living Practices, Building System Analysis, and Technology/Material Analysis.

Methodology

Past to Current Construction and Living Practices

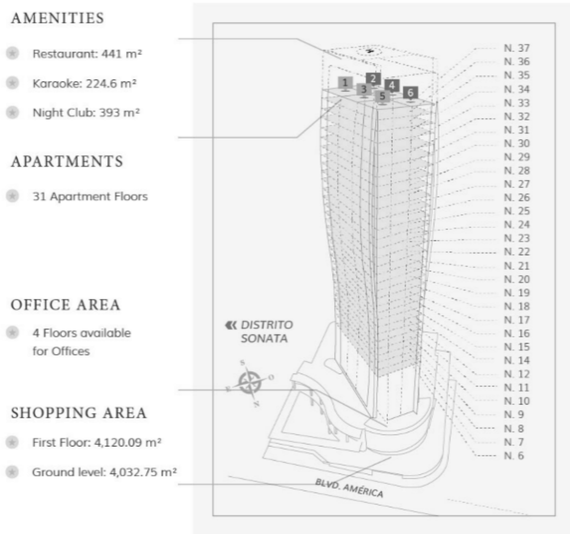
Throughout human history we have developed and change the way we live and interact within the built environment; due to the technological advances and the shift they have created in the way that we live and interact with one another. At first, we can see how humans developed the built environment to survive the harsh weather, and the surrounding environment, it being animals, insects, or natural disasters. In the in hotter places we can see how humans started to create shelters from adobe[2] to create a barrier that could block the heat and sunrays form coming in the building, or in cold environments where skimo's created igloos[3], by compacting snow and making bricks to create an insulator which could block the wind and the harsh cold, so they could survive. But as time passed shelters became more and more complex due to the development of our needs, not only where they used for shelter and protection but also for storage, cooking, working, etc. making shelters develop faster. The rapid development of our lives led our buildings to become complex making them something more than shelters, making them structures where we spent most of our time; thus, needing them to house many different things.

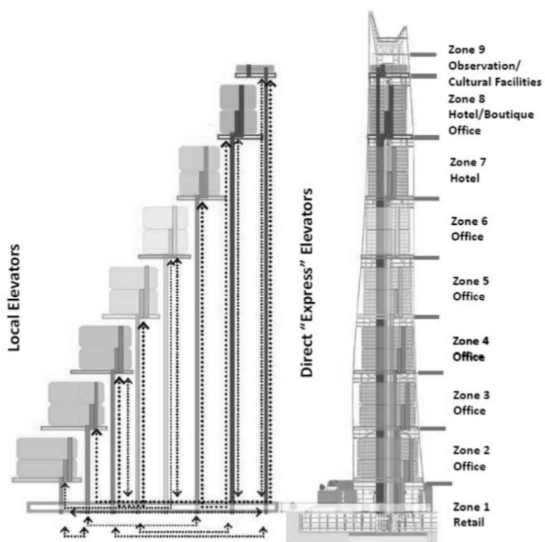
Buildings now more than ever are evolving due to the time we spend inside them and the way we interact with the built environment, according to the environment protection agency must humans spend 80-90% of their day indoors, requiring buildings to accommodate us in many different ways and forms. Although buildings are becoming more complex and are housing many different uses within them, they still need the ability to adapt and morph into different forms and spaces to allow for future accommodations without having to destroy the buildings and creating waste in our planet.

This brings us to the idea of creating buildings made with systems that can be reused, repurposed and recycled, thus this would allow us to create the buildings that could morph into any type of building by repurposing the building systems as needed now and in the future. Thus, allowing us to create buildings that can change overtime.

[2] Adobe: A kind of clay used as a building material, typically in the form of sun-dried brick.

[3] Igloo: A dome-shaped Eskimo house, typically built from blocks of solid snow.





Building Systems Analysis

When exploring the idea of making a fully flexible systematic building approach to fit different uses and tenants it can be complex. Since there are a lot of things that go into making a building, from the systems that go within it — Electrical, Mechanical, Plumbing, HVAC, etc. — to the partitions that will divide the spaces (which are needed to create different environments within a space), to the way the structure will function and will open the plan, to the construction waste and how we can manage waste in a better way. Along with those, one also has to take in consideration the materiality and the tectonics of the space, since these components will change with the flexibility of the space. In the following sections, there will be exporting the structure, walls systems, buildings systems, construction waste, and tectonics/materiality to begin thinking of ways to design a fully flexible systematic building approach.

Structure

Structure is the first component that one must consider when making a building flexible. If there is no flexibility within a building due to the structure, there is no reason to waste your time making the rest of the building flexible. If you are restricted by the structure you will only be able to do so much with the flexibility of the building. But if you eliminate the structure inside, you will have a free canvas that will allow you to be fully flexible which will call for the rest of the building to be flexible. This means that the partitions could be placed and adjusted wherever they are needed by the type of use as well as the desirable look that the tenant wants changes.

This requires the systems as well as the partitions to be flexible, since they need to take the shape desired and they need to be able to be placed anywhere. Without flexible systems a fully free plan where partitions can be placed anywhere will not work, since the systems will not be able to adapt as needed.

Wall Systems (Partitions)

The reason that partitions[4], not walls[5], are the second most important aspect for the idea for a fully flexible plan is because partitions can be moved while walls cannot. Partitions also govern the way the systems work within a building. If you have partition walls that can only be located in certain parts of the building the plan is not flexible enough for any type of use. The goal is to have partitions that cannot only be placed anywhere within the building but that can also be flexible themselves by taking any shape required and specified by the tenant. This idea brings up the following question: how can you design

[4] Partition: Divide the interior space into rooms but support no weight.

[5] Wall: Functions as dividers, but they also hold up part of the building.

the systems to be as flexible as the partitions themselves?

Building Systems

You can think of systems as the veins running through a building in the same way veins run through the human body. Systems serve all the different types of conditions and needs: form HVAC to the Electrical, and they are structured throughout the building to serve as needed. But in the instance of a fully flexible plan the systems, although structured, in some ways the systems must be designed so they can be flexible and adaptable depending on the positioning and needs that the partitions have to accommodate. With that being said, the systems although flexible should only be included where they won't go unused to prevent waste and unutilized lines. Architects and designers need to come up with ways to make sure every duct, piping, wiring in the building is always used to reduce waste. Since waste is a huge problem with construction and architecture around the world.

Construction Waste

Construction, and architecture in general, has a big problem with waste and is in fact one of the leading waste creators in the world. Waste is generated during construction, deconstruction, and the remodeling phases of buildings. In our day and age there are a lot of emerging technologies in materials, waste processing, and construction methods that we as designers don't often utilize and could serve to reduce or even eliminate construction waste. The idea is to incorporate the minimal to no waste concept into this project since it is already looking to revolutionize other methods of construction. In doing this the door opens to think of how architects can design building with technologies and processes to achieve this goal of waste reduction.

Tectonics/Materiality

Through the change in structure, wall systems, building systems, and construction methods, there is a common denominator which is the tectonics of the space. When you change the ideologies and building methods there is a change in tectonics[6]. This change affects the way a space and place look, how it feels, and even further affects the cognitive physiology of how we perceive a space; from a remembrance standpoint to an emotional one. For this reason, when designing a space, we must think of how it can affect and alter the way people perceive buildings, even more so when we are changing the way buildings look and work.

After considering which are the most important sections that architects need to focus on to create a fully flexible building approach, architects and designers need to consider: structure, wall systems (partitions), building systems, construction waste, and tectonics/materiality. Although they were explained above it is important to think about and explore them even further, by considering people that has done any research in these topics that could help develop and improve my idea further. This research is highly valuable information that will come from many case studies to provide the basis of how architects and designers should design for the future.

Technology/Material Analysis

When designing for the future we also must think of the emerging technologies and materials that could serve our buildings the best, even though now materials like steel and concrete are prevalent and widely used in the future that might not be the case. When designing systems, we must find a way to construct them with the existing possibilities while at the same time being able to be constructed differently and with emerging technologies or technologies that we don't have. As technology advances architecture will start using different materials like polymers, fibers, light weight metals, light weight concrete, and even 3d printed technologies that could be formed in many ways. The design that we create must be something simple enough that can be manufacture with different technologies and materials with ease, to speed up construction.

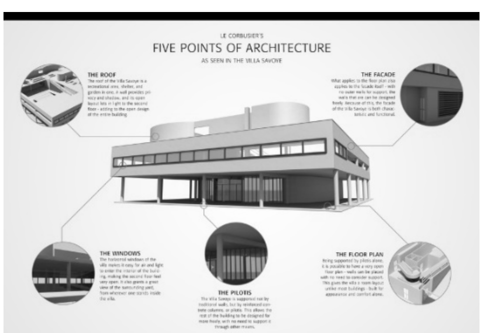
[6] Tectonics: the science or art of construction, both in relation to use and artistic design.

Case Studies

Structure

Five Point of Architecture
Architect: Le Corbusier
Idea Stated 1926

In"The Five Points Towards a New Architecture" – Le Corbusier conceived the idea of the"Free Plan" was first conceived. He explained that the way to achieve a flexible, or free ground, plan was to create a building in which there would not be any supporting walls, making each floor work completely independent from the rest of the floor, and all the supports would be systems(columns) that carries the immediate ceiling load. Therefore, making it easier to design and have a freedom to design the interior space through the use of partition walls. For his idea this opened the possibility to leave the façade free from structure, making it so you could design the façade freely.



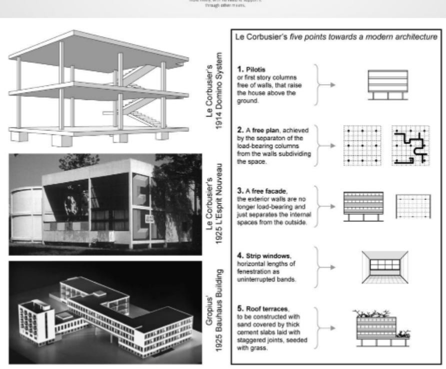
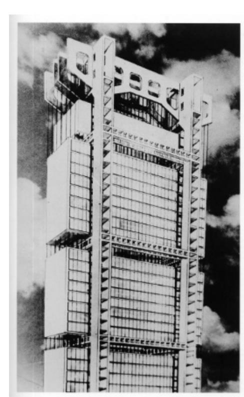


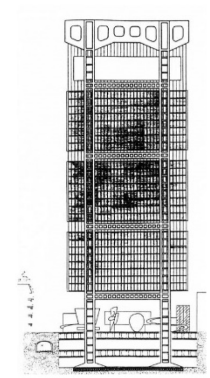
Fig. 1. Origins of modern architecture.

Suspended Office Tower
Architect: Amancio Williams
Never Built Idealized in 1945

Amancio Williams is thought to be one of the first to present the idea of suspending the building through the structure that is externally located to create an open and free floor plan design. Amancio Williams was a great thinker using and innovating technologies that where not used in buildings at the time, making him an important architect in Latin America. Although most of his projects where never realized, many of his innovations are still being used.

The way the structure of this building was designed to work was by a frame of four main pillars. This frame carried the weight of the building down to the ground for the two main beams that would carry the weight of all of the floors with the use of tension cables, between each floor it had stabilizing beams, which helped with the wind and seismic forces. The flooring would be made with metal decking with reinforced concrete which would make the floors lighter an in turn lower the forces excreted by the suspension cables. This building was a marvelous design then and it is still a marvelous design now, because it helped change the mentality of designers. What made this idea different and extraordinary was the fact that he was thinking of suspending the floor which no one at that time had thought of.





Neo Bankside
Architects: Rogers Stirk Harbour + Partners
Established: 2006-2012
Location: London

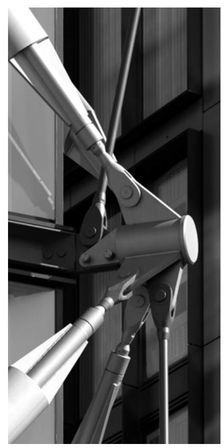
This case study consists of a Residential/Office project containing 212 units. The projects consist of multiple hexagonal pavilions, a six-story office building, and three residential buildings that range between twelve to twenty-four stories. The architects did a great job with the incorporation of the building to the surrounding vernacular—which is industrial in this part of the city—but at the same time designing a contemporary building. The contemporary design includes the use of materials, which follow the aesthetics of the materials on the surrounding architecture, as well as the colors presented in the building.

The cross external bracing structure give the buildings enough rigidity, which eliminates the use of structural walls in the interior of the space; making it highly flexible internally. The main structure of these buildings is their core which is made of concrete poured inside a frame. The external bracing and elimination of internal structural walls also allows the building to have a lot of glazing that is unobstructed creating great views for the residents and workers that are in the buildings.

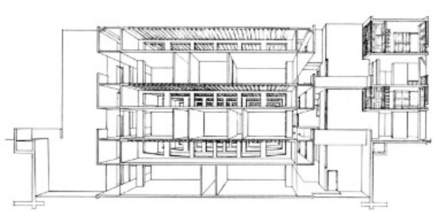
Building Systems

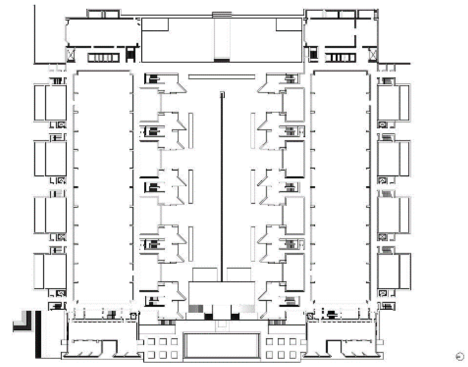
Salk Institute
Architect: Louis I. Kahn
Established: 1960

The Salk Institute was a donation of Dr. Jonas Salk the inventor of the polio vaccine. Dr. Salk commissioned Louis I, Khan to design a research institute in California. When Khan started designing the building, he believed that the laboratory space needed to be open so it could be modified depending on the use of the laboratory and future technologies and



equipment. He believed that if he didn't make a flexible space this building would go obsolete quickly due to the technologies and medicine field's fast development. The way Khan was able to create a flexible space was by having all the structural members placed on the exterior of the building and by taking all the systems of the building out of the laboratory area, creating an open floor plan. The way khan was able to achieve that was by creating a floor between each laboratory that was dedicated to the system. This spaced allowed the systems to be moved around so these could be readily available wherever needed depending on the laboratory layout on top. At the time this was a breakthrough idea which allowed for his design to be versatile and flexible in the laboratory floors, this is one of the main reasons the institute is still working the way it was intended to.





The Pompidou Center
Renzo Piano & Richard Rogers
Established: 1971

The Pompidou Center is one of the most innovative and revolutionary buildings form the late 20th century due to the careful design by Renzo Piano, Richard Rogers, and Team. The design was carefully analyzed so they could allow for flexibility in the spaces inside and the structure in the building, they achieved the flexibility by moving all the mechanical, electrical, plumbing systems to the exterior back façade and pulling the systems under the floorplate, thus eliminating the chases within the building allowing for a free open floor plan. The Pompidou Center also had a design concept of movable floor plates allowing the spaces from floor to floor to change depending on the event or need of the space, but unfortunately the system was never used after construction due to all the changed in structural balance and its inefficiency when doing so.

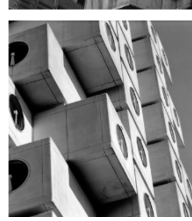
Innovative Architectural Approach

J57 Mini Sky City
Broad Sustainable Building
Established: 2015

The Mini Sky City is a revolutionary design from the 21 centuries, this design is on the first buildings to push the idea of modularity throughout the whole concept of the buildings. Through this process of creating a building that was modular they kept in mind they wanted to create a building that was easy to assemble, and was made from the same sort of pieces making it easy to attach and detach, allowing for the function of the space to change if needed, although this building shows the concept of the buildings with relatively equal modules to test the concept of modularity within architecture and construction. This process expediated the construction of buildings by a couple of years; It took 19 day to construct in site and 120 days for build the modules, while a building of this stature would normally take an approximate amount if time of 3-5 years minimum to complete, thus revolutionizing the way we construct.

Nakagin Capsule Tower
Kisho Kurokawa
Established: 1972

The Nakagin Capsule Tower was design as an idea of the Japanese Metabolism movement, this movement was to create to promote the organic growth of buildings as they are needed for to change, the Nakagin Capsule tower was designed with the concept of having interchangeable capsules that could house residential or office units depending on the future need of Shimbashi,Tokyo. This design had a great movement towards creating modular buildings and units that could be changed and used in a different tower, not only that but the proposal was to make the units have a certain life span (30 Years) so there would be a forced change to adapt for the future way of living and working. The design was meant to be replicable in many different parts of the world but due to its heavy capsules it was almost impossible to interchange them thus the concept never changed or grow, thus maintaining the idea of the Metabolist movement but not the project alive.



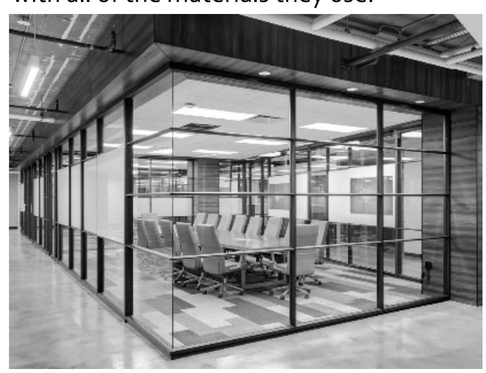
RediCore
Vulcraft

Vulcraft designed a system called RediCore, this system is revolutionizing the way we think of buildings. RediCore is a core that is modular can be easily installed and moved when needed, this is revolutionizing the way we see buildings because buildings cores are the most static parts of the buildings once in place most of them never get moved and if the need to be moved they are destroyed, so by allowing ores to be modular and movable there is a huge possibility to allow the rest of the building to change as needed.

Walls Systems (Partition)

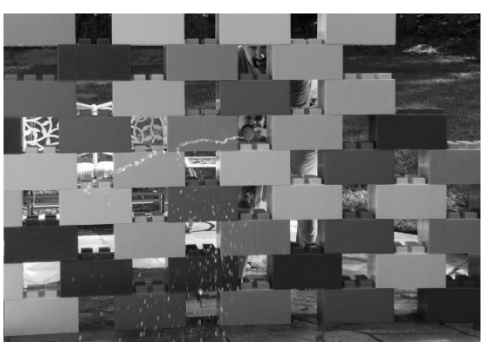
DIRTT

DIRTT walls are a highly customizable system which can be assembled and disassembled easily and as many times as needed without any waste since all of the system they use are reusable – from the frame to each of the material from insulation to finish. The wall has a fast clipping system which eases the use and decreases the time of assembly, the finishes can also be changed within minutes. Not only that but all their materials are made in a green environment where no harsh chemicals are used, and it all comes from certified sustainable manufacturers. It also has a sustainable storage and shipping priority, where they have locking clips that keep the partition sections together in a compact manner to use the least space as possible during shipping while keeping them safe. These clips are also reusable and can be recycled is they get damaged, same with all of the materials they use.



EverBlock

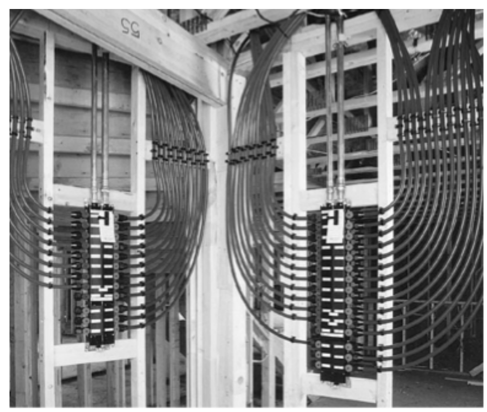
EverBlock is a Lego like product where plastic building blocks have been created that can be made up of different colors and arranged differently to create room divisions and partitions in a modular[7] manner. Walls made with this product can have interchangeable parts like doors, windows, etc. This product is economical and can be reused as many times as is needed and can be recyclable when broken or not in use. These products can also be used in form of temporary or permanent partition anywhere from a house, to a factory, and are safe to be used by an audience or any age.



