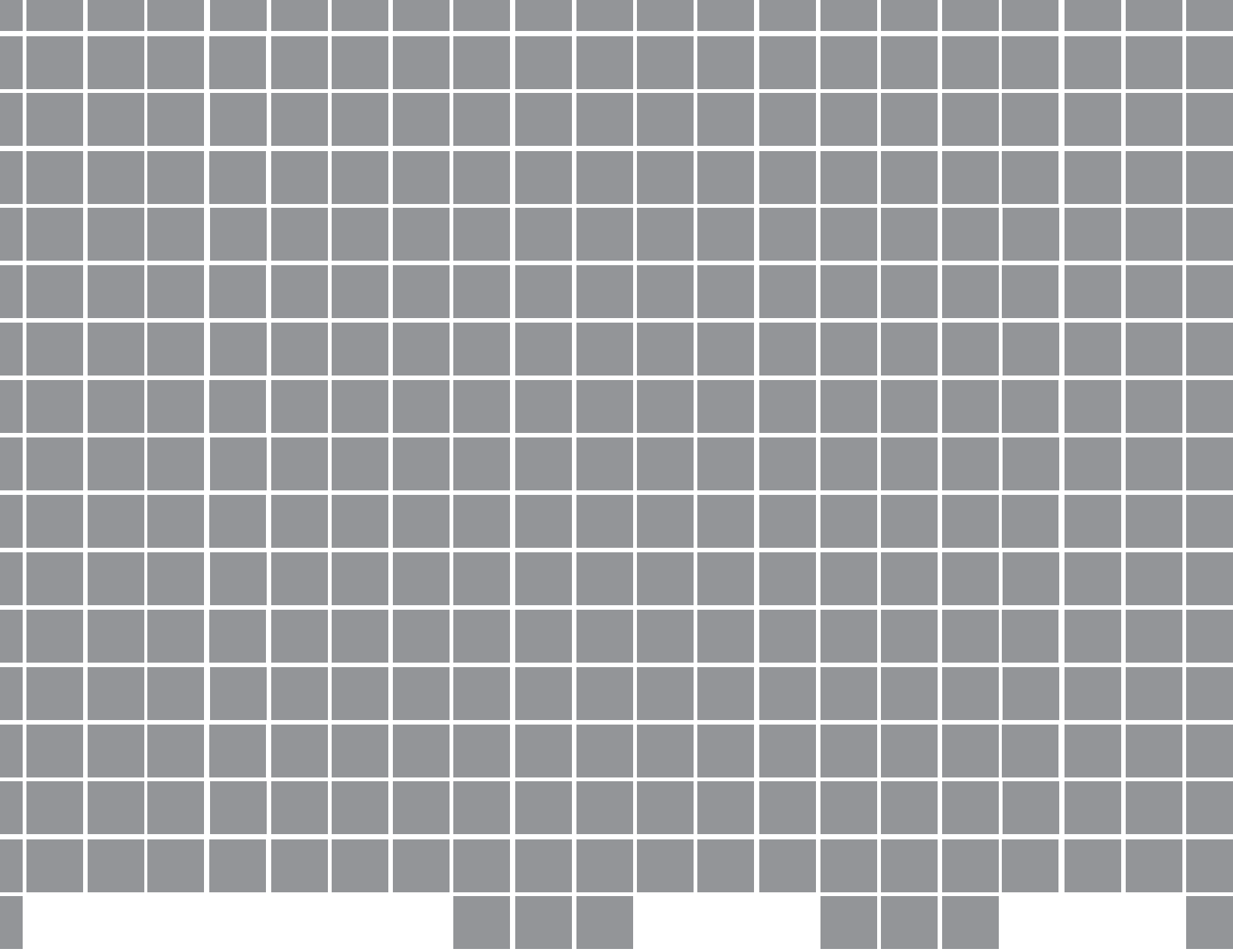
PLUG IT IN

A Design Thesis Submitted to the Department of
Architecture and Landscape Architecture
Of North Dakota State University

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In Partial Fulfillment of the Requirements For the
Degree of Master of Architecture

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Primary Thesis Advisor

Thesis Committee Chair

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Abstract

Plug it in explores the question -- are the principles and guidelines of modularity sufficient to accommodate a community and yield a city. The problem will be expressed by the design of a mixed-use potential building with retail, office, and residential. Using the principles of modularity, it is intended to design a space that citizens can live, drive, walk, bike, shop, eat, and socialize in a manner which is deemed comfortable. This will test whether or not a full scale design using similar materials and memorable and consistent sizes will satisfy the needs of a large community. If the test works on a smaller scale, i.e., neighborhood, then it is theoretically possible to construct a city using one modular base unit of space. The building blocks for this project will be comprised of 750 sqft modules. Not only will this test the limits of modularity, but this thesis will explore a faster, more economical and more efficient way of building.

Key words: City, Module, Neighborhood.

The Problem Statement

Are the principles and guidelines of modularity sufficient to accommodate a community and yield a city?

Intent

Statement of intent

Project Typology:

Residential

Claim:

By applying the guidelines of modularity and necessity, one can construct a self -sustaining neighborhood, using simple forms and modular base dimensions.

Actor:

Citizens.

Action:

Living, working driving, walking, biking, shopping, eating, and socializing.

Object acted upon:

Built environment, neighborhood.

Manner of action:

Comfortably, Flexibly.

Premises:

The citizens will be able to eat, sleep, work, shop, and live within a set scale of land constructed, using set volumes and materials, densifying the surroundings, while fulfilling basic and advanced needs. The actions of the citizens will be the deciding factor of the programming, layout, stratification, and sophistication of the solution. The object will conform to the needs and wants of the actors, displaying custom qualities, as deemed necessary. The prior guidelines must be prioritized to provide the manner that is necessary.

Theoretical Premises:

Using the principles of modularity, the intent is to design a space that citizens can live, drive, walk, bike, shop, eat, and socialize in a manner that is deemed comfortable. The spaces themselves will seem familiar, due in part to consistent material pallets, colors, and module sizes.

Project Justification:

The premise will test whether or not a full scale design using similar materials and memorable and consistent sizes will satisfy the needs of a large community. If the test works on a smaller scale, i.e., a sample building or cluster, then it is theoretically possible to construct a city using one modular base unit of space that satisfies the needs of the occupants.


Proposal

NARRATIVE

The city as a machine. This reference speaks volumes about how a city actually works. Much like a machine of any kind, the city is composed of parts that constantly work together to power the entity. There are districts, parks, projects, downtowns, and many more cogs all working in harmony to create the modern day city. From the City to the Module. Factory/off-site built design has taken front stage in the last two decades and offers great attributes when compared to on-site building. It lends itself to modular design that is more efficient on materials, produces less material waste during construction, has fewer site disturbances, and reduces construction schedules. The question posed is, whether we can combine the two to produce a modular city that functions the very same as its standard counterpart? As Italian architect Antonio Sant'Elia (1914) said, "Things will endure less than us, every generation must build its own city" (Sant'Elia, 160).

The research and applications in this thesis drive towards the goal of designing a working cog in the city machine; an indefinite design idea using base modules to satisfy all of the essential needs of the surrounding population. The idea is that if a working, related neighborhood can be created using off-site construction, in theory, the design can spread through a district and ultimately achieve an entire city. This particular project will be focused on a mixed-use building, retail, and public square. Not only is designing like this more sustainable, cost effective, and faster, it also can be implemented anywhere in the world with and tailored to the clients wants and needs.

The module is an important piece to this puzzle. Starting with several base dimension forms, the module is pushed, pulled, staggered, stacked, added, and subtracted to accommodate the everyday needs of citizens, ranging from low density residential to high density work space and everything in between. The modularity of the design is such that in a blink of an eye rapid additions and subtractions can be implemented to suit the needs of the current users. Imagine an adult set of legos -- a manipulative, form changing, indefinite design capable of everlasting expansion, all due to the fact that it is constructed with different pieces.

User/Client Description

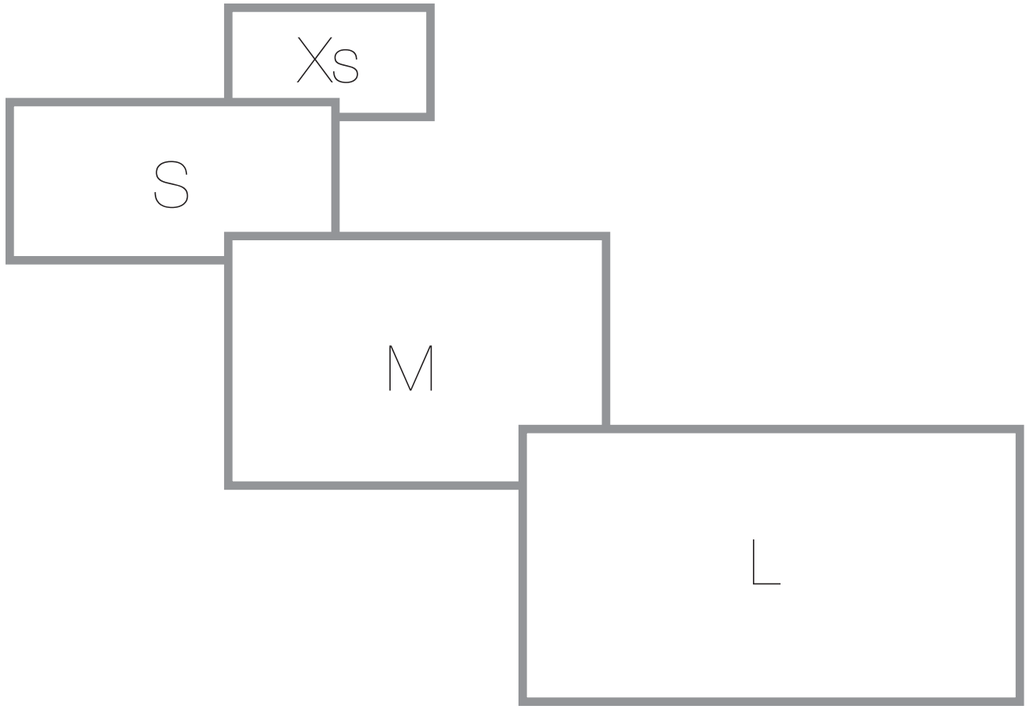
This project caters to the needs of residents, office workers, shoppers, and city goers. The mixed-use application helps the project become a hub in the nearby area, attracting patrons to the selection of retail and the ample green space. The varying sizes and prices of the residential units afford the opportunity to invite people of varied social and economical classes.

This project will advertise the adaptability and customization of modular off-site design in hopes of spreading the idea throughout the city. Because this type of design can be implemented anywhere and designed to be indefinite, the idea is suitable for any site with any size constraints or future growth concerns.

The project will be owned by a single entity, which will in turn lease the units, retail and office space out accordingly. All on site management/maintenance/ security is the responsibility of the owner.

Elements

The major project elements will consists of different types of prefabricated modules. From these types, a space comprised out of anything from residential to multi-use office, residential, and retail space will be formed.



LOCATION INFORMATION

City: Shakopee

State: Minnesota

Population: 37,076

LOCATION INFORMATION

LOCATION INFORMATION

Site Narrative

Nestled in the once rural town of Shakopee, MN, lays a plot of land surrounded by expansion and sprawl. To the north a half mile, lays a recently built elementary school. To the west, a newly produced subdivision of upscale single-family houses calls the land home. However, what mostly disturbs the site is the new addition of County Road 21 that bisects the land, encroaching from the southwest and meandering to the north. The picture being painted is not intended to be grim; urbanism is necessary to develop one of the nation's fastest growing counties. However, the way in which densification happens in suburbia has proven inefficient. The site proposed is intended to set an example in the new suburban sprawl. On the land that it would take to construct roughly ten single-family homes, it is intended to serve as home for up to 30 families. Flanked by a service road that connects directly to Highway 169, which in turn connects to Minneapolis, single-family homes, and an elementary school, this experimental typology has all of the necessities to thrive. By merely planting itself on the site, it is not harming but rather doing good. by demonstrating how land around the nation can serve much more efficiently.

A Plan for Proceeding

Research:

Research will focus heavily on pre-fabricated housing from the beginning of their inception to modern day application. Special attention will be given to dimensions based on transportation and minimal living requirements. Modularity and interchangeability will also be researched to get a good idea as to how to go about spatial stratification, reformatting and potential resituating. A very important topic will be modular system design and effective, efficient structures lending themselves to growth.

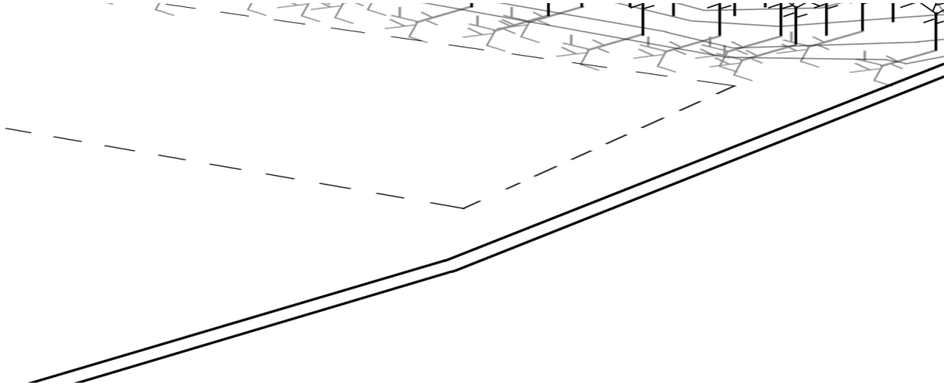
Design Methodology:

I will research existing modular buildings, such as Habitat 67 and container city, using the concurrent transformative strategy to understand the quantitative and qualitative data to analyze. Studies on systems,and construction techniques will present themselves accordingly.

