REVIVING THE DREAM OF THE PANEL HOUSE

AN ARCHITECTURE FOR NOWHERE AND EVERYWHERE

DAVID WERNER

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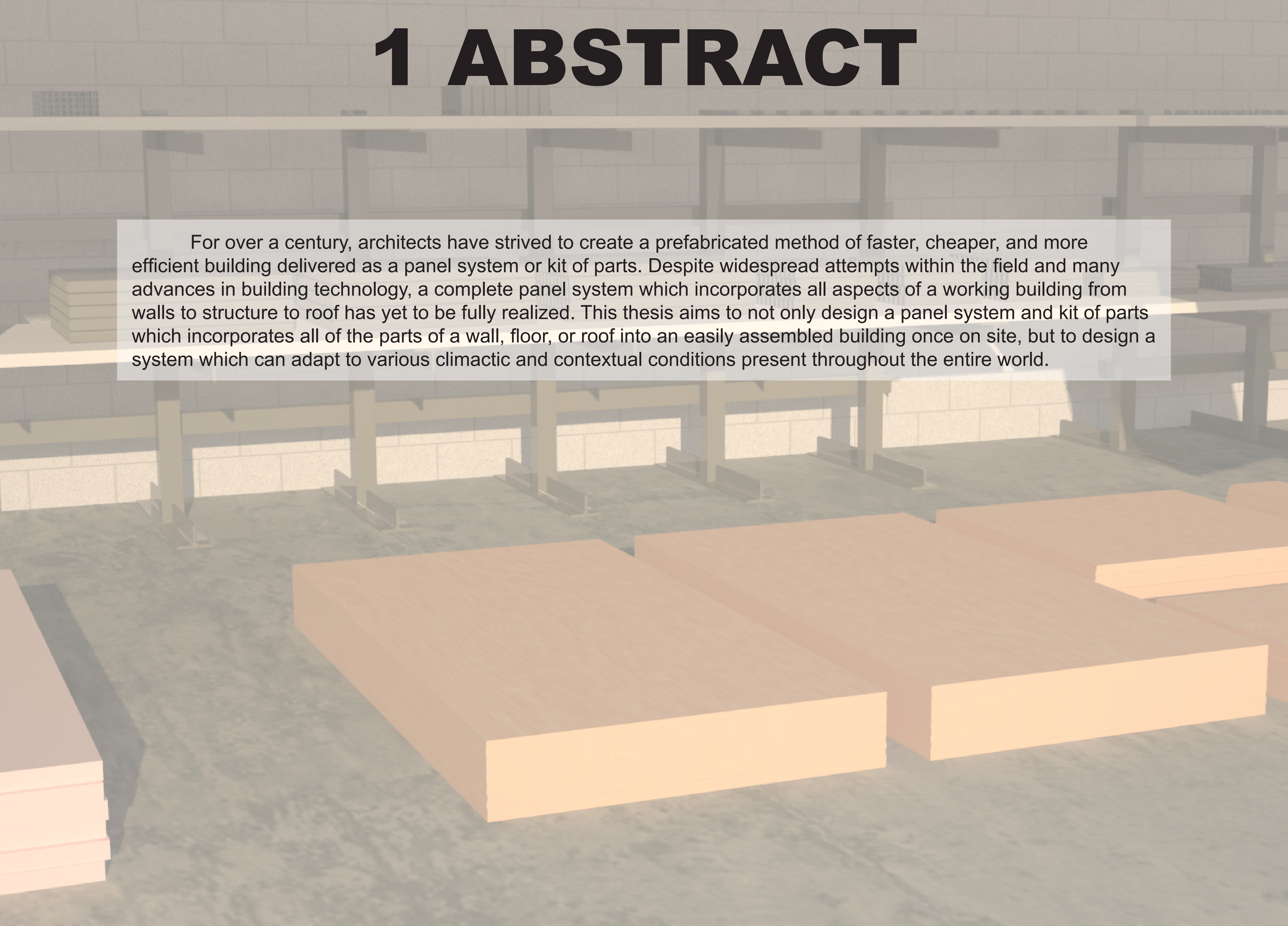
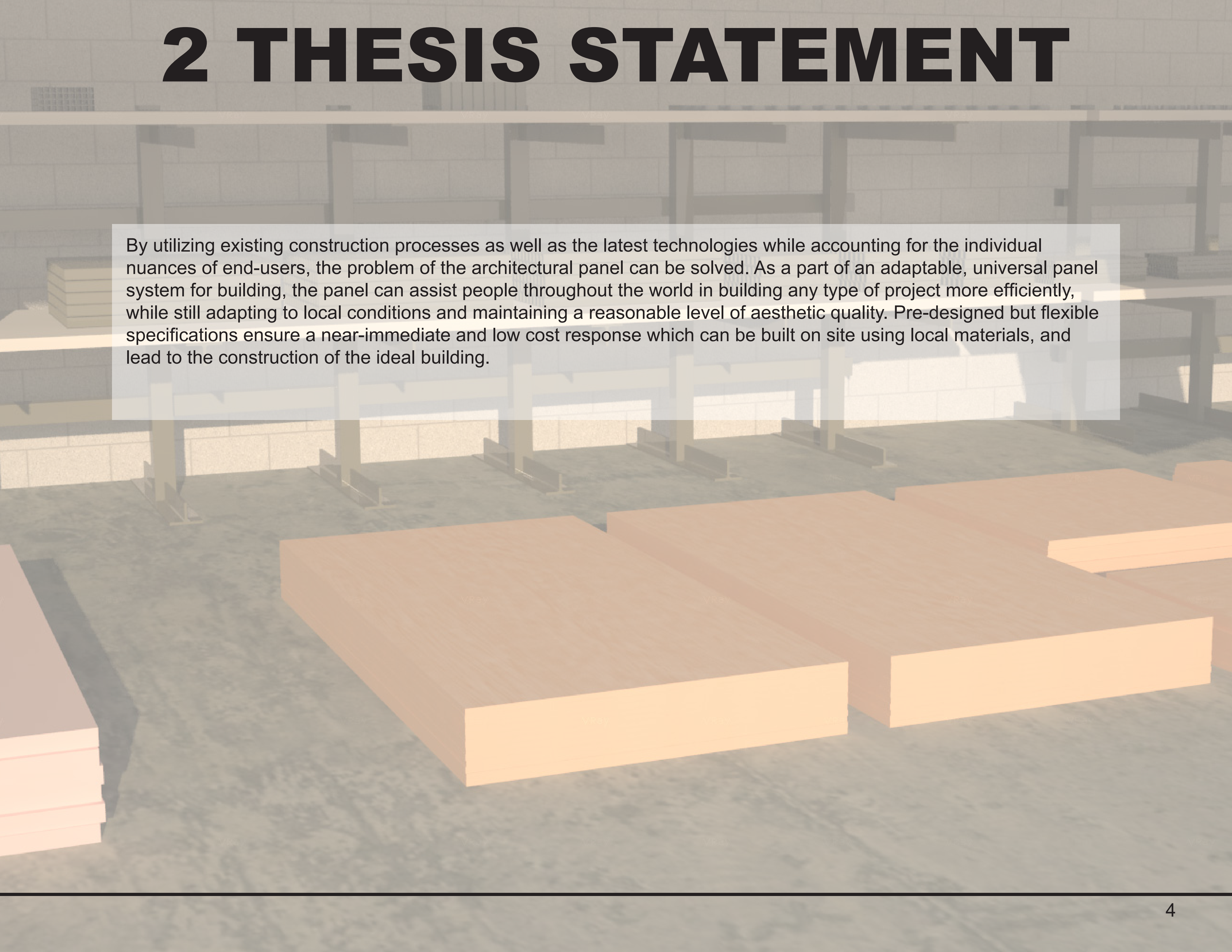
1 ABSTRACT



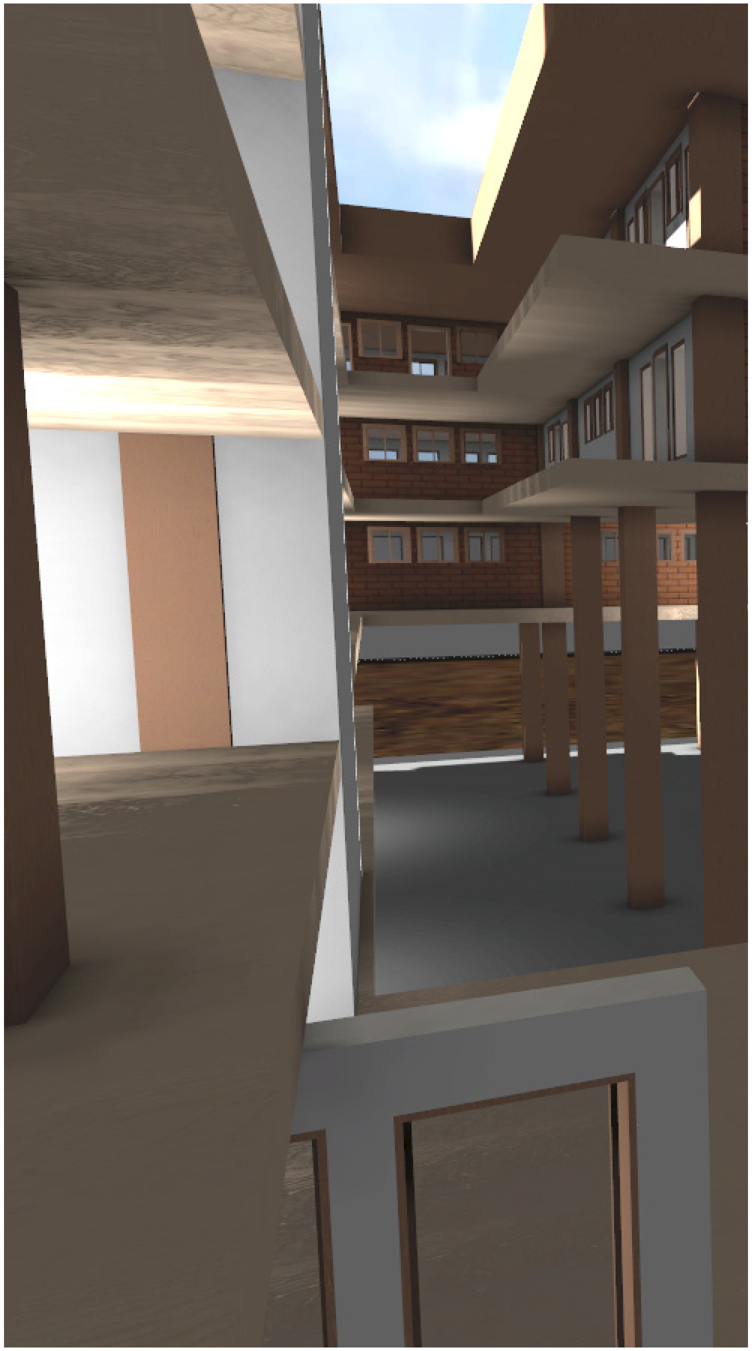
For over a century, architects have strived to create a prefabricated method of faster, cheaper, and more efficient building delivered as a panel system or kit of parts. Despite widespread attempts within the field and many advances in building technology, a complete panel system which incorporates all aspects of a working building from walls to structure to roof has yet to be fully realized. This thesis aims to not only design a panel system and kit of parts which incorporates all of the parts of a wall, floor, or roof into an easily assembled building once on site, but to design a system which can adapt to various climactic and contextual conditions present throughout the entire world.

2 THESIS STATEMENT



By utilizing existing construction processes as well as the latest technologies while accounting for the individual nuances of end-users, the problem of the architectural panel can be solved. As a part of an adaptable, universal panel system for building, the panel can assist people throughout the world in building any type of project more efficiently, while still adapting to local conditions and maintaining a reasonable level of aesthetic quality. Pre-designed but flexible specifications ensure a near-immediate and low cost response which can be built on site using local materials, and lead to the construction of the ideal building.

3 RESEARCH



3.1 AREA OF FOCUS SUMMARY

This project investigates ability for different materials to come together in order to make a universal, interchangeable panel and how those panels join together to make a building containing different types of programmatic elements, primarily residential.

Housing panels incorporate a number of different systems, such as structure, insulation, mechanical/electrical/plumbing systems, and cladding. All these systems must include the ability to be mass produced quickly, efficiently, and at a lower cost than standard construction. These panels must then join together to create an airtight transition between the exterior cladding pieces, while allowing for the required electrical, mechanical and plumbing systems or other features such as doors and windows. Individual panels must retain some semblance of interchangeability and allow for at least a minimal amount of customization.

At the scale of the building, the system must adapt to local conditions, including available materials, typical spaces and functions of a local house, and climactic conditions (e.g. sun and wind angles). All of these functional goals and objectives will be the focus of this project and be included, in some capacity, in the design.

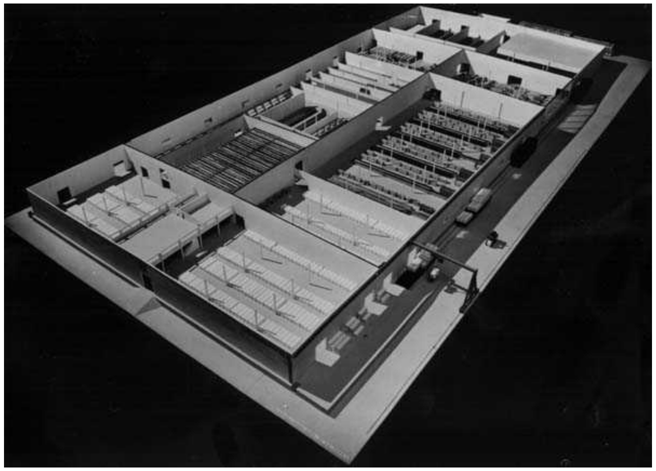
Many designers have attempted to create such a system as described, yet the vision of a panel building which fulfills the requirements as described by the idealists who sought to create it still remains elusive. An analysis of notable past attempts and how they both failed and succeeded would reveal the pitfalls of a failed system and potential characteristics of a successful system, ensuring that the mistakes of the past are avoided.

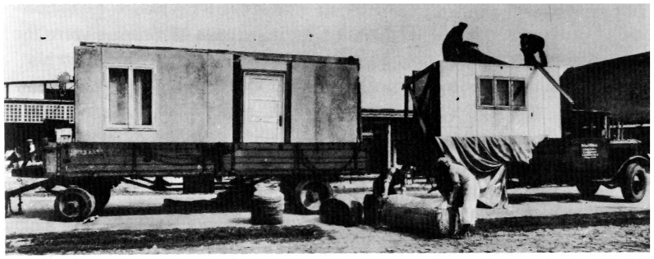
3.2 LITERATURE REVIEW

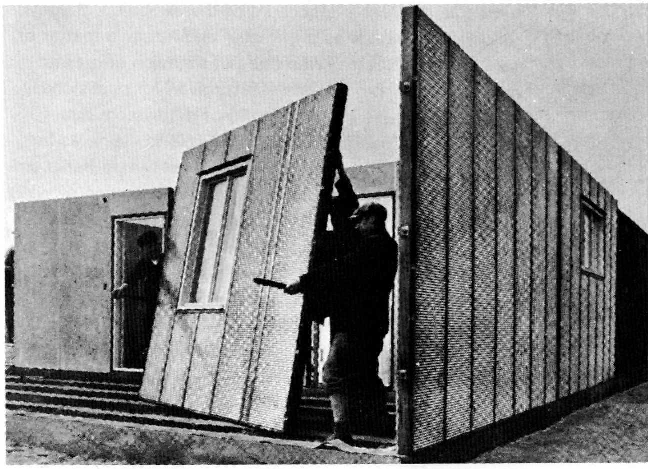
Many, many architects have attempted to create a panel system which provides the theoretical benefits of speed, efficiency, and low cost. None have succeeded so far, however several notable attempts made important changes to how buildings are built, especially in the late 1800s and early 1900s.

While many attempts at prefabricated housing existed in the 19th century, several German architects began the move towards making factory-produced housing a reality (Herbert, 31). Among them were Walter Gropius and Konrad Wachsmann. Gropius believed in a merging of architects and manufacturers which could utilize the new technologies of the industrial revolution and modernize housing (Herbert, 35). When Gropius and Wachsman moved to the United States during WWII, they continued their dream of factory-made housing through the company General Panel. Unfortunately, the company proved to be a failure due to unsustainable financial practices and only build a few hundred units (Herbert, 307). Many other architects also attempted to design and build factory-made housing modules, such as Frank Lloyd Wright and Mies van der Rohe, but their efforts proved just as unsuccessful.

