Making the Case for CMU Residential Design and Construction

NCMA Foundation Grant

PHASE 1

Syracuse University School of Architecture
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Making the Case for CMU Residential Design and Construction
NCMA Foundation Grant Proposal August 2018

Documentation PHASE 1

Syracuse University, School of Architecture

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Grant Partners:
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Upstate New York MCAA Chapter

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Collaboration, Exposed Block, Sustainable, Change of Perception, Residential Construction, Housing, NGO, Living Classroom

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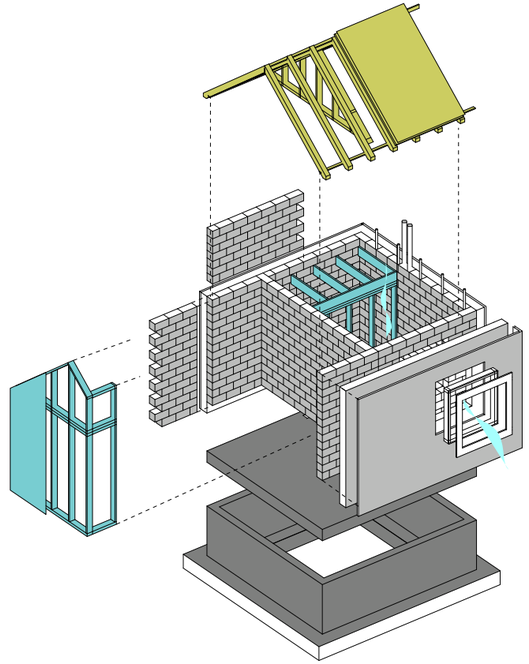
EXECUTIVE SUMMARY

PROJECT GOAL

One, to provide a platform for outreach opportunities to connect the CMU Industry with the local community. Two, to create a toolbox and manual that serves as an educational tool and drawing set, both during the design and development of the houses as well as during the construction. Three, to help stimulate the market in residential construction for concrete masonry.

We propose to achieve this through a system that consists of a series of pre-planned and an engineered spatial modules that are BIM integrated and adaptable to different climates. The varied space modules, when assembled and aggregated, can create a series of house configurations while ensuring design initatives are met.



Conceptual drawing of interaction between different modules and elements.

WORK DONE TO DATE

PRECEDENT STUDIES:
The precedent studies serve as a survey of projects of similar scale and program in different climates. The majority of the precedents are non-CMU structures, as to not limit the pool of references. The intention is to translate the strengths of these precedents into CMU-based structures. This also revealed a significant gap of CMU residential options currently available in the market that we intend to fill.

REFERENCE PROJECT:
To help define a clear research methodology for the next phase(s) we identified one case study to serve as the reference project. We will be using this project as a strong example of how to achieve an overall strategy and bring it to a level of similar detail at the scale of design, construction and management for the project. The images are also intended to provide a rough idea of the scale and scope of the final submission.

SITE TYPOLOGIES:
To ensure the house designs can adapt to a range of different ‘sites,’ we defined a series of prototypical regions and climates (dry/arid, humid, etc.) throughout the United States where the structural and performative benefits of CMU are most prevalent due to its strength, fire and flood resistance, as well as its capacity to retain energy.

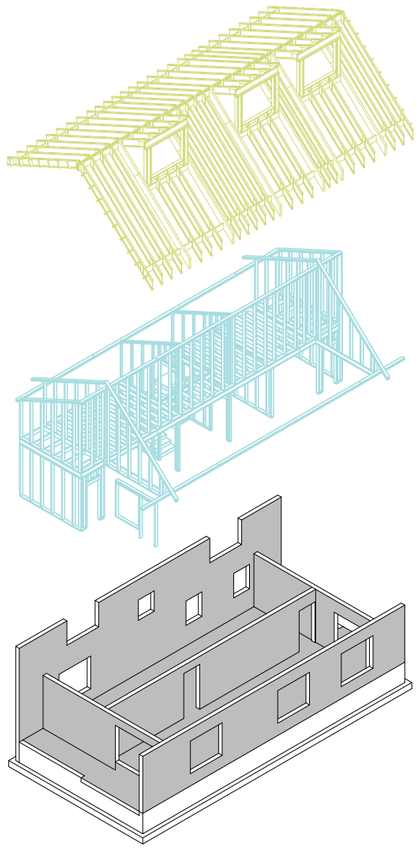
HOUSING AND MODULE TYPOLOGIES:
The goal is to develop house types (both single family and multi-family duplex) for each of the different regions and climatic conditions. There are a series of types configured from the same design modules in order to respond to the specific needs of that site. These types will be constituted by three different basic modules: 1. CMU main structure, 2. Framed roof and upper floor modules, and 3. Framed partition walls where needed. These modules will be refined in the next steps.