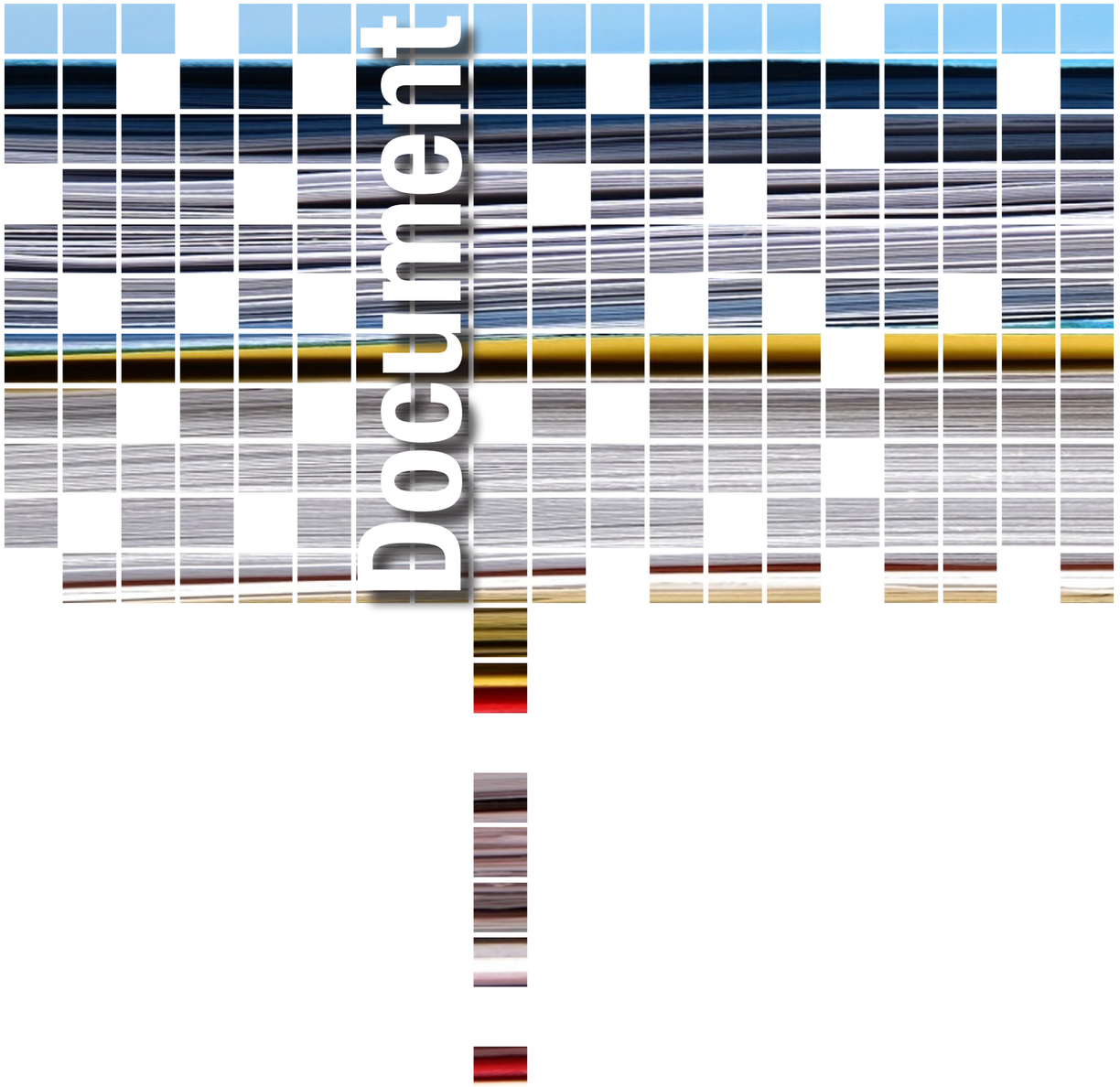
Documentation:

This project will be documented digitally, using the data I obtain and analyze. A copy will be placed into the North Dakota State University Institutional Repository and a hard copy will be provided at the final thesis review.

Spring work plan



Contex analysis.....
ECS passive analysis.....
ECS active analysis.....
Conceptual analysis.....
context redevlopment.....
envelope developement.....
materials development.....
spatial analyisis.....
Floor plan development.....
Section development.....
Structual redevelopment.....
Project documentation.....
Midterm reviews.....
Project revisions.....
Final thesis document due.....
Presentation layout.....
CD due to thesis advisors.....
Plotting & model building.....
Exhibits installed on 5th floor.....
Preparations for presentations...
Final thesis review.....
Commencment.....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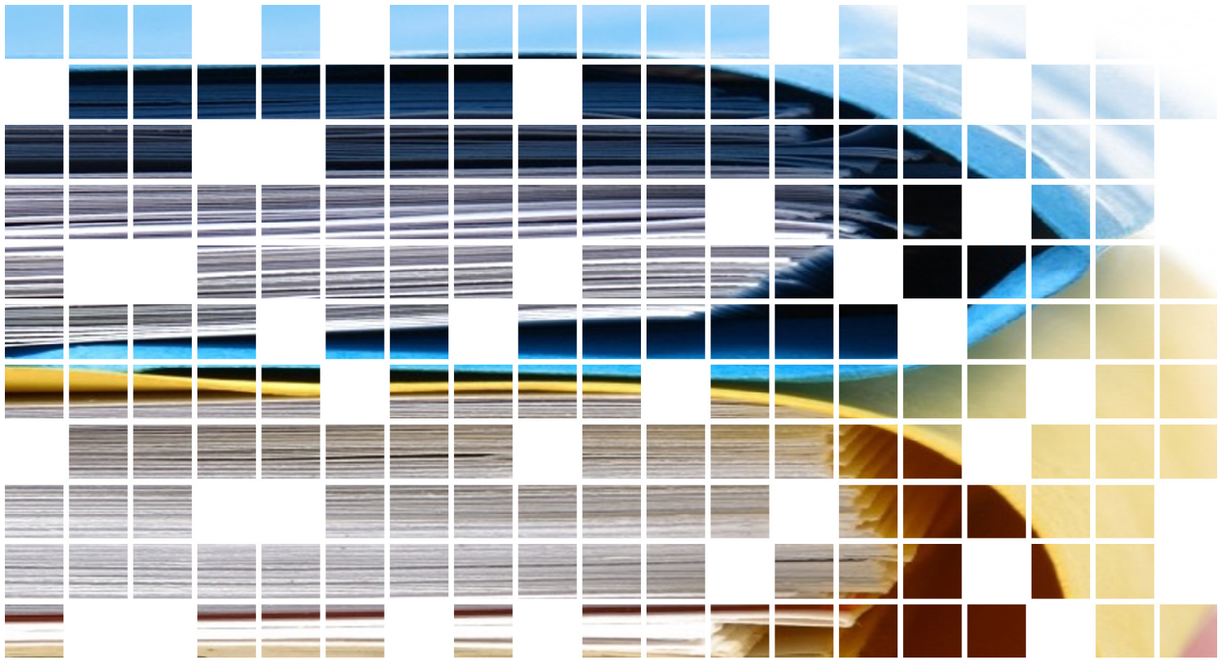


RESEARCH RESULTS

Prefabrication: to fabricate the parts at a factory so that construction consists mainly of assembling and uniting standardized parts.

Modular: constructed with standardized units or dimensions for flexibility and variety in use.

Often, architecture is boiled down to the finest detail. The meticulous thought and approach used in design has become a means of acceptance and a standard of continuing the profession. The thought in the decision of every window placement, the orientation of views, the location of the entries, all instill the very feel of personalization and customization. Lately, even environmental issues have been tackled by designers, righting many wrongs in old design methodology. Do not be fooled by what is being questioned. The attention to detail is very beautiful, and the incalculable thought put into design projects is quite possibly unmatched by any other profession. But, are the advancements in thinking and implementations of green design happening at too slow of a rate? Does one lose the authenticity of architecture if the design was one part of a whole, a mass production? Is it plausible to fulfill the requirements of past typologies, communities, and districts with a mass produced module of a prefabrication nature, conscious of the arising issues in the environment? Could this module be added to, subtracted from and modified enough to become a major milestone in design as we know it?

Futurist Antonio Sant'Elia once said in 1914,"Things will endure less than us. Every generation must build its own city" (Sant'Elia, 160). The notion of dilapidated, run down buildings has become more of a problem in recent years. Major metropolitan cities are starting to see centuries of wear, while serious renovation is needed to maintain downtowns across the nation. In lieu of all that we know now, it is hard to think that more than 100 years ago, there were people thinking of ways to solve problems of today's age. Futurists of yesterday foresaw major changes in the traditional building techniques with the birth of the industrial nation and assembly lines. Many either theorized or even experimented with ideas of the mega-structure, something onto which all spaces were to be attached, a way of designing to minimize waste and time, while maximizing efficiency. The mega-structure would be something from which the base of the prefabricated unit was to be designed. Sadly, very few ideas drawing inspiration from these theorists were actually created.

The movement of industrializing whole units of dwellings seems to ride waves up and down, with its own highs and lows separate from that of the construction industry. The prefabrication movement gained major steam in the early 1920s with countless ideas but very few physical studies. The movement then laid stagnant until WW2, when the government nearly single handedly revived the idea of industrial made housing for war related purposes (Reidelbach, 33). One again, the practices were dismissed in many eyes after the war, with very few still furthering the process of prefabrication. The next giant step towards popularity came in the 1950s and 1960s with the invention of the mobile home. Finally, a truly systematic way of fabricating homes and shipping them to their desired locations was perfected (Reidelbach, 54). Along with the new era of mobile homes came a new mindset towards prefabricated dwellings. No longer were Prefabs seen unfit to live in, but were now desired by many. In fact, in 1966, 22% of all single family non-farm privately constructed housing in the United Staes was mobile homes (Reidelbach, 41). This us not surprising, when the average cost of a mobile home was around $10 dollars per square foot – including furnishings and major appliances. Compared to that of a home with a low-priced bill of $12 dollars per square foot unfurnished, and $14 dollars for a moderately priced home, the mobile home was seen as very economical. A fully furnished double-wide mobile home, which was 24x60 feet would cost roughly $13,000 (Lewicki, 56). However, after the initial surge of support and interest in motor homes, the industry quietly went away and merely became more of a novelty in today's age.

A segment in a 1964 article of Progressive architecture seems to acknowledge this fact: We are no longer starry-eyed about the future, for it is not likely that it will be better than the best of the past, but we realize that the present methods of building, design and construction are inadequate for existing and future conditions; we know that a change must be made (Reidelbach, 15).

Studies taken in the mid 1900s show that the traditional house building method has been consistently unable to produce adequate houses for the income levels of one-third of our population. And in the mid-1900s one-forth of our population could be housed only through aid of the government (Lewicki, 65).

If the common perception of many for traditional home building tends to lean towards its inability to house the next generation of children affordably, then what radical change in how we build will we be in store for our lifetimes? Many new, talented designers have been undertaking the task of redeveloping how we build and are ready to offer some of their ideas to the world.

Still, the obvious solution to problems of the times seemed to be solved by the theory of prefabricated modular design. So started the so-called "mega-structure" studies. The new idea of prefabricates leaned towards a superstructure, to which modules can be attached. Structures as big as cities were theorized and penned on paper, all relating in one way or another to a new way of construction.

The thought of modular design is not new, we can recall Fuller and Bahnam speaking of modular mega structures back in early 20th century. However, as discussed before, the topic fizzled out without any full-scale tests – a more or less acceptable outcome for such an ambitious and theoretical idea. The closest thing one might be able to find of modular mega-structure thinking is Moshe Safdie's Habitat '67. A beautiful implementation of on site prefabrication of individual modules attached to one very large superstructure. Originally designed for residents and dignitaries for the 67 Montreal Olympics, few know the mountainesque design was meant to be just one piece in an entire design. In reality, the outcome is only roughly 1/5 of the size of the intended design. None the less, the building to this day is a very desirable place to live, and units sell for astronomical prices per square foot because of the notoriety attached.

More projects have recently taken on the challenge of mass-producing housing in the 21st century and tend to be much more ambitious than their counterparts of the past. The theories and philosophy stated in new designs tend to all converge on the problem of increased housing demand.

RESEARCH RESULTS

Schwinge (2006b) is anticipating his new design as the future of housing. The idea is to manufacture giant spherical "water drops" in the same way mega ships were and still are manufactured. Each drop would then be airlifted to its destination – anywhere in the world – by a fleet of high-capacity freight airships designed by civilian and military logistics companies. An added bonus to his approach would be the rejuvenation of the many abandoned shipyards across the seas (Schwinge, 12). Not small by any means, some key features include its spherical radius of 203 feet along with its height of 230 feet, it is also designed to use aluminum as its main structural material.

Schwinge gives insight onto his design by stating:

"Like water droplets spread across the landscape, each spherical mega-rural apartment unit can "dock" with existing towns and villages within the existing B-road network through peripheral farmland and woodland. Cluste2red in the countryside, the spheres could equally be used to create new settlements, or be distributed along the fringes of other transport infrastructure ." (Schwinge, 5).