Recently, many architecture firms have begun to rediscover the potential benefits of factory-produced housing and designed modular housing units from those methods. In Best Designed Modular Houses, the authors show examples of financially solvent prefabricated houses, stating that not only can houses be produced in a factory, but that method can save money and still be sustainable (Kunz, 4). Designs in the book, as well as resource tables in the CIA World Factbook, show that every country in the world contains either raw materials or production capacity for many common amenities found in building, such as iron and timber. In a global market, easier trade and transport can create a dramatic decrease in the prices of building materials, increasing the feasibility for financially solvent prefabricated housing. The vast majority of houses in Best Designed Modular Houses and many similar books, however, were only built once, rather than produced multiple times. The architects of these houses focused on building a single, stand-alone module using parts and materials which came from a factory and are assembled on site, unlike the focus of this project, which includes factory assembly of components into panels.







3.3 QUESTIONS/THEORETICAL ISSUES RAISED

So many different cultures exist throughout the world with so many differences in domestic life that designing a universal housing system designed to the appropriate level of sensitivity cannot be done in a short time frame. What one family perceives as adequate living space varies greatly from what another family perceives as adequate in another culture. How one family uses the spaces within their dwelling varies greatly from how another family uses theirs. As a result, the prefabricated housing industry has abandoned the engagement of local issues, and instead built structures incompatible with cultures in and around the site. With every structure remaining the same, residents have no ability to express their individual identity or their culture through their house. What are the ways in which modern, prefabricated housing can maintain its efficiency while expressing these values? How can modern housing be improved to accommodate its residents more?

Compounding the issue of cultural differences is the inherent monotony of prefabrication. While single, one-off houses created from prefabricated parts often create a unique aesthetic, large-scale prefabricated systems at present do not maintain the same level of variation. How can a prefabricated system of highly standardized components contain the potential for varied aesthetics?

Another worldwide variable is resources and local knowledge of their use. Highly industrialized countries such as Germany and the United States contain sufficient knowledge to build any possible form, but less developed nations contain fewer industries, available building materials, and knowledge of construction using them. Designing factory-made housing to be as simple as possible allows people from these countries to assemble the structure, but can such a design be sustainable or adaptable enough to be locally and culturally responsible?

An important final thought is the utopian nature of the proposed project. A housing project which can be built quickly, cheaply, and locally anywhere in the world remains a lofty ideal not met in over 100 years of residential housing systems. Adding an aspect of increased standard of living for the residents while performing all these functions completes the picture of the perfect, ideal housing system. Numerous architects have attempted to create this same system which meets these same goals, yet the completion of such a project still remains elusive. Can a panel system be created which meets the promises of the past proposals? Can it build faster, cheaper, and more efficiently? What was successful amongst the many failed attempts? Why can't the successful attempts be considered a solution within the area of focus of the thesis? Finally, the most important question: why hasn't the panel succeeded?

3.4 ARCHITECTURAL ISSUES

Why hasn’t the panel succeeded?

- New methods of construction require massive investments in order to establish the infrastructure to supply them.

- Deviations from standard construction practices require additional training of workers who must be open to try new practices.

- Houses built with the panel system were more expensive than traditionally built houses.

- Too much money was spent during the design phases, leaving little for actual construction.

- Many panel systems are conceived as an experiment and never considered beyond the initial building or proposal.

- Until recently, technology was not able to create a modular panel system as efficiently as theory predicted.

What worked?

- Panel designs often reached completion, with the vast majority having at least one prototype constructed. General Panel built a number of houses, which their clients inhabited permanently.

- Designers created a viable panel system which met all the functions of a standard house.

- Designs gained the attention of the architectural and construction communities, but only long after the idea was abandoned.

- Fritz Haller’s Mini/Maxi system continues today as a furniture design. Haller designed the system for the president of the company, who like it so much that he adopted it.

Solving the problem of the panel:

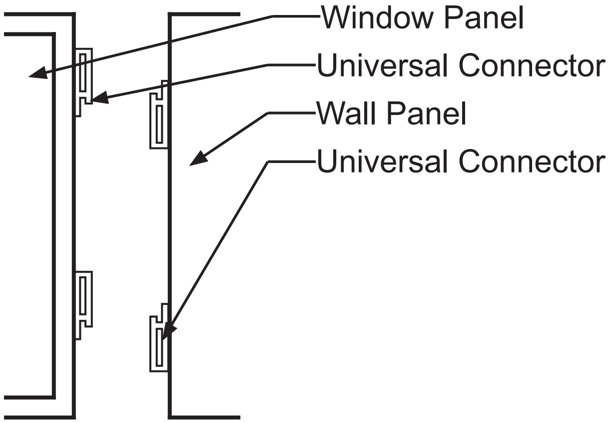
- The Architect must create a marketing and relations system to find interested clients after the first completed project.

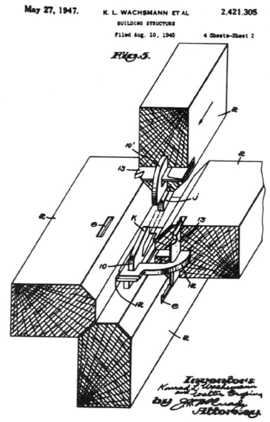
- Construction must utilize new technologies, such as CNC routing and robotics, in order to mitigate the time and monetary investments for infrastructure development and employee training.

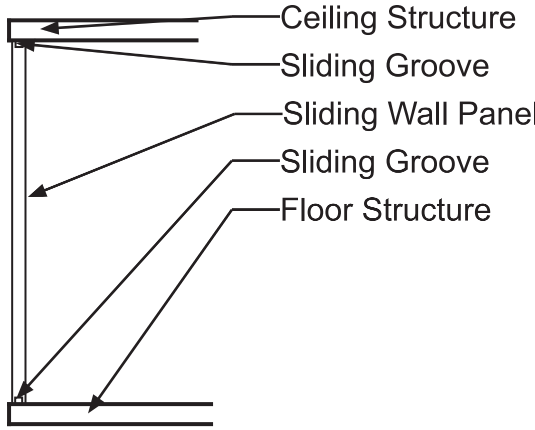
- Design must be completed using as little of the initial funds as possible.

- Initial systems must use materials with established infrastructure and supply pipelines while minimizing modifications to them as conventionally provided.

3.5 ARCHITECTURAL PRECEDENTS

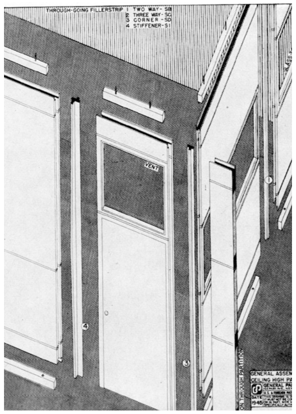


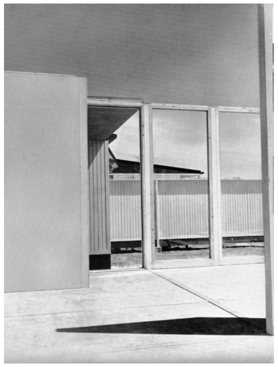




General Panel (1946)

Konrad Wachsmann and Walter Gropius



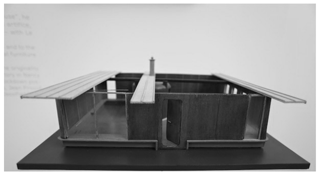


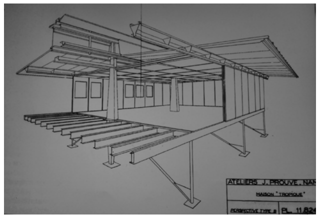
A universal connector system devised by Wachsmann allows each panel to come together at the ends. Metal shapes embedded on the edge of each panel can join together to form any orthogonal angle or flat surface. Each corner and intersection of the house must be carefully analyzed in order to ensure the right connection at every point.

Konrad Wachsmann first envisioned this system while working in Walter Gropius's basement as a solution to merging the professions of architecture, manufacturing, and business. The end of WWII brought a need for housing which suited Wachsmann's idea perfectly. With Gropius assisting on the administrative side, both architects formed General Panel, an ill-fated prefabrication company which managed to build only a few houses before closing due to a lack of funds for production.

Houses (1950)

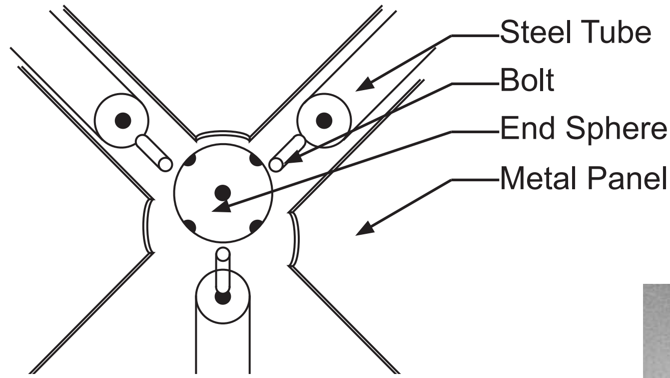
Jean Prouve

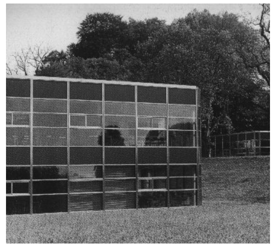




Prouve's two major houses: Maison Tropicale and Maison Pour Jeurs Meilleurs use a similar system of prefabricated components. The floor and internal structure are assembled first, then support the wall panels, which are attacehd at the top and bottom. Prouve's second house allows the wall panels to slide along a track at the top and bottom, while his first designates preplanned locations for them to fit into the structure.

Both of Prouve's houses were intended to solve housing shortcomings in both Africa and France. While his studio built and sent many prefabricated aluminum sheds, few houses were created and used in either location.



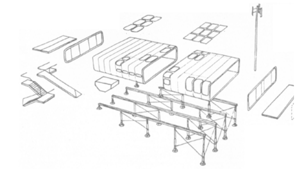


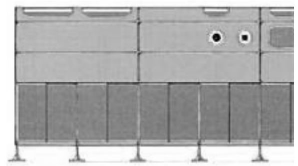
Maxi/Mini (1960)

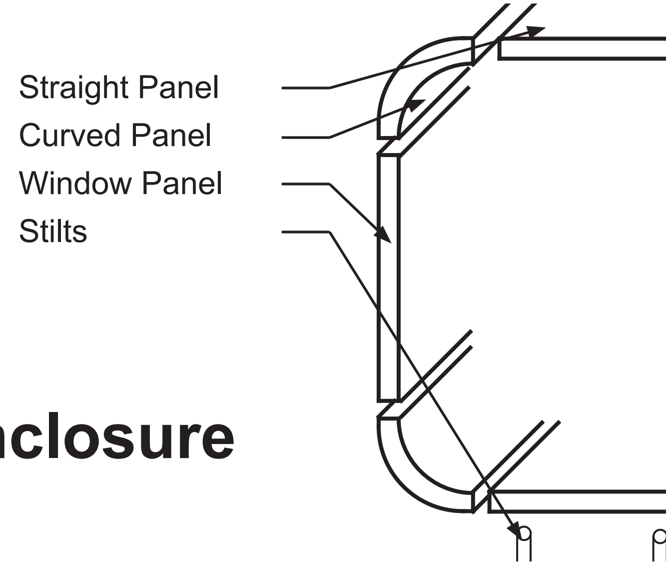
Fritz Haller

Haller's system uses only a few basic components: tubes, balls, metal sheets, and screws to hold the tubes and balls together. Haller devised two different versions of this system: "Mini" for houses, and "Maxi" for large buildings. USM furniture adapted Haller's system to use in their designs, giving Haller's system world renown.

Haller first devised this system as a method for building a house for the president of USM. He used a simple method of joining the structure together at the corners and enclosing the system with an exterior membrane. The president of the company liked Haller's system so much that he commissioned Haller to build a new furniture factory using the system, and then adopted it for his furniture designs. Haller continued to use his system, creating two variations: the Mini system for houses, and the Maxi system for schools and factories.



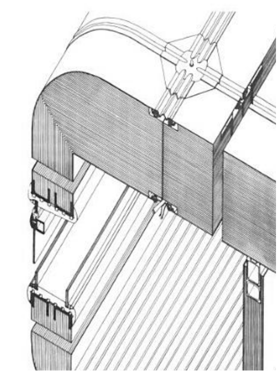




Zip-Up Enclosure (1969)

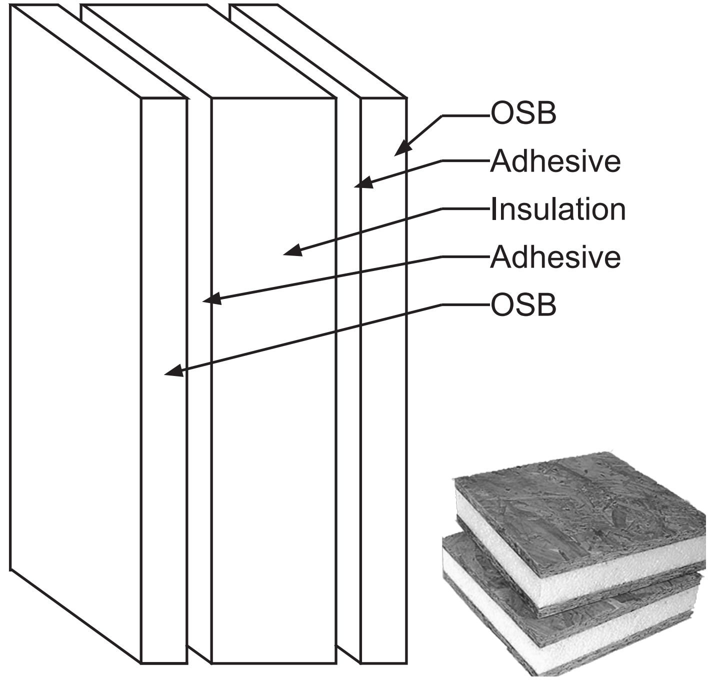
Rogers & Rogers

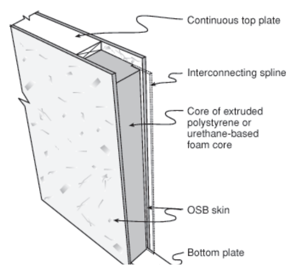
Inspired by trailers and other types of mobile homes, Richard and Su Rogers' thought experiment for a MOMA exhibit on prefabrication contains several important characteristics. The first: telescopic legs which allow the design to adapt to any hillside terrain. The second: a modular series of rings, which can be shifted in any direction the home occupants desire.

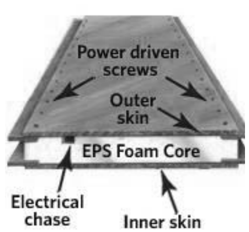


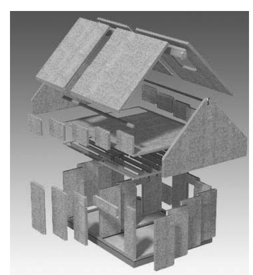
Structurally Insulated Panel (1989)

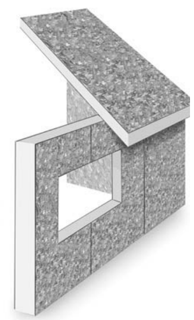
One of the only panel systems to see widespread use, the SIP has gained enormous popularity due to its simplicity, its easy adaptability to current construction techniques, and potential for recyclable and sustainable material use. Two sheets of OSB sandwich a layer of insulation, which is then placed on the structure of the house. Unlike many panel systems, the house structure and SIP have little to do with each other, meaning that the SIP often needs to be cut to fit in place.