NEXT STEPS

The report concludes with an outlook to future work and a general schedule overview.

INTRODUCTION

GRANT SYNOPSIS



Basic Structural Parti of Houses Developed for Habitat for Humanities, Syracuse NY
(see page 6)

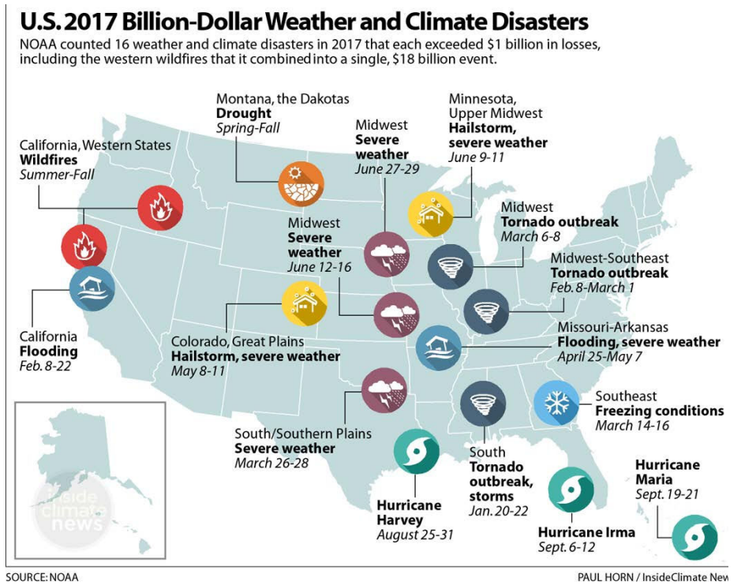
The following proposal develops a toolbox + manual for a comprehensive design for modular, adaptable, affordable concrete masonry unit (CMU) houses that serve as a 'living classroom' for the NCMA community to connect with their local affordable housing organizations. The grant has three main goals. One, to provide a platform for outreach opportunities to connect the CMU industry with the local community. Two, to create a toolbox and manual that serves as an educational tool and drawing set, both during the design and development of the houses as well as during the construction. Three, to help stimulate the market in residential construction for concrete masonry.

The proposed toolbox of modular designs will show how CMU can contribute to the construction of a well-designed sustainable housing market in the United States. The proposed toolbox of conceptually modular house(s), both single family and duplex, are located in four distinct climates across the United States that adapt to different site typologies found in most American urban centers. Such typologies for affordable housing that rely on high-quality, sustainable, and durable construction, offer an opportunity to broaden the scope of the CMU industry. The houses showcase the material through design that uses modern masonry technologies, integrates typical residential construction elements for ease of construction, and takes advantage of new construction technologies. The design for the house(s) aims to showcase how current advancements in CMU construction can help re-imagine the possibilities of Concrete Block Structures (CBS) for residential projects to advance the architectural expression and performance of single and multi-family housing.

INTRODUCTION

GRANT GOALS AND PHASE 1 DESCRIPTION

'Shearing Layers' (Frank Duffy)



The Cost of Weather and Climate Disasters in the USA, Source: NOAA

The intent of the first phase is to generate a framework and methodology for further design development of the housing toolbox + manual. The architectural design strategy for the residential houses aims to provide flexible design solutions for the toolbox + manual that accommodates the following necessities:

1. Modularity - For the toolbox to be useful in many different regions, the modularity of the design can be replicated into many housing forms that suit different types of sites and climates across the United States. The modularity of the system offers flexibility in terms of scale, size and scope of project and site, allowing for more suburban and urban site situations. The conceptual modularity of the toolbox accommodates both single family and duplex scale houses that can be used by many different users, family structures, and be located in different types of sites. The modularity also offers flexibility of replacing materials for extended lifespan and sustainability of the houses by establishing a clear hierarchy of construction layers and assembly, also known as 'shearing layers,' a term by architect Frank Duffy (see diagram on the left).