Systems

PEX Plumbing

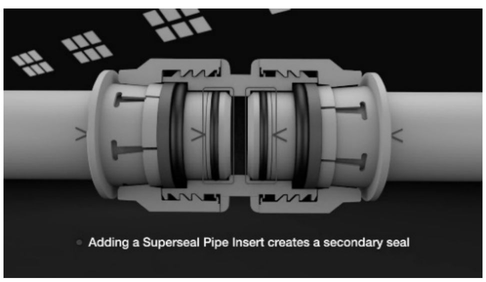
PEX plumbing tubing has been in the market for the past 10-15 years, and it is widely used in housing projects because it brings a versatility and flexibility that standard piping does not have. Because of this versatility PEX eliminates the use of elbows and joints, which prevents leakage in those areas, and it is also more resistant to bursting because it has a higher flexibility. The flexibility of the piping allows it to meander through walls and tight spaces, as well as it allows it to bend creating a continuous system to reach its destination. This allows us to create systems like water heated floors, and walls that use a reduced size pluming from conventional methods. This shows us how other systems can be thought out further to make them more flexible, and sizes could be reduced like PEX has done with plumbing.

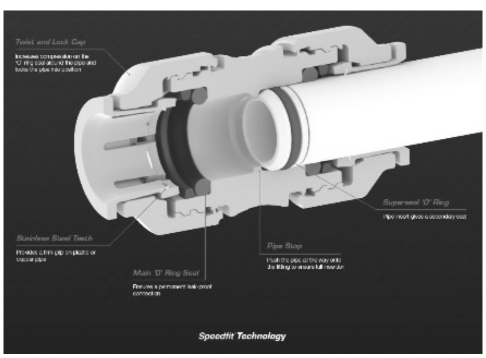


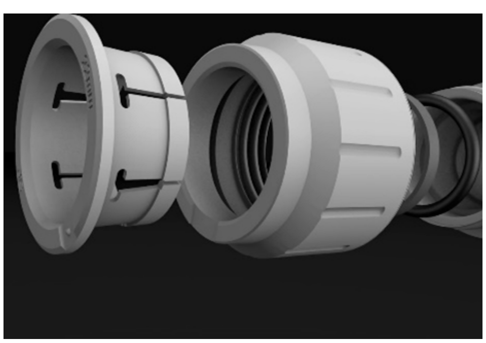
[7] Modular:
Composed of standardized units or sections for easy construction or flexible arrangement

JG Speedfit Technology

John Guest has designed a system of fittings/connection pieces that can be moved and removed with low effort, allowing plumbing jobs to be done faster. This also allows you to connect and disconnect plumbing pipes in case of a leak or remodeling without having to cut the pipes in the connections, which allows for less waste. These fittings/connections can also be reused as many times as needed which is wonderful when thinking of a flexible building where you must move plumbing around whenever you change the layout of the floor plan. This could help us think of different ideas that we could use for electrical, HVAC, etc., that uses a similar concept of fast connections to allow us to design flexible systems all around.

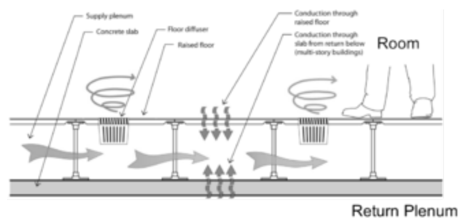






HOK Underfloor Air Distribution

HOK has developed an idea for creating an Underfloor Air Distribution System. This system would allow for buildings to be more sustainable by allowing the systems to be adjusted by pressure sensors in the floor which turns the air system on when there are occupants in the room. This system also allows for a higher flexibility since it does not use conventional metal ducting. The flexibility from the systems is great for personal control. This means that the system can be designed so everyone in an office building, house, etc. has their own personal vent where they can control the air flow allowing for a higher comfort—due to the personalization of the space—for the occupants.



Design Approach

Fully Flexible Buildings need to be adaptable in many senses. From the way the floor plan is laid out, to the way the systems need to be arranged and adaptable, to the materiality that needs to be used for resilience and adaptability, and even more. But to achieve a fully flexible and adaptable building, first we need to figure out how to make the floor plan fully open with no permanent columns or bearing walls. This would prevent obstructions that would limit the flexibility of the building and the use of the interior space.

After looking at the case studies and doing some research, I have developed an idea for creating a structural system which pushes all the structure to the exterior and floors of the buildings. Doing this would create an exoskeleton structure which unlike traditional buildings this structure would allow for the cores to be movable as needed. Although the exoskeleton structure will be the main structure of the buildings that holds the floors up and brings all the forces down to the ground, a big part of the structure engineering must go in designing the floor plates. Since there will be no permanent internal structures and the spans would be larger, all the forces that are normally supported by the columns and bearing walls need to be re-distributed through the floor plate in a way that it will transfer those forces to the external structure, and then to the foundation and the ground. The core/cores of the buildings also need to be moved to the exterior to prevent them from causing obstructions that could disrupt the flow of the floor plans, because if we have obstructions it would defeat the purpose of developing a fully flexible building where partition walls could be moved anywhere within it.

The partition walls need to be flexible and movable so they can allow for the accommodation of different tenants and uses. To do that I believe that the partition walls need to be as flexible as possible in their materiality, shape, size, and form. For this reason, I think that the best way to achieve that is to use modular walls. But there was a problem, the majority of the manufactures that make modular walls do not produce anything with the flexibility needed to accommodate to the adaptability that the building requires. So, I have engineered a wall that has interlocking members that allows for the wall to take any shape—from straight, to a circular form by locking in different positions—allowing it to be formed to the tenants needs and the architect's specification. But that's not all, the interlocking members can also be removed to create space for windows, doors, and to allow for the walls to change in height. Another thing that the members have is that they are hollow to allow piping, wiring, ducting and more to go through them as needed.

With a change in tenants and use, there is also a need for change in material. But since the wall is modular, there would be no problem because the material of the partition walls can be changed with no effort. This may lead to the following question: "How can you change the material if the walls change shape? Don't you have to manufacture a new piece to the required shape?" Yes, the walls will change shapes and forms, but the material panels that I have created are also modular so they can take any shape because they are made from an elastic material that can conform to the straight and even the circular wall, and it can also be cut if needed to take the shape of the wall.

But you might have another question "If the walls are so flexible and they can be placed anywhere within the building how you can make it so the systems and floors accommodate to them". Well let's start with the floors and then move to the systems. For the flooring I also believe that a modular system is the most appropriate method for the design since they can be adjusted to the needs of the walls, systems, and specifications of architect. So the way this system will work is by connecting to the floor plate of the building structure with an open frame that will allow the systems to run through them, the walls to connect to them, and at the same time having interchangeable walking surface, where there can be a change of material, layout, and feel of the space, allowing for a fully flexible environment within the structure.

Now let's talk about the systems, the systems need to be structured but at the same time flexible. The way that I have designed it to work is by having floors, or sections of floors, having equipment that can be moved or replaced depending on the need of the tenants and the requirements of the use of the space. The equipment will have the flexibility needed to serve plumbing, electrical, HVAC, etc. wherever they are placed in the floor plates. But you might ask "How will the systems run through the building if the walls are movable?" Well the response is quite simple; the systems will run from the mechanical floors through the exoskeleton-like structure which will carry it up to the floors those systems are serving. From there the systems will run through the floors through the open frames where they will find their desired location depending on the use of the room and the walls. I will go more in detail with specific systems: Plumbing/Sewer. For this system there will be flexible plumbing which will not require too many connections, except for at every wall that the system is required to go in and where it connects to the fixtures (Toiled, Sink, Shower, Service Sink, etc.). HVAC: For these systems I will do something around the same concept ask HOK with their Underfloor Air Distribution System, so I will have the main duct system running through the exoskeletal structure, and through the open frame floor where they will go to their desired location. In their desired location the system will come up through the floor, into every space so they can be adjusted if the space is being used and to the occupants' desirable temperature. And last but not least Electrical: For this system once it comes through the exoskeleton structure, it will be distributed through the floor system like a mesh creating a full coverage that will then produce an electromagnetic induction—The same way wireless chargers work—to power all the equipment on the floor.

All these together will make the building fully flexible, allowing for walls to be placed anywhere within the exoskeletal structure, and adapting to the use required by the tenants and specified by the architect. The flexibility and modularity of this building will help prevent construction waste, due to the reusability that all the systems have. All the systems from walls, floors, and building systems can be either reused in the same project or on a completely different building, and if the materials of the walls and floors can be reused, or no one wants to use them they could be removed from the panel/flexible panel and recycled, and all you have to change is the finishing of the panels creating a highly sustainable building.

Conclusion

Architecture and design are currently under the influence of construction practices, that although have proven to be effective don't allow room for change and development on the ever-evolving field of architecture. So, we have to do something about it by revolutionizing architecture through its Structure, and Systems like: Walls Systems, Floor Systems, Building Systems, etc., while keeping in mind the tectonic of the place because we want humans to have a good experience from the physical stand point to the psychological one. Keeping the essence of what a building is but changing it technologically and to the times we live in, while thinking of the future and how it will serve it.

At the end, we designers must create buildings that serve a purpose for different uses and tenants, while exploring different possibilities, materials, and technologies to improve our designs, and move towards the future while thinking of the past. The ideologies form the past are good but at the end designers need to figure out how to use it and adapt it to start creating a different buildings system approach that would allow for change in the future to come.

To prove this thesis, I needed to find a site that would allow me to test the flexibility and adaptability of the building and built space. For that I looked at many different locations that had a high and rapid influx of people as well as change, after looking through many options I opted to pick México City, México as my test site due to its rapid growth, but also the high influx of people from the rural areas, as well as other countries due to the job, educational, and economical opportunities that come with a city that has rapid change and development like México. Most importantly I focused on area of Santa Fe, located in the west part of the city in the delegations of Cuajimalpa and Álvaro Obregón. The focus on this sector of the city was due to it being the fastest developing part of the city as well as it's many different uses within it like: corporate offices, commercial, shopping, entertainment, educational and residential, which means that if we allow a building to be flexible and adaptable in this area it could potentially change and be used in many different ways depending on the demand at the time and the tenants requirements; Thus making it a great place for a revolutionary design that would allow for change.

Within Santa Fe, México City, I picked a site that would allow me to test the revolutionary design, but that it was also abandoned and not in use, to allow me to develop my design but also bring that sector of the city back to life. For my site I picked Alameda Poninete in Santa Fe since it was abandoned, and I wanted to revive the historical park that was there in the early 1990's, not only that but within a five block radius you can find many different uses that would allow me to explore buildings that would benefit from change through time.

To allow for change within one building I needed to find a way to create something that could be built in many different forms, could be easily assembled and disassembled, and could be reused to allow for the system and the buildings to be long lasting. Allowing the systems to be reusable and modular meant that I had to do a deeper exploration of how I wanted them to work and serve the built space, for that I decided to take a look any many different case studies, to see what could work and what could be improved from preexisting systems and implement them into my design. The case studies that I explored further to create my building approach where:

The Salk Institute in La Jolla California, United States of America by Louis Kahn due its open floor system and how it functioned, with its split level serve and served idea of having on whole floor dedicated for the systems such as electrical, mechanical, plumbing, etc. to allow for systems to be movable and adaptable depending on the needs of the floors above it and the technological advances that happened through time, this building has worked well through the adaptation of the laboratories that used the space as time has passed.

The Pompidou Center in Paris, France by Renzo Piano and Richard Rogers due to it being one of the most innovative and revolutionary designs of the 20th century. The building was designed with the systems in the exterior of the building to allow for open floor plans and unobstructed architecture in the interior of the building, allowing to the floors to be open for different uses; this building was also picked due to the way the systems were placed right underneath the floors to allow for easy access and the ease of movement and reparations, as well as the floors theoretically moving up and down to allow for change of floor to ceiling space depending on the space intentions, although it never happened, it brought the idea of movability to the plate.

The Mini Sky City in Changsha, China by Broad Sustainable Building Group due to its versatility and rapid construction prototype building due to its modularity. The Mini Sky City was manufactured in a controlled environment to allow for perfect fit within the puzzle of the design as well as the it allowed the systems of the building to be placed as needed in the spaces without creating waste, and time. This modular construction system allowed for the spaces to be changed if needed at a future date.

The RediCore System by Vulcraft due to its versatility within the built environment, this system helped revolutionized how we as architects and designers see building cores, one of the most static sections of a buildings. RediCore creates building cores that can be movable, adaptable, and reusable allowing for buildings to change the placement of the cores with ease and as needed.

After looking at this case studies I know that I needed to create somethings that is adaptable, can carry the building systems like Plumbing, Electrical, Mechanical, HVAC, can be repurposed, reused, recycled, and modular to allow it to create flexible floorplates and adaptable buildings. But for that I needed to figure out how to make a modular system that would allow me to create different forms, shapes, spaces and buildings, so I had to do an extensive exploration into geometry that could be assembled in many different forms, for that I looked at the books "Order In Space by Keith Cirtchlow" and "Tilling & Patterns by Branko Grüngaum & G. C. Shephard" where I explored and learned about different geometries and the way they work together and tile.

After the exploration of many geometries I decided to pick a hexagon as the main shape for the module, the reason that I picked the hexagon was due to its versatility of form creation as well as the infinite tiling possibilities. But after looking at the possibilities and ways this could be arranged I was not happy with the result although it allowed me to create a vast variety of forms and it could tile forever it was still to restricting to allow for the adaptability and flexibility of the space that I wanted, so I decided to break it down to its basic deriving shapes (Rectangle and Equilateral Triangle). When splitting the hexagon into it basic deriving shapes I noticed that it could create a larger number of iterations and forms, but there were still some restrictions of what I could and couldn't do within the layout of the space since it would create some spaces that I could not patch with what I had; So I decided to split the hexagon into its secondary deriving shapes (Smaller Equilateral Triangles, Elongated Obtuse Triangle, and An Acute Triangle). The secondary deriving shapes gave me a greater palette that I could work with, this palette not only patched the spaces that where created with the basic deriving forms, but it also allowed me to have greater flexibility and adaptability within the forms.

After finding the six basic shapes (Hexagon, Rectangle, Equilateral Triangle, Smaller Equilateral Triangles, Elongated Obtuse Triangle, and An Acute Triangle) , I noticed that this geometries would allow me to form many different shapes and forms while at the same time allowing me to create an infinite irregular tiling sequence that would allow to create floorplates for big scale buildings as well as small scale buildings, allowed me to create an adaptable and flexible buildings system.

But then the question came of how I was going to create a modular system that could not only form my 6 basic shapes but would also allow me to create a vast variety of forms that could be utilized in many ways and could be transported and constructed easily in the site. So, I decided to break the six basic shapes apart into one essential shape that would not limit the adaptability of the forms. This basic shape is a small-scale equilateral triangle, that not only allows for freedom of placement in many ways, creates different floorplates layout, but would also allow for the ease of housing different systems within it; that is when the engineering of the module came into play.

The building system is composed of the cores of the buildings which are modular and movable to allow the spaces and buildings to change as needed, as well as the floor plate system that allows for the floor to be arranged in many different forms. The hexagonal cores which are the main shape are the cores of the buildings carrying all the systems like Plumbing, Electrical, Mechanical, HVAC, etc. as well as the circulation cores allowing for the rest of the floor of the buildings to be fully adaptable through the basic component deriving from the six basic shapes. This component is a small equilateral triangle that could be made out of many different materials, but most specifically a light metal, fiber, or polymer to allow it to be light and strong creating the floor structure, but also hallow in the center lo allow the floor system to carry all the buildings systems through the building with freedom and where needed.

But to prove that this system worked it had to be implemented into different buildings and designs, housing different used and being completely different forms and styles. For this I created three different iterations the University iteration, the Residential iteration, and the Stadium iteration, within these three different iterations there are seven totally different buildings and layout some that are built with simple typical contrition forms of the 21st century and others that are more complex and irregular buildings to show the versatility of the system. All these iterations where assembled piece by piece in a computer to make sure that all the forms can be put together and function the real world. This process was not only done in different buildings but also within one building to show how this one modular system could function to create different style and form within one space to allow for change deepening on the need of the present and the future, as well as different sites, while at the same time making them reusable to prevent construction waste, as well as making them interactable in buildings and building forms.

Addendum

This thesis developed into a project in which architecture can be adapted and reconfigured in many different forms, and spaces depending on the eve-evolving needs of the user, due to the evolution we as humans have in our way of living, and interacting with the spaces that we liv in and our selves do to different advances and technologies that drive our lives like computer, the internet, robots, etc. The reason that we as humans need buildings that can adapt to the way we live is because if buildings do not adapt with us, they will become obsolete in 10, 20, 30 years, making it unacceptable.

The reason that short lifespan buildings are unacceptable is due to many reasons, one is that buildings will become obsolete and they will have to get demolished, remodeled, or reconfigured thus costing a lot of money and not only that but needing resources that that we can't be wasting, as well as creating a huge amount of pollution in the world.

That is why architects, engineers, and designers need to design a flexible building approach that can adapt, get reconfigured, reused, and still fits and accommodates the evolving needs of the tenants and uses the building can provide. That is why creating a modular system that can be reused not only in the same buildings and within one construction, but in many more would be a great way to make buildings easily changeable, and adaptable, while at the same time creating almost none to zero waste.

Thesis Reflection

After working on the thesis and my presentation, I think this system could work and be extremely beneficial to the way we need to move forward in our way of designing buildings so they can change with the our needs, but before moving forward there are many more things that I have to rethink an reconfigure within my thesis.

The first thing that I must rethink and look into further is how to create a system like the one that I have created for my thesis, economically and available for people to use and designers to use, another thing that this system could benefit from is by making it in different scales depending on the buildings size and use, making it easy to manufactured and with materials that can be reused and can be fully recycled, and even making different systems though the same ideology like building skins and facades, floor systems, walls and more to create a building approach that is fully rounded. And finally looking at the actual building systems and how they can become fully flexible to adapt or change depending on where they are needed.

Moving Forward

Moving forward I believe that I will continue working on this and expanding my idea, to find a way to make buildings flexible, adaptable, easy to assemble, and economical to the public, as well as giving architects a new tool that they could use to design new buildings that could be adaptable, I am thinking to make a system that could be manufactured anywhere with the proper machines by charging for a license and per part printed or manufactured. Having a website where you could find the pieces of the puzzle, you can design your buildings and it will calculate the pieces needed and that will be the cost of the files and license per building, making it easy for everyone in the world to get the same system, without having to spend money in overseas transportation.

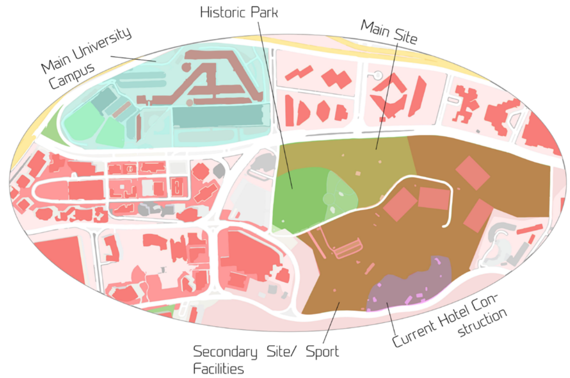
I will also be looking at different materials that would work the best structurally and being light to allow for the system to be easily movable without requiring heavy machinery to assemble. We will see where this takes me.

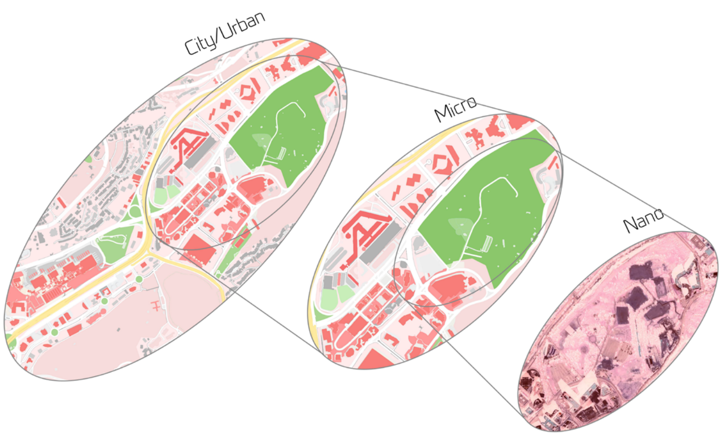
Concept

UNIVERSIDAD IBEROAMERICANA

Lomas De Santa Fe, Mexico DF, Mexico

-The reason that I have chosen this site is due to the exponential growth that its happening here in the area, due to this there is a high influx of people coming from all over the country as well as rural areas around it, due to the growth in economic classes, so looking at the Univerisdad Iberoamericana as a site is a great oportunity to help the comunity that does not live in the city grow. I want to create a couple of buildings that will house multiple things, first adding dormitories not only for this university but the surrounding ones also, as well as adding restaurants, dining halls and even some educations sectors with in them. Making flexible and adaptable buildings will help the university and the community that is to come, becasue there is rapid growth we dont know what will be needed in the future, so to prevent waste, and creating an obsolete building it has to be adaptable.