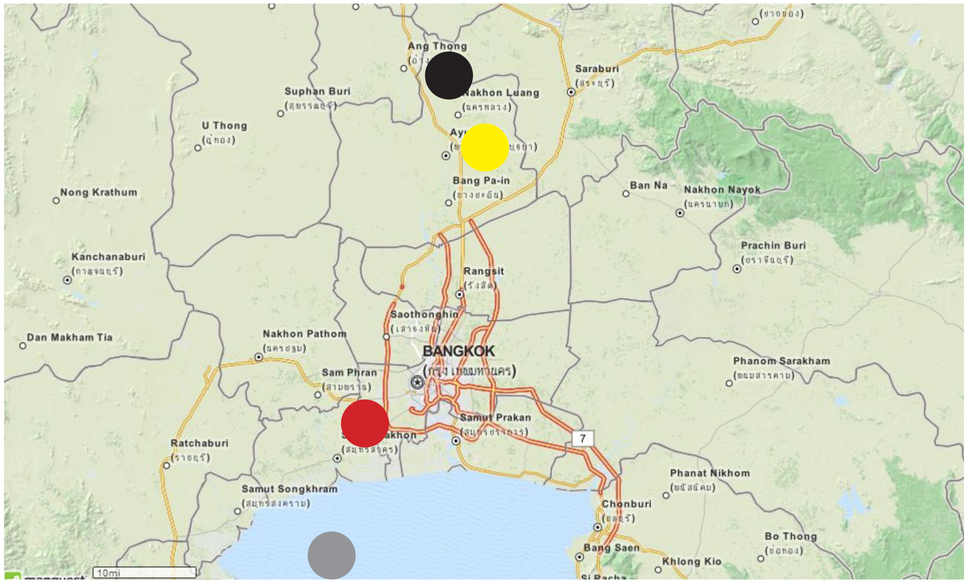






4 WORLD ADAPTATION INVESTIGATION

4.1 LIST OF SITES FOR INVESTIGATION



Bangkok

One of the most humid cities in the word, Bangkok's buildings must account for comfort while reducing environmental impact. Due to the city's relatively close proximity to the equator, the sun will be almost directly overhead for significant portions of the year, allowing easy potential for shading.

The three most readily available materials in Bangkok include concrete, steel, and glass, used for the vast majority of buildings in the city. While wood is far less plentiful than many other areas, bamboo grows natively within a reasonable distance of any site.

- Wood/Bamboo
- Steel
- Stone
- Brick

Los Angeles

The more temperate climate of costal California allows residents to remain comfortable during much of the year. Hot temperatures from solar gain combine with cool sea breezes to equalize temperatures outdoors for much of the year. Over the mountains, however, the cooling breezes cease, creating one of the hottest deserts on earth.

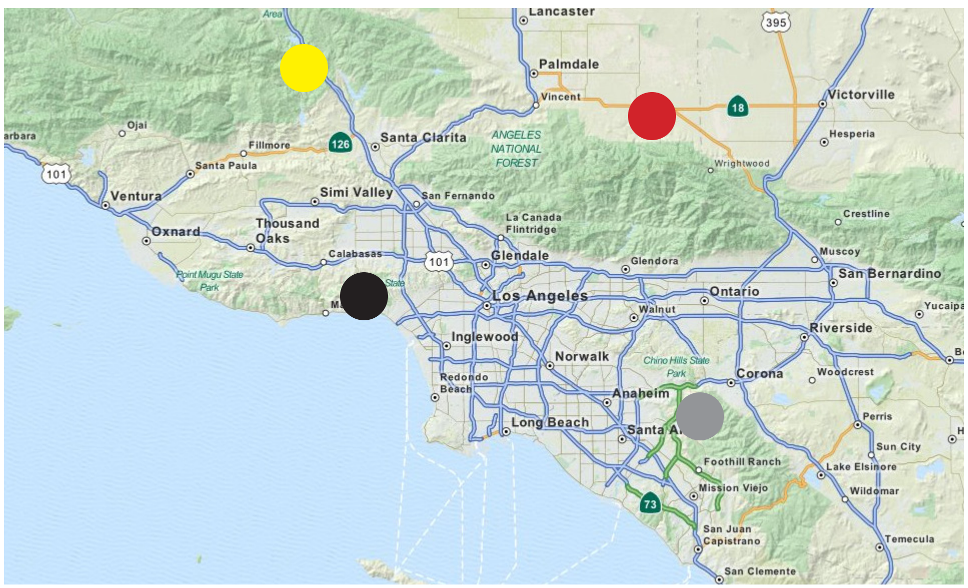
Major hazards in California include, most notably, earthquakes, which require a resistant but flexible structure and bracing on cladding or other conventionally loose components. Forest fires often impact the surrounding areas as well, requiring both proactive prevention methods through fire rated materials as well as active fire suppression methods.

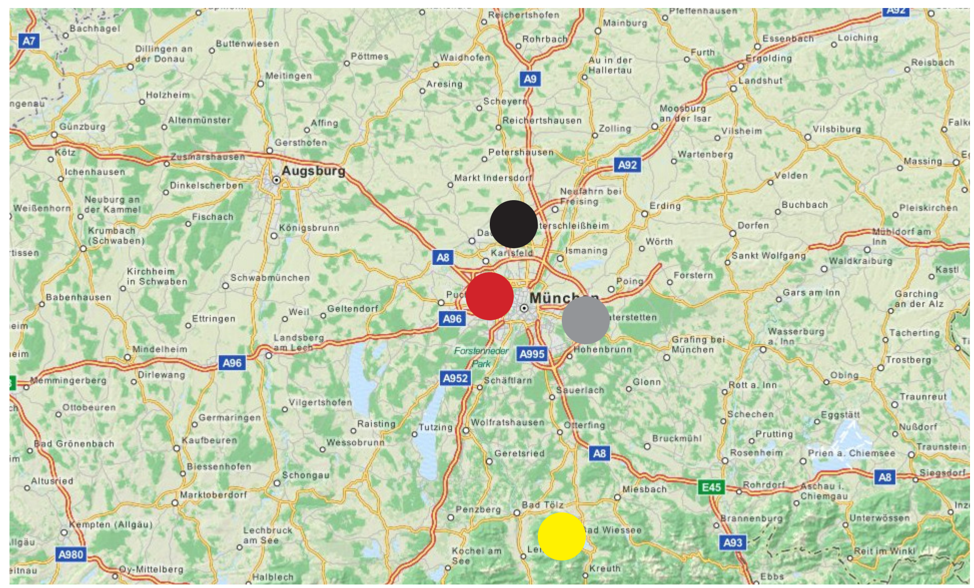
All major types of building materials are available either locally or nearby, due to the major manufacturing ability of the United States as a whole.

Munich

While Munich’s climate is slightly colder than many others through out the world, the conservative values of both aesthetic and construction methods remain the most pressing concerns. Any project built in Munich must fit aesthetically with the pervasive local styles, both modern and medieval. In addition, German construction often uses mass walls, with lightweight construction seeming completely alien to builders and architects.

In addition, Munich has few resources of its own located in close proximity to the city. Many of the building materials used within are transported from other areas, creating a potential concern for pollutants relating to transportation with present technology. The German country as a whole contains a significant amount of infrastructure to process those materials, including high-tech manufacturing methods which may offset concerns from transportation.





4.2 DOCUMENTATION OF POTENTIAL SITE CONDITIONS

Numerous different conditions exist which will affect the system's ability to adapt and perform adequately. Based on investigation of the three sites, these conditions can be reduced down to five major areas of focus, with the other challenges implemented to a smaller extent.

Cold Climates

Areas where temperatures reach levels below standard human comfort levels. In order to accommodate residents in these areas, the system must include sufficient amounts of insulation and mechanical systems to heat the building.

Warm Climates

Areas where temperatures reach levels above standard human comfort levels. The system must contain mechanical systems which can cool the building to mitigate these effects. Natural ventilation can reduce the need for these systems.

Seismic Zones

Earthquakes present a major problem for panel systems. Cladding must be fully secured to the panel structure to avoid debris hazards, while the materials and connections within the panel structure must be strong enough to withstand most major and minor tremors.

Aesthetically Sensitive Areas

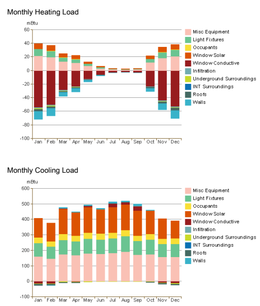
Many cities, towns, and villages contain a strong architectural aesthetic, present for a significant period of time. The system must be able to adapt to the local aesthetic in such a way as to avoid disrupting it.

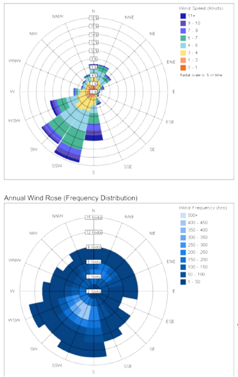
Resource Deficient Areas

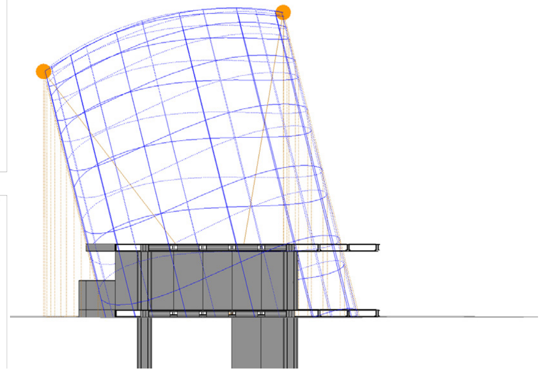
Not every material is present in every location on earth. Some countries contain numerous raw materials and the infrastructure to process them, while some contain none of these. Interchangeable parts and materials will be mandatory for worldwide deployment in order mitigate the costs and damages associated with transport of materials and goods.

4.3 CLIMACTIC ANALYSIS

Bangkok

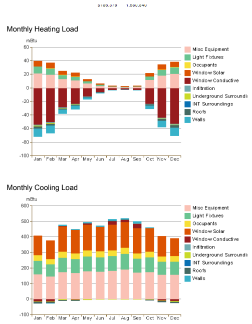


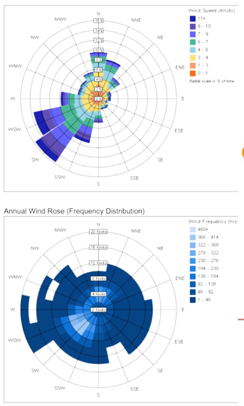


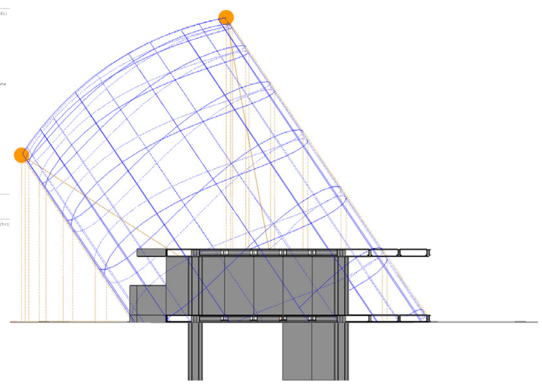


The most striking statistic on Bangkok’s climate is its complete lack of need for heating. According to analysis, all energy load will be focused on cooling, due to Bangkok’s warm and humid climate. Shading and natural ventilation may offset some of the load.

Los Angeles

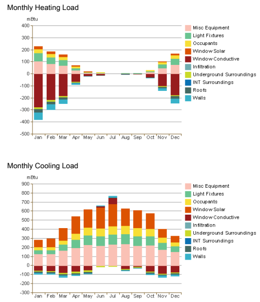


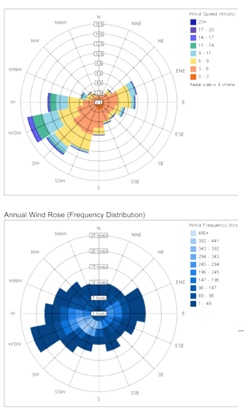


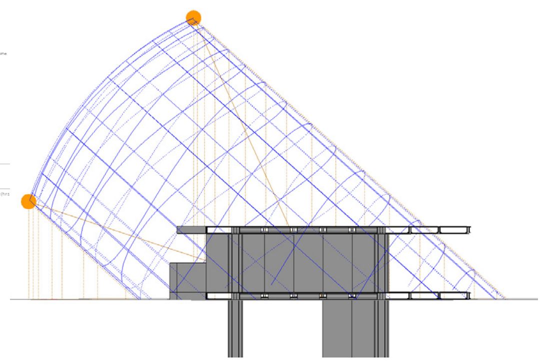


A relatively sunny climate allows for ample solar gain, while cool breezes from the Pacific Ocean provide significant opportunities for natural ventilation. Steep sun angles mean that shading is not required during the entire year, but still helpful for controlling temperature.

Munich







Colder temperatures mean more insulation is required to pre-
vent
heat loss. Internal heat gain and southern exposure are the key
to
decreasing the need for mechanical heating, while removable
shading will keep it in check during the summer.

5 DESIGN PROJECT

5.1 CHARACTERISTICS OF THE SYSTEM

5.1.1 COMPLETE PART SCHEDULE

0A
Footer

Dimensions:
3’ x 3’ x 1’

Location:
Primary Structure

0B
Pillar

Dimensions:
2’6” x 2’6” x 4’

Location:
Primary Structure

0C
Slab

Dimensions:
20’ x 20’ x 1’

Location:
Ground Floor

3A
Column

Dimensions:
2’ x 2’ x 8’

Location:
Primary Structure

1A
Wall Panel

Dimensions:
4’ x 1’ x 4’

Location:
Walls and Floors

1B
Thin Wall Panel

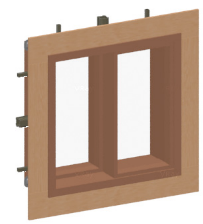
Dimensions:
3’6” x 1’ x 4’

Location:
Between Walls and Columns

1C
Thin Wall Panel B

Dimensions:
1’6” x 1’ x 4’

Location:
Walls



1D
Window

Dimensions:
4’ x 1’ x 4’

Location:
Walls

2A
Double Wall Panel

Dimensions:
4’ x 1’ x 8’

Location:
Walls and Floors

2B
Double Thin Wall Panel

Dimensions:
3’6” x 1’ x 8’

Location:
Between Walls and Columns

2C
Double Thin Wall Panel B

Dimensions:
1’6” x 1’ x 8’

Location:
Walls

2D
Door

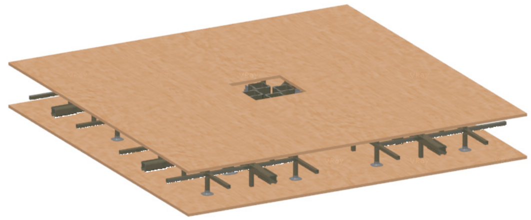
Dimensions:
4’ x 1’ x 8’

Location:
Walls

3B
Column Boost

Dimensions:
2’ x 2’ x 1’

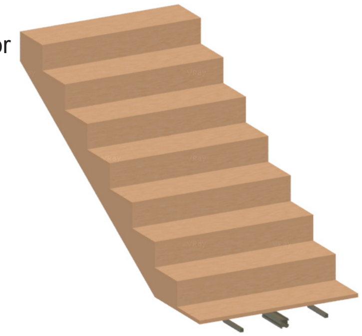
Location:
Between 2 Columns



3C
Column-Floor Connector

Dimensions:
8’ x 8’ x 1’

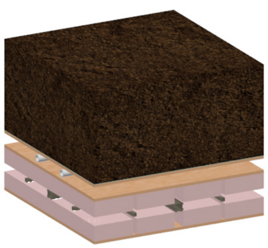
Location:
Floor Connections



3D
Stairs

Dimensions:
(Varies)

Location:
(Varies)



1E
Greenroof

Dimensions:
4’ x 4’ x 4’

Location:
Roof

2E
Glass Panel

Dimensions:
4’ x 1’ x 8’

Location:
Walls

2F
Double Thin Glass Panel

Dimensions:
3’6” x 1’ x 8’

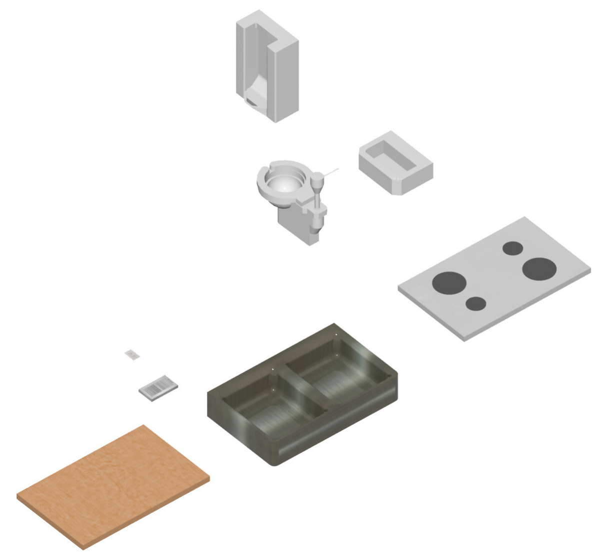
Location:
Between Walls and Columns

STRUCTURAL BEAMS

Dimensions:
(Varies)