An other design looking at the prefabricated mega-structure would be Cloud Piercer. This mile high city project is designed to fit the anticipated population growth throughout the world. Taken from the book *Manmade Modular Megastructures* Jonathan Schwinge tells about his tower design:

*"Three 5280 foot steel lattice towers would be located north and west of Whitstable and Herne Bay in the Thames Estuary, south and east of Southend, off Sheppy. They are clear of the navigable channels along the Thames and into the Medway, and close to the Mainsell sea forts. Each tower contains all the functions of a city, and provides a relief to, and extension of, overcrowded old London. He inhabitants of the three tower cluster would have links to the mainland via ship, tilt rotor aircraft, coastal defense barrage and submerged tunnel (*Schwinge, 45*)."*

While the ideas for this project deal less with modularity and prefabrication, what is important to note is the thought of producing a mega structure containing all the features of a city – a step in the theoretical direction of modular prefabricated mega-structures. Schwinge goes on by saying

"Each tower is also divided into 3 'urban villages' arranges around service and rapid vertical-transit cores. These villages would be multi-use, in a constant process of periodic redevelopment, supporting all the activities expected of a city . (Schwinge, 45).

Though Schwinge's view of tackling the idea of radical housing changes may be a bit improbable and uneconomical by today's standards, it is important to acknowledge the fact that he and many others have been thinking about the problem of traditional building.

Back to the present realm of design, with a study like Habitat, it is hard to believe not many modular communities have made their way through the design-build process and into the built universe. One might suspect the want for individuality might be overriding the needs of cost effective, sustainable design. The result of developing a system of modules being a small part of the whole could lead to much more than just residential or mixed use design. Potentially, the idea could be used as relief to disaster areas in which the affected zone needs quick, modular housing for those who have lost a home. It would require a certain type, with flexibility to accommodate new needs, while still leaving room for future growth. Another great use would be for urban infill. After all, the destructive force nature and humans have on their surroundings applies to buildings as well. The fact that a building could just subtract an old piece and add a new piece would also allow for far less expenditures and maintenance.

So, where is this thinking in the built world? The majority of prefabrication and modular design belongs to the residential sector. There are thousands upon thousands of prefabricated homes designed in a way to be added to in order to accommodate future needs. More importantly, these designs take on a personality of their own, as stated in the book *Modular Housing* "Most people associate modular housing as boring or even bourgeois pre-fabricated housing" (Kunz & Galino, 5). However, *Modular Homes* details 40 case studies of pre-fabricated modular houses that have individuality. One of the greatest aspects of designing with modularity in mind is that, more often than not, one will have a base module ripe for pre-fabrication. The plus is that construction cost of prefabrication is far less, while the installation time period is incomparable to traditional on-site construction. All of these facts make the modular design a very real contender to traditional onsite final construction.

Back to the question at hand. Are the principles and guidelines of modularity sufficient to accommodate a community and yield a city? For all intensive purposes the answer is yes. One can create something on a mass production scale to help solve the problems known in our cities and towns today. However, the question of community is not so much quantitative as it is qualitative. And, therein lies the dilemma, as Miliband (2006), asserts, "architecture on its own can't make a community, civic pride depends on people, not structures" (Schwinge, 22). In order for a mass production modular system to be effective, first and foremost, the users have to be able to take pride in the design. There cannot be shortcuts taken, no cookie cutter styles; the modules must be unique and preferably, more than one to choose from.

The end result could potentially change the way archiects design in the future. Growth in new cities could be calculated extensively, and predicted exactly. Imagine a city of similar modules, all interconnected and interplaying with each other. The edges of the mega structure simply keep growing when new needs arise. Already, existing structures have the infrastructure and the means to adapt and grow if need be. There is even the opportunity to disassemble and make void what was once a solid. The technology is there, the opportunity is there, and the need is great, so why not try?

RESEARCH RESULTS

It is evident throughout my research that prefabrication comes and goes with the tide. In theory, it seems too be a no-brainer, develop a system that can be mass-produced. In theory, the system should be able to cut tremendous labor cost down on construction while maintaining employment for laborers. In theory, the idea of modular housing using prefabricates seems to make perfect sense. Design something, which is radically cheaper, and seemingly indefinite to house virtually any need humans would ever need. This all seems very, very good, in theory.

The truth is prefabrication comes with fads. America has seen it when it first glowed in the limelight in 1921. It was then reintroduced in the 60s with grandiose fanfare, just to creep quietly back to the cave from which it came. It has been steadily continuing, showing up here and there, but nothing to the extent many think it should.

To me, it seems it is not a problem of the idea, far from, it rather seems to be a problem of execution – with a little bit of public perception sprinkled on top. The examples shown seem to lack something…something like hominess. I understand that some prefabricated homes show to the contrary, but by and large, the public perception with prefabricated modular homes seems to be cheap (not the good kind) and bland. It is my goal in this project, using my research gathered as a springboard, to develop a system of prefabricates that can be viewed by all as home.

HISTORICAL CONTEXT

Prefabrication: to fabricate the parts at a factory so that construction consists mainly of assembling and uniting standardized parts.

Modular: constructed with standardized units or dimensions for flexibility and variety in use.

The typology of prefabrication construction walks hand in hand with the idea of modular building. The very idea of prefabricating homes and businesses to be shipped to their desired location epitomizes the next obvious step in construction. As Bohdan Lewicki, member of Institute for Building Research stated in his (1966) book *Building With Large Prefabricates*,

"The industrialized building is said to be the antonym of the traditional building. The term traditional building describes the methods prevailing in Poland around 1950. These were characterized by a prolonged cycle of operations with a large outlay of manual labor, as a rule upwards of 8 hours for every cubic meter of the building. All basic operations were carried out on the building site, resulting in a pronouncedly seasonal industry." (Lewicki, 34).

It would be very difficult to label a definitive time in which prefabrication was used to great extent. One could argue ancient builders, such as the Egyptians, showed great use of prefabrication during excavation of pyramid stone at the quarries. Others might say the British pioneered the technique and cite the examples of homes shipped over seas to the colonies. Whatever the case may be, when dealing with the United States, there seems to be one particular time period and way of thinking that birthed the idea of prefabrication.

Bruce and Sandbank state in their (1972) book, *A History of Prefabrication*,

"although it would be difficult, if not impossible, to determine the exact date of the beginning of prefabrication, there can be no question about the beginning of prefabrication movement. As it developed in the United States the prefabrication movement was the child of depression." (Reidelbach, 4).

One might find the connection between the great depression and a fast, affordable way of building obvious. Bruce and Sandbank go on to say "it sprang to life after the collapse of the stock market in 1929 and after the deflation a year earlier of the boom in traditional building which had just swept the country. A market-hungry nation suddenly became aware that in the field of low cost housing, it had neglected one of its greatest potential markets. FORTUNE, in one of its issues, dubbed prefabrication 'the greatest commercial opportunity of the age.' Even the crudest statistical estimates indicated that traditional built houses costing $5,000 or more could serve only a small segment of the population." (*Reidelbach, 25*)

Knowing these facts about the housing market, many large companies got on board with prefabrication. However, before mass-production could be applied to housing, a system was to be developed that could satisfy the needs of producing large, ready-to-move houses. Another woe that weighed heavy on the minds of investors was that, besides the data and projections given by theorists, there was yet to be a scale production or even a test on the feasibility of mass-producing homes from factories.

It is important to note that during this time period, partial fabrication of buildings, such as structural members for houses or chicken coups and prefabricated walls for the military during the First World War, had been occurring. One can argue that though those techniques may have been occurring for a decade, they never sought to threaten the strangle hold of the home building market and turn the craftsman tradition upside down as the new prefabrication thought did. Although the first thoughts of serious prefabrication never intended to dethrone traditional builders, the speculation of profits and commercial agendas helped propel prefabrication into the limelight.

After reports of large corporations eyeing their own ways of prefabricating and speculation, prefabrication suddenly became respectable to many. Soon, the building industries were not the only ones interested in prefabrication; reports that the automotive manufacturers and even railcar businesses were looking into their own ways of developing a system of building. Many of the earlier reports were found to be exaggerated and debunked in time; however, this did not stop the whirlwind of public amusement and set forth the eager mindset of mass-produced homes (Reidelbach, 32).

The next logical step in the chronology of prefabrication design and build was to then test the ideas and theories, and that is exactly what a couple of companies did.

"Individual companies, such as American Rolling Mills, U.S. steel and Republican steel, played a part through special housing subsidiaries in the efforts to utilize steel in developing a house suitable for prefabrication. Other companies with equipment adapted to a certain approach to there subject, such as the Harnischfeger Corp., Milwaukee machinery manufactures, applied their knowledge and their process in an effort to produce mass scale housing, based on that knowledge and those procedures (Bruce & Sandback, 55)."

However, steel was not the only material or industry that took notice of prefabricates. Many companies eager to show off their products climbed on board. Companies like Celotex Corp. and Homasote Co. showed off their new material, such as new insulation boards. Along with new insulation, plywood companies, through The Douglas Fir Plywood Association, felt their product would be a perfect compliment to the fabrication of homes off-site. By this time, not only hundreds, if not thousands, of companies tried to develop their own system of prefabrications, but many more architects, builders, inventors, developers, and contractors also tried out new methods and ideas.

During this time period, Bruce and Sandbank state

"It is sufficient to say that none achieved a clear-cut position of permanent leadership nor any substantial volume of production. Rather, the situation developed as one of the most up most complexity, in an atmosphere of claims and counter claims which had as its net effect the undermining of public and professional confidence in even those firms that were in position to delver actual houses. Moreover, many of the most promising of the earlier systems were predicated on the assumption of large-scale, mass-production methods, and expensive in terms of the small-scale operations which were all that actually developed. Many such systems therefore disappeared from the market, or were gradually altered until they bore little semblance to the original idea. New systems, based on a more realistic appraisal of the necessary steps through which prefabrication would have to developed before achieving real mass-production status,

appeared only gradually, since such an approach was foreign to thinking on which most of the early enthusiasm for the prefabrication ideal was based (Bruce & Sandback, 60)."

Through the smoke of all of the commercial agencies trying to cash in on the new prefabrication movement, there were also a small number of non-commercial agencies interested in the advantages of prefabrication. These non-commercial agencies can be divided in to two pivotal groups. One was special organizations committing all of their efforts to research in the housing field. This division specifically was home to the Albert Farwell Bemis Foundation in Boston, Massachusetts; the John B. Pierce Foundation in New York and the Purdue Research Foundation at Purdue University, Indiana. The second set of groups was a subset of government agencies. The agencies affiliated were the Bureau of Standards of the U.S. Department of Commerce, the Farm Security Administration, the Forest Products Laboratory of the U.S. Department of Agriculture, and the Tennessee Valley Authority.

The Bemis Foundation: The Bemis foundation was established at the Massachusetts Institute for Technology after the death of the man behind Bemis Industries Inc. During his life, Albert Bemis devoted much of his time studying trends and statistics in housing, while also conducting experiments dating back as early as 1921. For almost 10 years before the prefabrication movement gained steam, Bemis was studying structural materials and methods and using his own research and development money, developed 22 different types of construction using varying materials. Multiple final models were developed around the late 1930s and some were even sold to the public. The Pierce Foundation: Unlike the Bemis foundation, the Pierce Foundation was formed shortly after the prefabrication movement and was founded by John B. Pierce, the vice president of American Radiator Co. The purpose of the group was to carry on educational, technical, and scientific work on heating, ventilation, and sanitation. They also advocated for prefabricated houses that would help advance the indoor environment. In 1932, the group erected its first experimental house on top of the Starrett-Lehigh building.

Purdue Research Foundation: Founded in 1935, this group was to research the qualitative and quantitative numbers with previous prefabricated houses on the market. Its most notable contribution was its extensive report published after five different prefabricated houses were purchased and studied after an extended period of time.

The Forest Products Laboratory: This group mainly tested the notion of using timber materials in a prefabricated construction. Their first "stress-skin" plywood house, erected in 1935, gave a path for timber construction in prefabrication.

Farm Security and Tennessee valley Authority: these groups were two of the most important during the mid-1930s. The focus between the two was for the first time actual mass-production construction and low-cost erection of homes. The Farm Security Administration even attempted to develop full-scale plans for communities based on mass-produced modular homes. The Tennessee Valley Authority may have been the first full-scale mass-produced housing to be completed in the United States. The Authority built entire communities for its own workers and paved the groundwork for new communities in the Tennessee valley.

Without question, the next great event in America's history, World War Two, played the biggest role in the rebirth of the prefabricated unit. Towards the mid-late 1930s, the lackluster of the factory home had worn off. Many initial investors had to deal with the consequences of their fruitless labor, and the movement was coming to a stand still. In fact, the biggest contributor of prefabrication homes thus far had been the United States government. According to *A History of Prefabrication*,

"The Federal housing agencies, through their purchase in less than two years of almost 75,000 prefabricated dwelling units for war workers, have brought the prefabrication movement out of the stage of an experiment and into the stage of actual mass-production. The government has become the prefabricators best – and virtually it's only – customer (Bruce & Sandback, 57)."

The next major breakthrough in prefabricated homes is not until the mobile home, which was conjured up in the 1950's and almost perfected during the 60s. The new prefabrication system devised was a revolutionary thought with a radical design. Mobile homes gain so much popularity during this time period that some statistics were staggering. One statistic is that in 1966 the mobile home provided 22% of all single-family, non-farm, privately constructed housing. In 1965, the mobile home represented 76% of all new single-family homes produced in the United States sold for under $12,500. (Lewicki, 65).

In the book *The New Building Block*, the authors state,

"The growth of this form of factory produced housing coincides with the interest and experimentation in somewhat similar concepts what were taking place in western Europe and the U.S.S.R. These developments call for a closer look at the mobile home industry (Lewicki, 66)."