2. Climate/Weather - The United States is comprised of approximately four predominate climatic zones: 1. Desert/Semi- Arid, 2. Humid/Subtropical 3. Temperate Midwest and 4. Continental/Cold. Each zone comes with its advantages and disadvantages to constructing a house in that region of the country. According to the NOAA, in 2017, climate disasters exceeded $1 billion in losses. Whether it's the desert/semi-arid zones being prone to forest fires, the humid/subtropics being prone to tropical cyclones and flooding, the temperate Midwest plains annually confronted with tornadoes and high winds, or the continental region confronted with freezing temperatures, the CMU modular system adapts to these different regions and confronts the challenges faced with construction today in such extreme weather conditions most regions face annually. Foregrounding the benefits of mass construction for the construction of affordable and sustainable, small scale housing projects.

Focusing on Climate/Weather and Modularity the following report of the Phase 1 of this design research project describes, at first, a series of Precedents (page 7 - 18) that serve as architectural case studies showcasing the value of modular housing, adapting houses to a particular environment and various climatic conditions, as well as, advantages of using CMU (solid construction) in housing. These projects are the foundation for the thereafter outlined design strategies and preliminary project ideas that serve as the basis for the next phase of the project. These Precedents are followed by a housing project that was done in the offices of Kieran Timberlake Architects. Their project serves as a Reference Project outlining the methodology and scope of production for the overall research project (page 19 - 22).

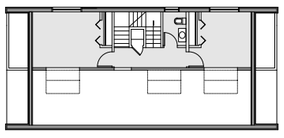
It is important to note that Phase 1 defines a clear design methodology and schematic architectural concepts that will serve as a strong foundation for future phases. For that reason, we restrained from efforts of cost comparison, as mentioned in the grant. In retrospect, cost analysis was too premature at this stage and will not provide accurate information. Cost comparisons will be researched in Phase 2,

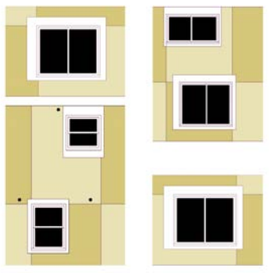
BACKGROUND

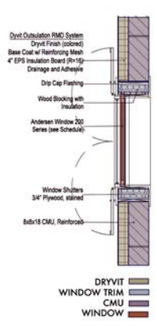
HABITAT FOR HUMANITIES - SYRACUSE, NY CHAPTER

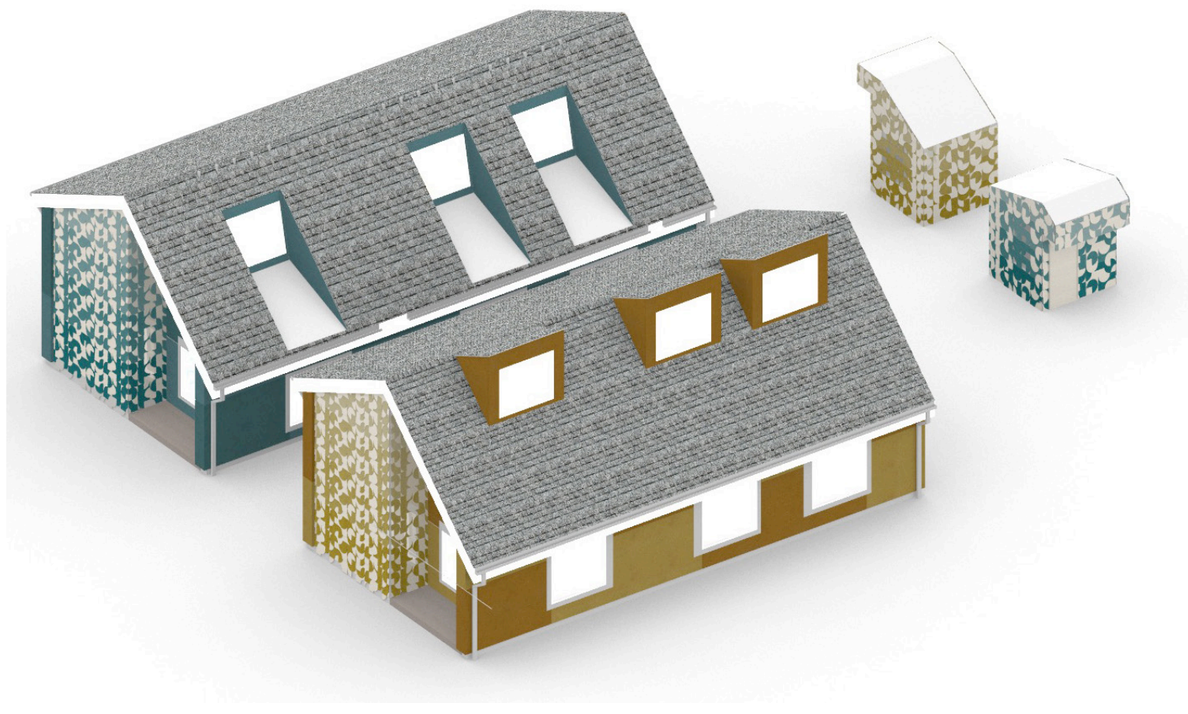
The foundation for this project is based on two initial Habitat for Humanity affordable houses that are currently under construction as a “living classroom” in Syracuse, NY. The project is a collaboration with the local Habitat for Humanities Chapter, APTUM Architecture, structural engineer Jamie Davis of Ryan Biggs | Clark Davis Engineering & Surveying, the Upstate New York Mason Contractors Association of America (MCAA), and the local CMU industry and trades. The design of these first two houses aimed to provide the highest design standards in terms of aesthetics and performance and relied on fundamental advantages of building with CMU. The CMU is showcased for its structural effectiveness, durability, energy efficiency and afford-ability.