Location:
Primary Structure

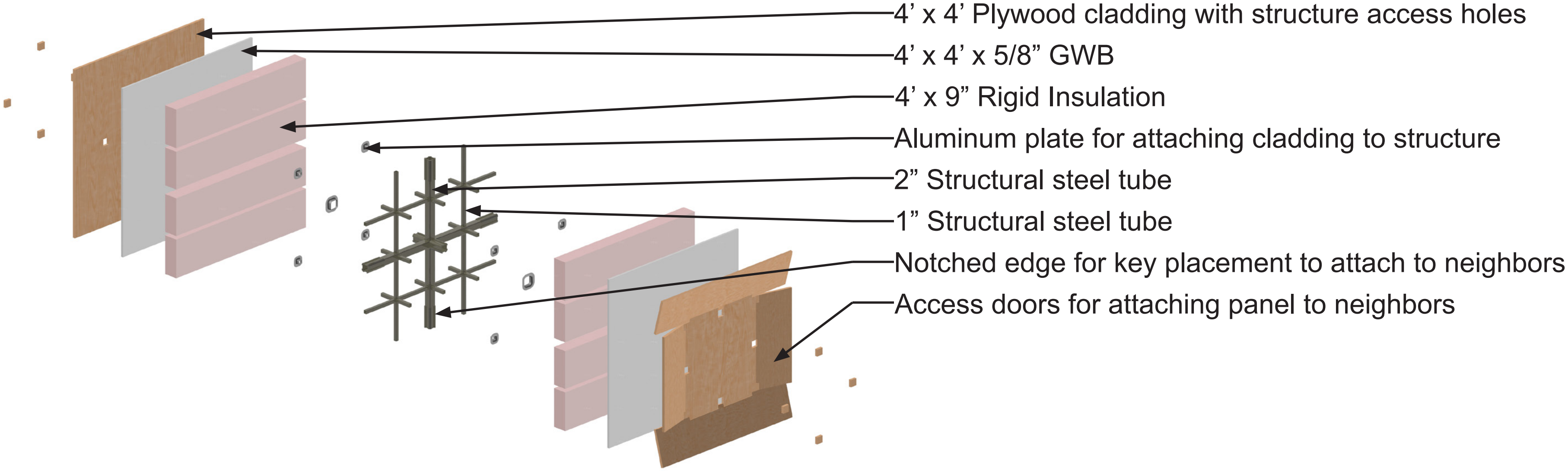
ATTACHMENTS

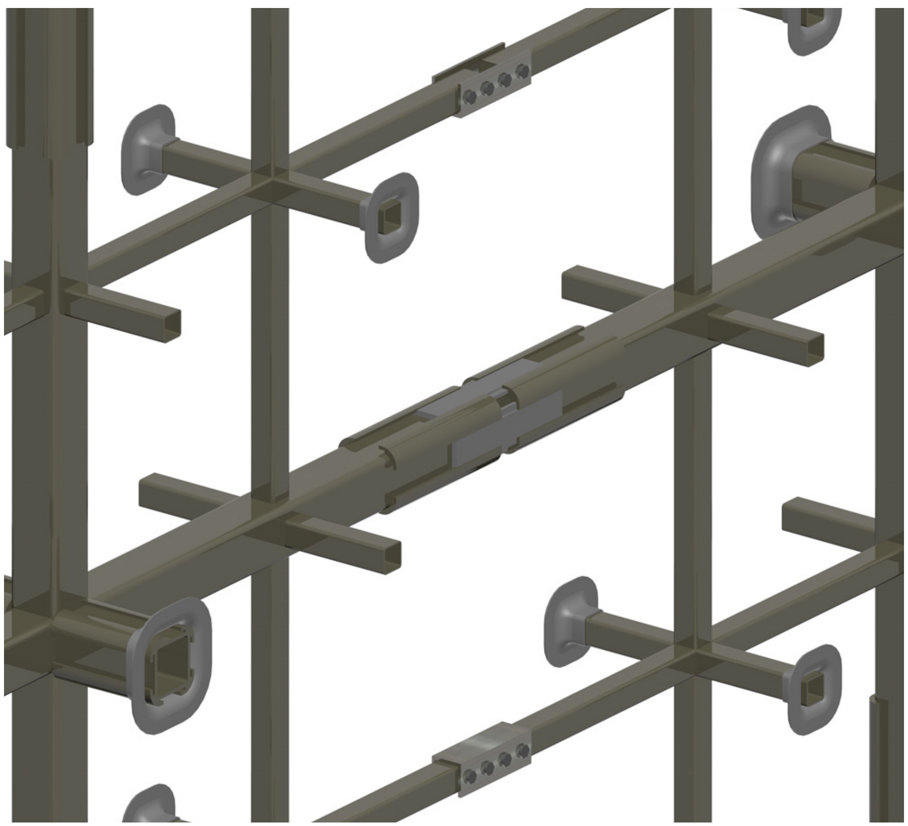


NOT INCLUDED IN SYSTEM:

Chiller
Heat Exchanger
Boiler
Washer/Dryer
Hot Water Heater
Furniture
Oven
Refrigerator
Cabinets and Cupboards

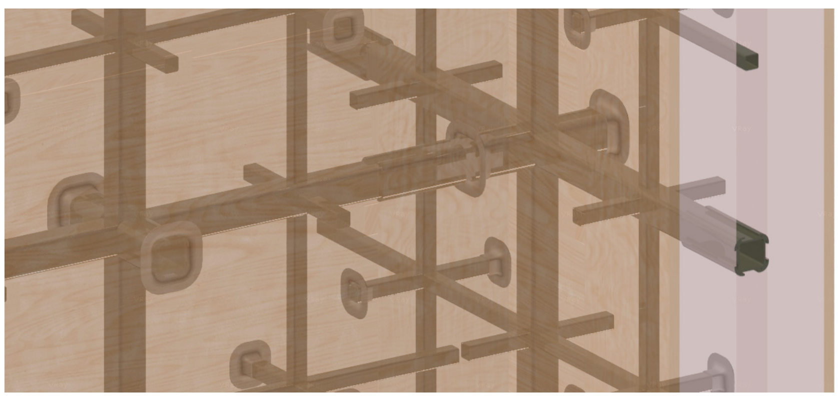
5.1.2 PANEL FEATURES REPRESENTATION



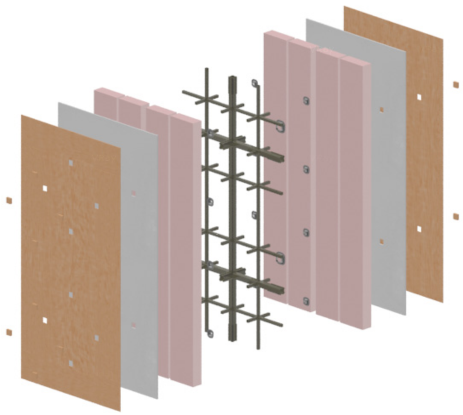


Each panel contains the same basic components: cladding, fireproofing, insulation, structural attachment, and structure in that order. All panels are variations of the same basic 4’x4’ panel, 1A. These methods of simplicity and redundancy give the system is universality and interchangeability.

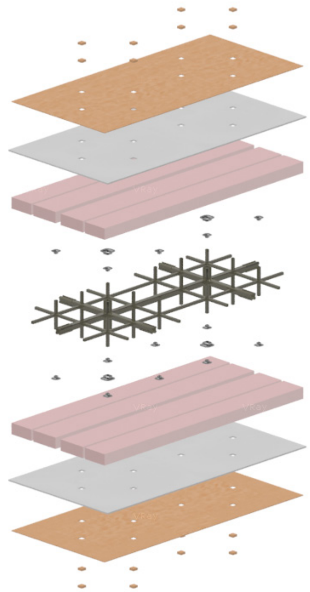
The panels connect to each other via a notch and key system. The ends of the structure as well as the center of the panel contain notches which accept a key. Another panel can then be placed into position, aligned with the notches and keys. Notch locations at the ends create a flush wall or floor, while the notches in the center allow panels to create corners without requiring a column.



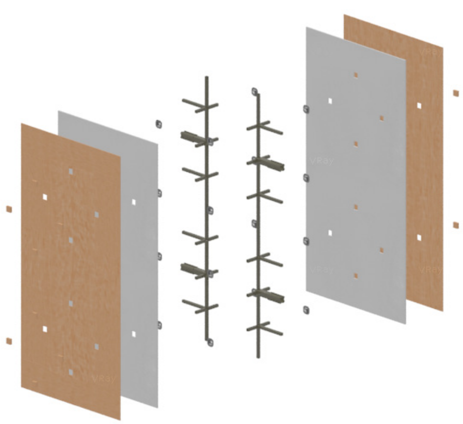
2AE
Contains extra insulation for use in exterior and interior walls.

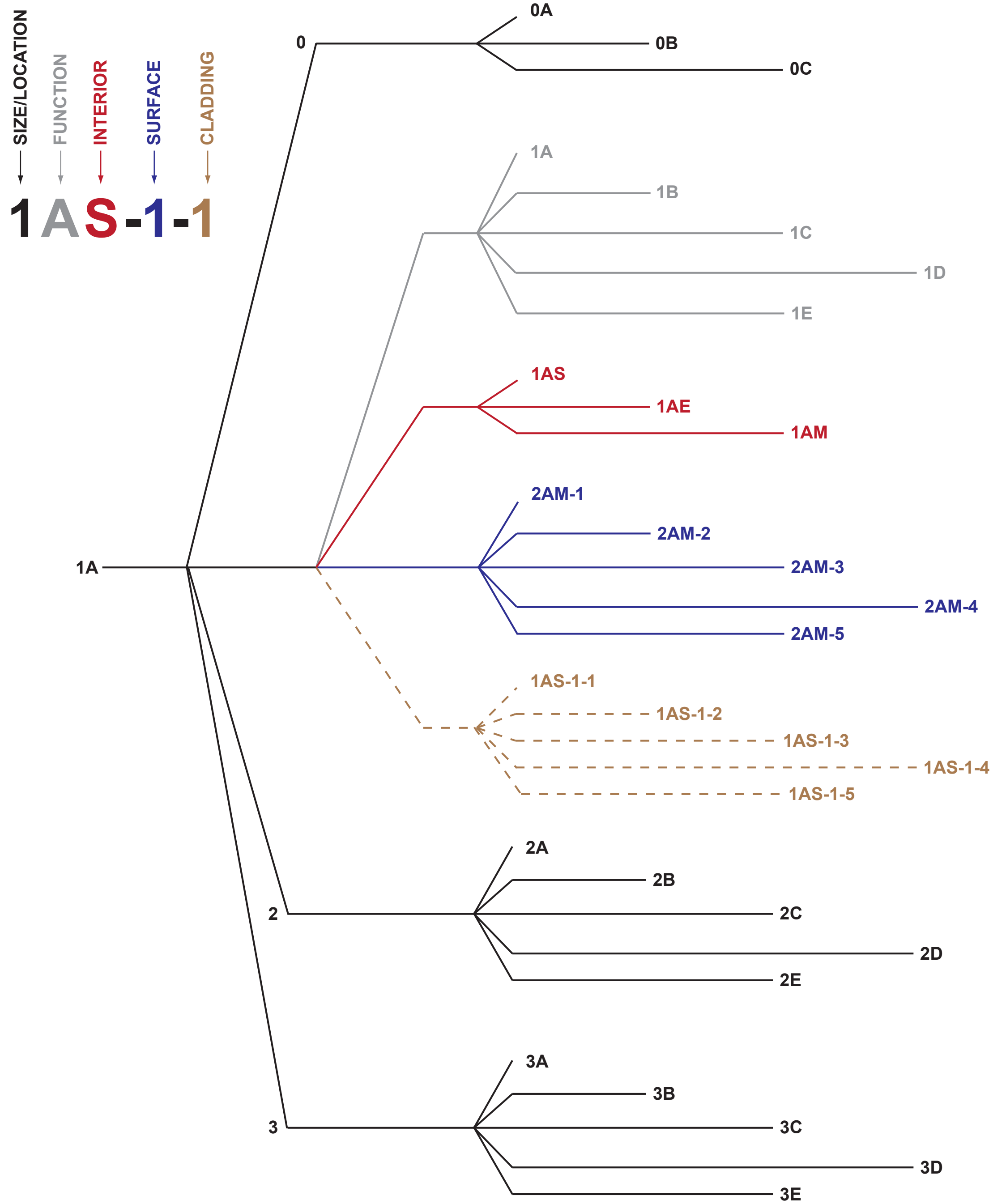


2AS
Slightly thinner dimensions allow for structural beams to be placed between each panel in the floor/ceiling.

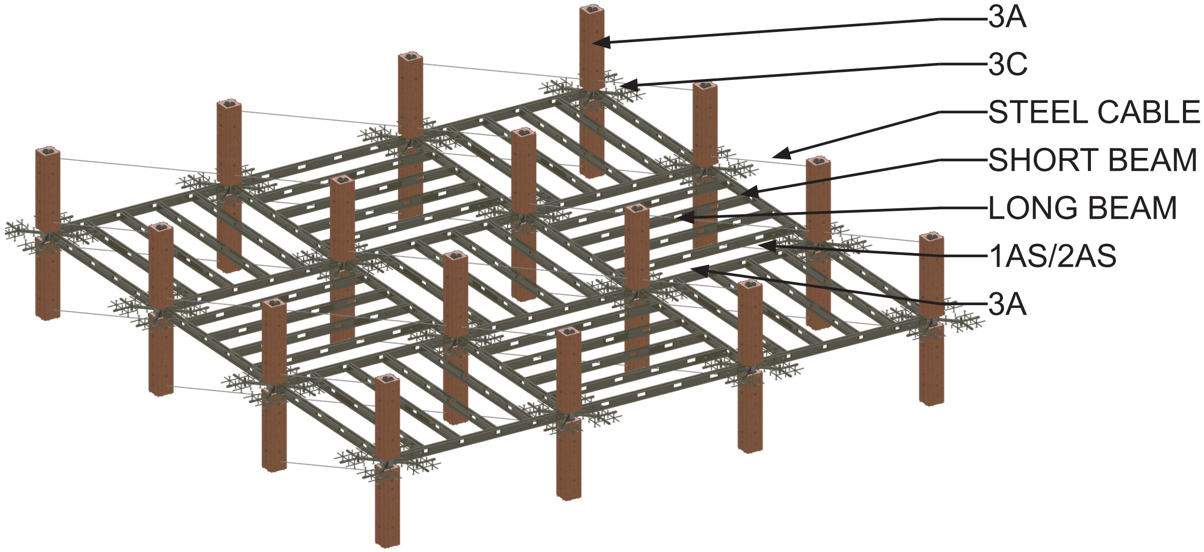


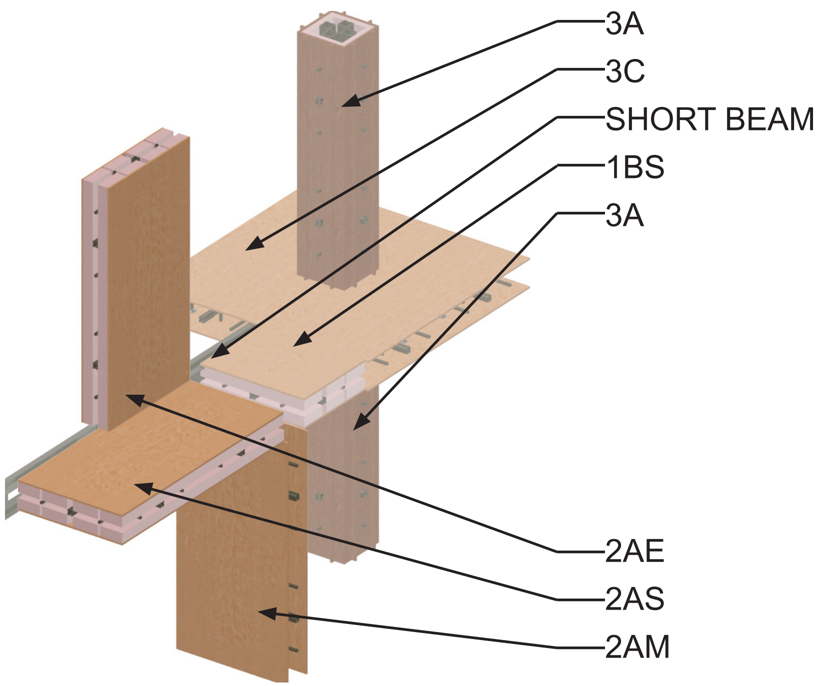
2AM
Removal of major structural components creates a void for MEP shafts and other utility runs.