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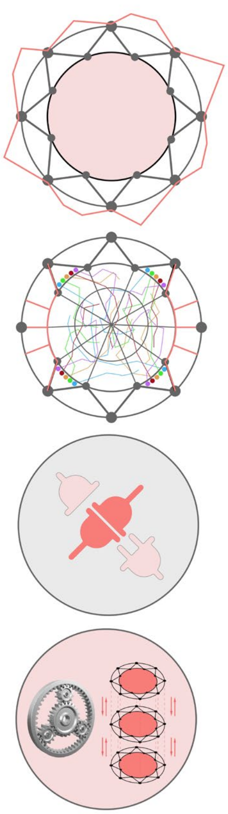
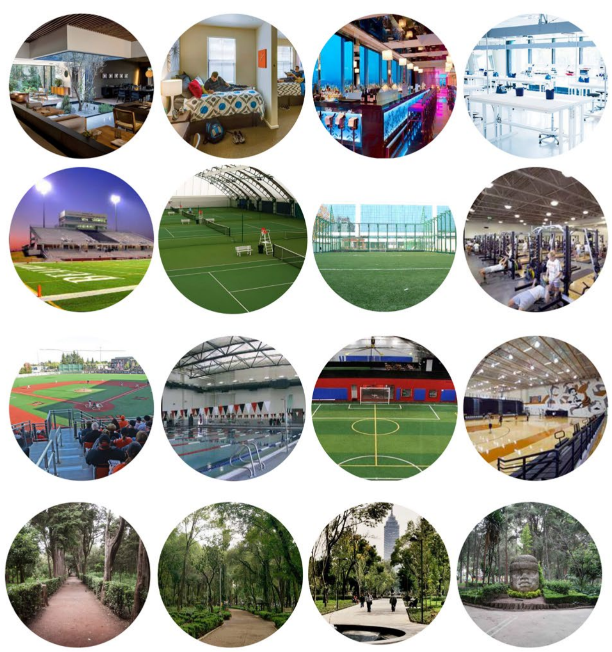
Programming





-Main Site its around 602,000 SF
-- The Main site will be made up 2 to 3 buildings that will be multi-use, they will be adaptable to accommodate any of the use required by the university. But mainly I am Thinking they could be mostly dormitories/student apartments,classrooms, laboratories,restaurants, dinning halls, entertainment, and more.

-Secondary Site its around 1,560,000 SF
--The Secondary will be made up of sport facilities not only for this university but for the three surrounding once as well as the as the for the community to use.

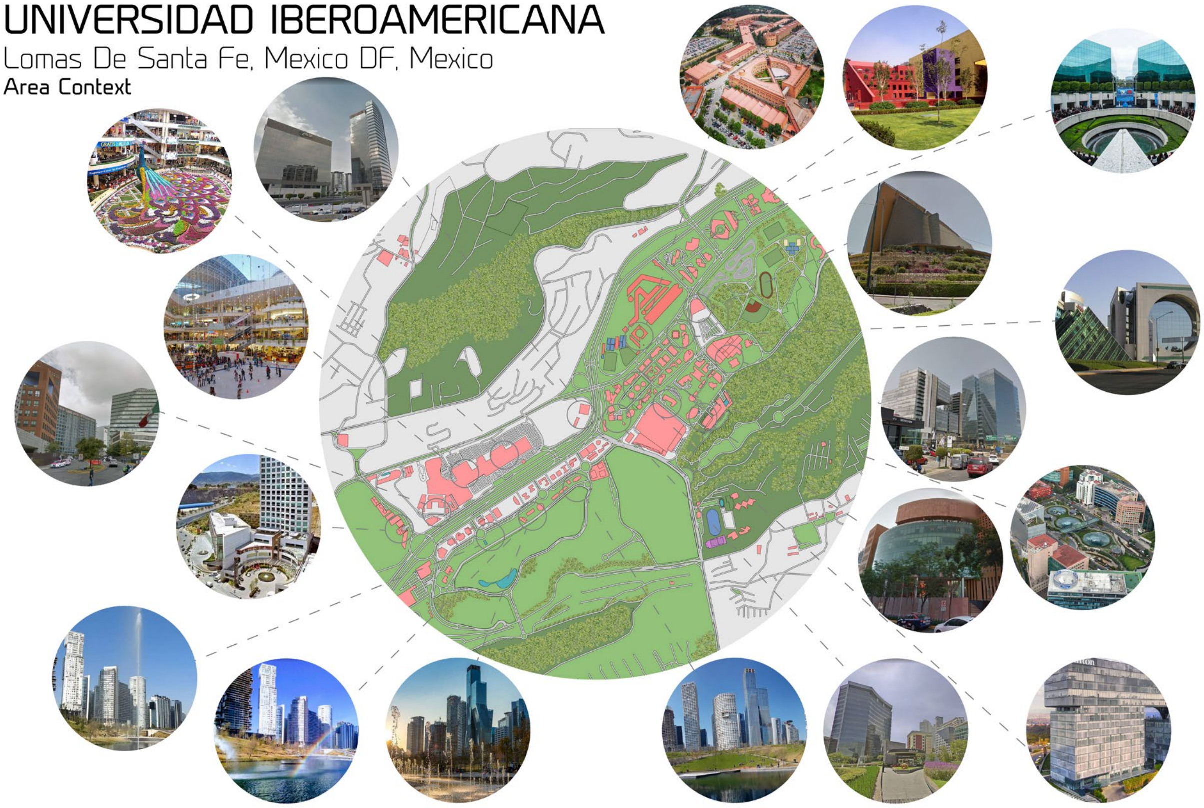
- The Park Area is around 1,633,400 SF
-- This will also be a par for the community as well as use for the members of the university. This area also contains a historical section which although not used at the moment I will try to maintain.

-This whole area although owned by the Universidad Iberoamericana de Mexico, it is no active right not it sits without much use, for this reason it would be a great opportunity to work here and revamp the community

UNIVERSIDAD IBEROAMERICANA

Lomas De Santa Fe, Mexico DF, Mexico

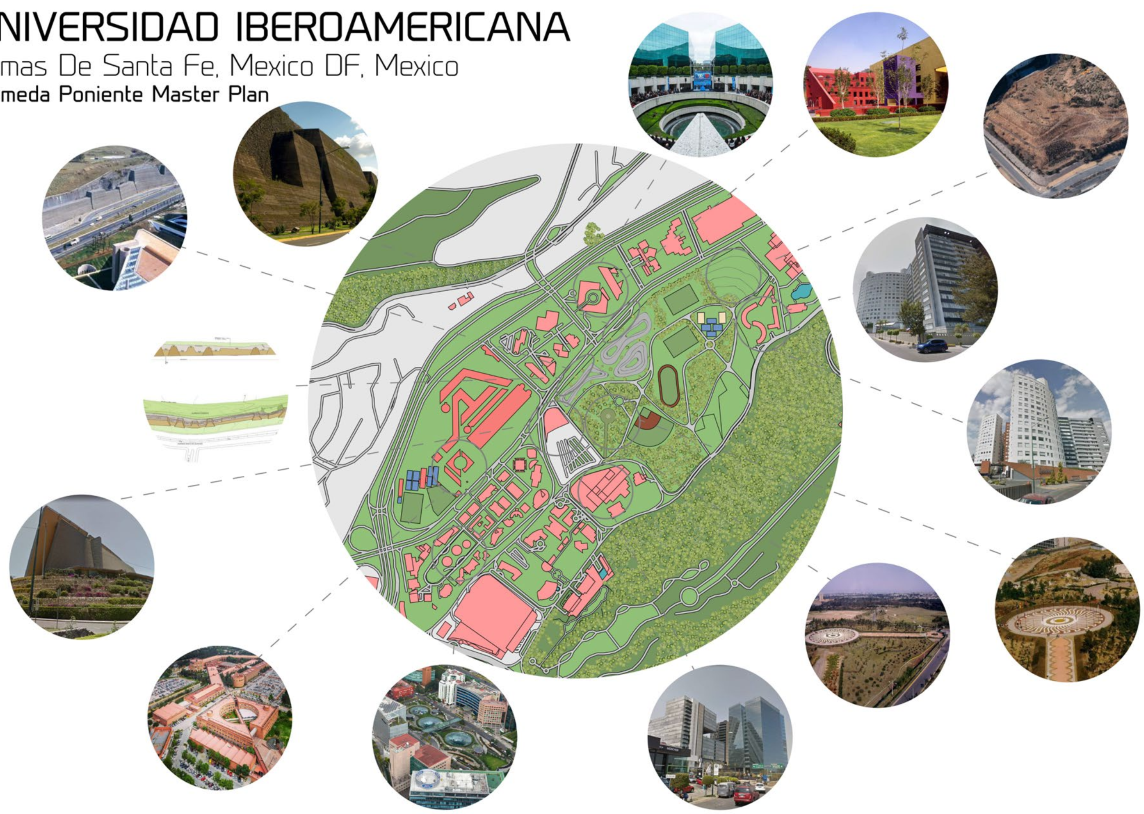
Area Context



UNIVERSIDAD IBEROAMERICANA

Lomas De Santa Fe, Mexico DF, Mexico

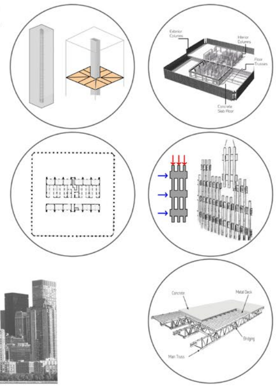
Alameda Poniente Master Plan



WORLD TRADE CENTER

- New York City, USE
- Designed by Minoru Yamasaki, Emery Roth & Sons
- Modern/High-Tech
- Built from 1968-1973
- Office Building

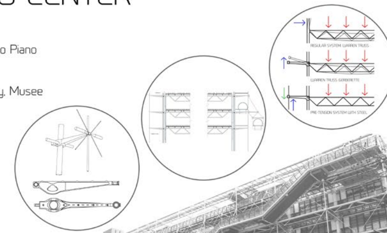
--Structure
- Floor Area:65,000m^2
- Super structure: 110 Levels
- 410m tall
- Open Plan Architecture

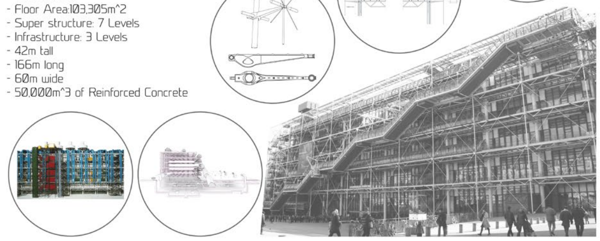


THE POMPIDOU CENTER

- Centre Georges Pompidou
- Paris, France
- Designed by Richard Rogers & Renzo Piano
- Postmodern/High-Tech
- Built from 1971-1977
- Housed the Public Information Library, Musee National d'Art Moderne, and IRCAM

--Structure
- Floor Area:103,305m^2
- Super structure: 7 Levels
- Infrastructure: 3 Levels
- 42m tall
- 166m long
- 60m wide
- 50,000m^3 of Reinforced Concrete





SHANGHAI TOWER

- Shanghai, China
- Designed by Jun Xia, Gensler
- Contemporary/High-Tech
- Built from 2008-2014
- Mix-Use Super-Tall Office, Residential, & Retail

--Structure
- Floor Area:380,000m^2
- Super structure: 128 Levels
- Livable Space: 127 Levels (587.4m tall)
- 632m tall

Water Efficiency
- The building contains water harvesting in the contour and on the podium terrace, which is used for landscape irrigation and other uses. Which reduces the potable water demand by 40%.

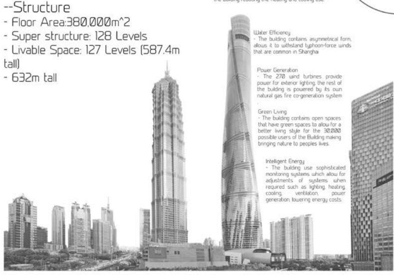
Double Facade
- The two skins that wrap the building allows for 9 zones to be created within the building, while at the sometime cating as an insulating blanket for the building reducing the heating and cooling use.

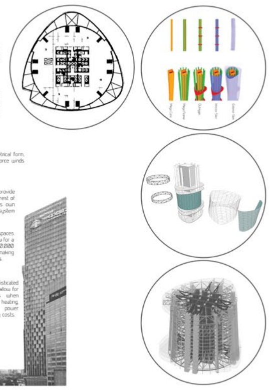
Water Efficiency
- The building contains asymmetrical form, allows it to withstand typhoon-force winds that are common in Shanghai

Power Generation
- The 270 wind turbines provide power for exterior lighting, the rest of the building is powered by its own natural gas fire co-generation system

Green Living
- The building contains open spaces that have green spaces to allow for a better living style for the 30,000 possible users of the Building making bringing nature to peoples lives.

Intelligent Energy
- The building use sophisticated monitoring systems which allow for adjustments of systems when required such as lighting, heating, cooling, ventilation, power generation, lowering energy costs.

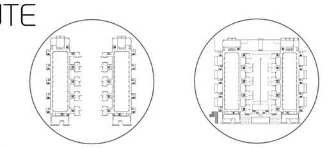


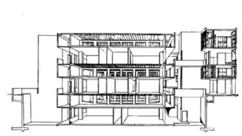


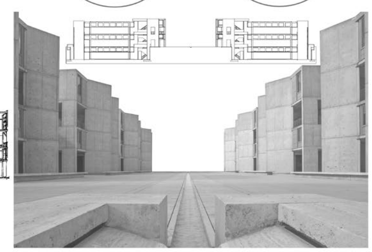
THE SALK INSTITUTE

- Jonas Salk
- San Diego, California
- Designed by Louis Kahn
- Pre-modern/High-Tech
- Built from 1962-1927
- Biomedicine Research Institute

--Structure
- Floors: 6 Levels
- Laboratories: 3 Levels
- Utilities: 3 Levels
-Movable Systems
-Modular Offices

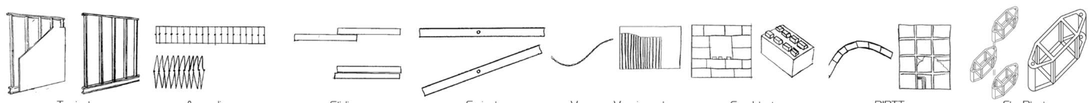




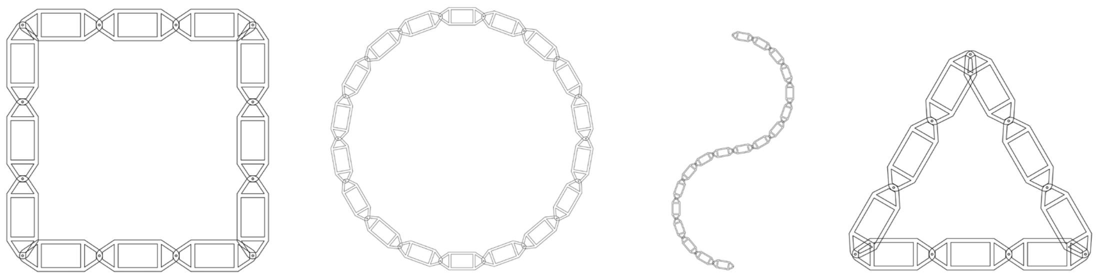


Design Development

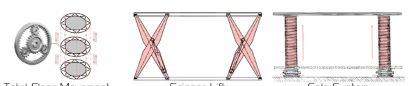
INTERIOR WALL SYSTEM ANALYSIS



	Typical	Accordion	Sliding	Swivel	Versare Versipanel	Everblock	DIRTT	FlexBlock
Modular						●	●	●
Fully Recyclable								●
Reusable					●	●	●	●
Structural								●
Easy Assembly	●	●	●	●	●	●	●	●
Specialists Required		●					●	
Flexible		●			●	●	●	●
Plug and Unplug						●	●	●
Rigid	●	●	●	●	●	●	●	●
Adjustable Vertically						●	●	●
Adjustable Horizontally						●	●	●
High Waste	●	●	●	●	●	●		

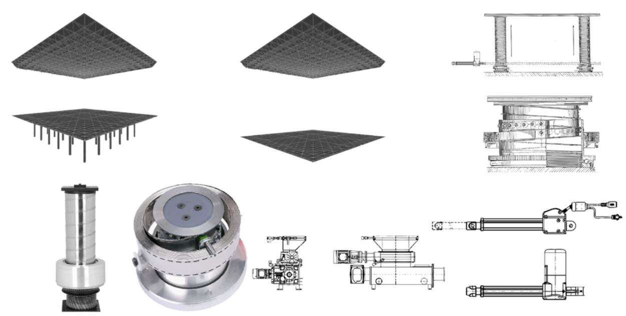


FLOOR SYSTEM ANALYSIS

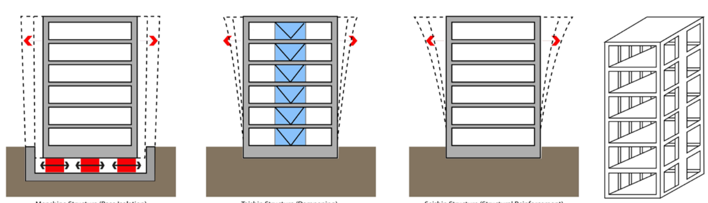


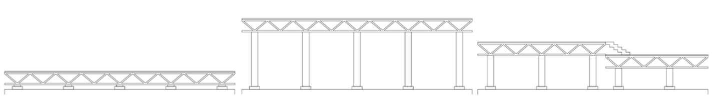
	Total Floor Movement	Scissor Lift	Gala System
Loss Of Center Of Gravity When in Motion	●		
Sturdy	●	●	●
Minimal Maintenance		●	●
Noisy	●	●	
Main Structure Special Adequation	●		
Highly Compact			●
Reliability		●	●
Easy To Install		●	●
Adaptable			●
Low Power		●	●