The mobile home itself was not a technological masterpiece, by any means; in fact, the basic unit was constructed of 2x2 wooden frames on a steel chassis, sheathed together with wood panels. However, where the mundane aspects end, the real advantage is the speed of which a unit can be built. Because each home had a respective factory with respective locations for certain components, the process of construction went by extremely easily. Another often-overlooked advantage was the way in which Americans perceived the home. It was now acceptable and often times desired to live in a mobile home. Not only did one have less space to maintain and less cost of maintenance, but also, if one wanted, the home could simply be transported with relative ease. The mobile home truly revolutionized the idea of prefabricated units and is arguably one of the only success stories to the mass-production ideal thought of in the 1920s.

Today's designers have embraced the movement of prefabrication, with some specialty firms only using prefabricated modular units. With the new awareness of sustainability, one source of prefabricated units is being recycled from their intended purpose and are now being taken and retrofitted for a new purpose. Shipping containers in the United States litter ports across the sea line. Many people have been using shipping containers as dwellings for years now, including a great example named "container city" design by "Urban Space Management." With so many new and exciting technologies, prefabricated modular dwellings will start to see a rise in demand especially due to the relatively bad economic times Americans have fallen on.

HISTORICAL CONTEXT

Since the move to industrialization as a nation, aspects of building construction have greatly been affected in the way in which they are constructed, the shift from traditional building to the so-called improved traditional building to more recently prefabricated building. As the market for lower cost housing changes, and the need for rapid construction takes the front seat, prefabricated modular design will see it's share of actual construction. As long as there is a market for affordable and customizable building, prefabrication will stay with us.

THESIS GOALS

The Professional

The thesis project I am embarking on will challenge me in more ways than just design. One important aspect of the project is its extensive use of research to help guide the process. This amount of research and the methods employed to obtain the research will no doubt benefit me as I continue my education and practice into the professional realm. Not only is the research a big aspect of the professional practice that will need to be displayed, but also the aggressive nature in which I will need to design will help me stay on track to keep my skills sharp before leaving for the professional world. I have long heard the “horror stories” of architects having little sleep with a workload that seems to be unachievable. As much as people try to discredit this, I am aware that I will probably be working long hours, with little sleep to achieve a reputable position, and the behavior used during this project will help keep me on course. The research will be tough, the long nights and little sleep have to be endured, but I know that the professional practice I use to complete my thesis will be invaluable to me in the near future.

Academic

With the finalization of my collegiate career comes the duty of producing a thesis project. Using extensive knowledge I have gained through four years of undergraduate schooling and half of a year in graduate learning, I will attempt to dissect a question I have proposed. Through the use of research and modeling, I will try to satisfy myself with a necessary solution to a small, but very complex question. Living in the days of an almost “great depression” like recession, I am encouraged to believe my design could be helpful, as a way of thinking and moving forward in a housing market that has nearly seen the worst of its days.


Studies

The modules is a loving quarters aimed at housing students attending Temple University. Located in Philadelphia, Pennsylvania, this 80,000 square foot project, constructed in 2010, shows the versatility of prefabricated modular housing. Not only does this building appear just like any other standard apartment, it also flows much like a standard living quarters, demonstrating that prefabrication and modular housing can perform the exact same as their site-built counter part but with fractions of the labor cost.

The project responds to an emerging student housing need of the university, as it transitions from a commuter school to a residential institution. The response was a 160-bed, 80,000 square foot project, consisting of 60 rectangle modules aligned in a hybrid I formation. The result of the formation was an abundance of natural light and plenty of common spaces. The design is tied together with itself, which would make the option improbable, and down right uneconomical.

The system used helped keep cost of construction down due to few labor hours, while simultaneously fulfilling the requirements of space and time. In fact, the whole process of design-bid-build and occupation was within the time span of one year.

The Modules

The Modules

The Modules project sheds a bright light on the notion that modular prefabrication has to look unusual or at the very least, noticeable. The design of the housing complex is sleek in nature and elegant in style. The one draw back of the building that comes to mind is the fact that one cannot simply swap out an old, dated unit and replace it with a new one.

Overall, the design of the modules satisfied their client's needs, while doing it much quicker than a regular on-site construction team would have. Not only does this building serve a site that is permanent, but the system used is now also readily available to go back and reiterate to satisfy future needs of clients, who simply cannot wait for the traditional building method.

The Nagakin capsule tower was completed in 1972 in the Ginza area of Tokyo, Japan. The tower was the first of its kind employing a “capsule” technique, each which would be interdependent of other units. The premise for the hotel like tower was to house traveling businessmen who worked in the central Tokyo area, and do it cheaply. The architect behind this design was then radical thinker Kisho Kurokawa. This design not only boasts an ingenious way of attachment, but it also advocates recycling in that when a unit is worn down or simply needs upgrading, it can be detached and hauled down while another unit is simply plugged in.

The tower structure is composed of two solitary concrete cores, which house all of the mechanical and circulation. The capsules are rotated around the cores to optimize view and sunlight. The connection between the cores and the pods are quite unique; each unit is simply “plugged in” to the cores using four large high-tension bolts.

The capsules were all prefabricated in a factory in Shiga Prefecture and shipped ready to be installed. The base components of the pod is a large circular window, a built in bed, and a bathroom. The unit also came with a television, radio, and alarm clock. The total space of the pod is 4x2.5x2.5 meters, enough space for one person to live comfortably.

Capsule Tower

Capsule Tower

Unfortunately, in 2005, the current residents of the tower voted to demolish the building citing unsavory conditions. The Japanese Institute of Architects and Kisho Kurokawa himself advocated replacing the capsules with new ones, to which the residents countered stating asbestos and earthquake concerns. Still today, the tower has not been demolished.

The tower is a prime example of the Metabolism movement in Japan. The movement emphasized the ever expanding, growing nature of a city. The idea is to design something that could be added to and manipulated to satisfy needs of occupants after the building was already set into place.

The tower attacks the idea of never ending design, and, in its own right, had done something that hadn’t been done before. However, one look at the overall design and one finds the natural limits to which capsules can be added. The core towers – the anchor for the capsule and a necessity to the project – only protrude up to 14 floors, therefore, limited number of capsules can be attached. Never the less, Nagakin tower serves as a great milestone for the metabolism movement and lends itself greatly to a study in indefinite design with adaptability.

This unique project, located on the De La Osa Pier in Gijon, Spain, is designed to be the future maritime station of the sea highway. The building's purpose is to serve future paths for ships that link Gijon with Nantes, France and Cork, Ireland.

The timetable given to the designers was a mere six months to generate an operable building. On top of the stringent time strain was the very real possibility of expansion in the near future. These limitations ruled out almost every conventional design build method and played perfectly into the role of prefabricated modular units. The boxes were built off-site in pieces and were then shipped to the pier for assembly.

The individual modules themselves are composed of a steel box frame with a mineral wool paneling system for cladding. The unit of measure for a single space is 15 meters by 3.6 meters by 3.6 meters tall. The exterior standard RGB coloring is inspired by the common colors often used on cargo ships.

Maritime Station

Maritime Station

The Maritime Station is a great example, showing off the efficiency of prefabricated modular housing. In just six months the team was able to design and build a move-in-ready structure for their clients. The modular aspect also affords the clients a readily available option for addition, if the program calls for it.

The building program contains two distinct areas of focus; one dealing with pre-embarkation, while the other deals with embarkation. A large parking area, meant to handle many container trucks, flanks the structure as well. Due to its modular design, the structure can attach more units as it needs to support the growing entourage it houses. Due to the nature of the site, it also affords the opportunity to expand any which way, allowing maximum efficiency.

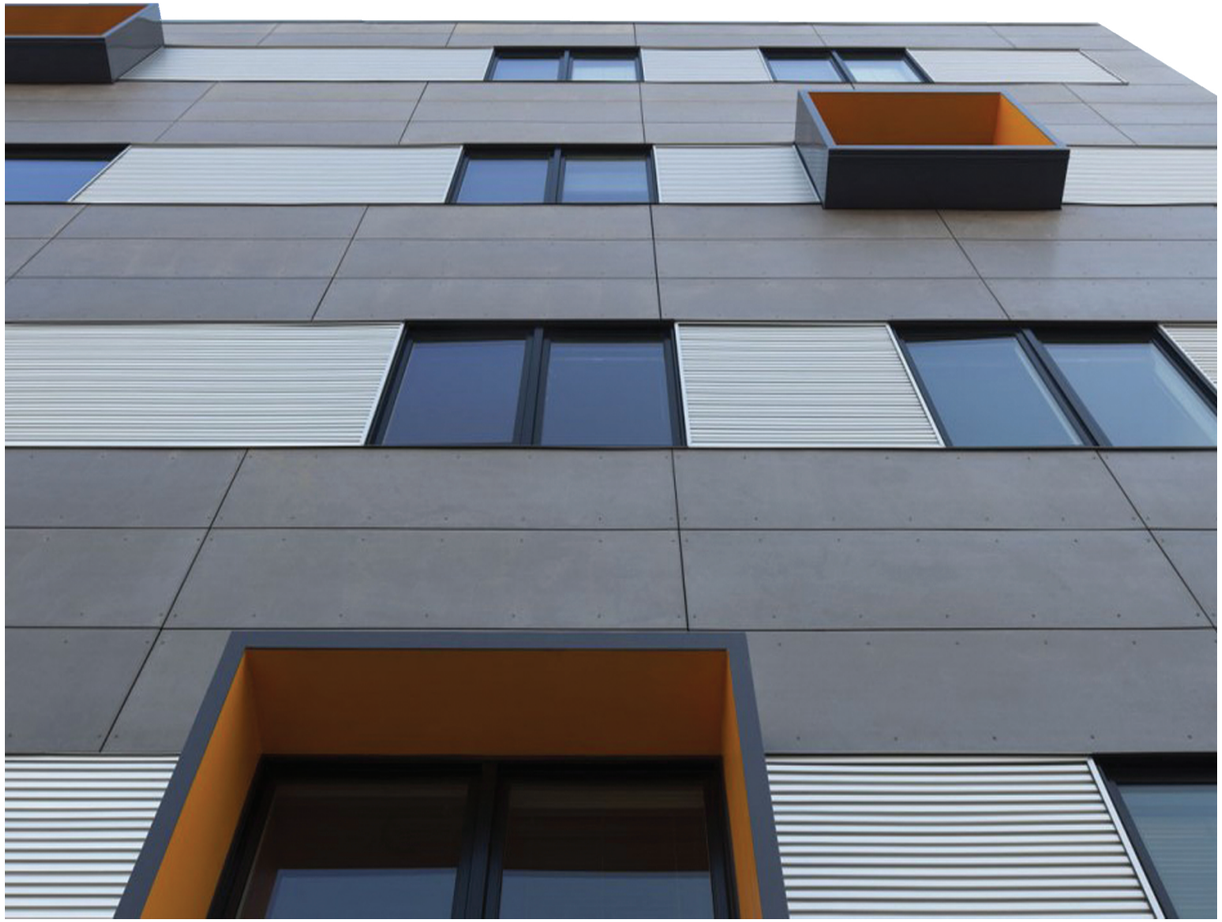
From the evidence demonstrated by the case studies viewed, it is clear that the question of prefabrication working should rather be a question of why it is not in use more commonly. Using just three of many studies, I have found that not only do the projects satisfy the needs; they also exceed in the quality and cost effectiveness of what the client desired.

Summary

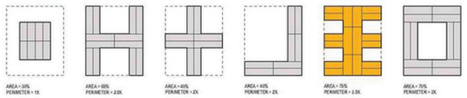
Summary

It is evident that a prefabrication system can be developed for a site generic building of any type. Not only has prefabricated modular design worked for a dwelling requirement but has also excelled in office and retail typologies. I have no doubt that the types can be mixed and matched to suit the client's specific needs. What is important to note is the mass-production capability of this type of design. It may just be the solution for the problems seen in today's traditional building methods.