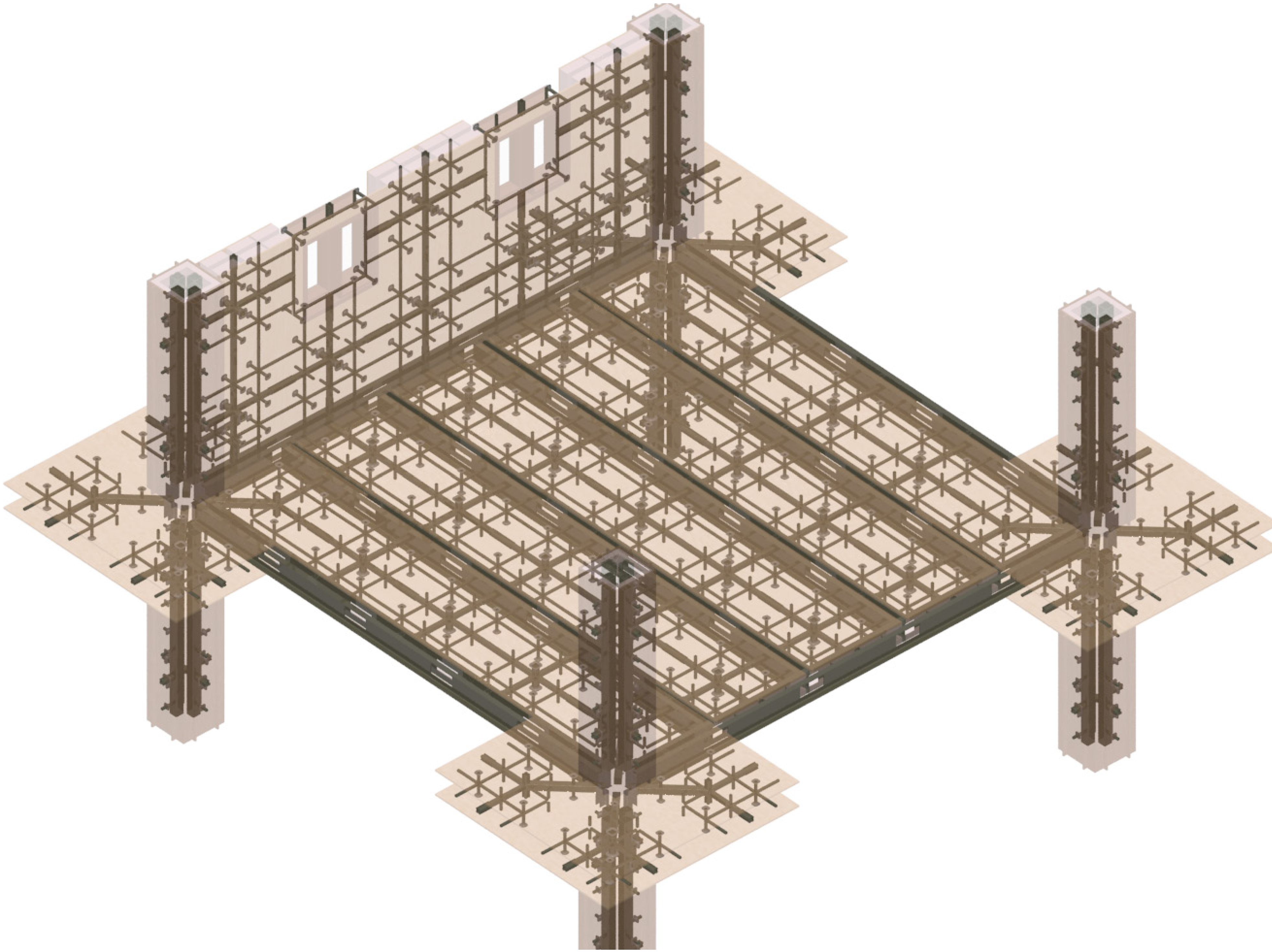
5.1.3 REPRESENTATION OF STRUCTURAL SYSTEMS





The beams in the panel system are not a panel. They are custom made, however, in order to allow panels to fit between and on top of them while allowing room for HVAC ducts and piping. By default, each structural bay is 20'x20', but varying the length of the beams can produce bays of different sizes, as long as the size is a multiple of four to accommodate floor panels.

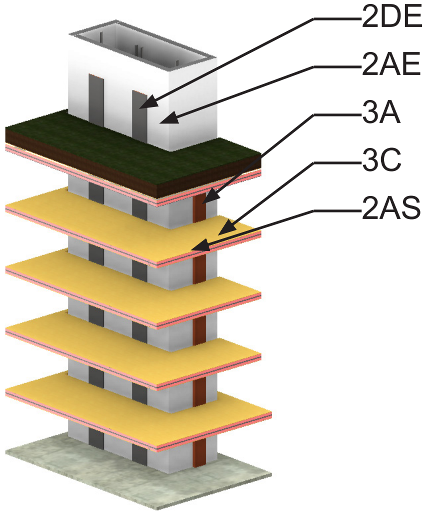
In addition to the main building structure, the panels also contain their own internal structure, which serves the dual purpose of holding the panel components together rigidly as well as allowing the panel to attach to the primary structure.



5.2 PROJECT PARAMETERS

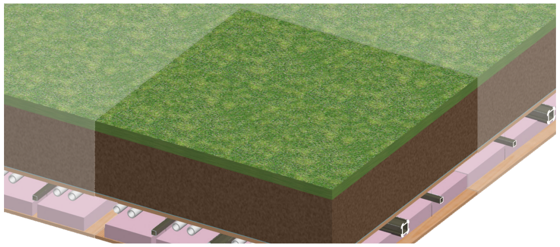
5.2.1 ACCESSIBILITY AND OTHER ADA REQUIREMENTS

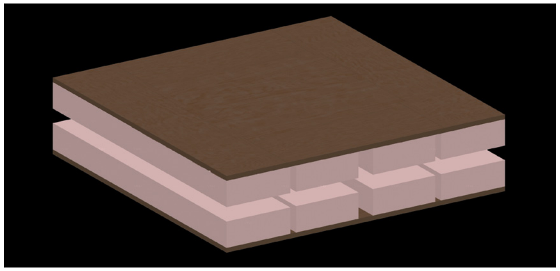
For projects greater than one story, the building will contain elevators. As the floor and wall surfaces will be completely flat, and railings are inherent in the system, transporting wheelchair-bound residents presents the main challenge. The panel system will form the main shaft for the elevators, assembled by the local construction team, while the elevator and equipment will be installed by a separate contractor

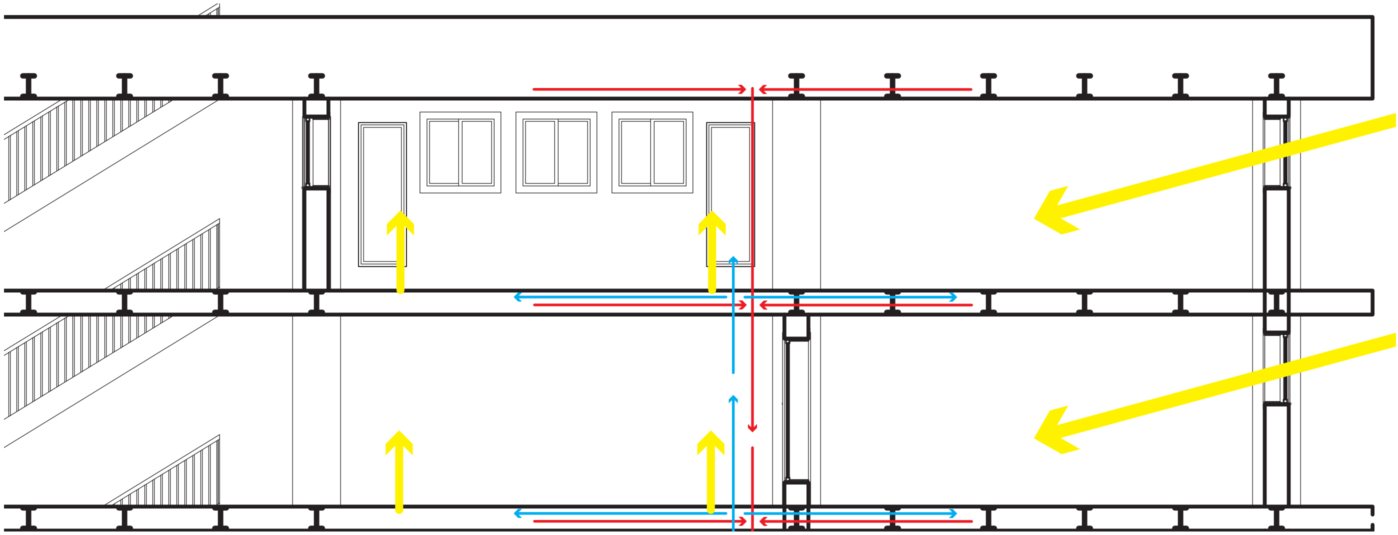


5.2.2 SUSTAINABLE DESIGN FEATURES ASSESSMENT

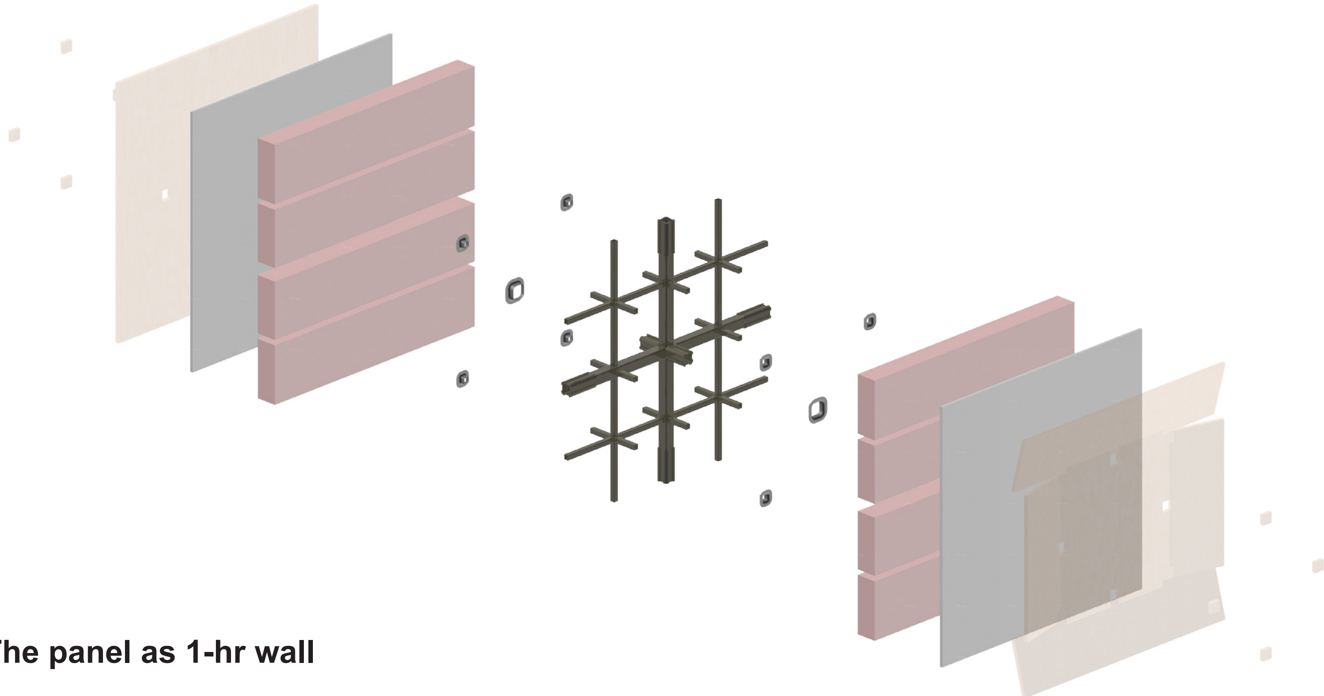
The system contains allowances for both passive and active systems. The potential active systems include a greenroof panel for the roof and a heat exchange system as part of the mechanical system. Possible passive systems include natural ventilation and latent heat gain from insulation. These systems can only be considered as potential solutions, due to the system's requirement to change based on building requirements.





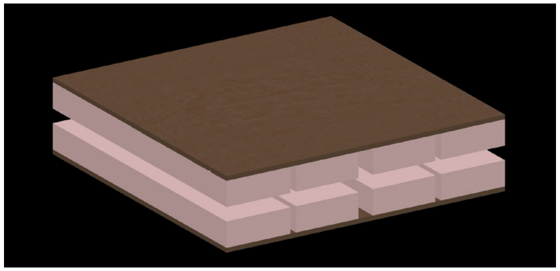


5.2.3 CODE ANALYSIS



The panel as 1-hr wall

Every wall and floor panel in the system contains two 5/8” layers of gypsum wall board. Combined with the steel structure and insulation, the materials in every panel form a 1-hr wall, according to Underwriters Laboratory standards. Panel cladding may add additional ratings, such as another layer of gypsum board adding an additional hour. Section 603 of the 2012 IBC permits wood solely as an interior finish for construction types I and II, as long as the assembly is tested and meets NFPA standard 286.



Insulation Requirements

The 2012 IBC requires an R-value of at least R40 on each exterior wall. This requirement is met by using 8” of R10 rigid insulation. Alternative types of insulation may provide better R-values, however they may not be suitable for use in a panel due to a lack of solidity and ability be secured.

6 BUILDING AND SITE

6.1 PROGRAM TYPE AND DESCRIPTION

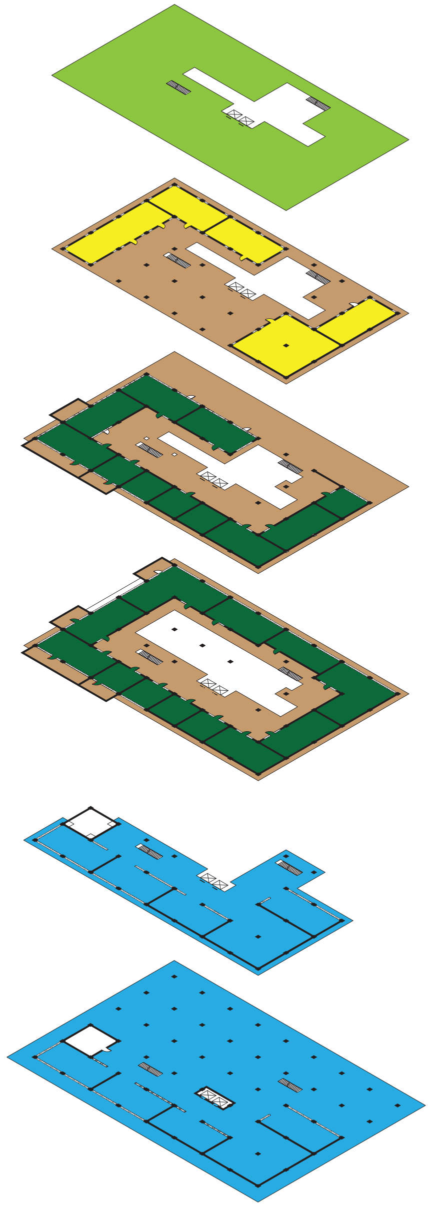
Central to the project's mission is the housing, which will constitute the majority of the project area. Individual house units will be designed for families of 2-6 people and include bedrooms, bathrooms, living room, and kitchen. All of these spaces are found in a standard Western apartment.

Many Western apartments (as well as apartments in other regions of the world) lack facilities in order to build community. One floor of the proposed building will include several communal spaces. Among them: an auditorium/meeting room, a lounge, gardens, and daycare facilities for young children. These spaces may change based on the needs Of The residents in a particular locale (i.e. lounges geared more towards elderly and retired residents vs. large families).

While these communal spaces promote engagement amongst the residents, they cause the entire complex to remain in isolation by themselves. Commercial spaces (such as shops and a market) constitute the final category of programmatic spaces. These spaces will bring residents from throughout the complex together and simultaneously engage the greater community, enticing them to visit the project, even if only in a limited capacity.

Overall, the program provides many elements of mixed-use building. The project contains housing, assembly, and commercial space.