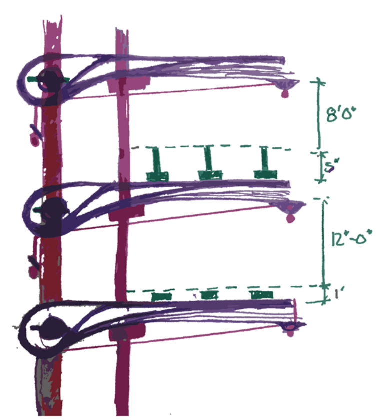
GALA SYSTEM

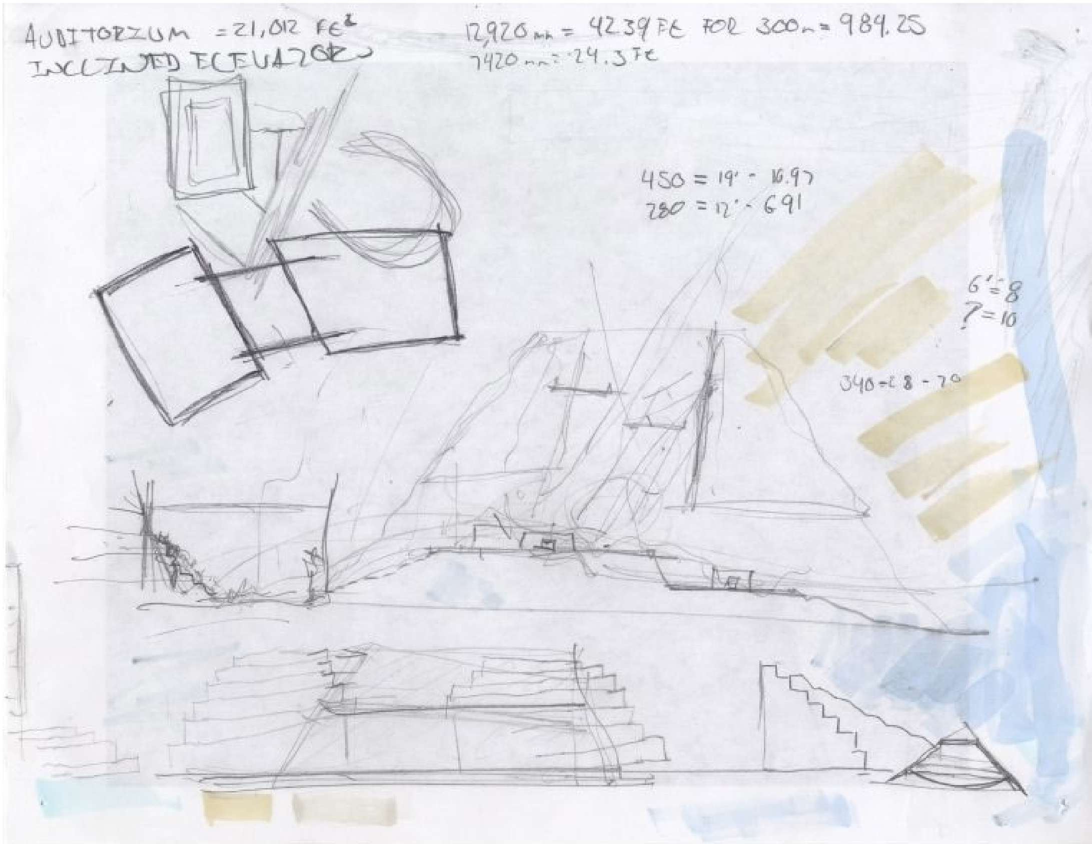


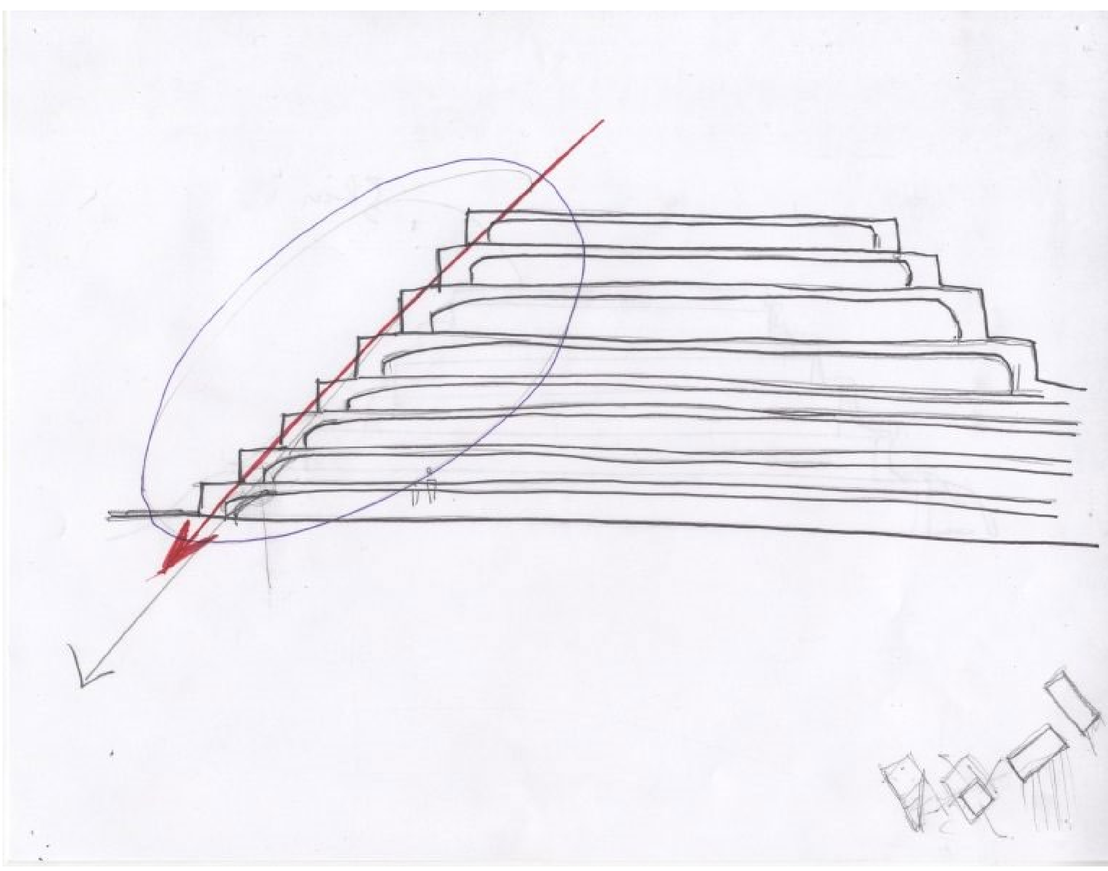
STRUCTURAL SYSTEM ANALYSIS

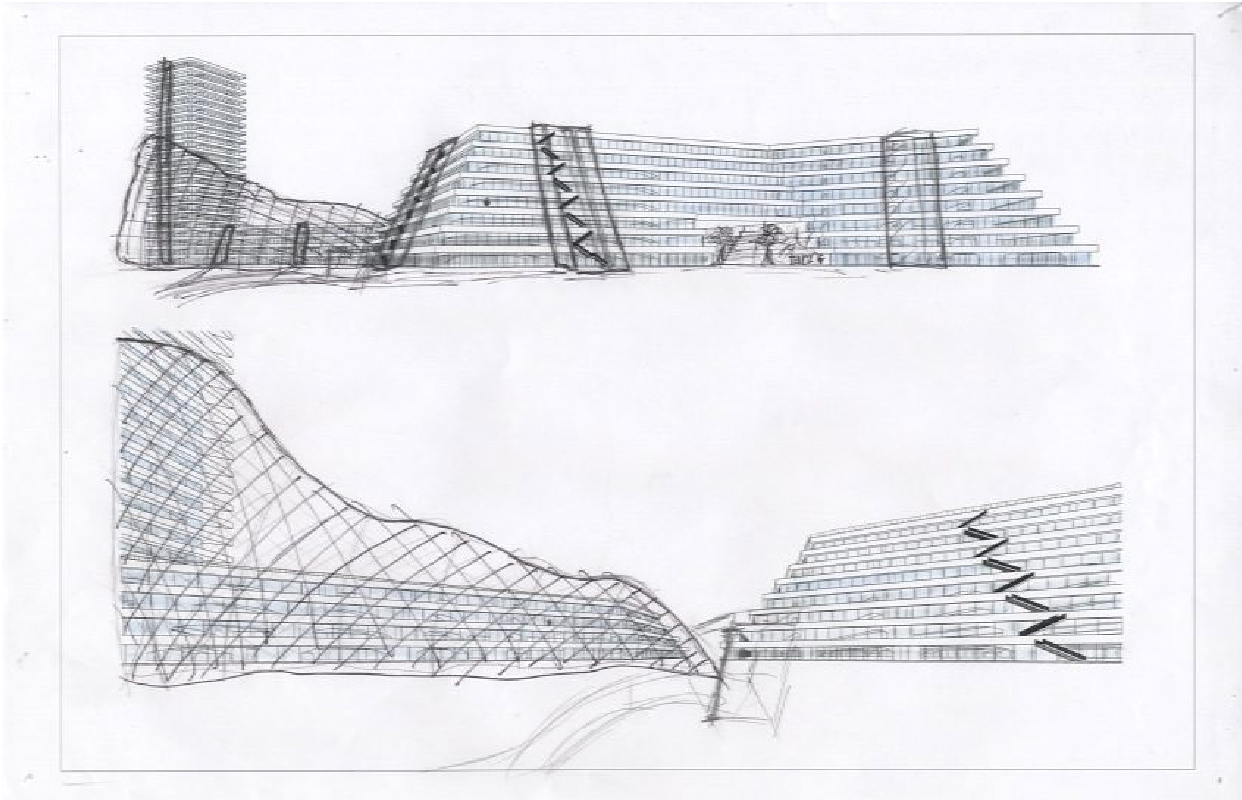


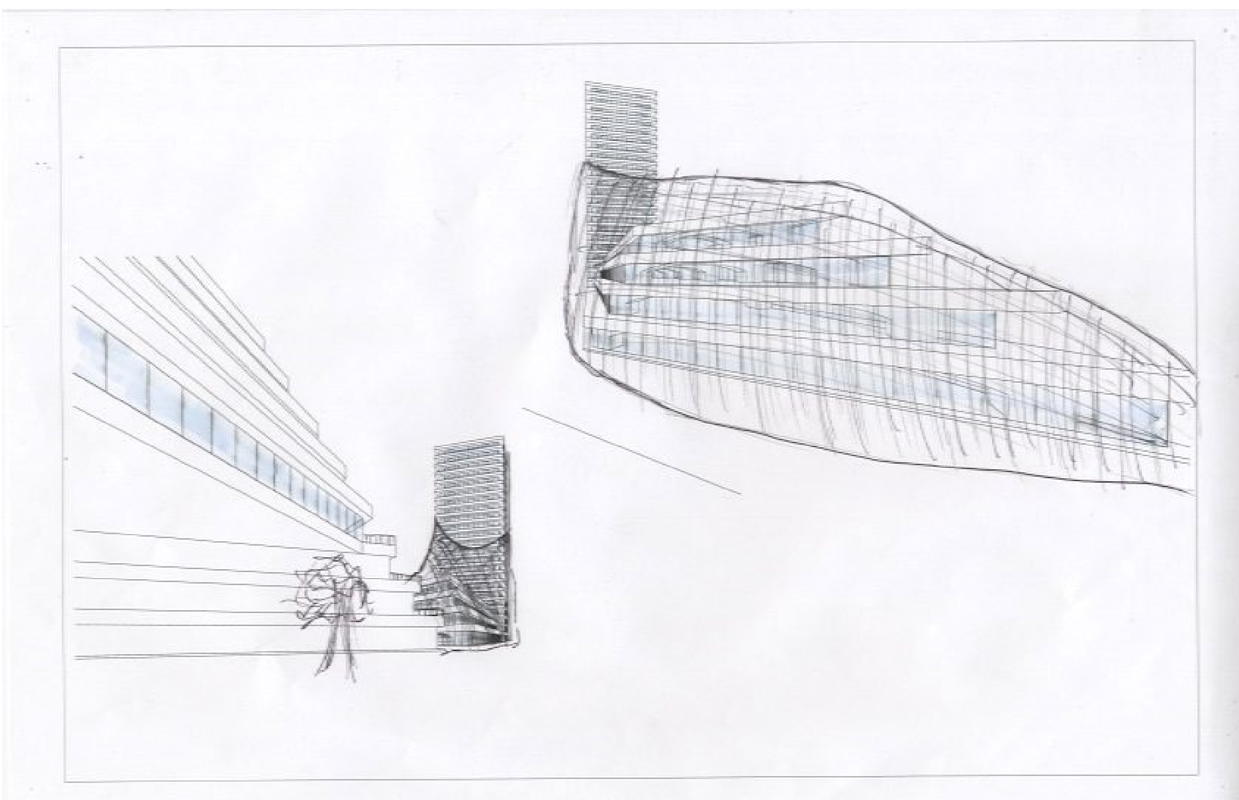


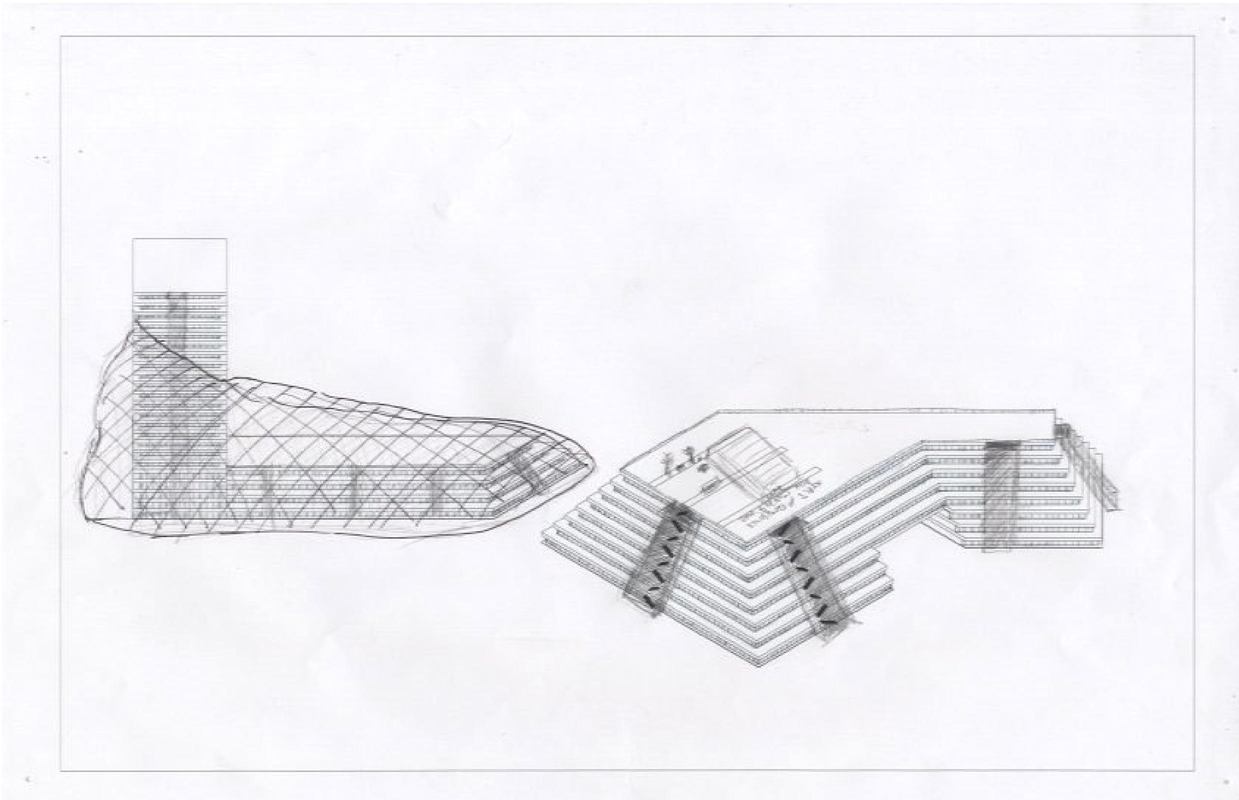


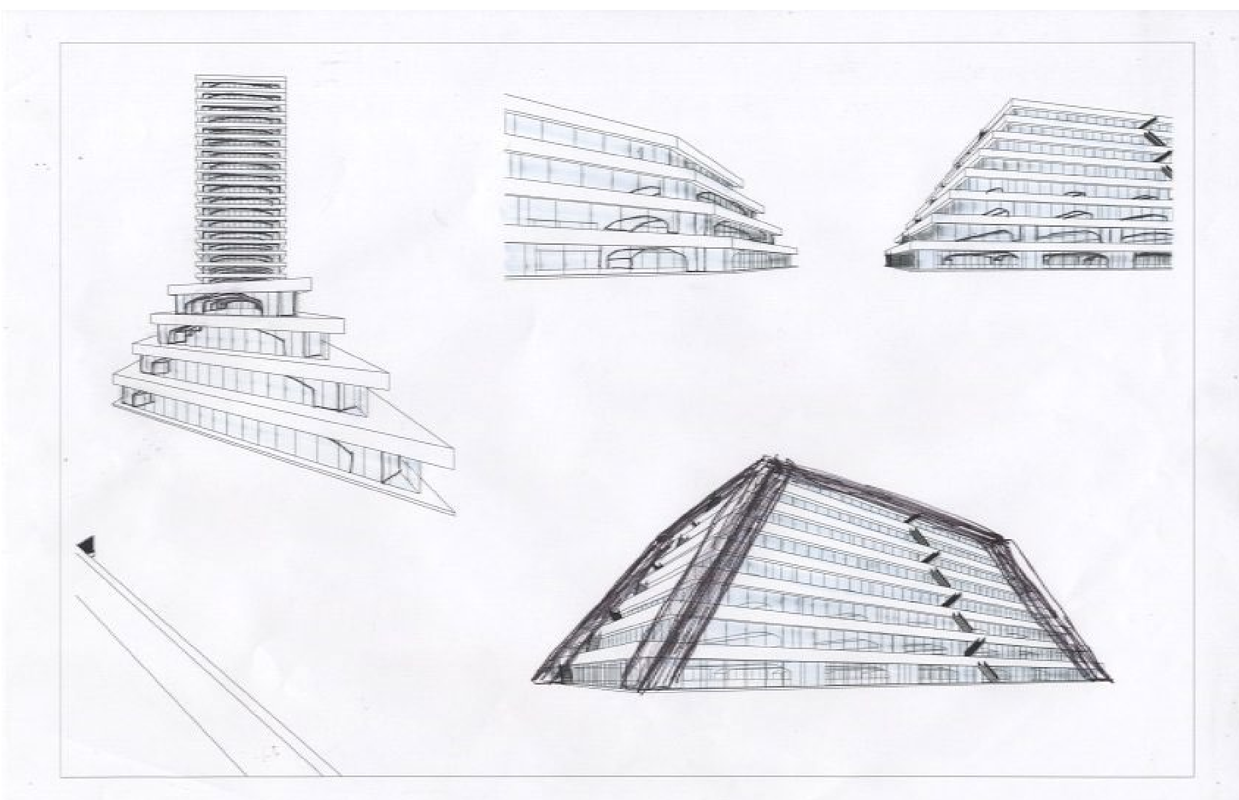

AUDITORIUM = 21,012 ft²
INCLINED ELEVATOR
12,920 mm = 42.39 ft FOR 300 m = 984.25
450 = 19' - 16.97
280 = 12' - 6.91
6' = 8
7 = 10