The two houses consist of CMU load-bearing wall construction with typical wood frame construction for the roof framing, dormers, and partition walls. The design of the houses were based on the ‘shearing layers’ concept of maintaining material autonomy as much as possible to avoid overlap of layers that could be problematic for the homeowners when replacing / renovating the house. For example, the assembly of the EIFS systems makes it easy to remove and replace residential windows and doors due to wood furring and trim to cap edges to avoid replacing substantial amounts of the EIFS system.









FLOAT HOUSE - MAKE IT RIGHT

New Orleans, LA,
Morphosis Architects
2009

Climate Zone 2	
Ceiling R-value	30
Wood Frame Wall R-value	13
Mass Wall R-value [i]	4/6
Floor R-value	13
Basement Wall R-value [c]	0
Slab R-value [d], Depth	0
Crawlspace Wall R-value [c]	0
Fenestration U-Factor [b]	0.65[j]
Skylight U-Factor [b]	0.75
Glazed fenestration SHGC [b, e]	0.30

STRUCTURE:
Wood, GFC, Steel

FABRICATION:
Prefabricated

SF:
1000

SF COST:
N/A

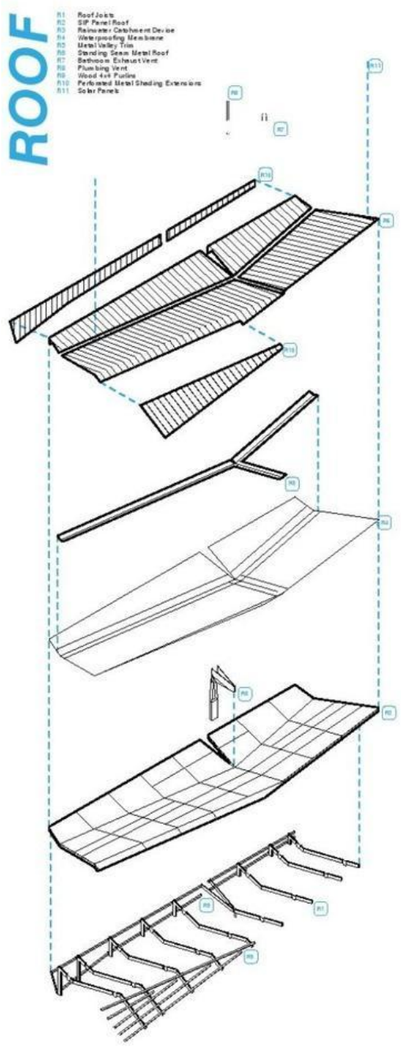
LINK:
https://www.morphosis.com/architecture/126/