6.2 PROGRAMMATIC ELEMENTS



Greenroof:
- Individual Crop Plots: 100ft^2 each
- Communal Lawn: 400ft^2

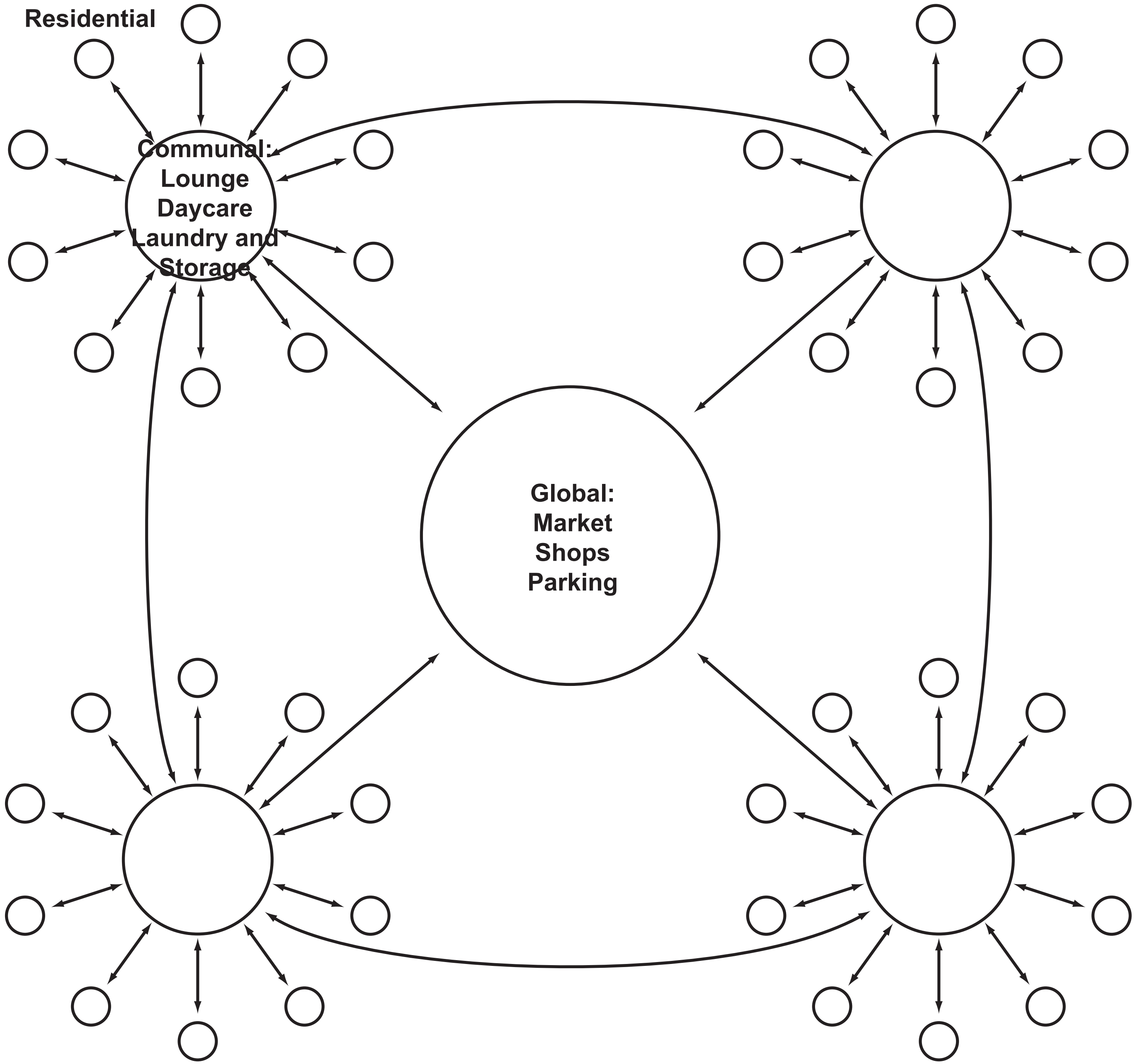
Communal Floors:
- Lounge: 1121ft^2
- Daycare/Meeting Room: 1521ft^2

Residential Floors:
- Large Apartment: 1121ft^2 each
- Medium Apartment: 741ft^2 each
- Studio Apartment: 361ft^2 each
- Laundry/General Storage: 1121ft^2
- Spare Panel Storage: 1121ft^2

Commercial Floors:
- Utilities: 361ft^2 or 722ft^2
- Commercial Space: 361ft^2 per leasable unit

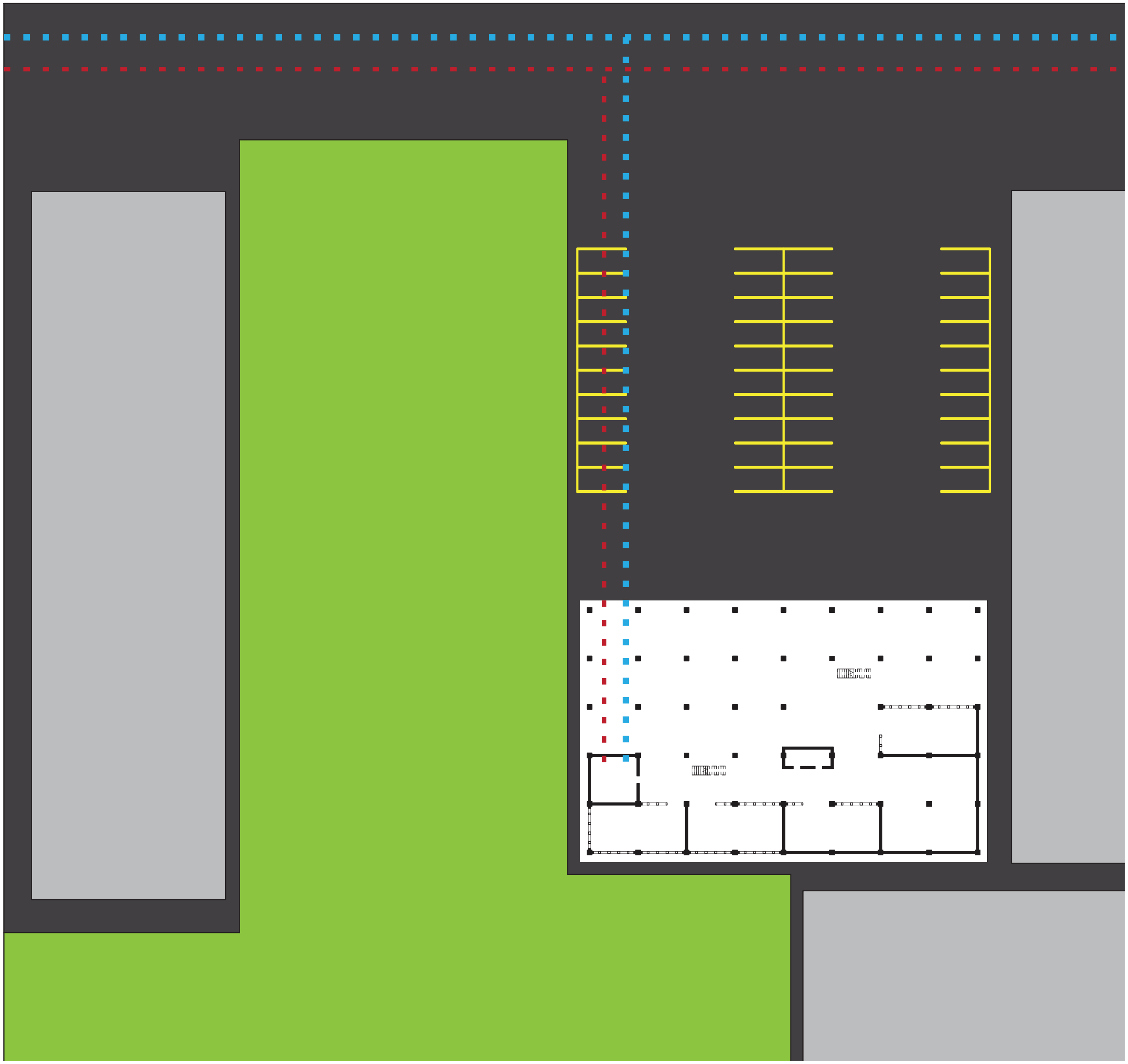
Market Floor
- Market: (varies, proposed size is 11346ft^2)
- Utilities: 361ft^2 or 722ft^2
- Commercial Space: 361ft^2 per leasable unit

6.3 GRAPHIC REPRESENTATION OF PROGRAM



6.4 SITE

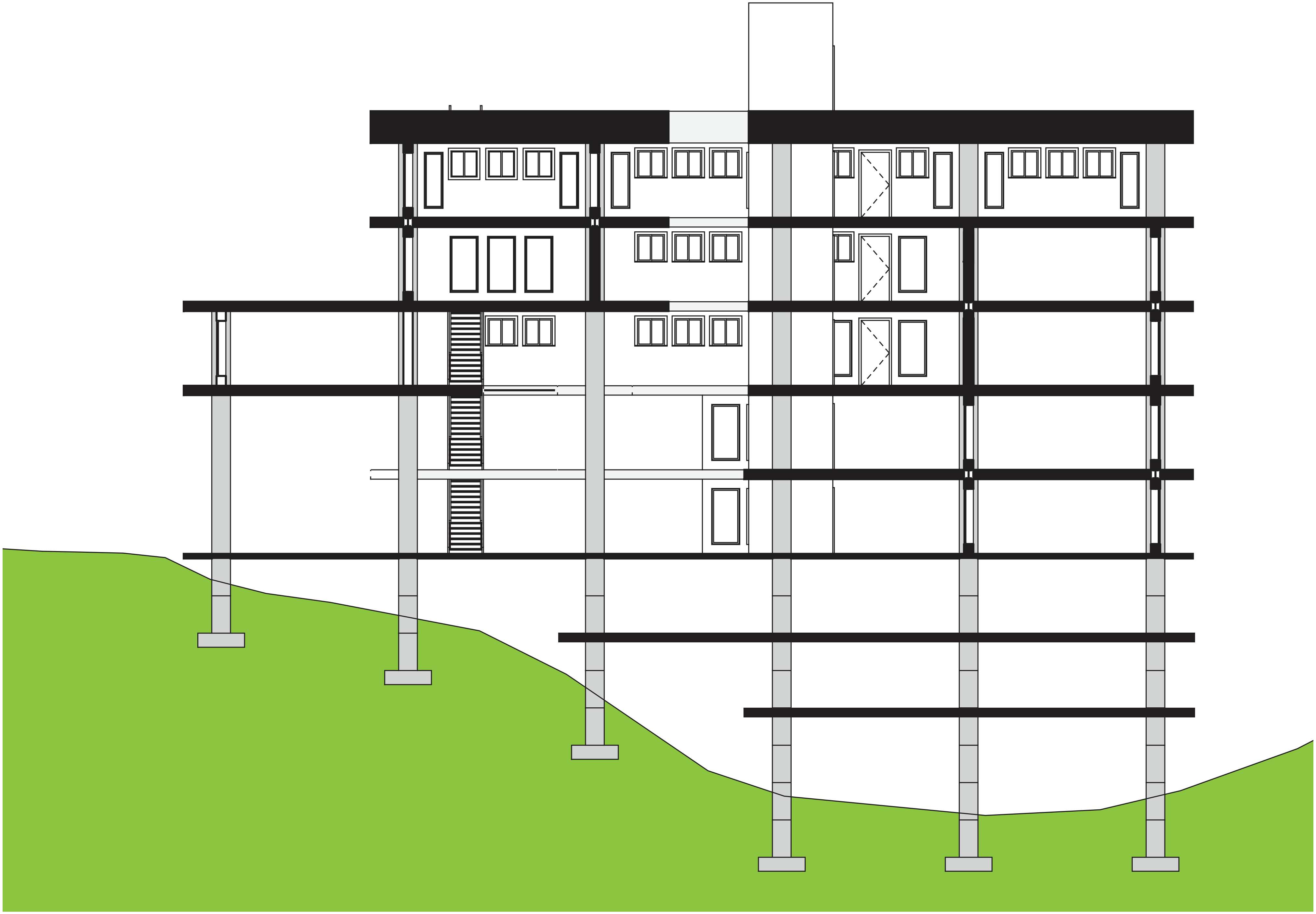
6.4.1 SITE PLAN



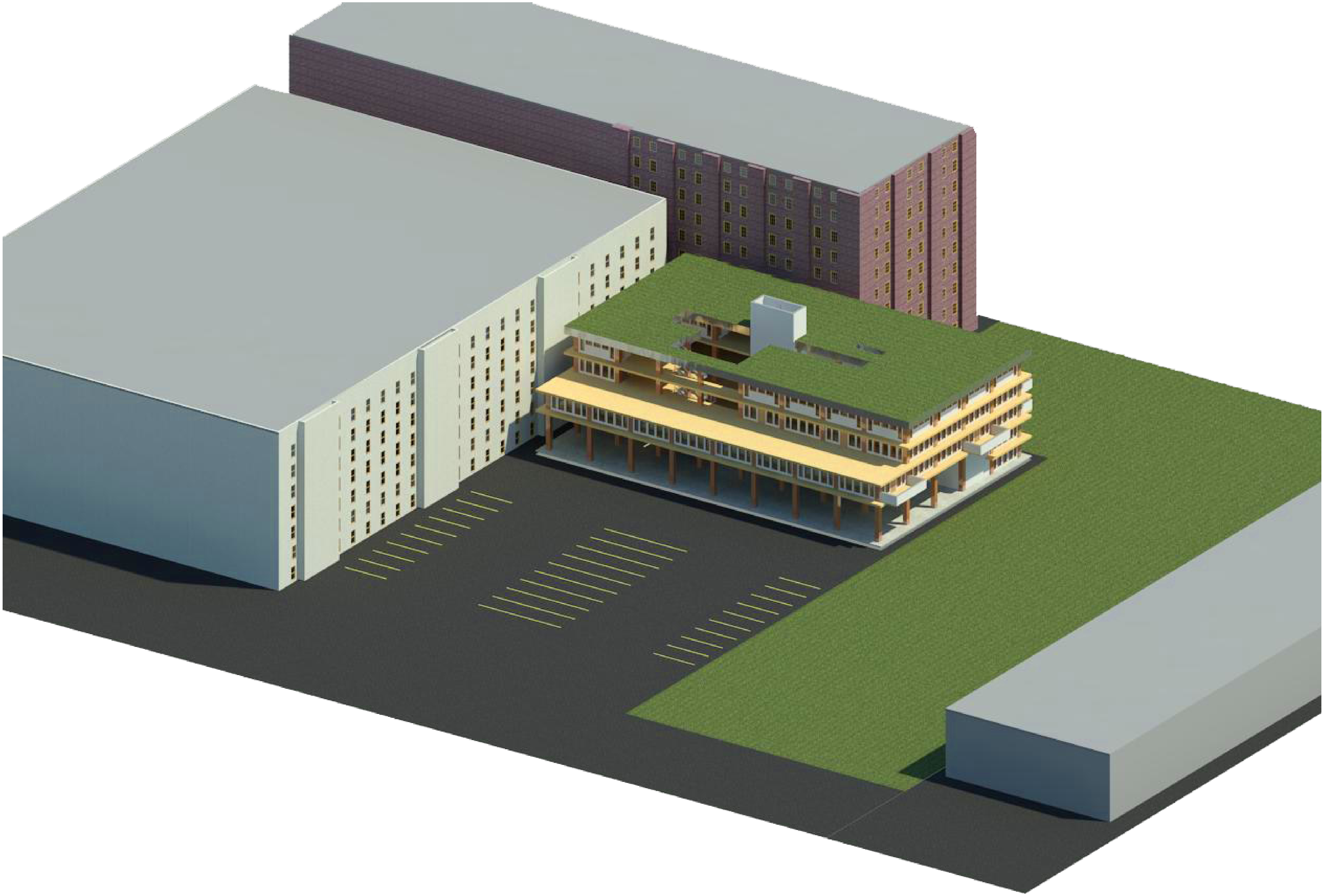
An integral part of the system is its ability to handle any type of site. The proposed test site for the project includes two major features: an urban, enclosed half and an open, grassy portion. A perpendicular road with utility lines and parking emulate urban conditions, although these conditions would also be present in some form in less built environments, even if they need to be constructed specifically for the project.

The terrain of the hypothetical site is uneven in order to explore the project's potential to be built on any type of site. Panel 0B, the concrete column, can be stacked to essentially prop the building on stilts and create an even ground floor. On particularly steep sites, the space under the ground floor could be used for parking and storage, as shown in the section.