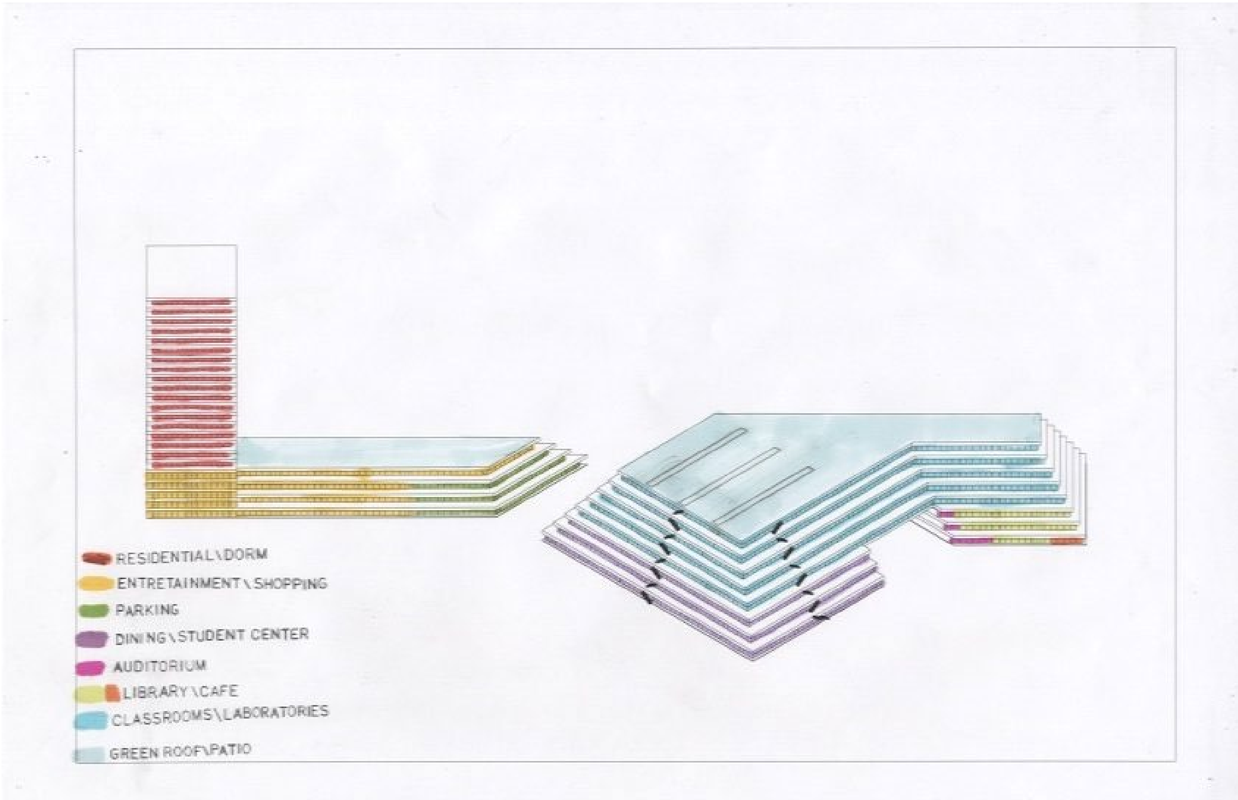


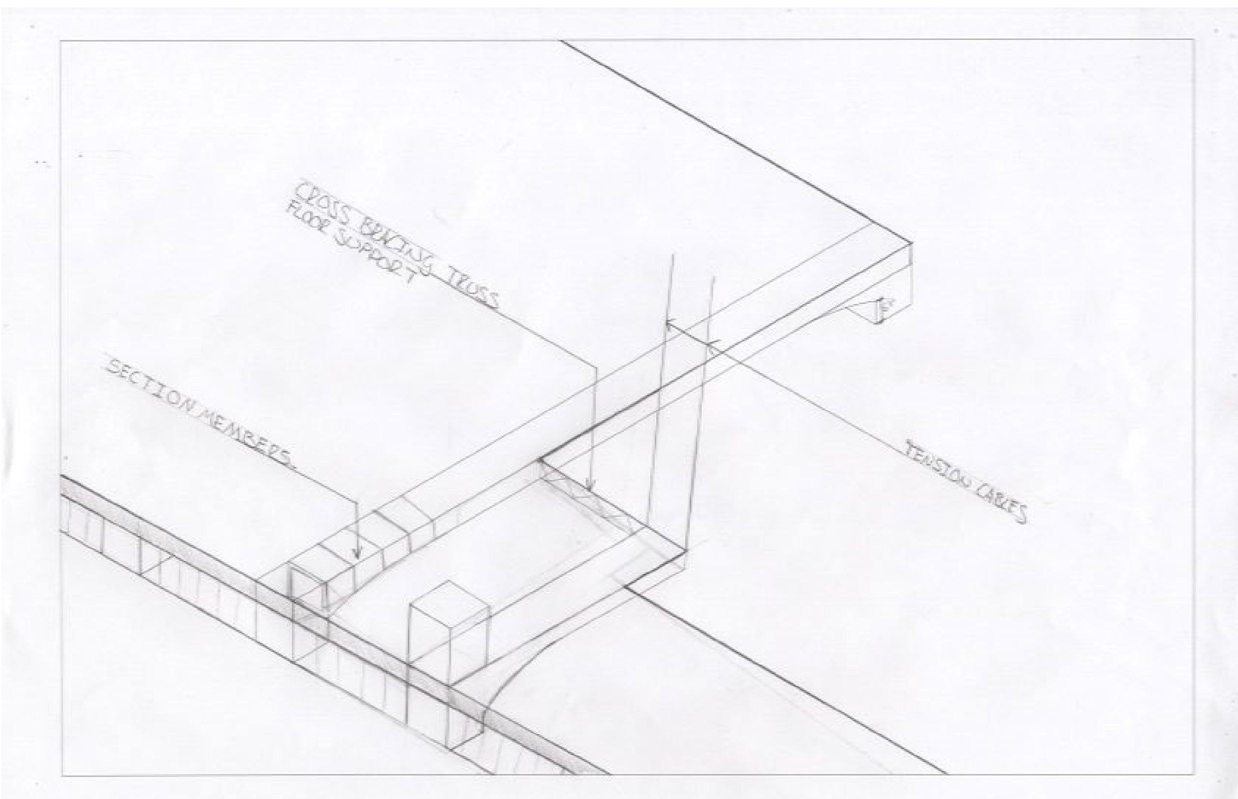


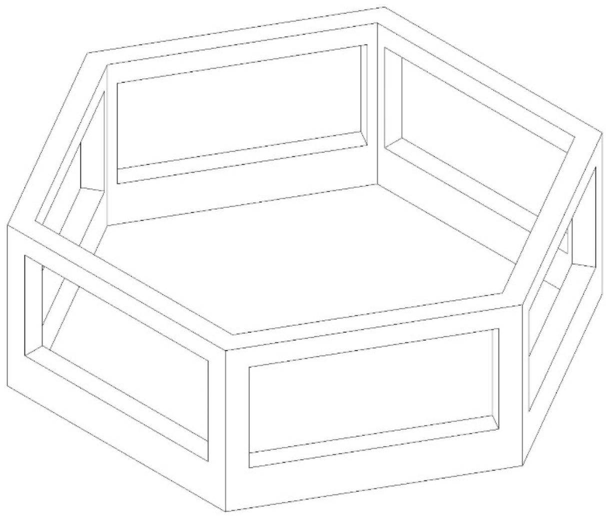


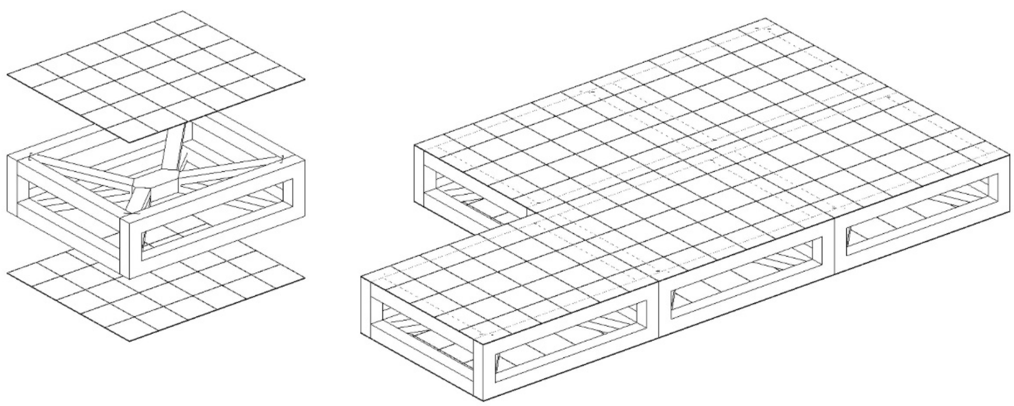


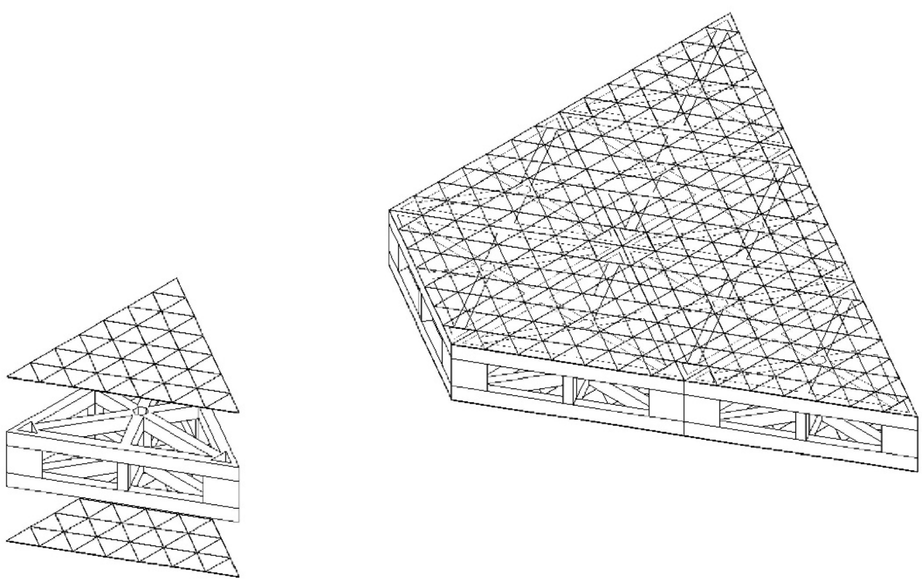


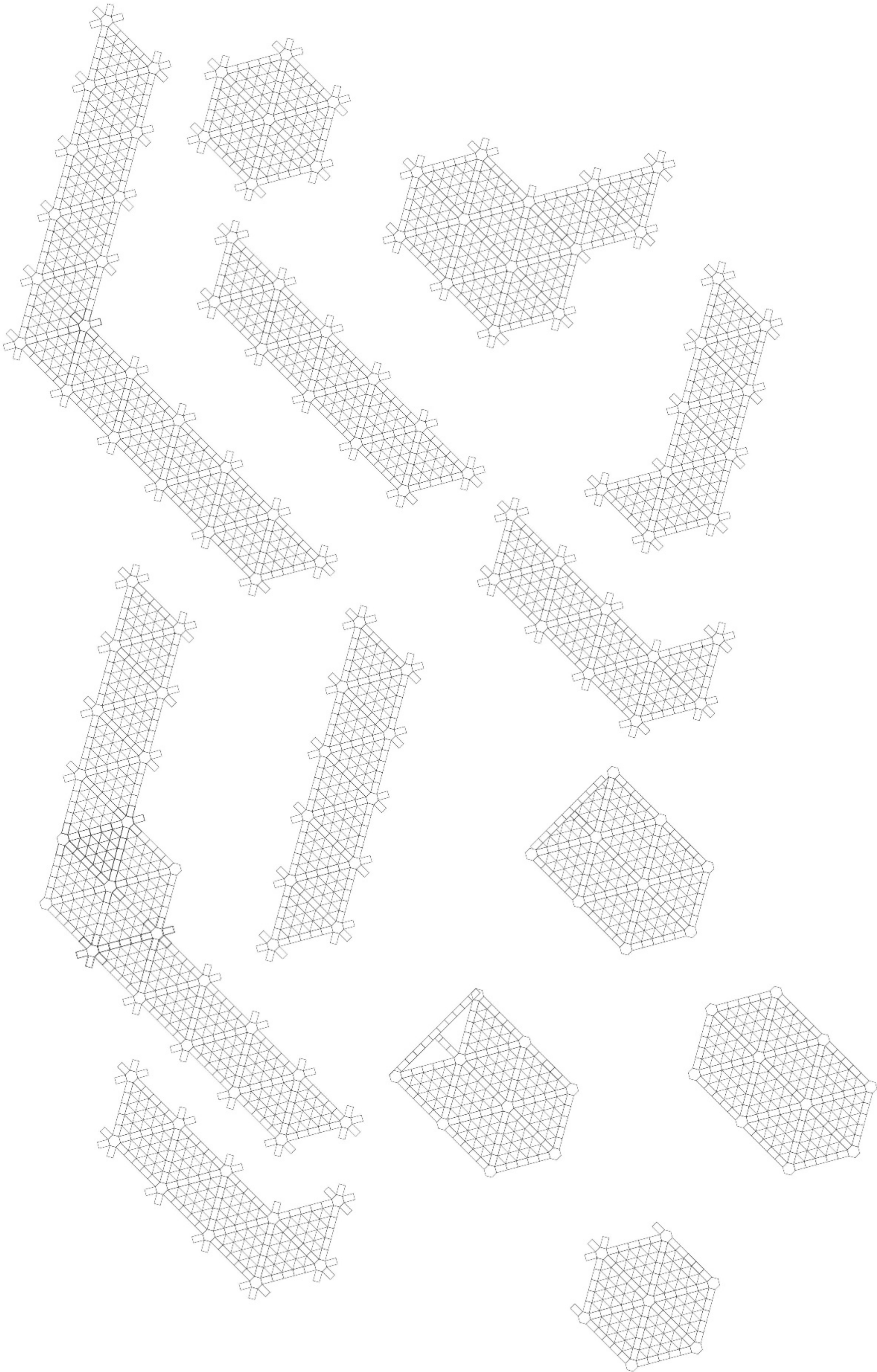

RESIDENTIAL\DORM
ENTRETAINMENT\SHOPPING
PARKING
DINING\STUDENT CENTER
AUDITORIUM
LIBRARY\CAFE
CLASSROOMS\LABORATORIES
GREEN ROOF\PATIO


CROSS BRACING TRUSS
FLOOR SUPPORT
SECTION MEMBERS
TENSION CABLES










Av. Javier Barros Sierra
Av. Javier Barros Sierra
Vasco de Quiroga
Supermark
Selecto Chedr
Samara Santa
Av Sta Fe
amex
Citibanamex
Vasco de Quiroga
Estacionamiento
Alfonso Nápoles Gándara
redIT Santa Fe
Catholic Church
Parroquia de San Josemaría Escrivá
IBM de México, S. de RL de CV
Vasco de Quiroga
Antonio Dovali Jaime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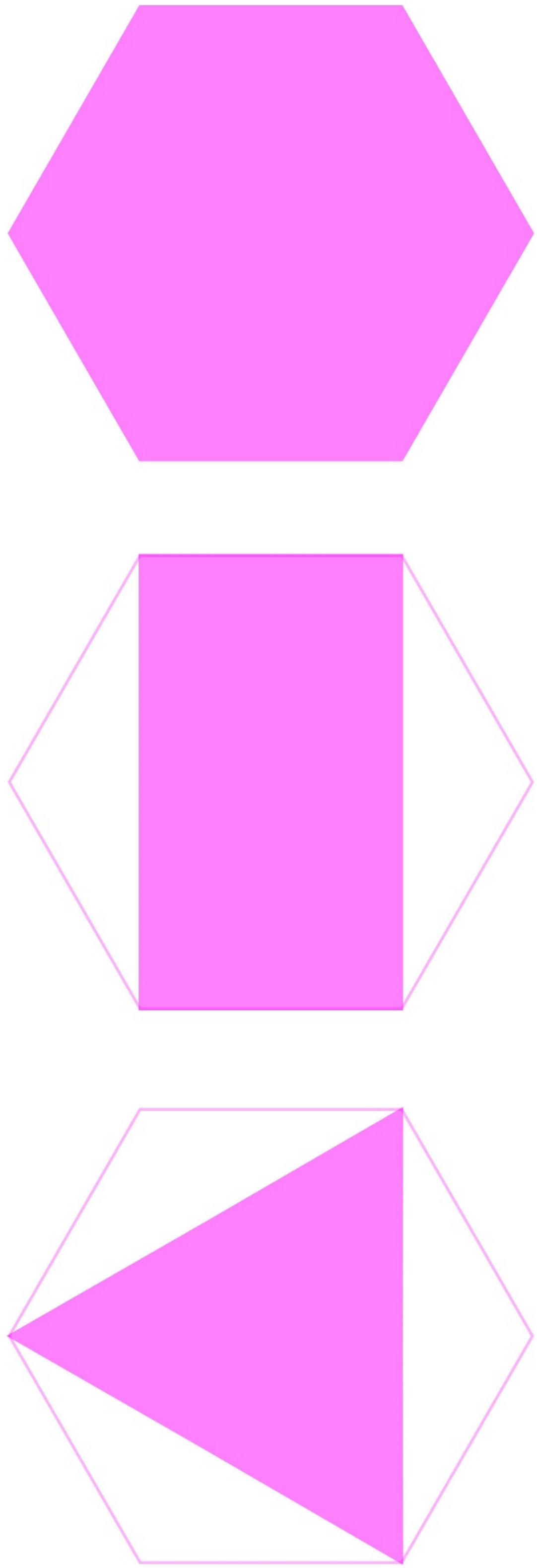
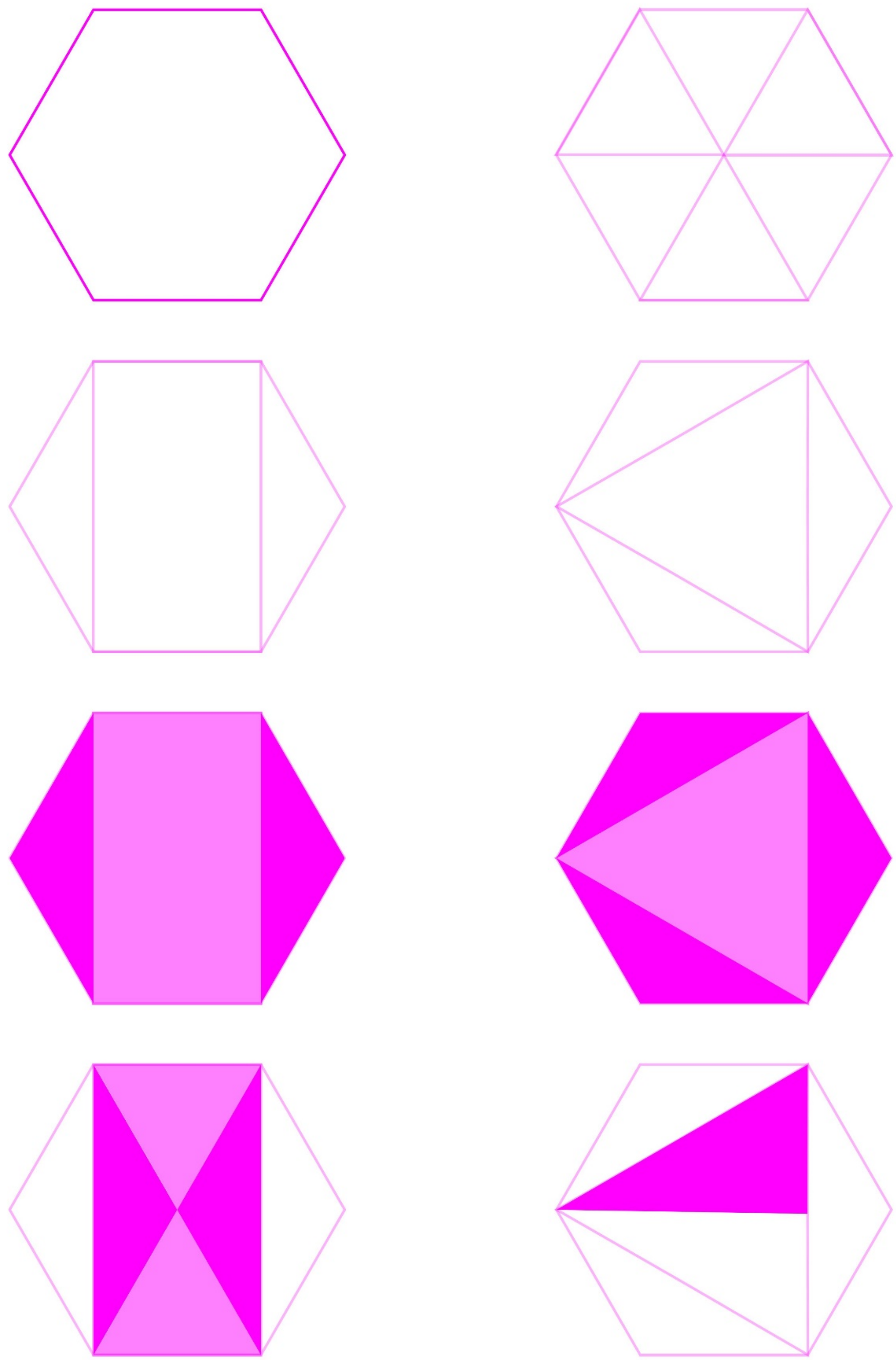
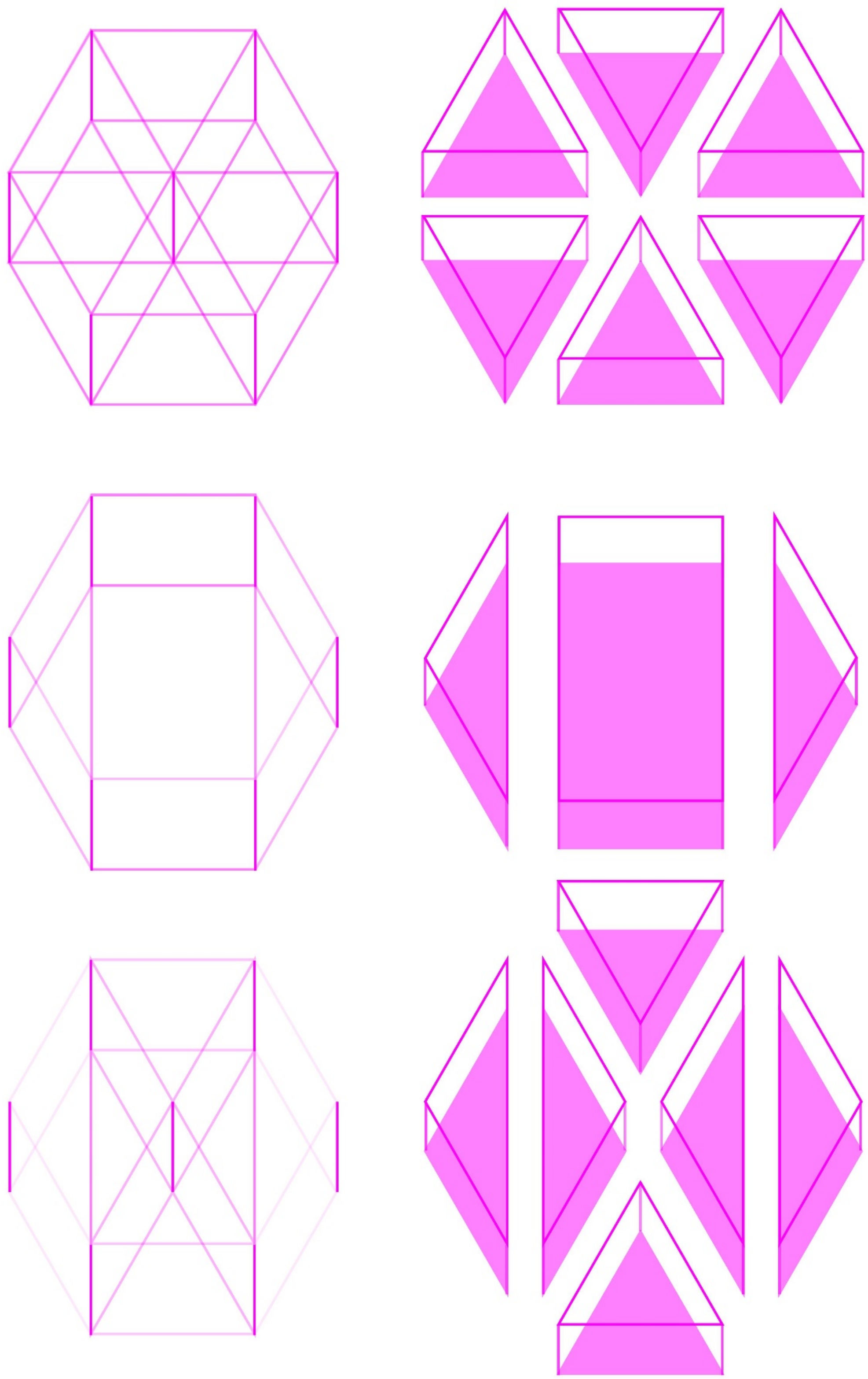
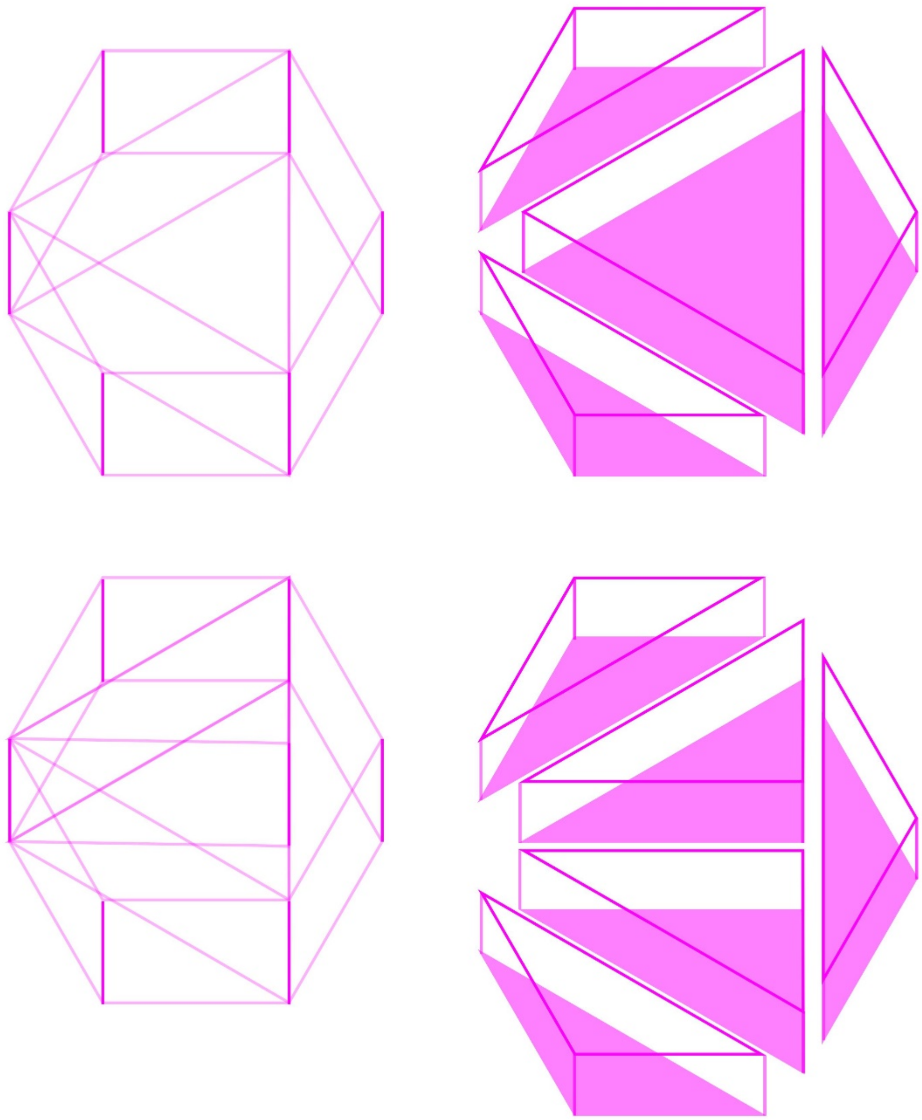
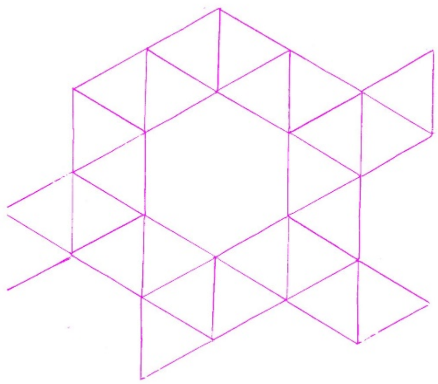
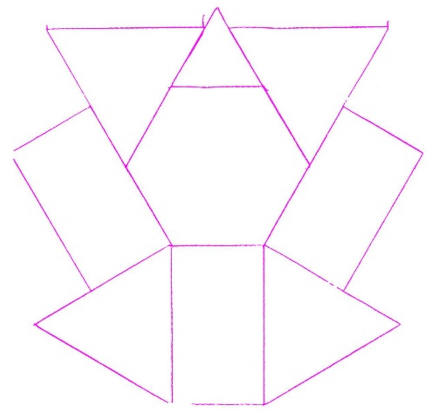