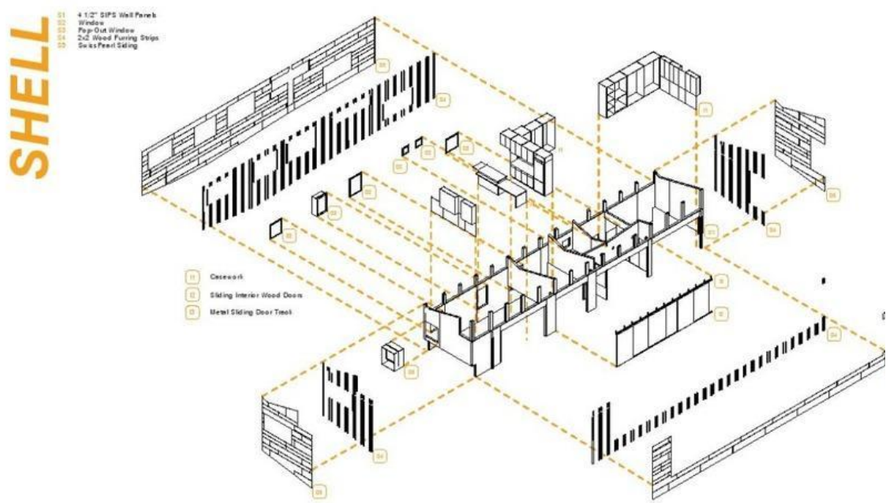
"The FLOAT House is a new kind of house: a house that can sustain its own water and power needs; a house that can survive the floodwaters generated by a storm the size of Hurricane Katrina; and perhaps most importantly, a house that can be manufactured cheaply enough to function as low-income housing. The FLOAT House optimizes the efficiency of mass-production, while respecting New Orleans's unique culture and context. Like a typical shotgun house, the FLOAT House sits atop a raised base. This innovative base, or "chassis," integrates all mechanical, electrical, plumbing and sustainable systems, and securely floats in case of flooding. The FLOAT House's chassis is designed to support a variety of customizable house configuration modular chassis is pre-fabricated as a single unit of expanded polystyrene foam coated in glass fiber reinforced concrete, with all required wall anchors, electrical, mechanical and plumbing systems pre-installed. The chassis module is shipped whole from factory to site, via standard flat bed trailer. The piers that anchor the house to the ground and the concrete pads on which the chassis are constructed on-site, using conventional construction techniques. The panelized walls, windows, interior finishes and kit-of parts roof are prefabricated, to be assembled on-site. This efficient approach integrates mass-production with traditional site construction to lower costs, guarantee quality, and reduce waste." - Morphosis Architects

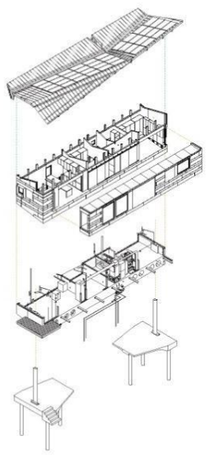
OBSERVATIONS: The float house is a unique precedent from the perspective of its ingenuity to work with the local climate and culture but also to integrate all the systems into a pre-fabricated system. Ideally, we would like to use this as a model for integration and pre-fabricated of the utilities/mechanical systems as well as some aspects of the structural system. The layers of the house, from structure to envelope to details of assembly are similar to the way the original Syracuse Habitat for Humanity houses (by APTUM) were designed. This house as a precedent for the manual will be beneficial in showing assembly of parts, how to organize the construction drawings, and integrate the systems holistically into the design of the modular system of the houses.