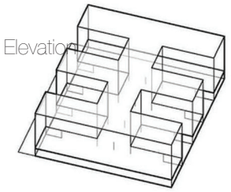
The Modules

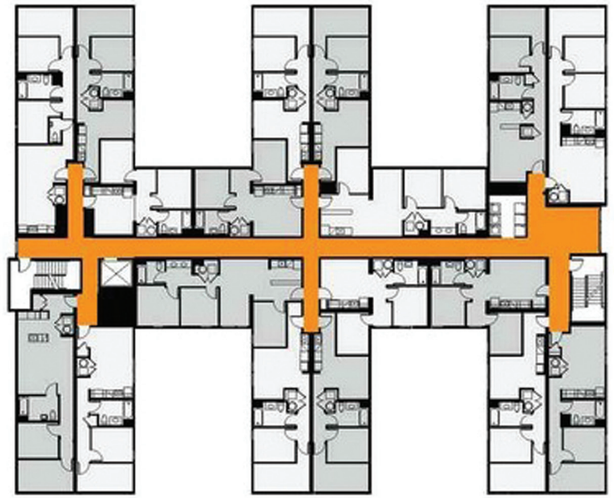


East Elevation



West Elevation

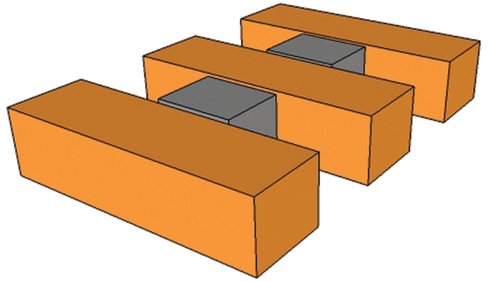


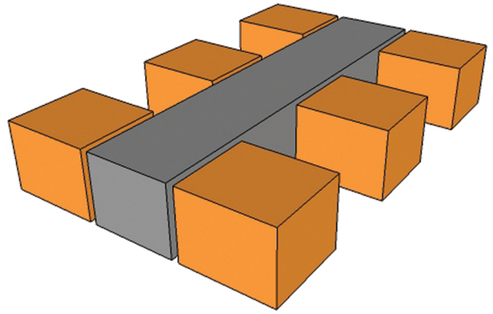


Common plan

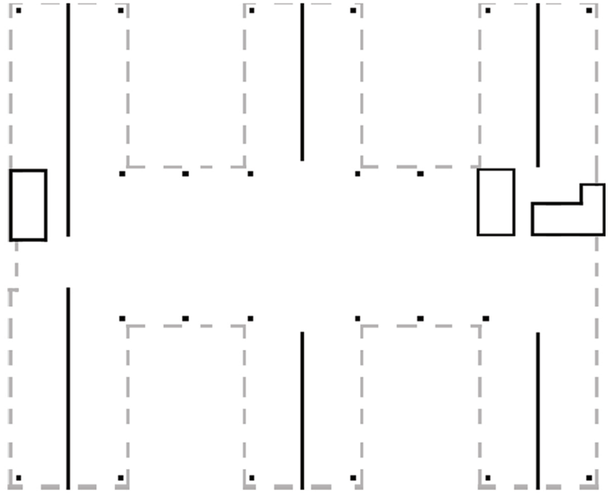
Section

35'

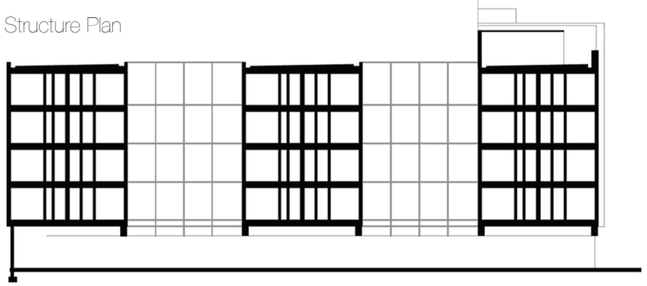




Massing

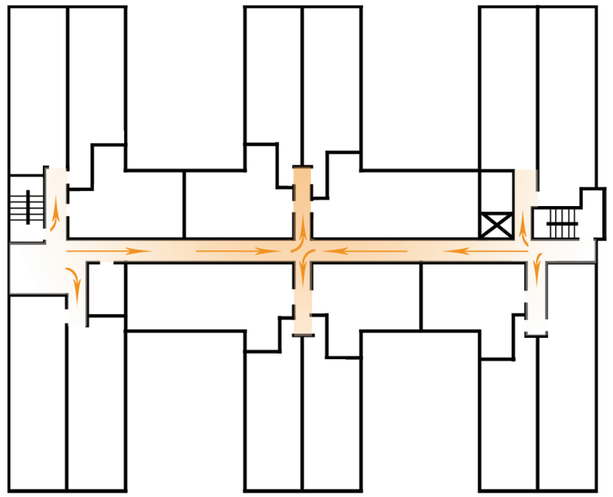


Structure Plan

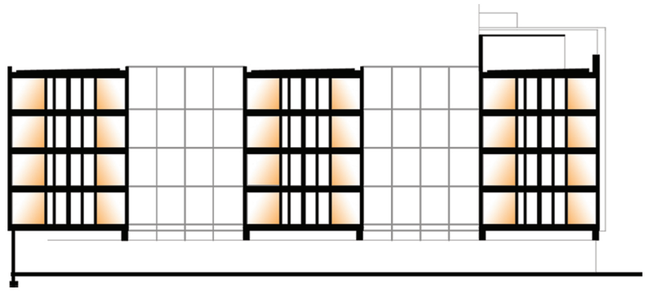


Plan to Section

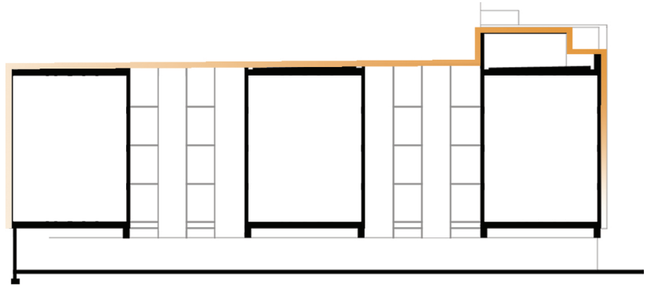
Geometry



Circulation to use

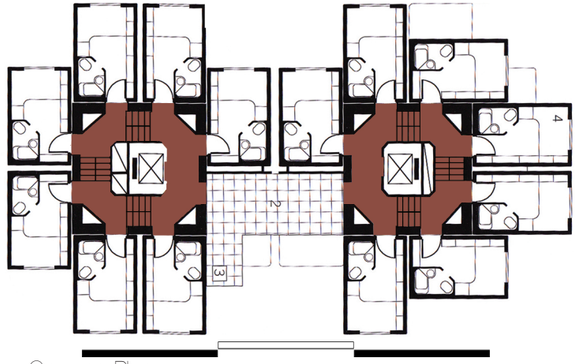


Natural light



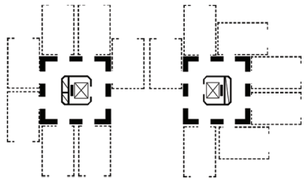
Hierarchy

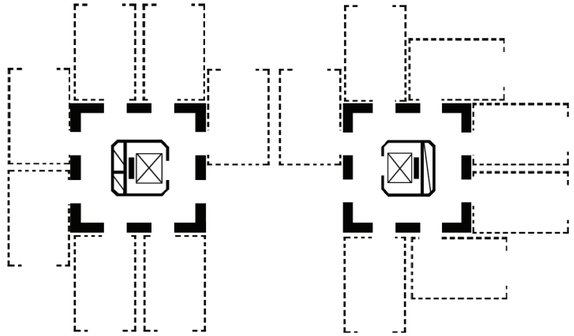
Capsule Tower



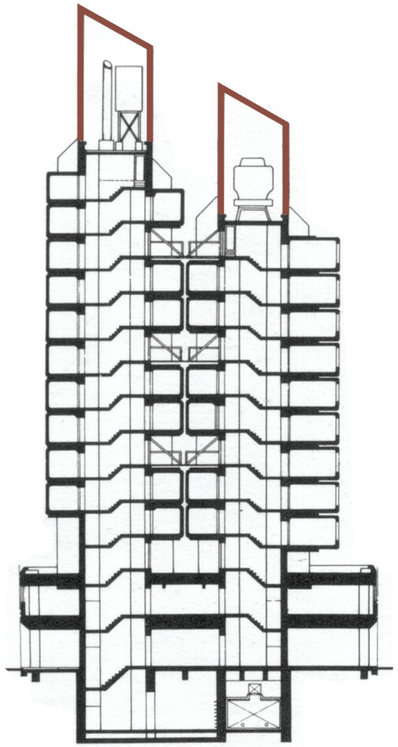
Common Plan

25'

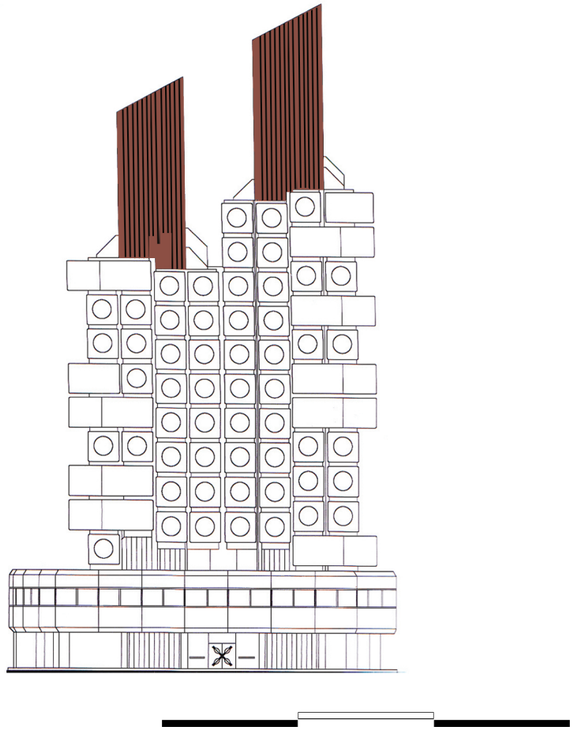




Structure Plan

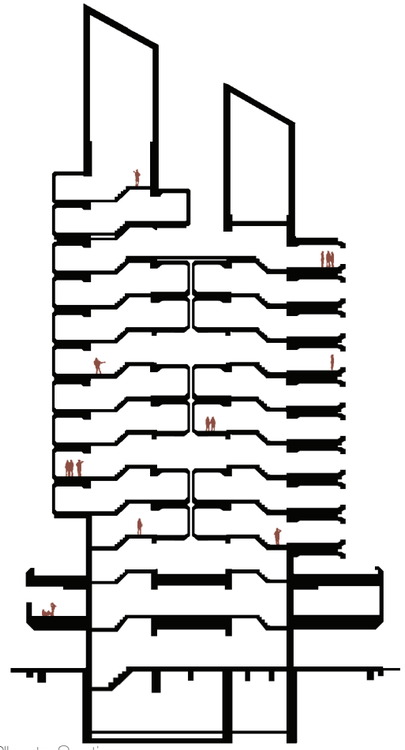


Section

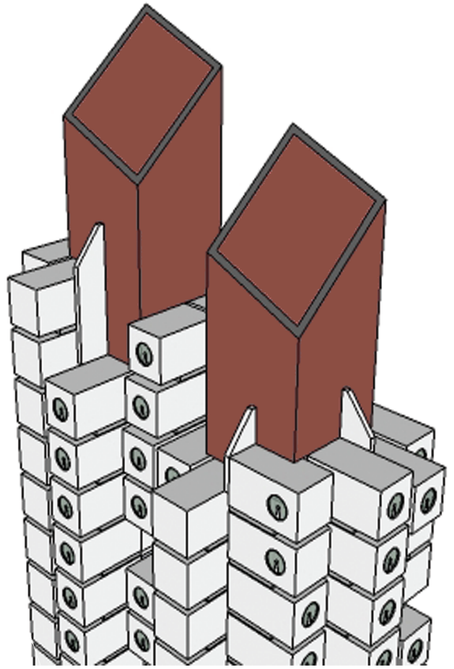


Elevation

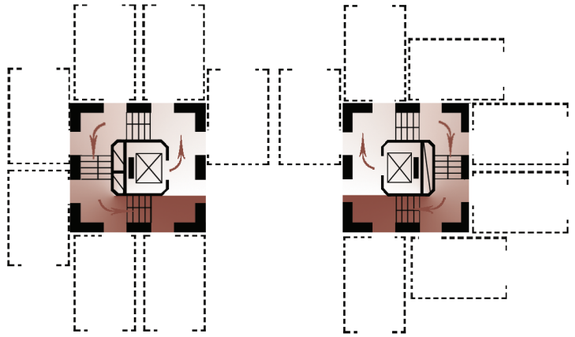
50'



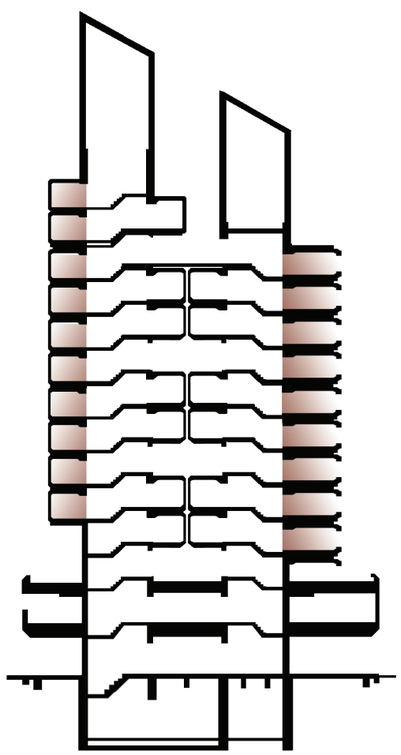
Plan to Section



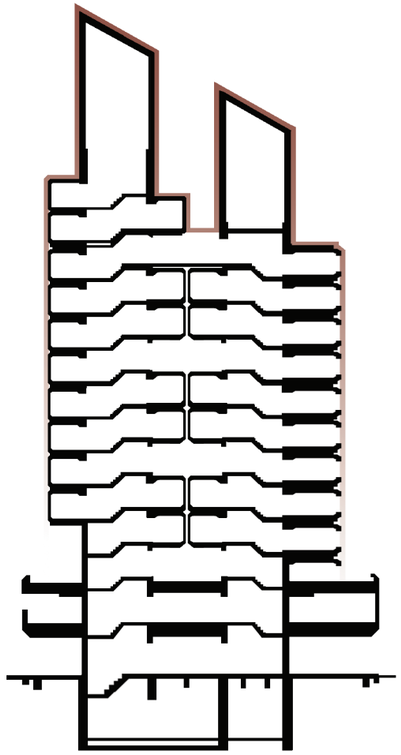
Massing



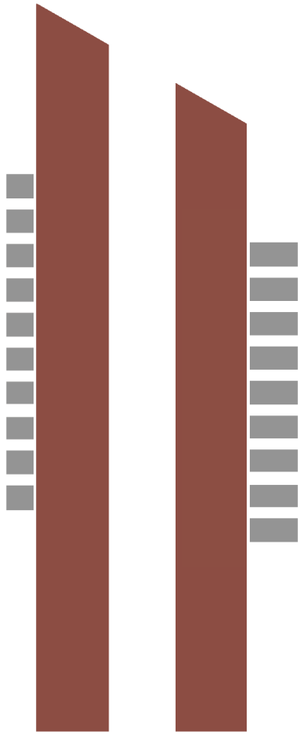
Circulation to Space



Natural Light

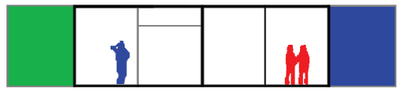


Hierarchy

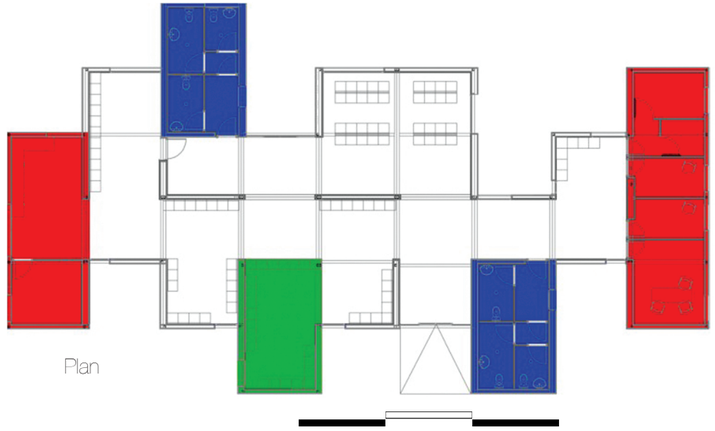


Geometry

Maritime Station



Section 1



Plan

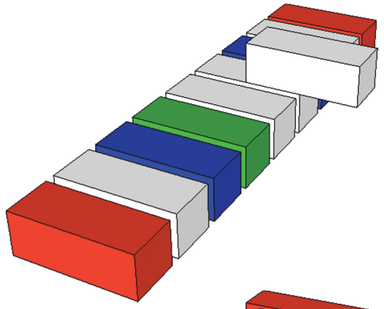
15'