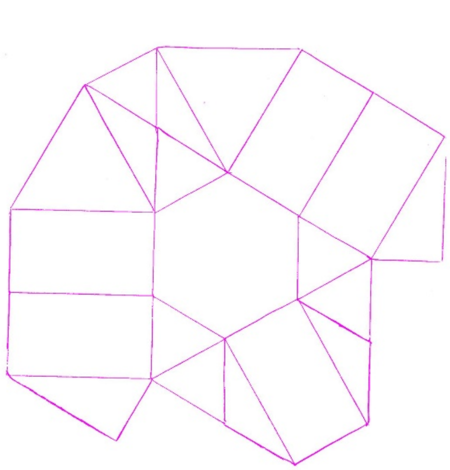


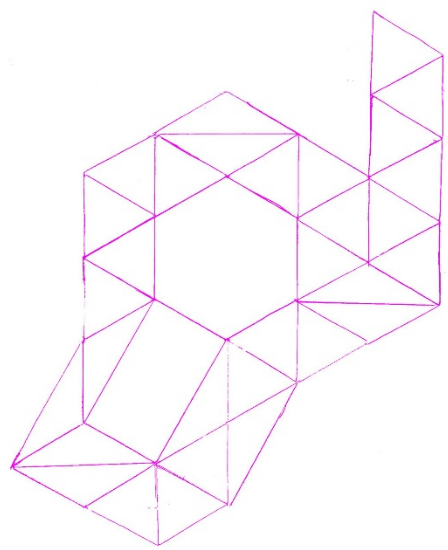


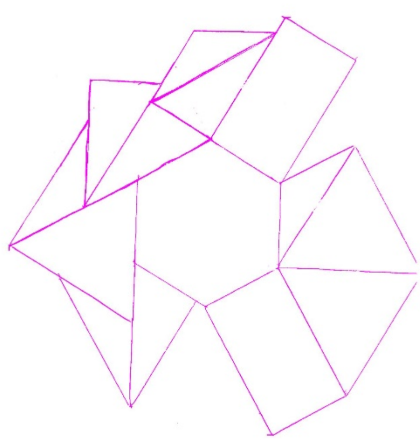


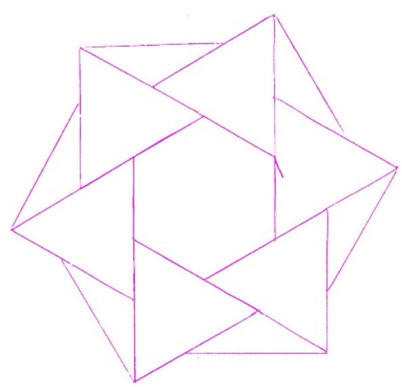


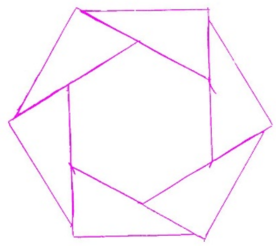


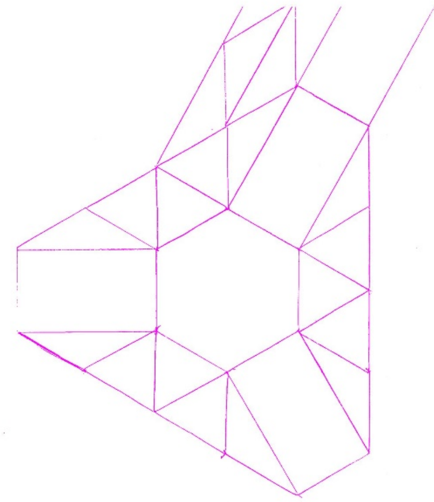


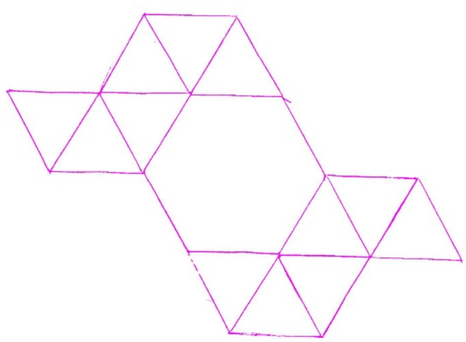


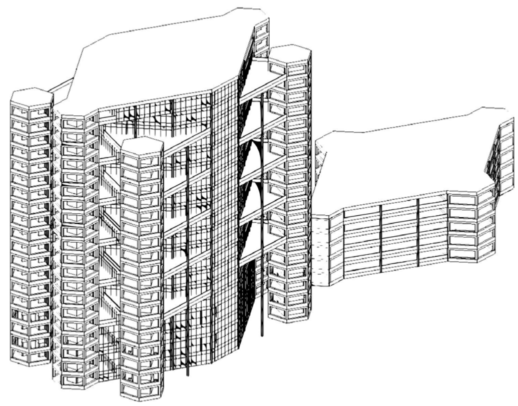


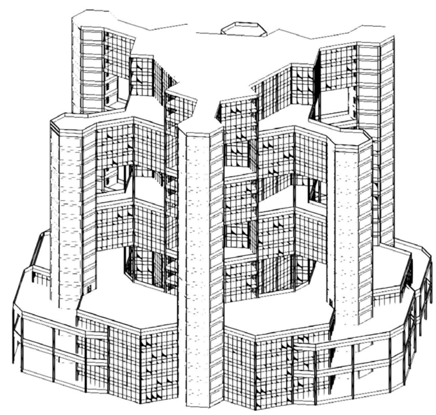


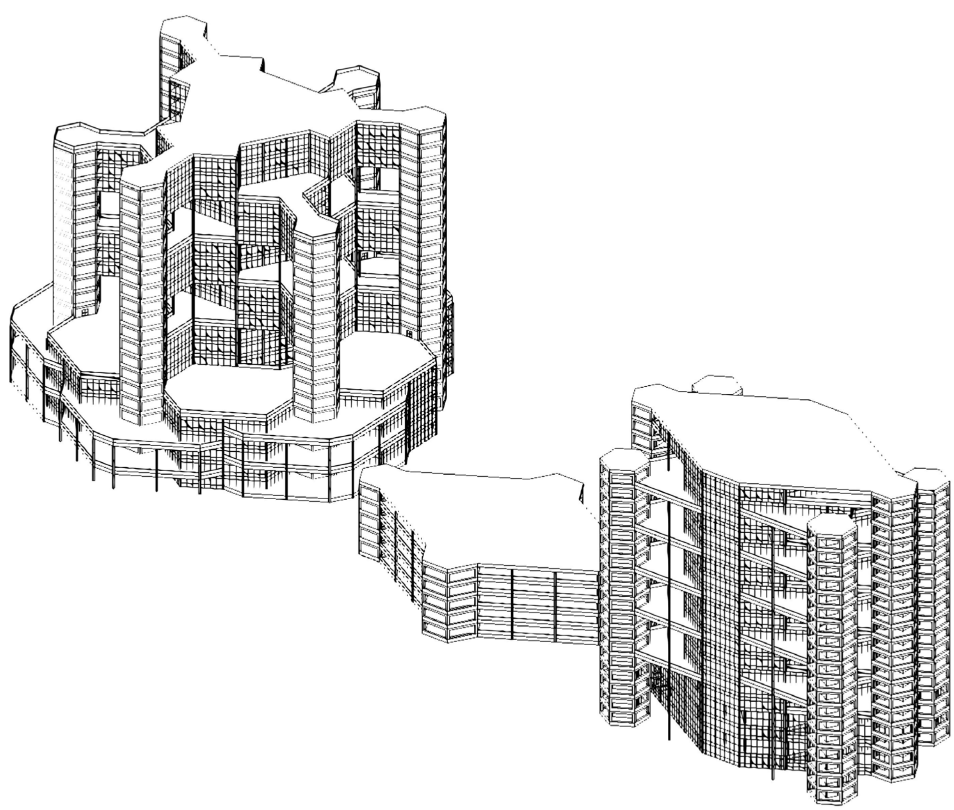


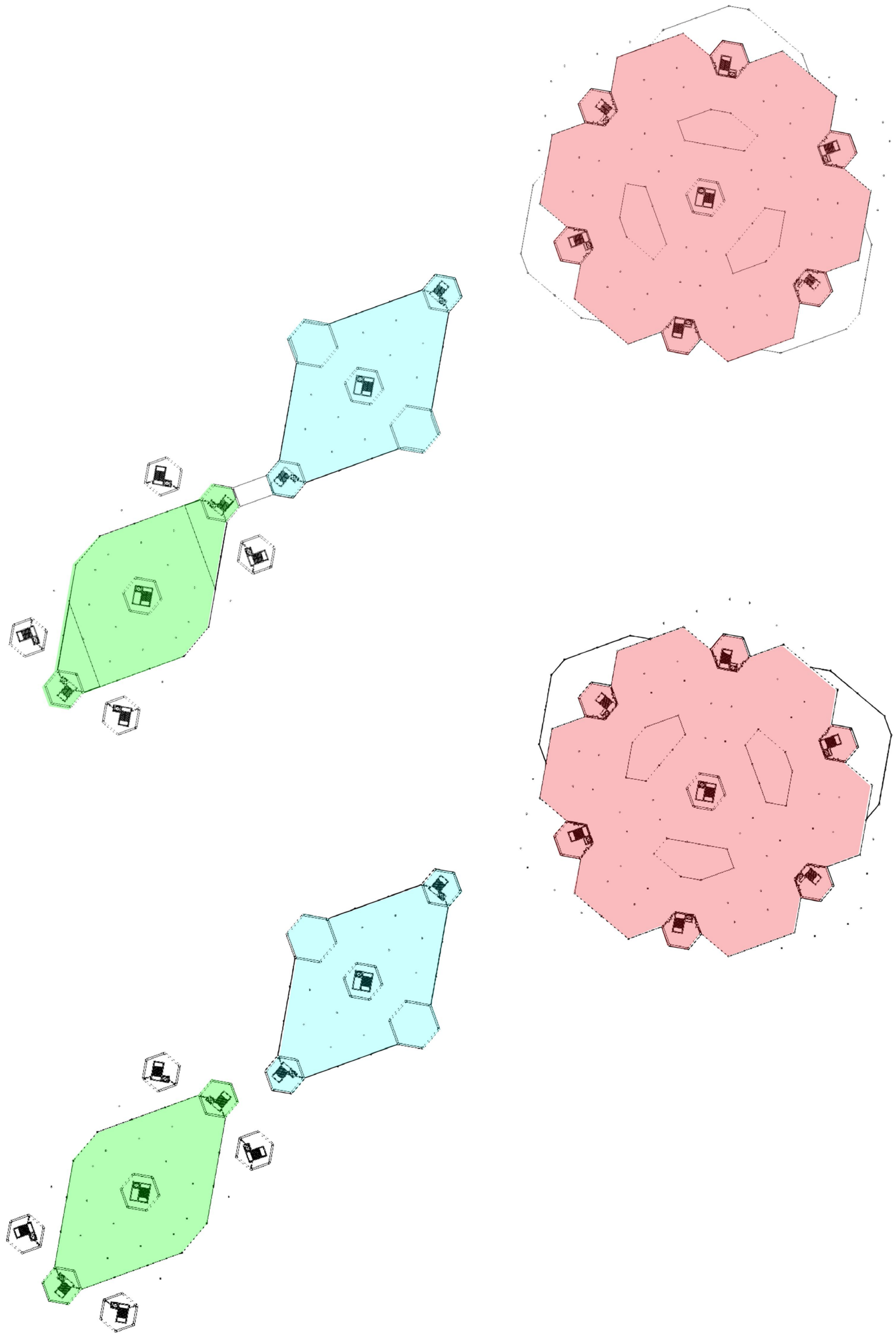


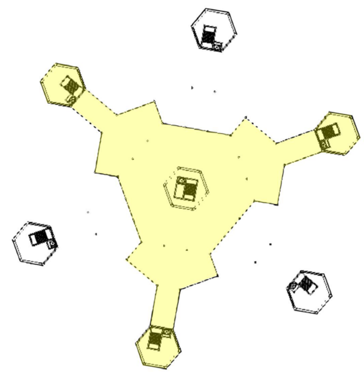


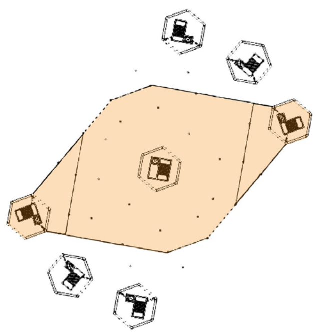


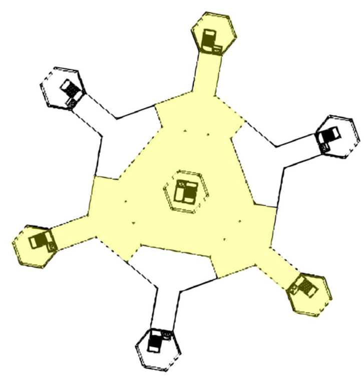


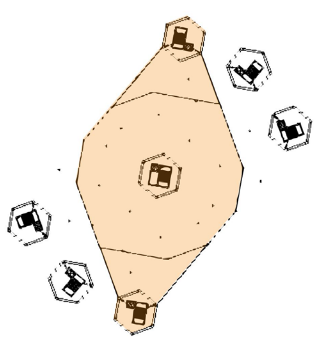


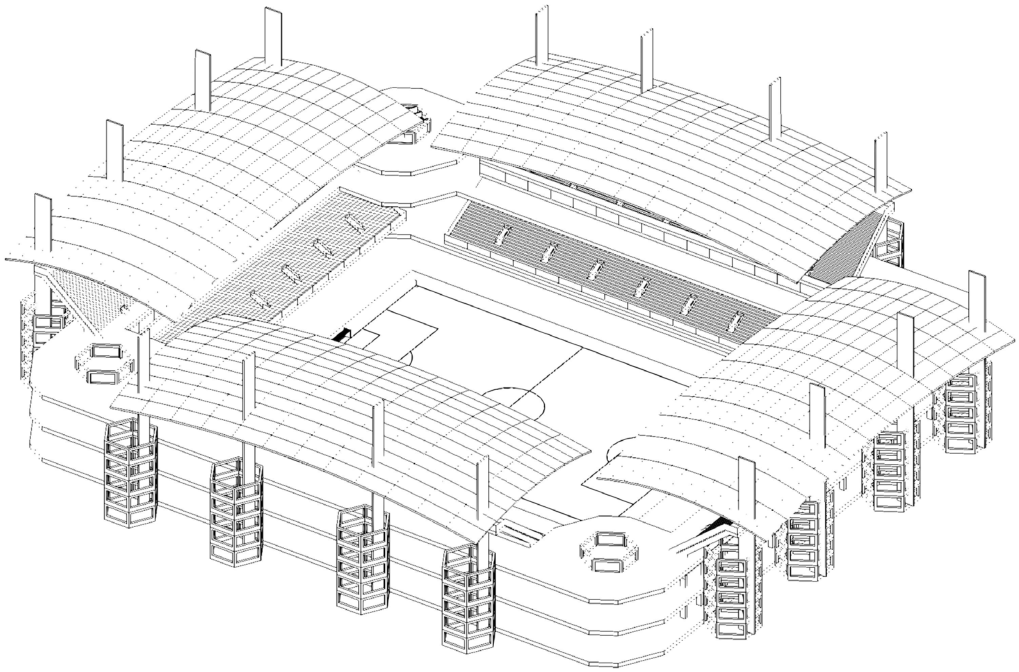


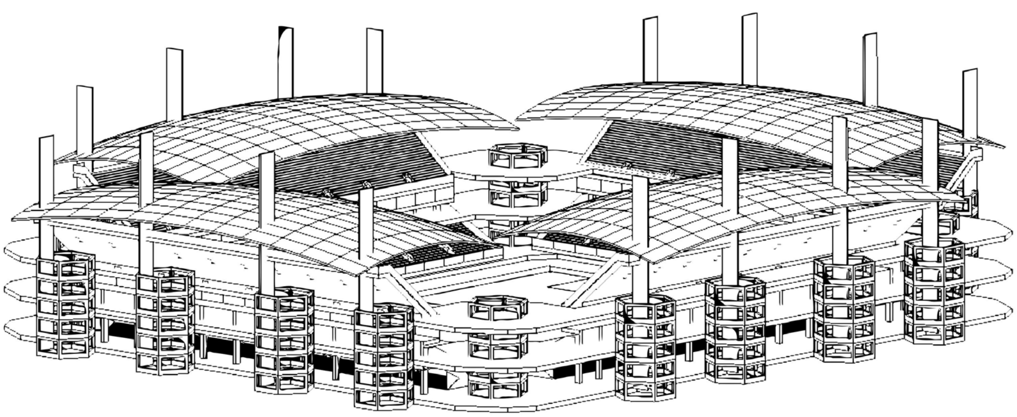


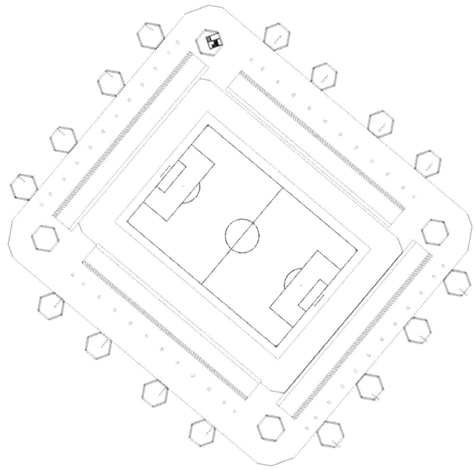


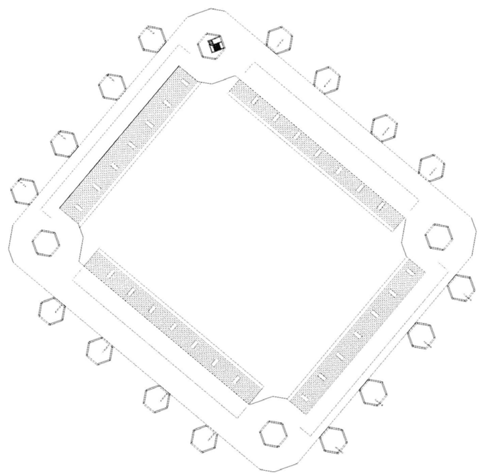


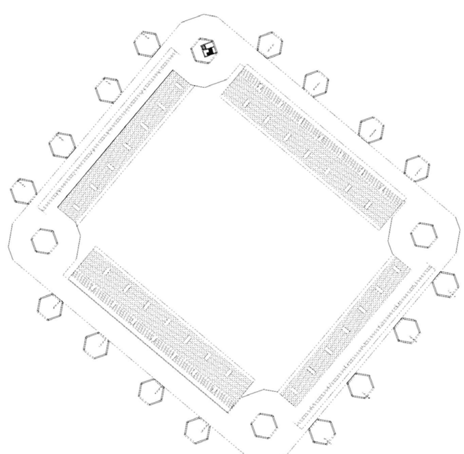




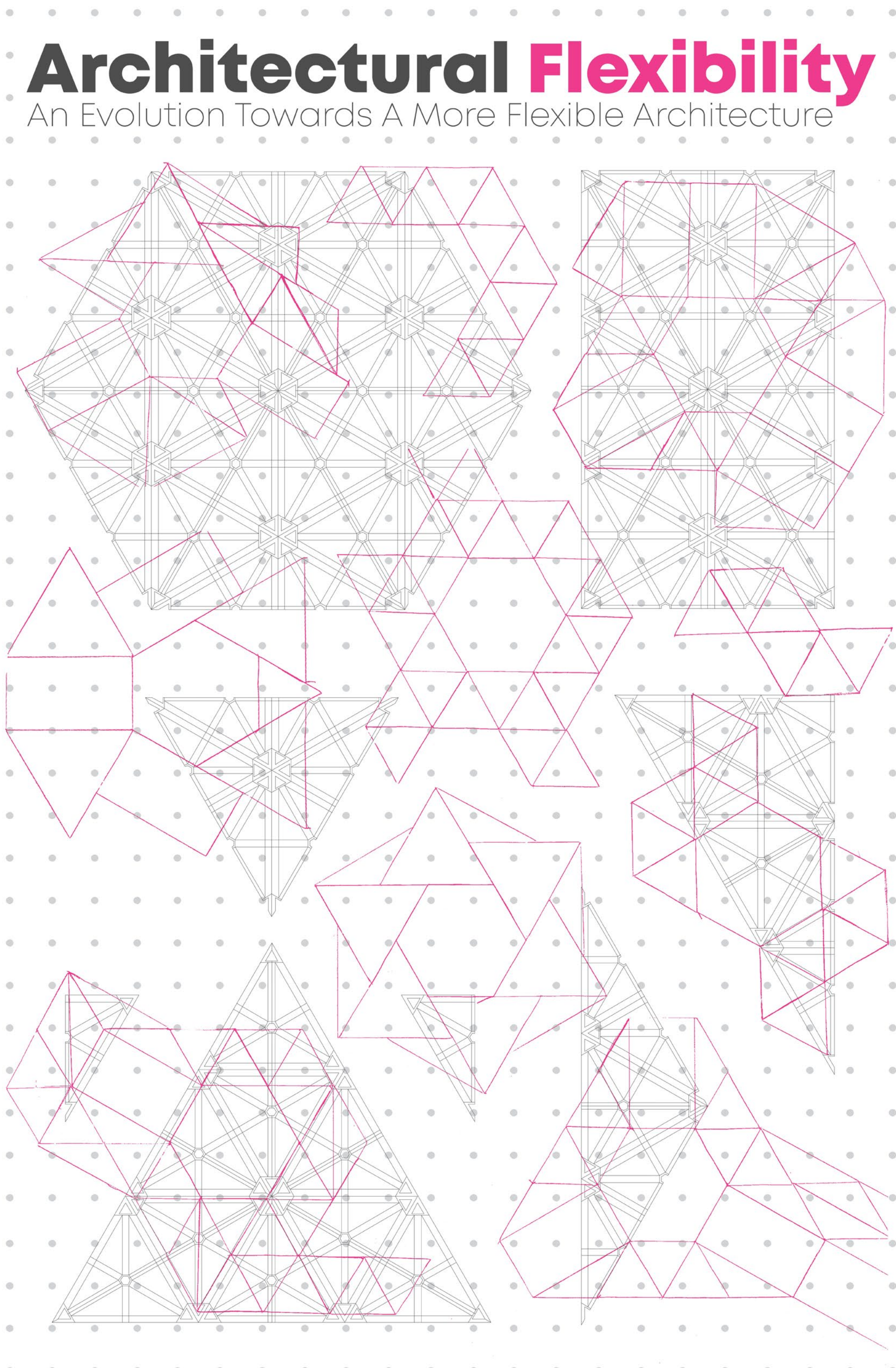








Final Design

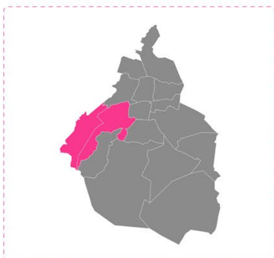


Architectural Flexibility

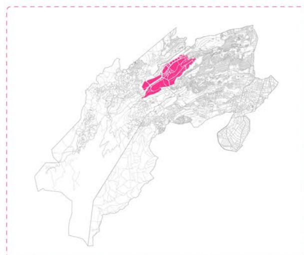
An Evolution Towards a More Flexible Architecture

Mexico

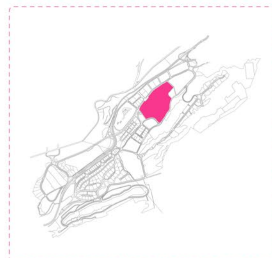
Distrito Federal, Mexico



Delegacion Alvaro Obregon & Cuajimalpa



Santa Fe, CDMX

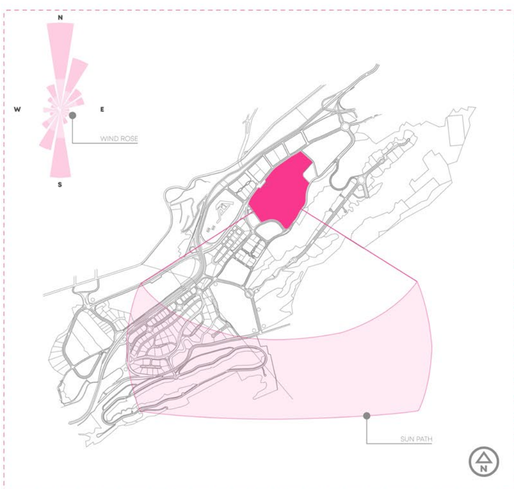


Alameda Poniente - Santa Fe, CDMX

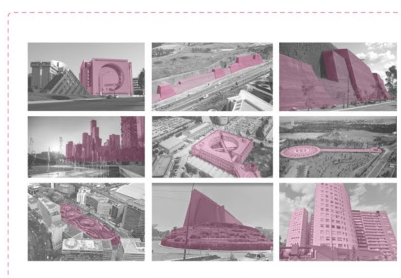
WORLD LOCATION

THESIS STATEMENT