6.4.2 SITE/BUILDING SECTION



6.4.3 SITE MODEL



6.5 PROJECT PARAMETERS

Investigated

Los Angeles

Current Building Code:
2011 LA Amendment Building Code

Current Zoning Code:
Los Angeles Municipal Code, Chapter 1

Site Zone:
R4-2 (High-Density Residential)

Allowable Area:
6 times buildable area

Maximum Building Height:
75 Feet

Floor Area Ratio:
4.5:1 (CRA District 2)

Yard Requirements:
Front - 15’
Side - 5’ + Number of Stories (16’ max.)
Back - 15’ + Number of Stories (20’ max.)

Bangkok

Current Building Code:
Building Control Act, B.E. 2522 (1979)

Current Zoning Code:
1999 Bangkok City Plan

Site Zone:
Medium-Density Residential

Allowable Area:
(No restriction)

Maximum Building Height:
23 Meters

Floor Area Ratio:
3:1

Munich

Current Building Code:
BayBO (2007)

Current Zoning Code:
BauNVO (1993)

Site Zone:
MI (Mixed)

Allowable Area:
(No Restriction)

Maximum Building Height:
18.5 Meters

Floor Area Ratio:
1.2:1

Applied

Zone Type: Mixed Use

Number of Floors: 6 (R4-6, Los Angeles)

Lot line setback: 5’ (R4-6, Los Angeles)

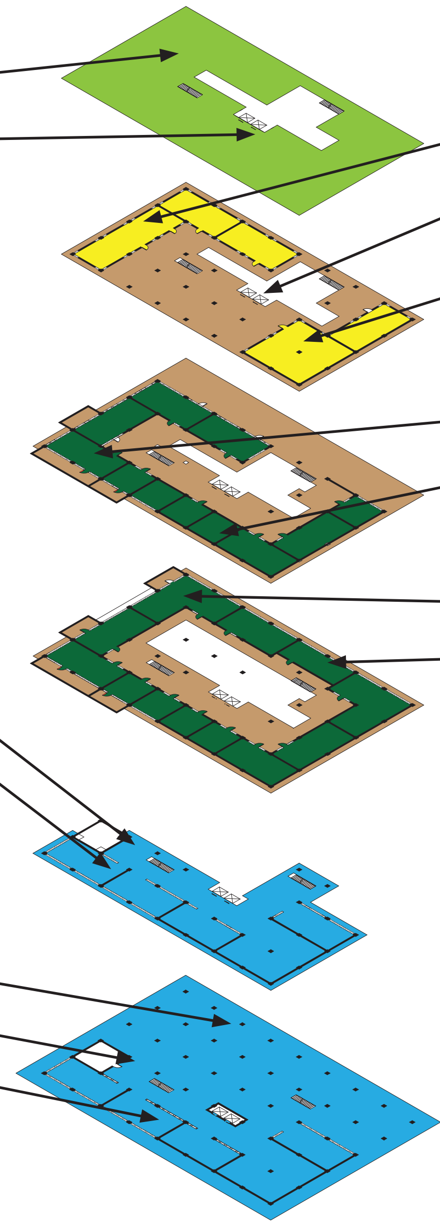
Street Facade setback: 10’ at 30’

FAR of current design: 1.6 (C2, New York)

Parking Spaces: 1 per unit (R, Chicago)

6.6 POTENTIAL BUILDING PLANS

The building floors shown here are purely hypothetical, meant to demonstrate the potential programmatic capabilities of the system. In reality, each building would vary both in its layout and in its contents.



Greenroof

Individual Crop Plots: 100ft^2

Communal Lawn: 400ft^2

Communal Floor

Lounge: 1121ft^2

2 Elevators
(For ADA access)

Daycare/Meeting Room: 1521ft^2

Residential Floor 2

Medium Apartment: 741ft^2

Studio Apartment: 361ft^2

Residential Floor 1

Large Apartment: 1121ft^2

Laundry and Storage: 1121ft^2

Commercial Floor

Utilities: 361ft^2

Commercial Space: 9282ft^2

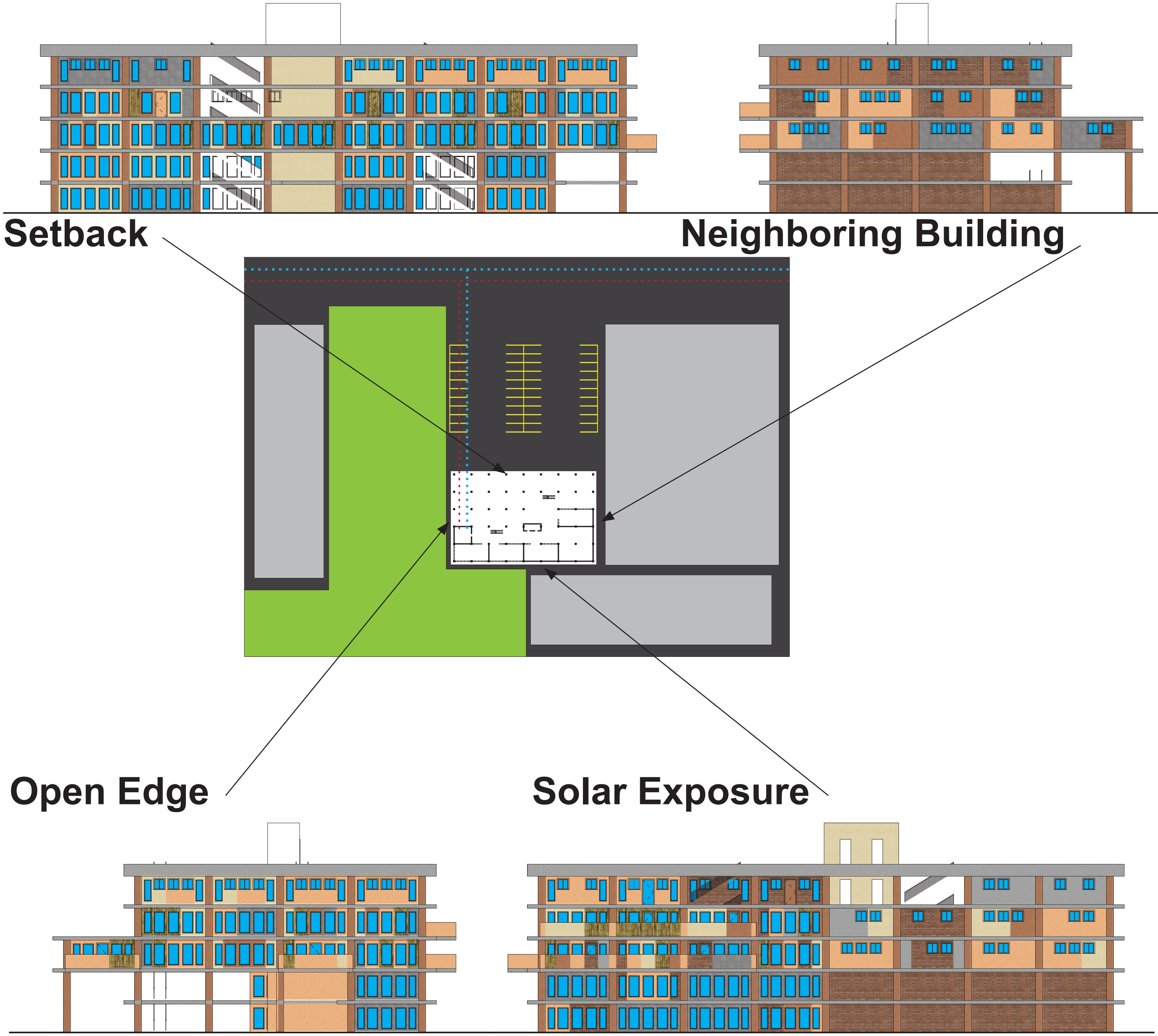
Market Floor

Market: (varies)

Utilities: 361ft^2

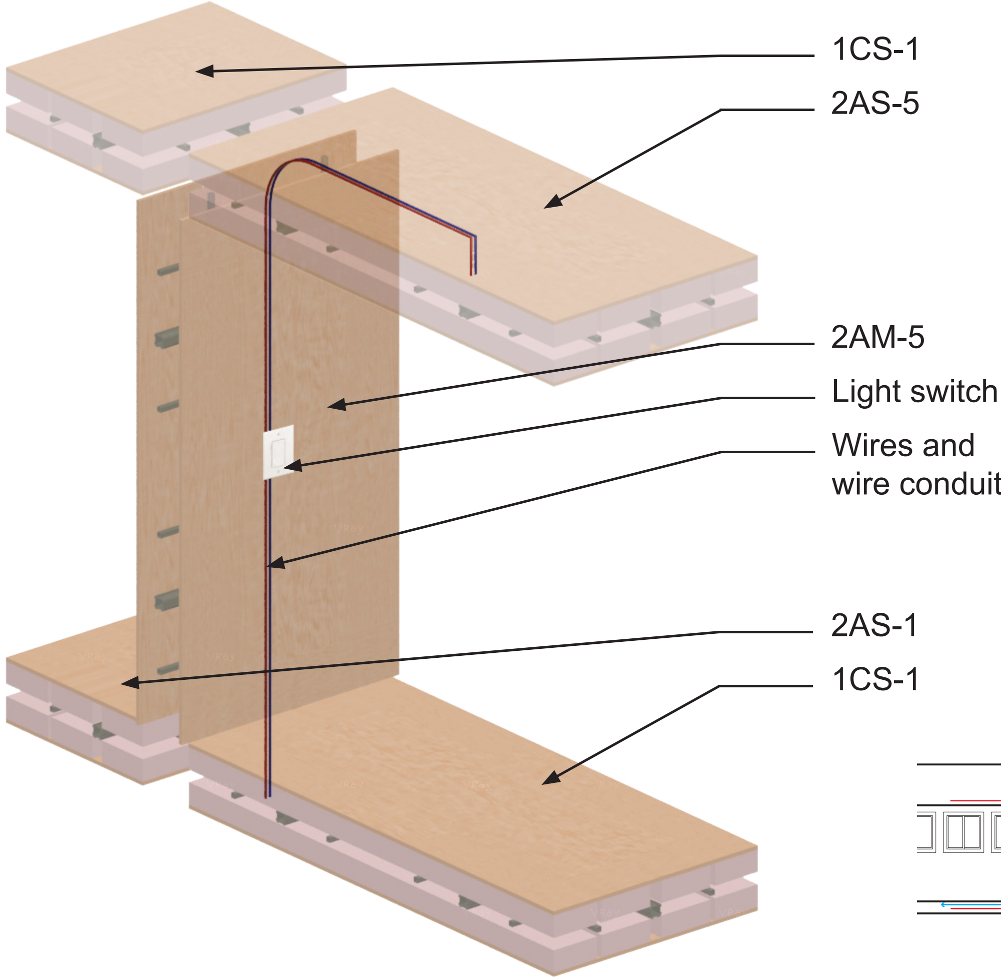
Commercial Space: 9282ft^2

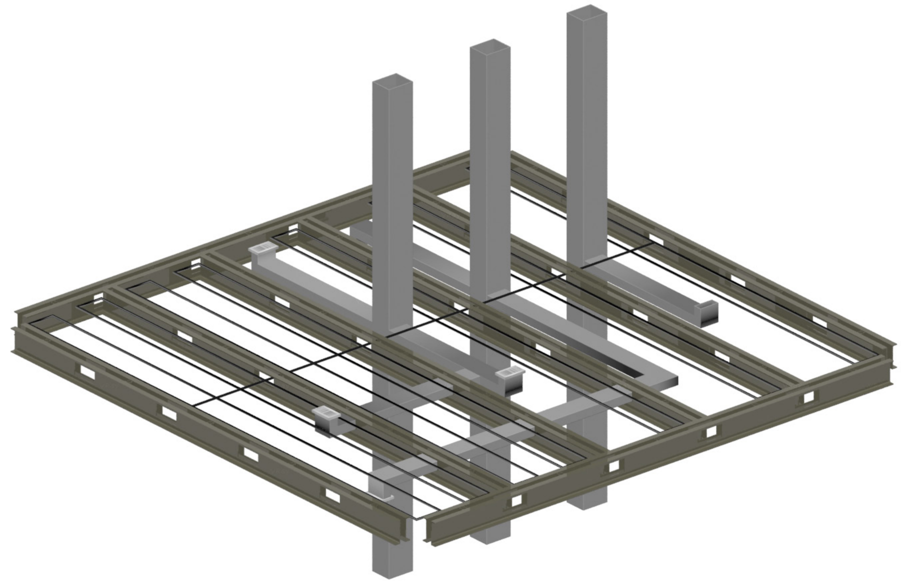
6.7 ELEVATIONS AND FACADE STUDIES

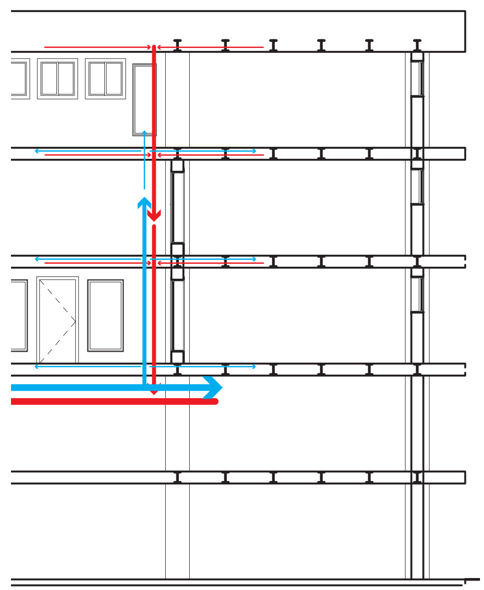


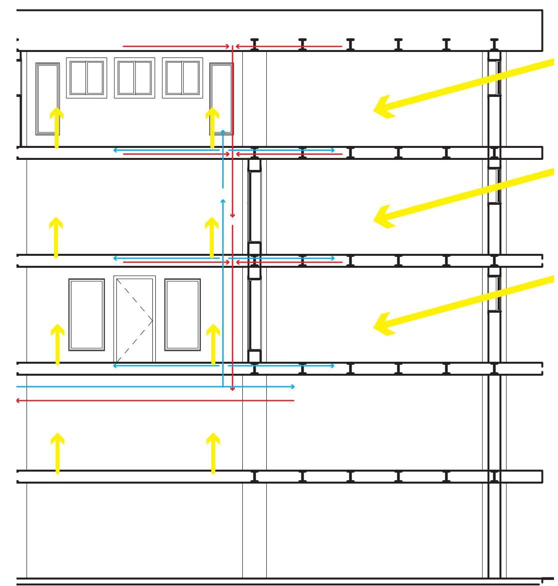
Based on the primary conditions of the hypothetical site, the building has four main elevations with differing characteristics. On the open sides, with no building or a large distance to a neighboring building, the exterior walls contain many large windows to take advantage of solar gain and natural ventilation. On the sides close to neighboring buildings, the windows are smaller, as they won't be able to take advantage of light and ventilation, in addition to the potential negative aesthetic of the neighboring walls.