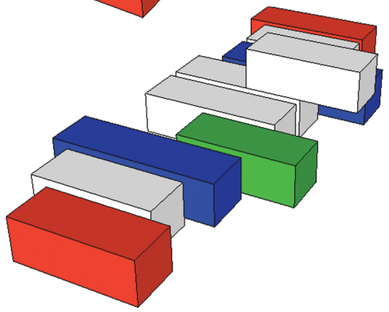
Elevation 1

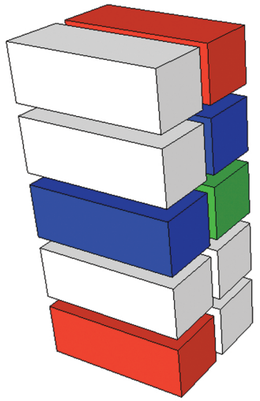
Elevation 2

Elevattion 3

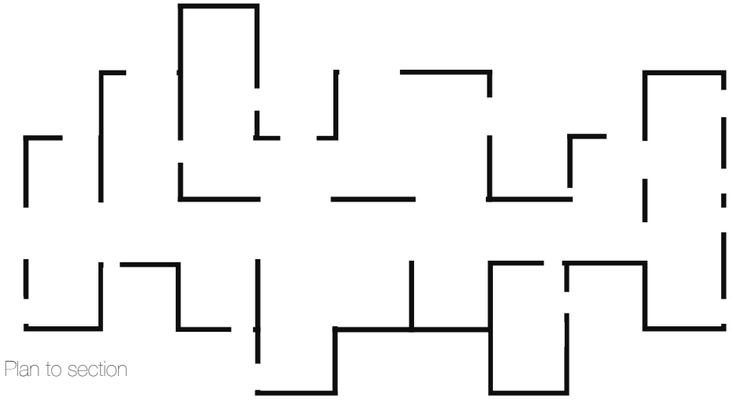
Elevation 4



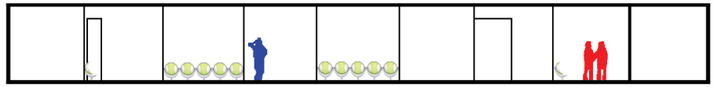




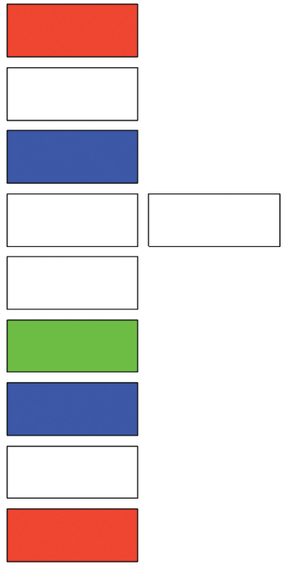
Massing



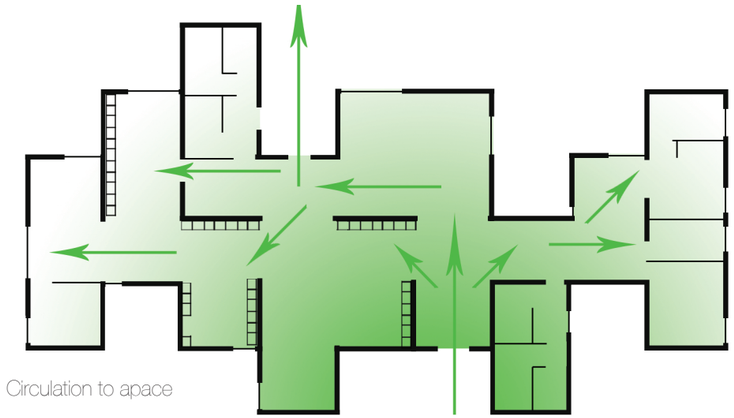
Plan to section



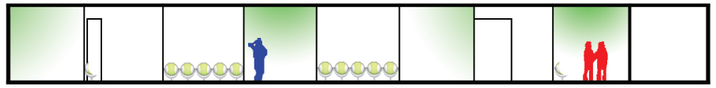
Section 2



Geometry



Circulation to apace

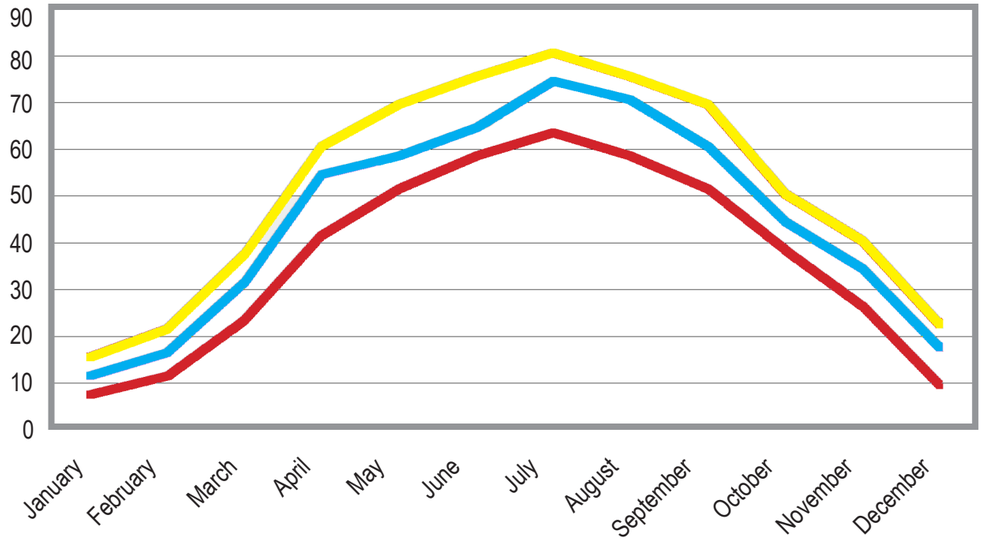


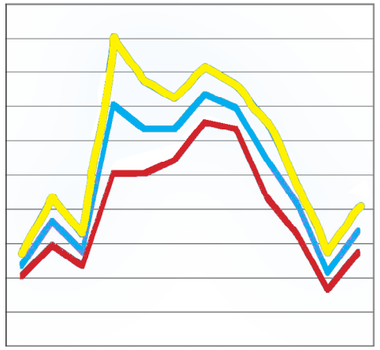
Natural light

Hierarchy

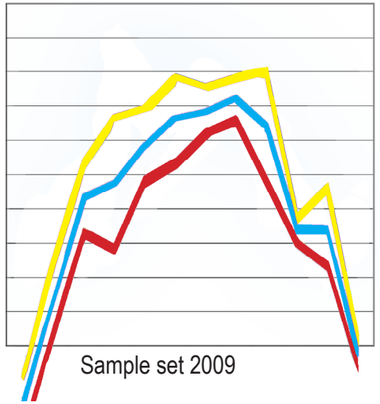
LOCATIONAL ANALYSIS

Average Temperature 2001-2011



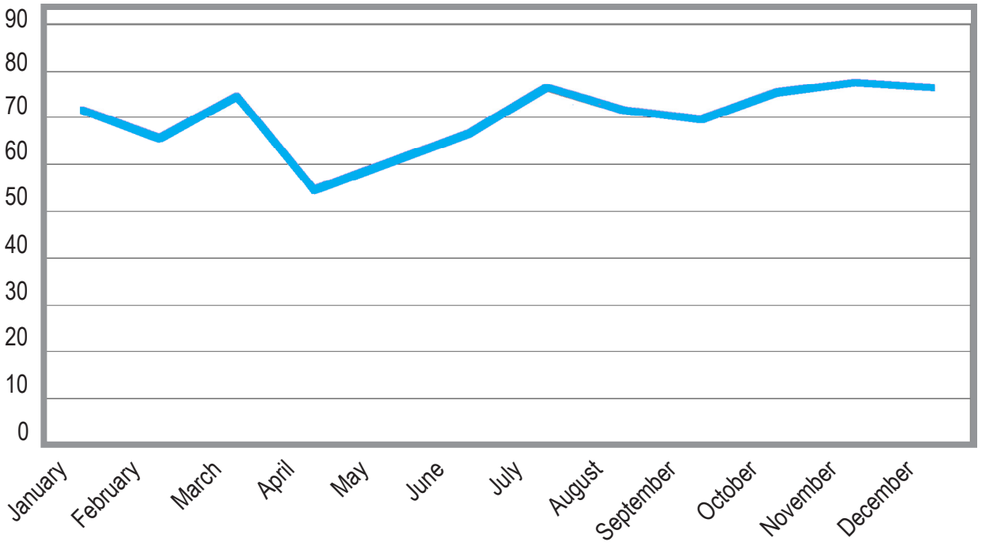