Architectural Flexibility and adaptability are required for the future. As humanity becomes more complex architecture needs to have a way to adapt to the new needs that humanity and the environment requires. By creating an architectural system that allows for change and can be re-used we can create buildings that are long lasting and allow for the user input anytime the buildings need to change. Mexico City was picked as my site because it is a city that has and will continue having a high influx of people coming and living the city, thus it would be a great case study of how this building system could work in an environment that requires frequent change through the life span of the building. By creating modular systems, it allows buildings to have small as well as big changes done to them depending on the situation with little effort. With the implementation of all the required buildings systems in the modules we can create a chain within the system that could be connected in many different ways to allow for the freedom of design and adaptability.



Site Analysis

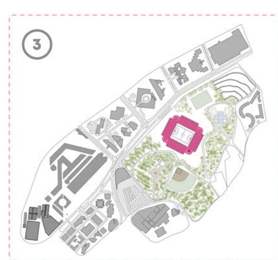


Surrounding Context

SITE

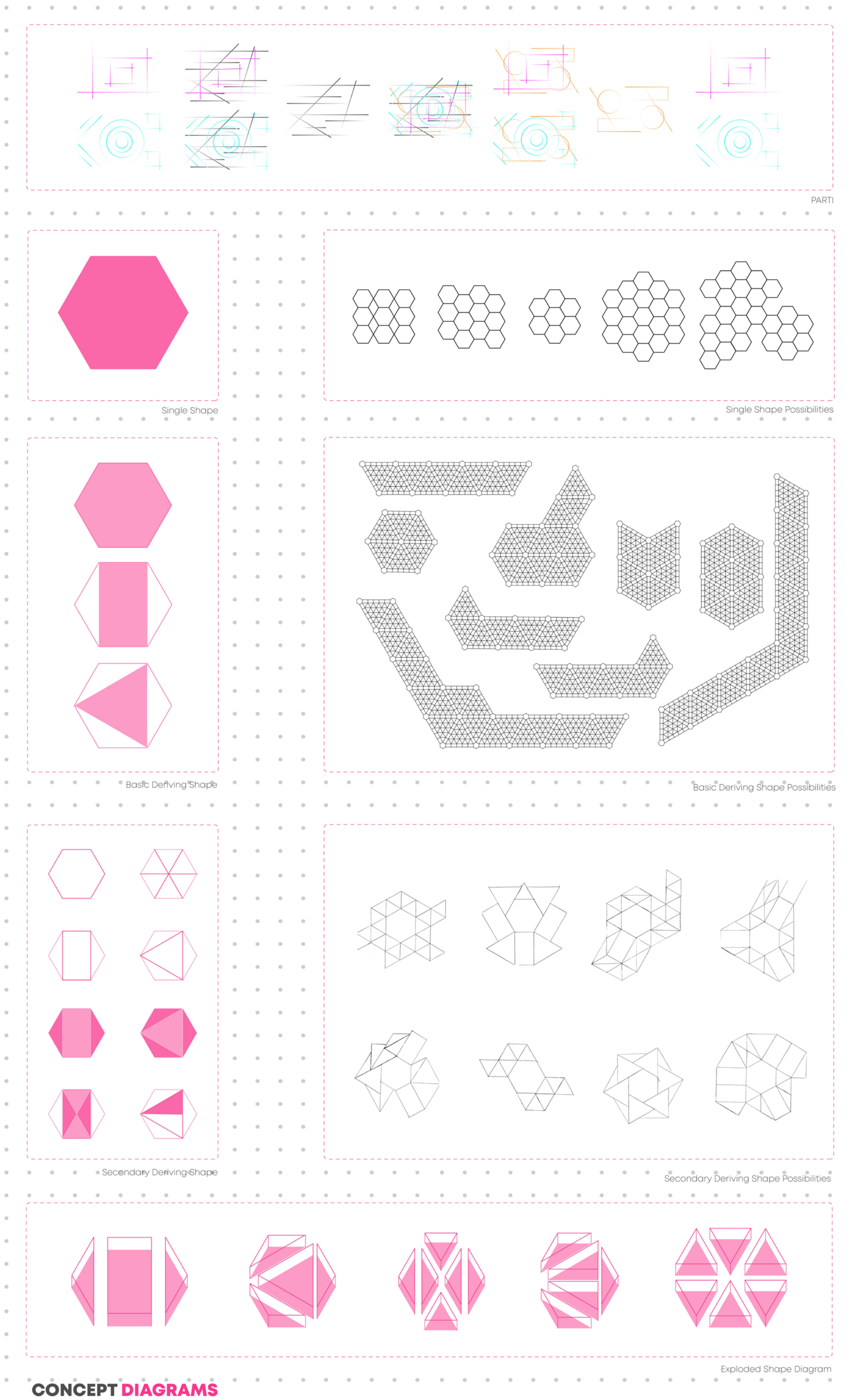
University Iteration

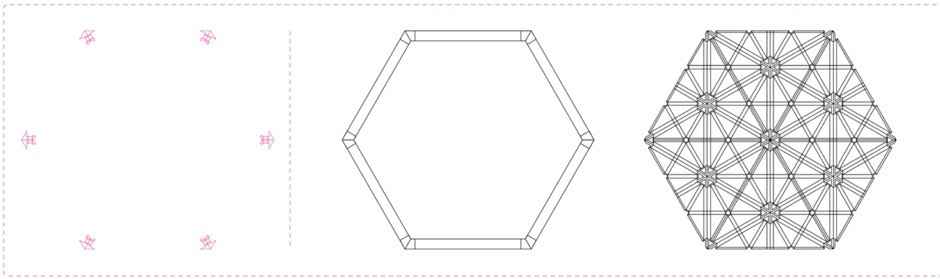
Residential Iteration



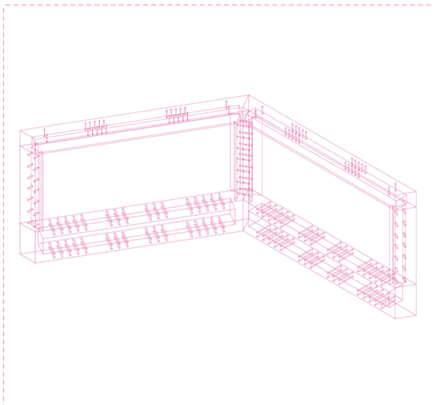
Stadium Iteration

MASTER PLANS

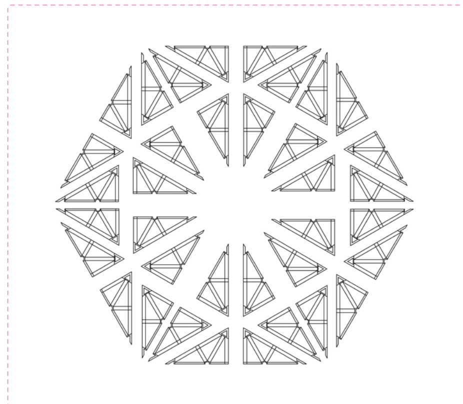

PARTI
Single Shape
Single Shape Possibilities
Basic Deriving Shape
Basic Deriving Shape Possibilities
Secondary Deriving Shape
Secondary Deriving Shape Possibilities
Exploded Shape Diagram
CONCEPT DIAGRAMS