6.8 REPRESENTATION OF MEP SYSTEMS

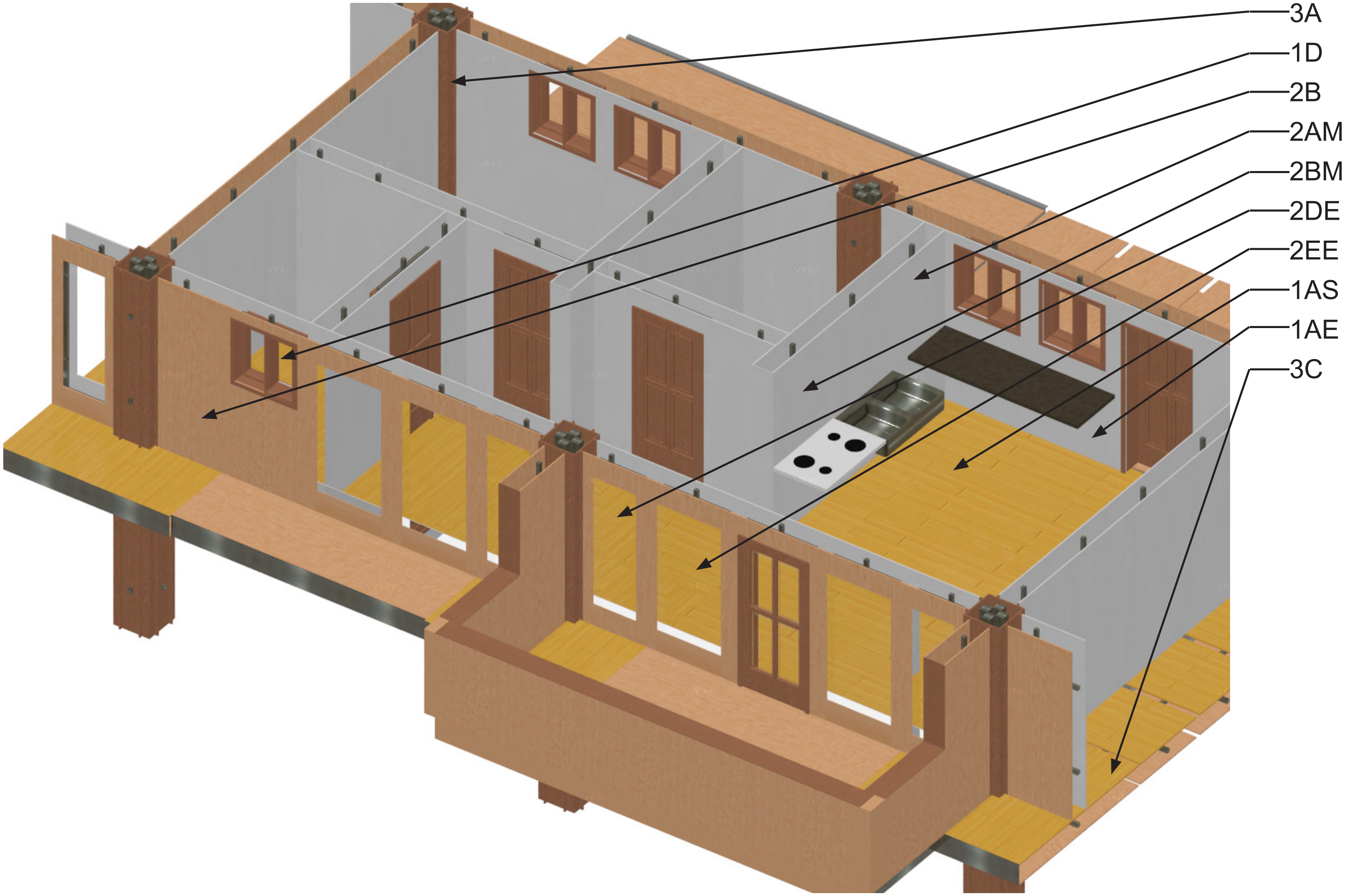




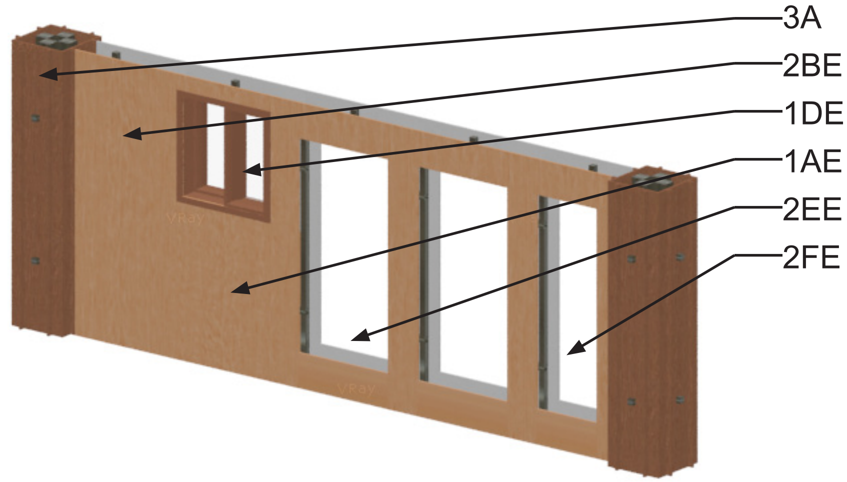


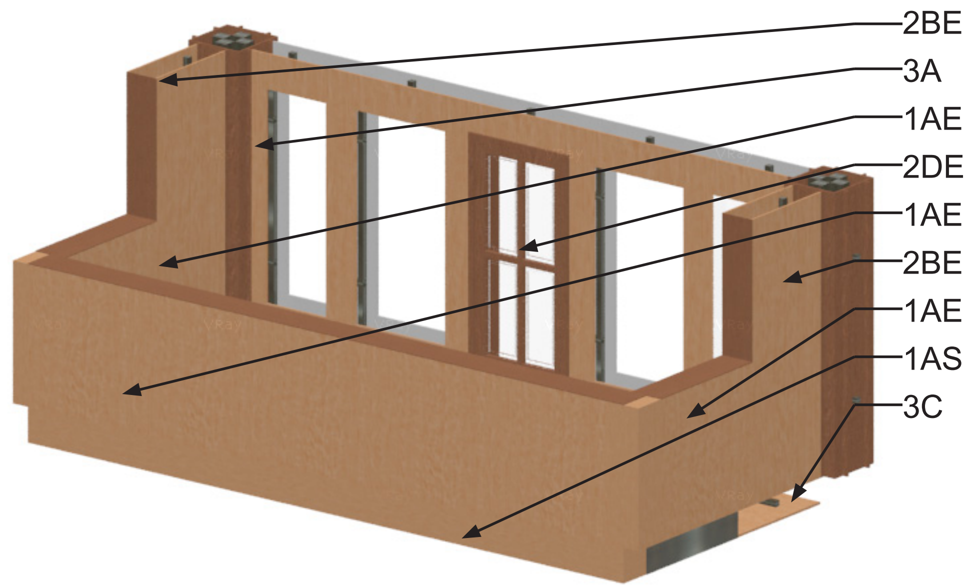


6.9 EXAMPLE PANEL ASSEMBLIES

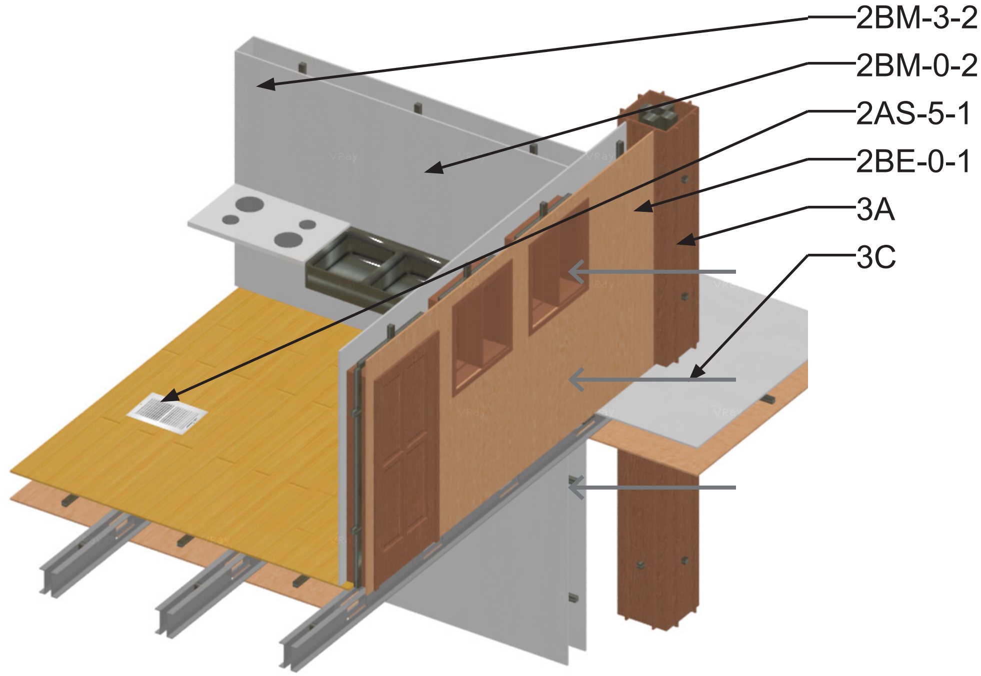


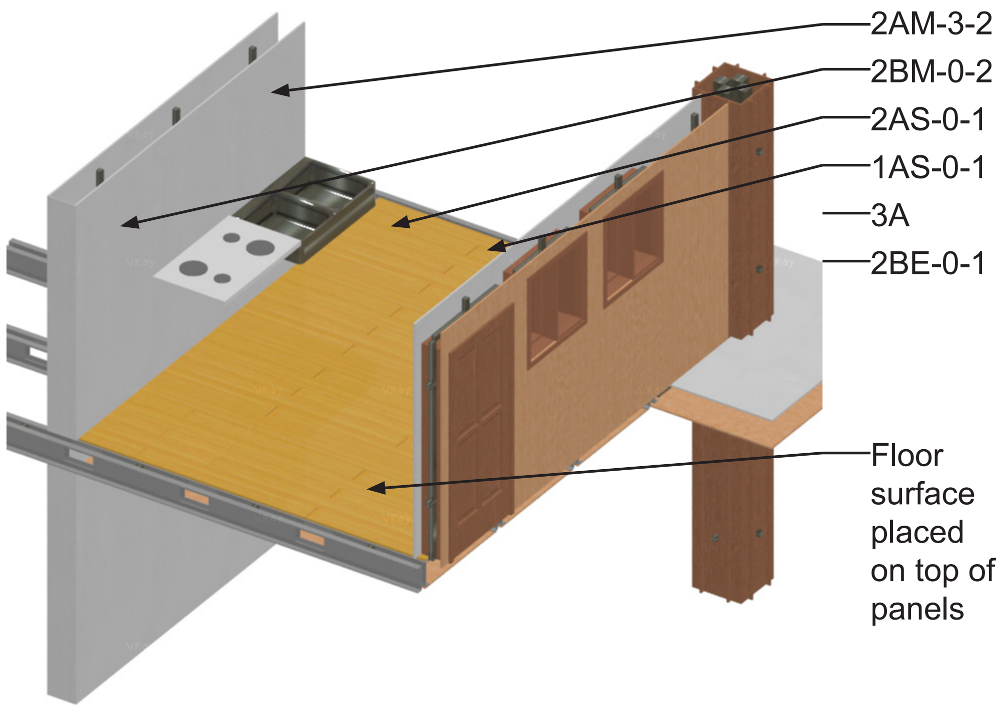
Exterior Walls



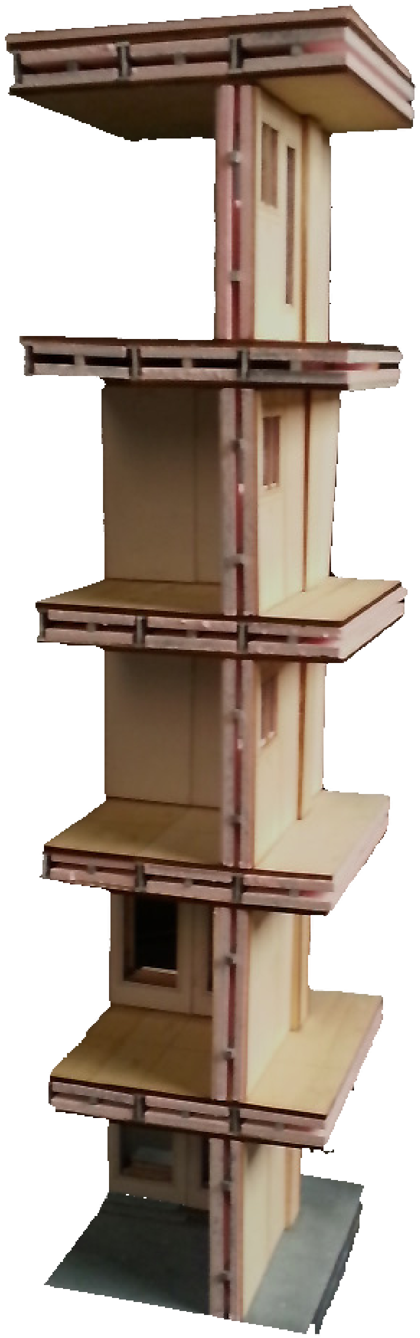


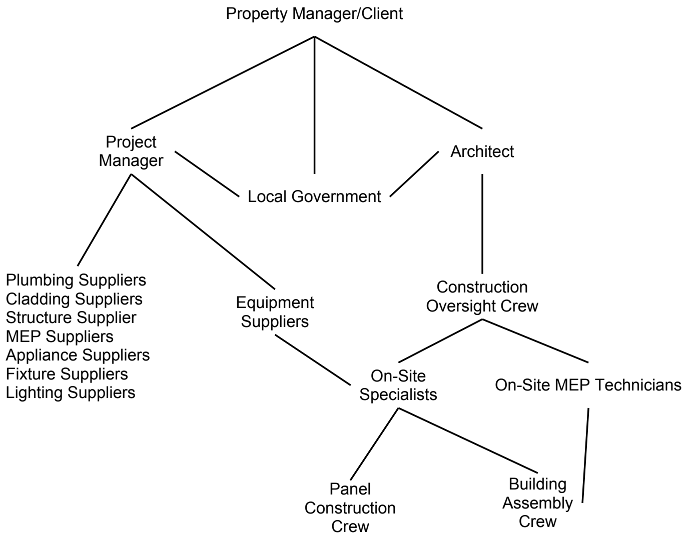
Kitchens





6.10 ADDITIONAL PROJECT IMAGES





6.11 DESIGN ASSESSMENT

Through the use of universal components, a panel design which closely resembles current construction methods, interchangeable parts including both structural and material, as well as adaptations to conventional construction practices, the proposed panel system can create a building which can be built efficiently, but still adapt to the needs of its residents. The modularity of the system easily allows for its construction, planning, and future modification.

By changing the exterior cladding to locally available materials and decreasing waste through efficient assembly and manufacturing, the system can mitigate the negative effects large, multi-family buildings often have on the project site. Flexibility to allow natural lighting on the south side, given a more glazing-centric design proposal, and a proposed greenroof system incorporate sustainable values into the panel system, further reducing the system's impact locally. The system also allows for an expedited design and delivery process, due to the consistency of each component. Pre-designed assemblies, composed of a number of panels, provide several different design options for the building, speeding the early phases of the project along if required. Flexibility and variety within the assemblies still allows the system to adapt at this scale.

Many architects have attempted to create a panel system that allows housing to become more affordable and more efficient, both in terms of manufacturing and material use. The vast majority of these projects either ended in bankruptcy or remained purely theoretical. Only a select few panel systems managed to be built at all, and very few of those built more than once, often due to the cost of the system. Despite the numerous attempts at a viable system, the financial solvency of the panel system still needs to be addressed. The system proposed as part of this project aims to reduce cost through universality, material adaptability, and flexibility of scope. Projects may be as large or as small as they need to be or as the budget allows, while utilizing the cheapest or most common materials available near the project site if needed. Further analysis of production costs and alternative methods is still needed, however.

In addition to budget concerns, the system also does not currently address the major problems of water and air penetration. Very few systems to handle rain and moisture exist as a part of the system. The roof does contain drainage components, but floors and walls are very lacking in vapor protection. Gaps between panel edges as a result of manufacturing errors will also create ways for air to enter and leave the building, forcing the HVAC system to work harder to control the environment and thwarting any attempts to control temperature or humidity indoors. Both of these concerns, air and water control, are major aspects of a building which meets codes and would need to be addressed, possibly independently of the system.

Despite these shortcomings, the system remains a viable solution to create buildings using prefabricated components which can adapt to local conditions and meets the proposed goals of the system within the scope of the thesis.

7 CONCLUSIONS

By creating a consistent panel system, with an adaptable exterior and universal structural core, the proposed panel system will allow residential buildings to be built quickly and utilize the benefits of mass production. All panels can be constructed using the same production systems, all contain the same elements, and all are attached together using the same key system. This universality within the system further expedites the construction process through ease of assembly. Ease of construction allows residents of the project to assist in non-specialized construction (i.e. construction not associated with plumbing, mechanical, or electrical systems) and contribute to a house they can truly call their own.

By changing the exterior cladding to locally available materials and decreasing waste through efficient assembly and manufacturing, the system can mitigate the negative effects large, multi-family buildings often have on the project site. Flexibility to allow natural lighting on the south side, given a more glazing-centric design proposal, and a proposed greenroof system incorporate sustainable values into the panel system, further reducing the system's impact locally. As demand for high-density housing increases, cities and communities will need to respond. By using the panel system, these places can build housing which specifically addresses their needs and desires anywhere in the world.

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