Sample set 2002

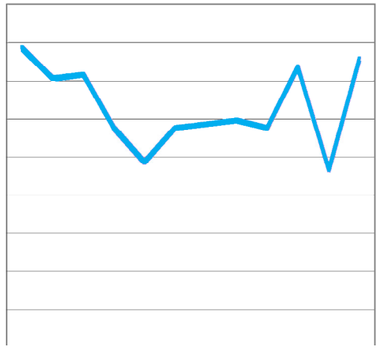


Sample set 2009

Average Humidity 2001-2011

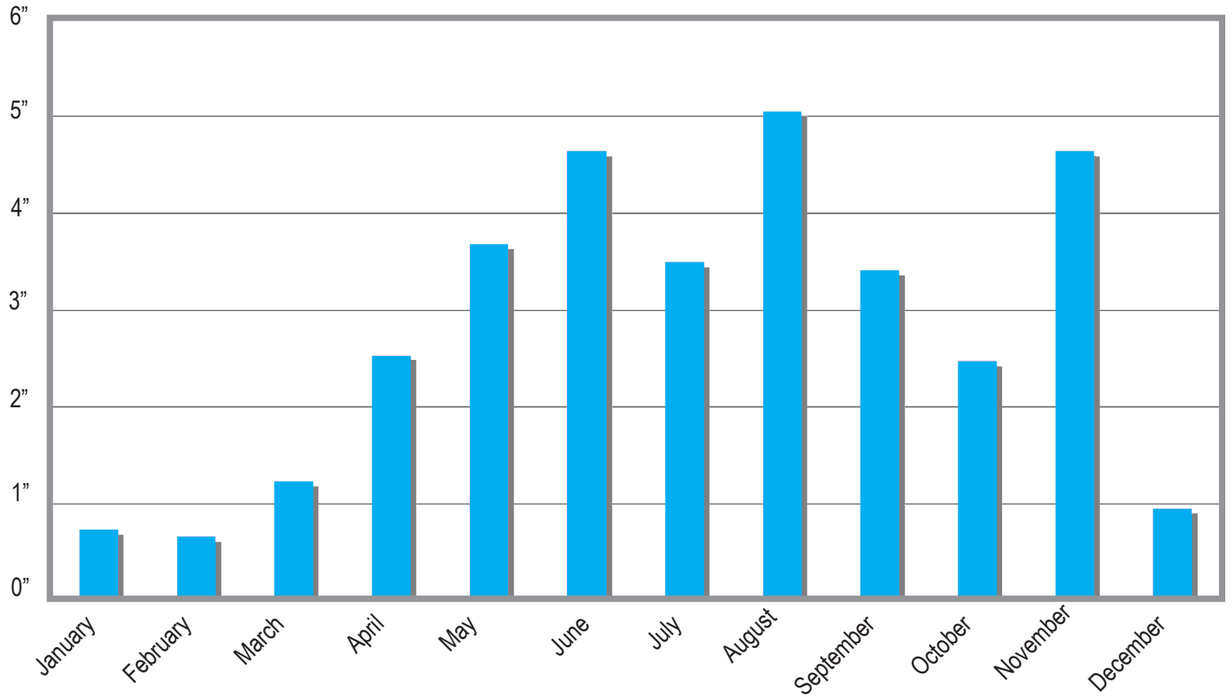


Sample set 2003

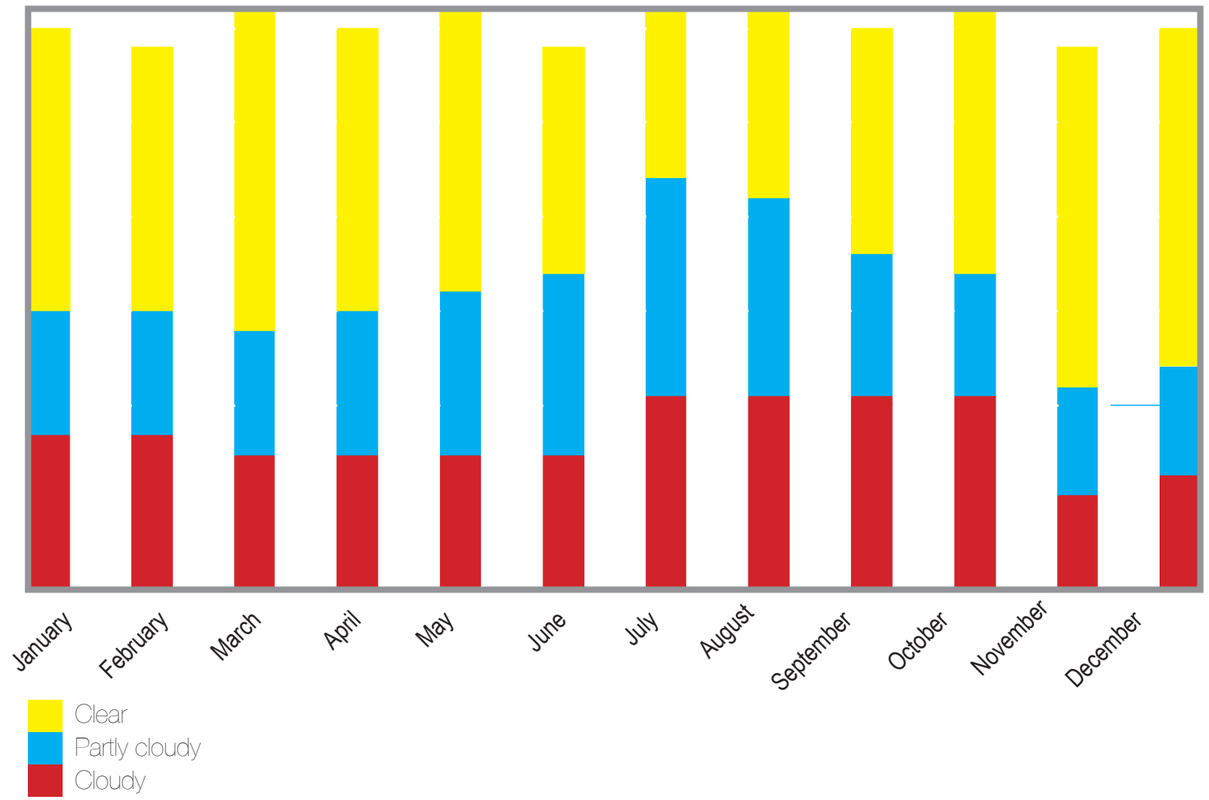


Sample set 2007

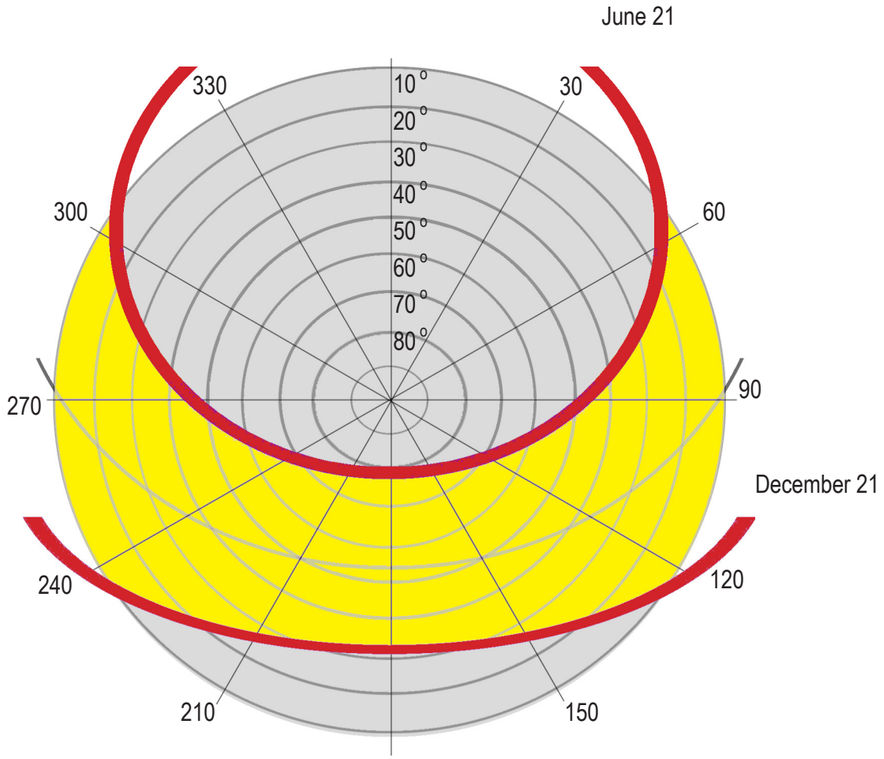
Average rainfall 2001-2011



Average cloudiness



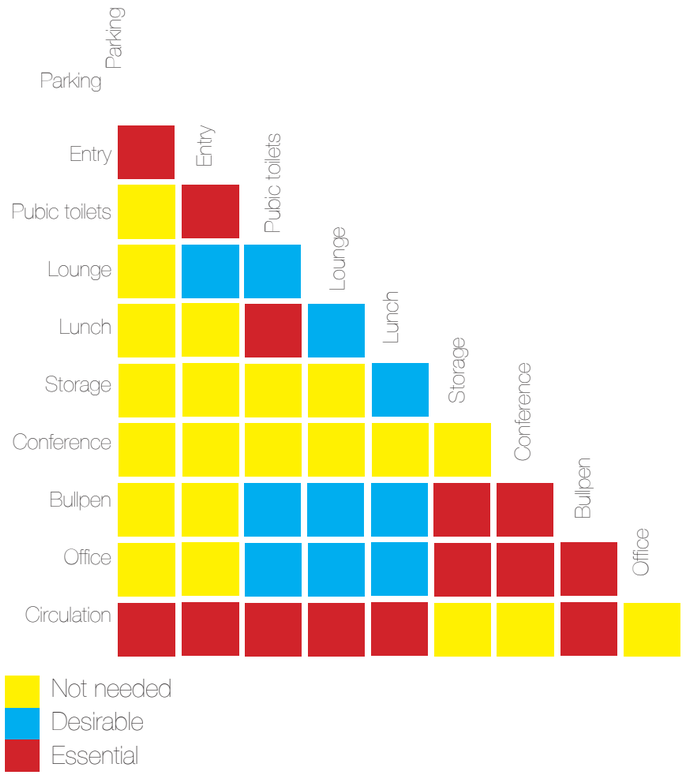
Sun path diagram



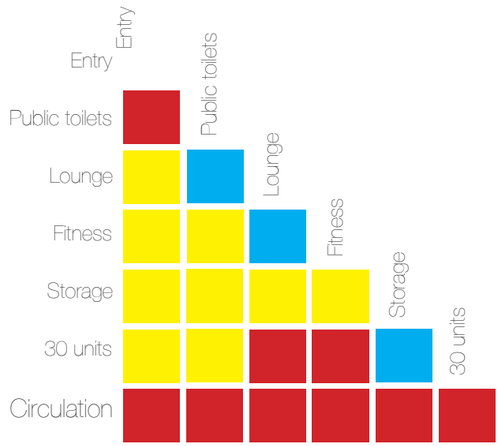
Wind direction

Interaction Matrices

Work

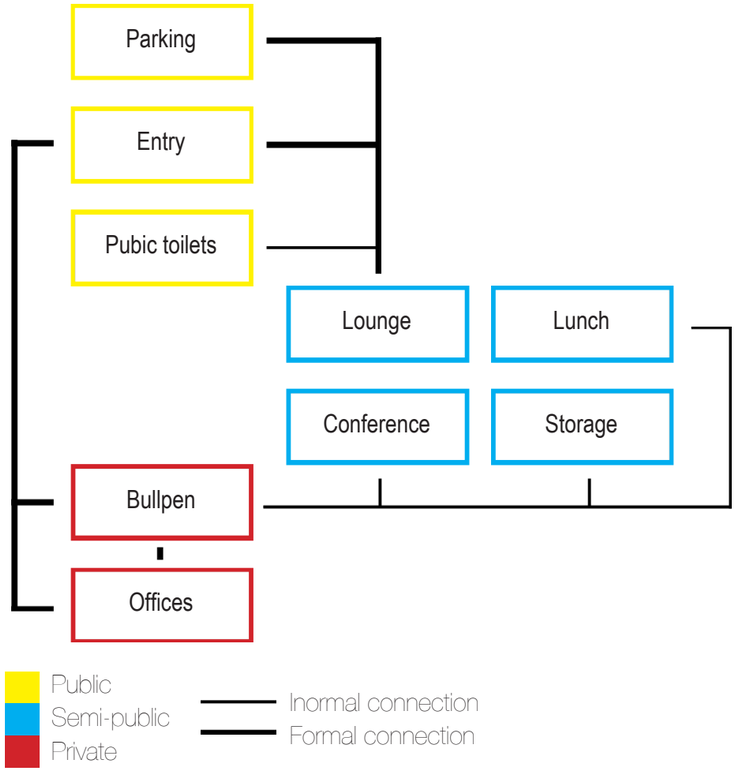


Play



Interaction Net

Work



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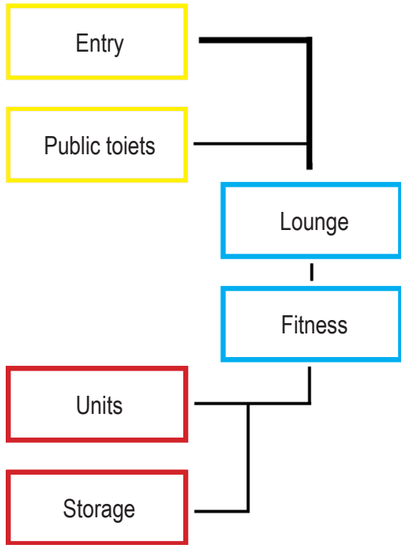
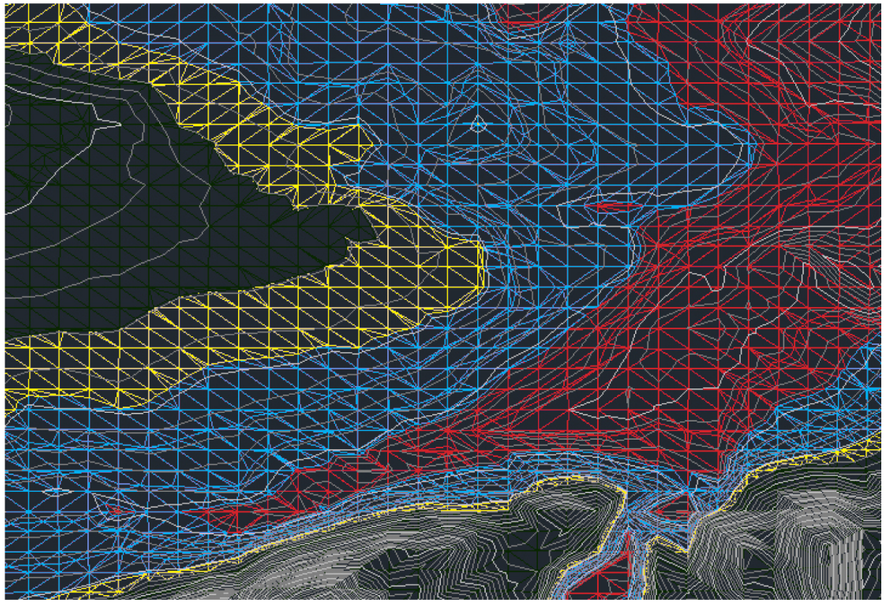