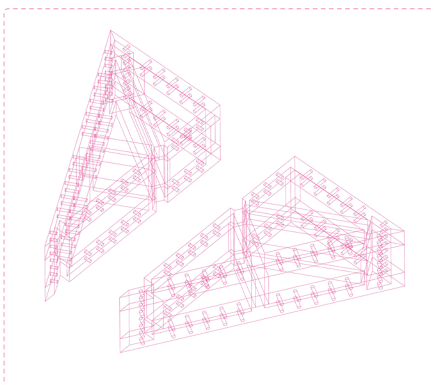
Hexagon Basic Construction



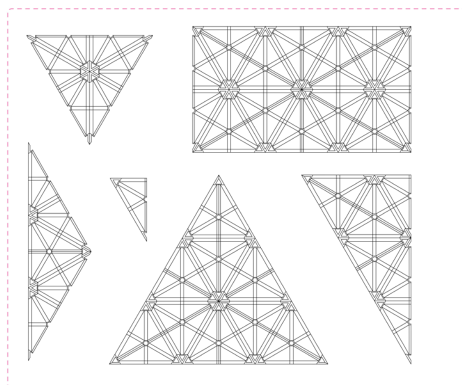
Hexagon Connection



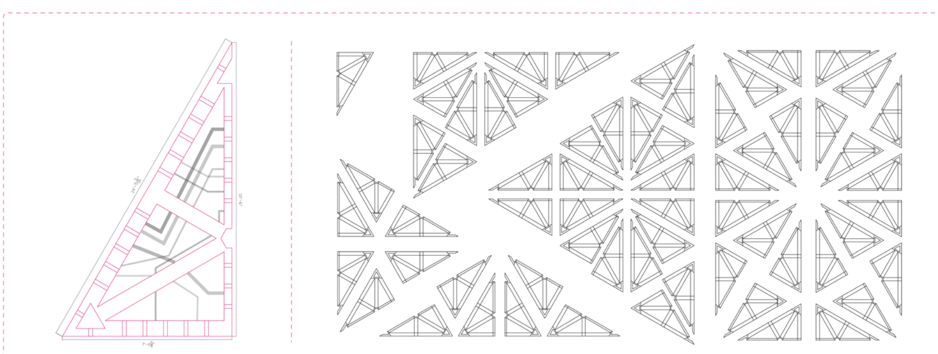
Hexagon Construction Exploded



Related Shapes Connection

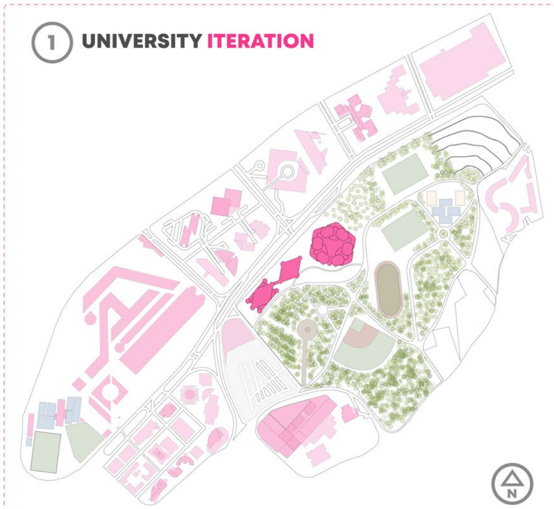


Related Shapes Basic Construction

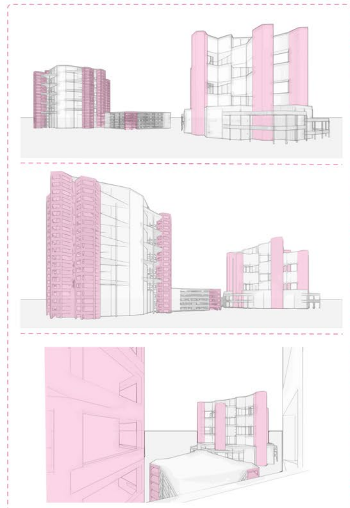


Related Shapes Construction Exploded - Basic Shape Dimensions

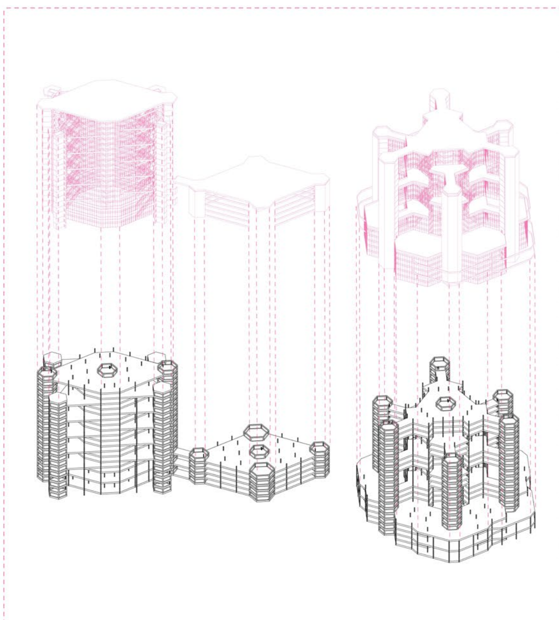
BUILDING PIECES DIAGRAMS



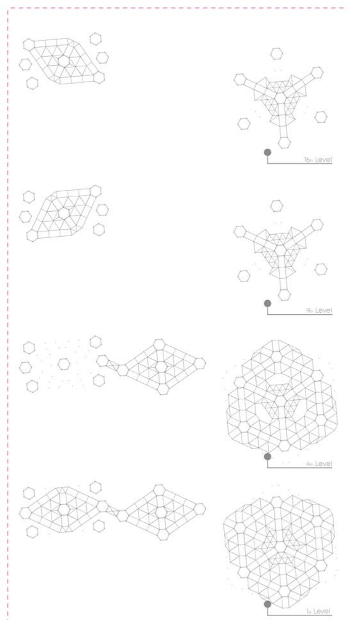
University Iteration Master Plan



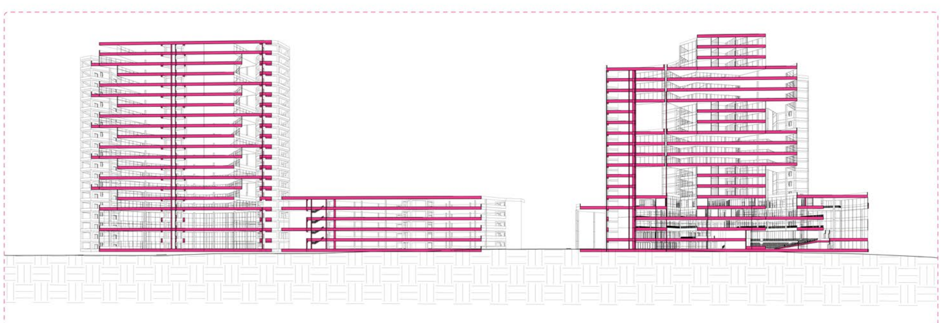
University Renderings



University Exploded Axon

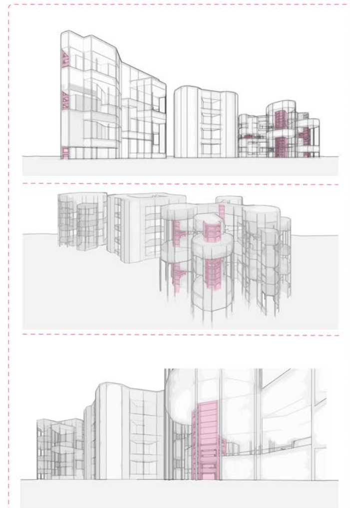


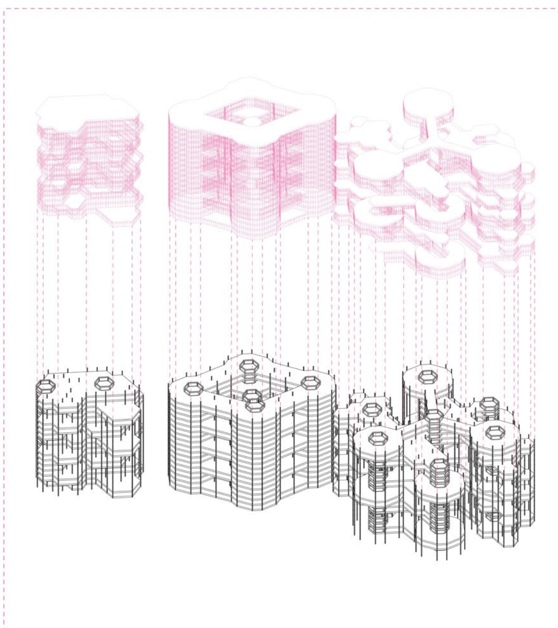
University Floor Plate Assembly

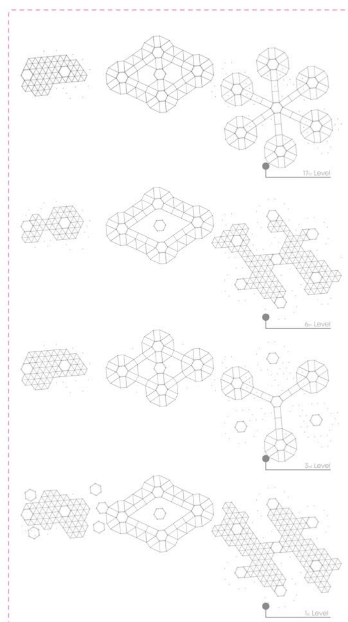


University Perspective Section

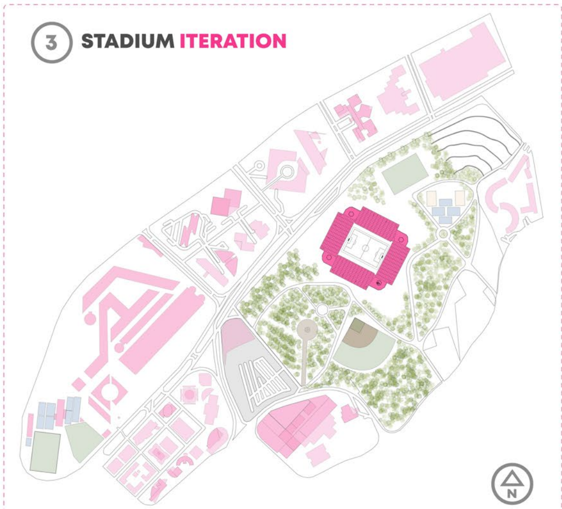
Residential Iteration Master Plan


Residential Renderings

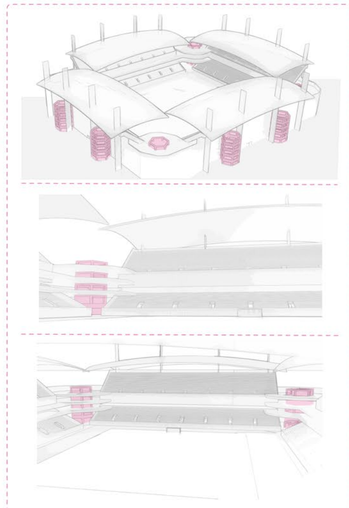

Residential Exploded Axon

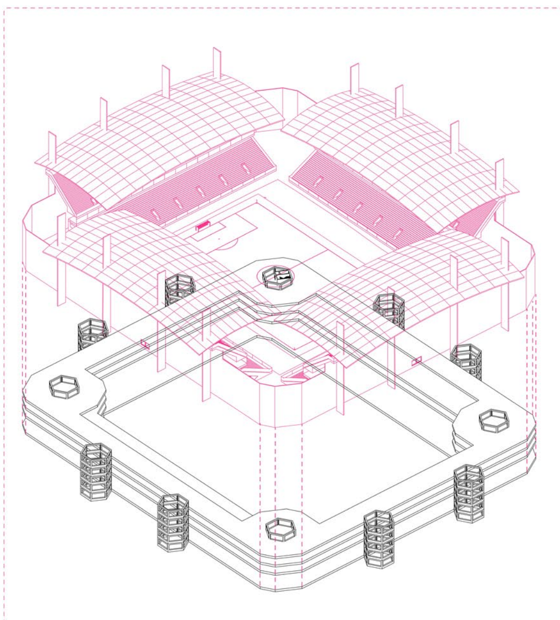

Residential Floor Plate Assembly

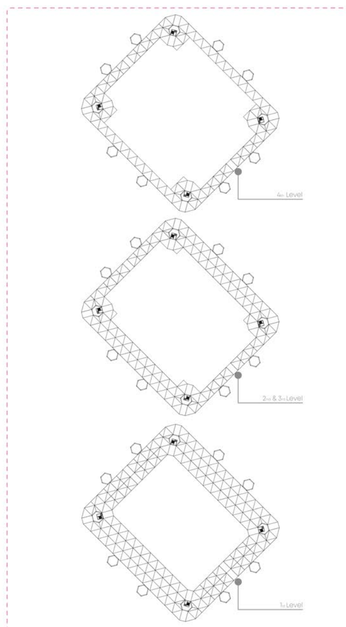

Residential Perspective Section



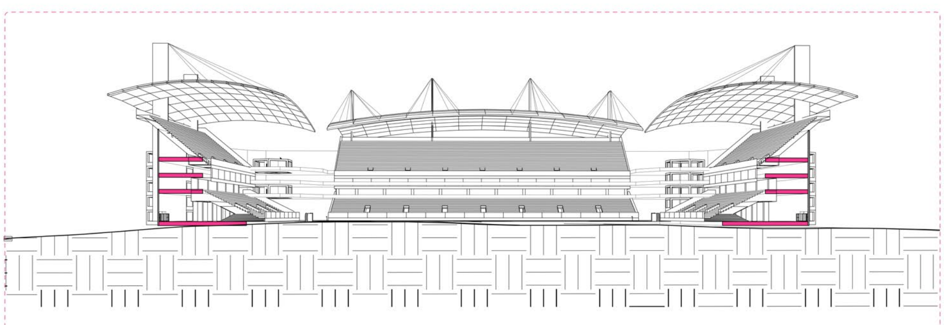
Stadium Iteration Master Plan

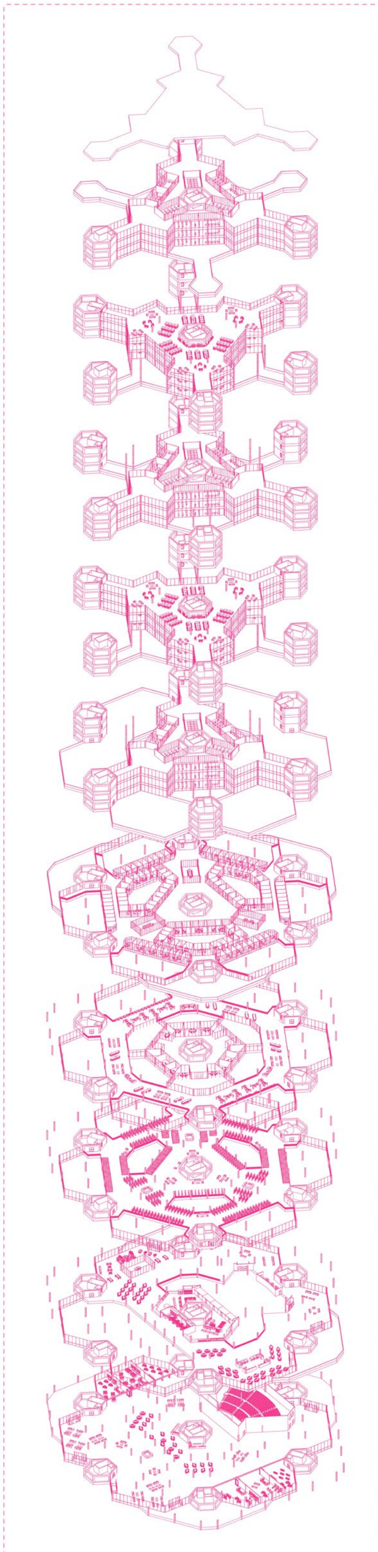

Stadium Renderings


Stadium Exploded Axon

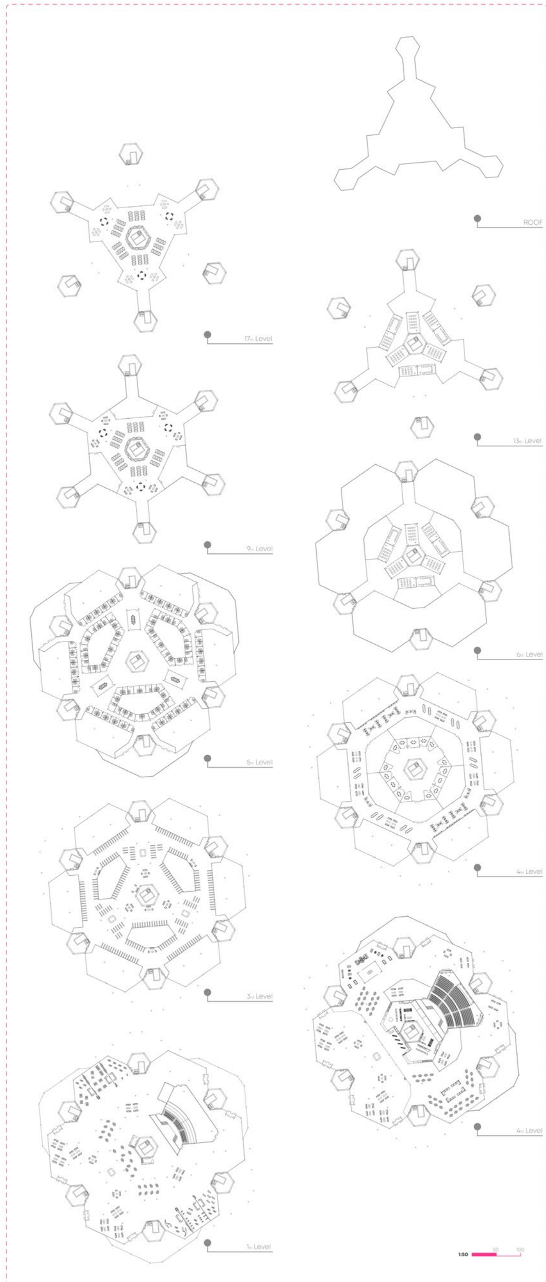


Stadium Floor Plate Assembly


Stadium Perspective Section



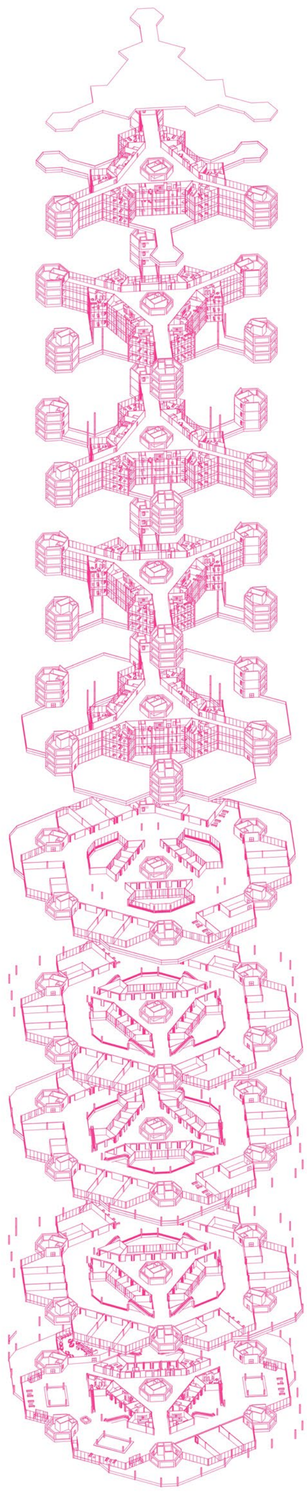
Exploded Building Diagram



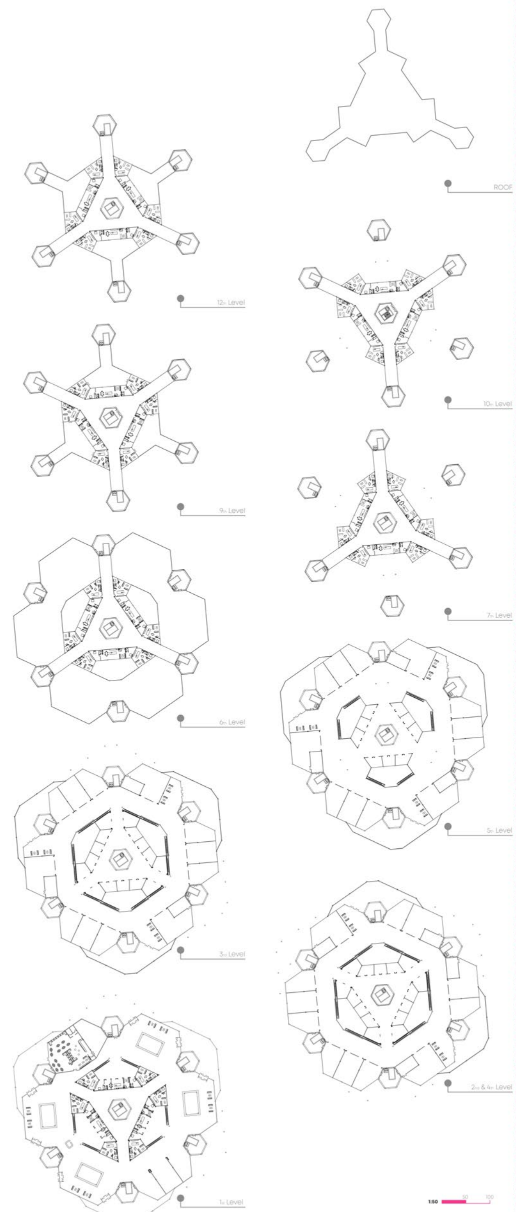
Floor Plans 1" = 50'

University Interior Rendering

1° **UNIVERSITY ITERATION**



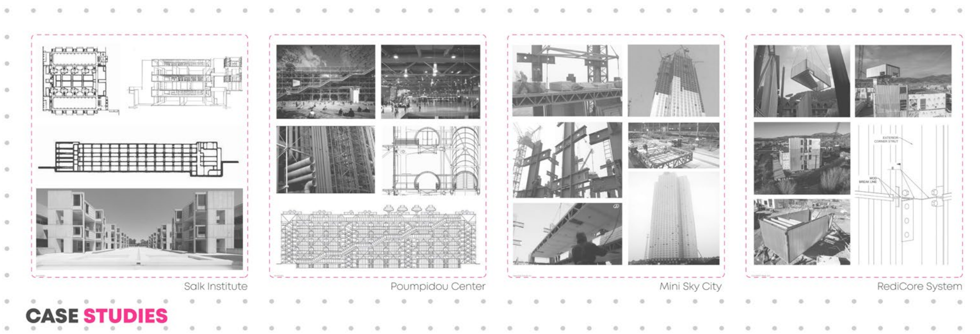
Exploded Building Diagram

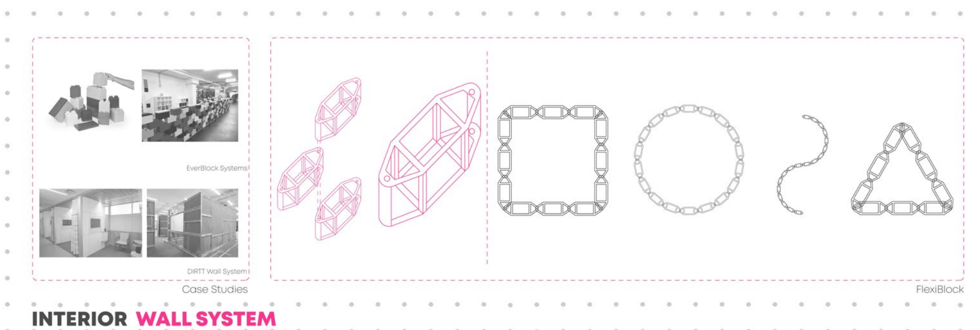


Floor Plans Scale: 1" = 50'

Apartment Interior Rendering

1 HOUSING - MALL ITERATION


Salk Institute
Poumpidou Center
Mini Sky City
RediCore System
CASE STUDIES


EverBlock Systems
DIRTT Wall System
Case Studies
FlexiBlock
INTERIOR WALL SYSTEM

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