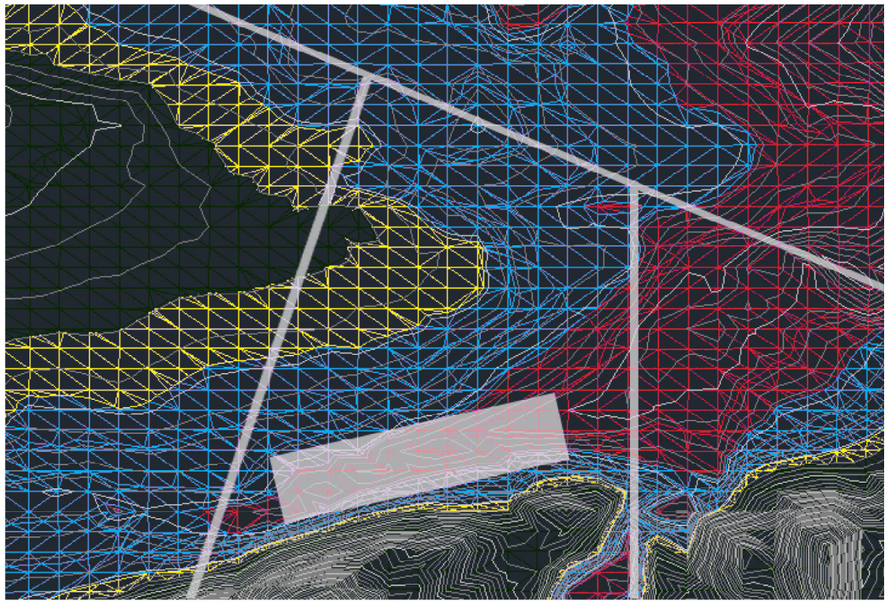
Topography analysis

Shakopee, Mn



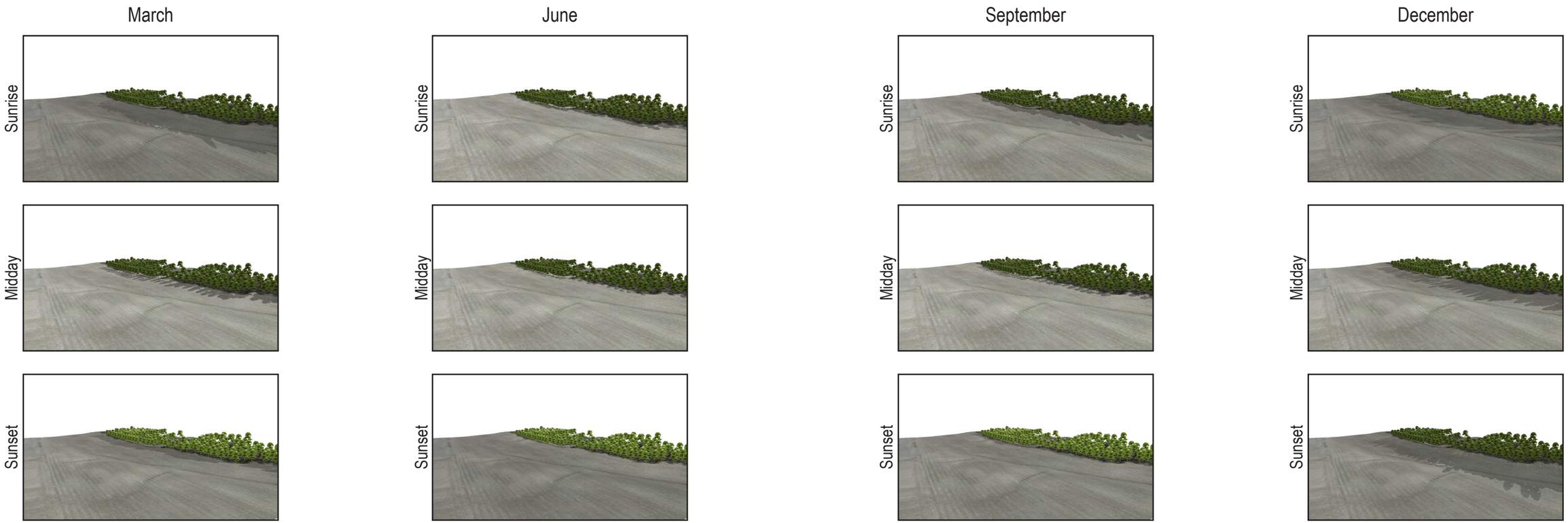
Steep slope
Intermediate slope
Slight slope

Shakopee, Mn



Steep slope
Intermediate slope
Slight slope

Shading analysis



PROGRAMMATIC REQUIREMENTS

Dwelling Unit 1

Kitchen/living/sleeping.....800sqft

Dwelling Unit 2

Kitchen/living/sleeping.....1600sqft

Dwelling Unit 3

Kitchen/living/sleeping.....1600sqft

Retail Unit

Storage/floor/toilet.....800sqft

Office Unit

Work/toilet/.....800sqft

Community Unit

Play.....800sqft

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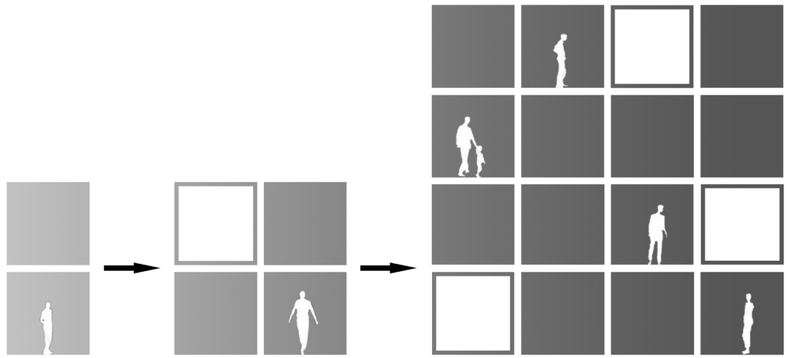
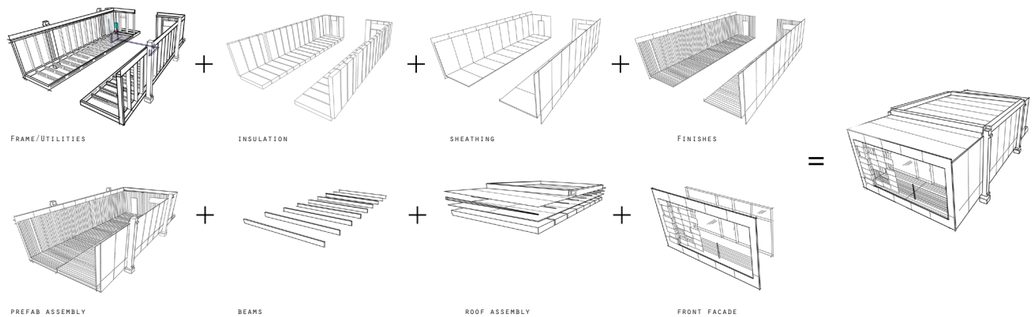


Plug it in: A perpetual living system

Build

Prefab + site construction

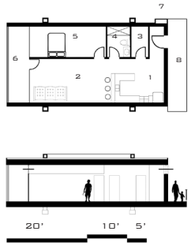


Customize

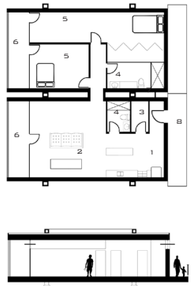
Key

1. Entry/kitchen
2. Living/dining
3. Utilities/storage
4. Bathroom
5. Bedroom
6. Deck
7. Utilities chute
8. Circulation

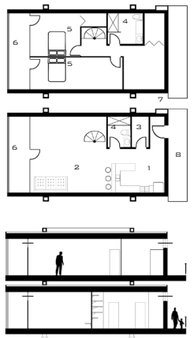
Module 1.0



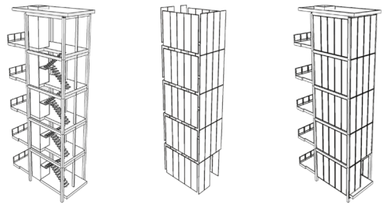
Module 2.1

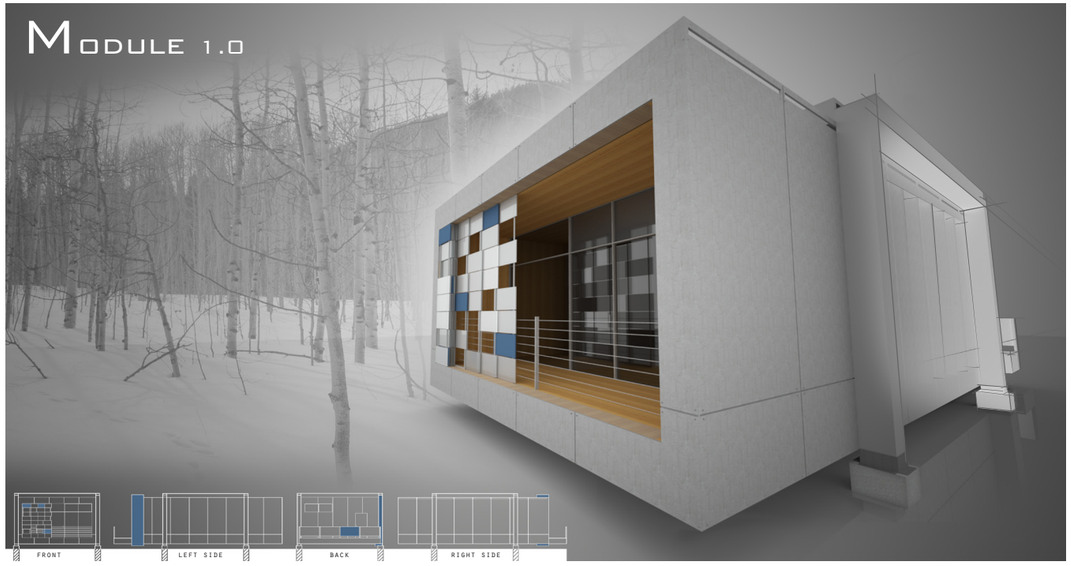


Module 3.0

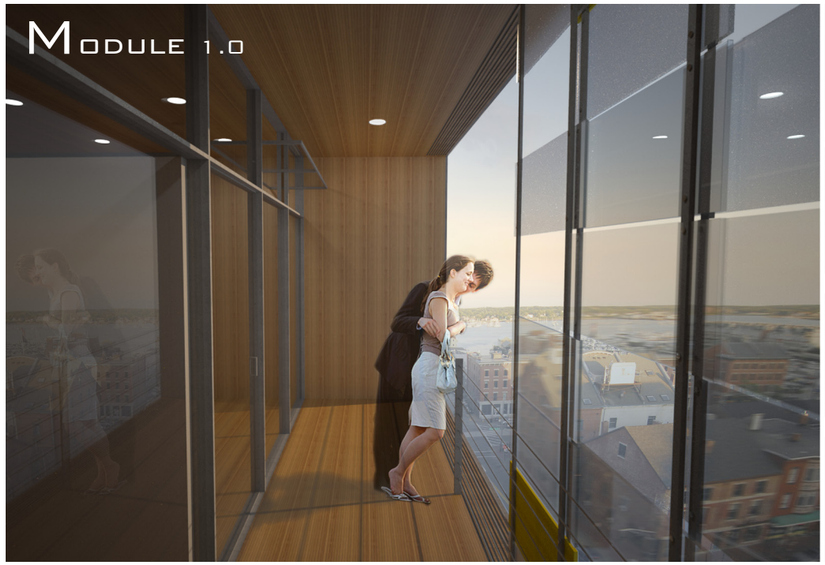


Site-constructed vertical circulation





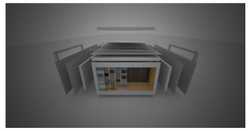
Module 1.0



MIDDLE OF EVERYWHERE

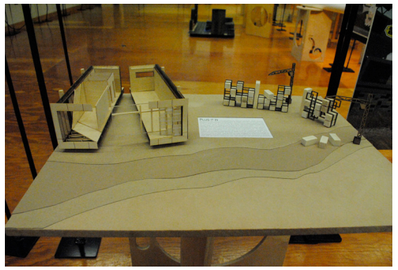
INTERIOR PERSPECTIVE

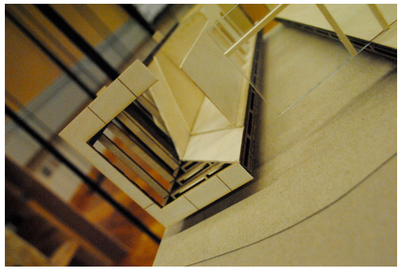
INTERIOR PERSPECTIVE/EXPLODED

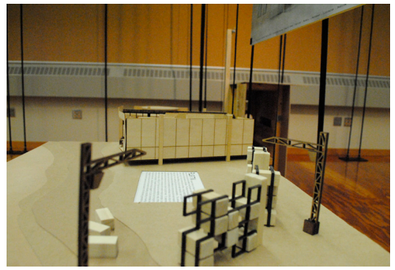


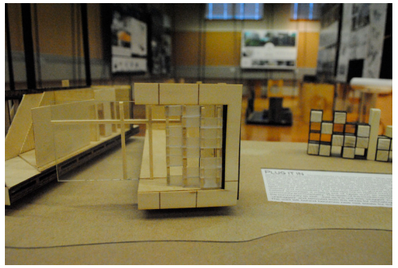
Integrate

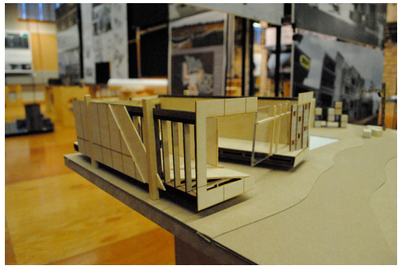
Relocate

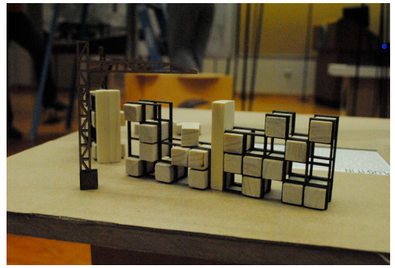












PERSONAL IDENTIFICATION

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Prior Lake, MN

“Anything is obtainable, the question is, how much do you want it?”

Second year

Arch 271
Meghan Duda
Heather Fischer
Teahouse : Boathouse

Arch 272
Darryl Booker
Dwelling : Dance studio

Third year

Arch 371
Cindy Urness
Center for Excellence : Satellite wellness center

Arch 372
Ronald Ramsay
Shaker barn : Consulate building

Fourth year

Arch 471
Bakr Ahmed
San Francisco Highrise

Arch 472
Don Faulkner
Marvin windows contest : Williston master plan