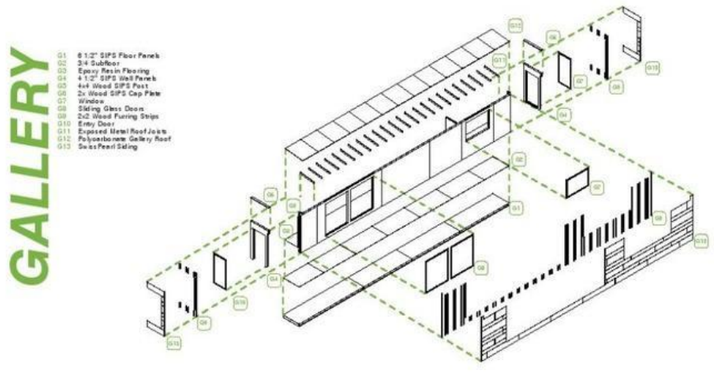
PRECEDENT

SINGLE FAMILY HOME TYPOLOGY









JIM VLOCK BUILDING PROJECT

New Heaven, CT,
Yale School of Architecture
2015

Climate Zone 5 & 4 Marine	
Ceiling R-value	38
Wood Frame Wall R-value	20 or 13+5[h]
Mass Wall R-value [i]	13/17
Floor R-value	30[g]
Basement Wall R-value [c]	10/13
Slab R-value [d], Depth	10, 2 ft
Crawlspace Wall R-value [c]	10/13
Fenestration U-Factor [b]	0.35
Skylight U-Factor [b]	0.60
Glazed fenestration SHGC [b, e]	NR

STRUCTURE:
Wood

FABRICATION:
On Site Construction, Platform Framing

SF:
1000

SF COST:
N/A

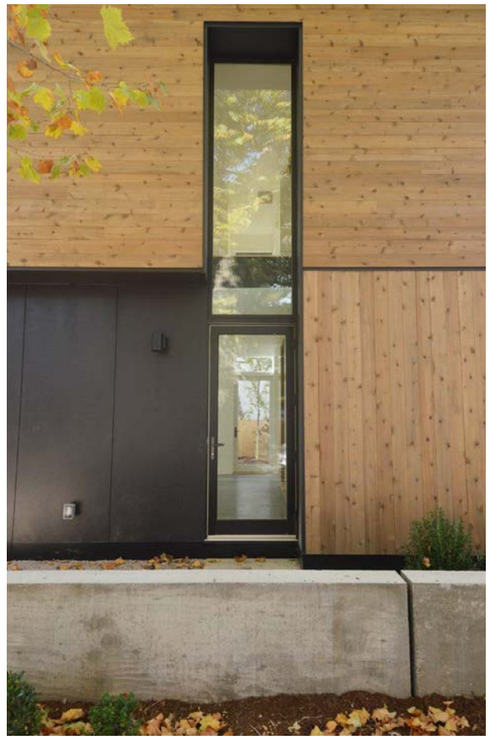
LINK:
http://yalearchitecture.org/buildingproject/bp15/

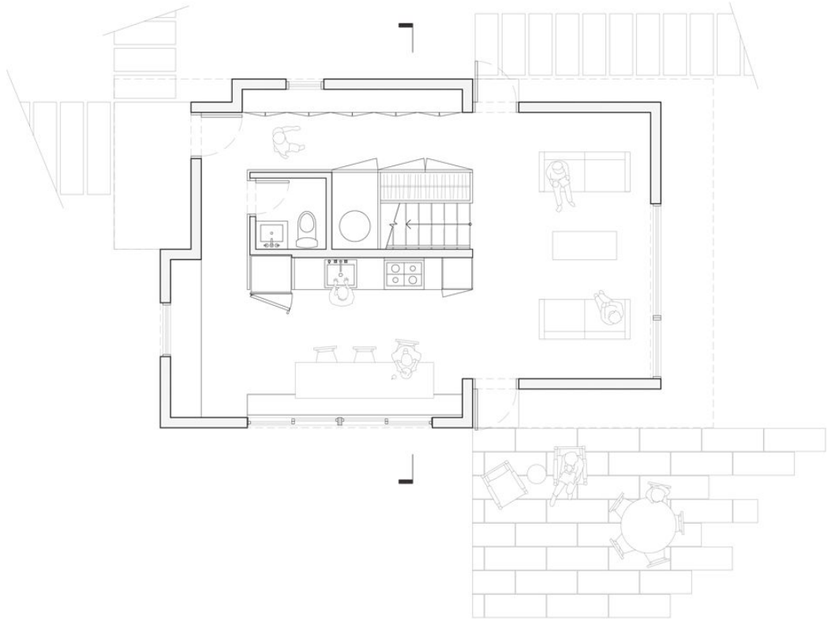
"The two-story house is clad in red cedar and is topped with a pitched roof made of galvanized aluminum. "The pitched roof was a contextually sensitive response to the traditional New England gable roof," said the school. Stairs within the core lead to the upper story, which contains a communal space with built-in cabinetry, along with bedrooms and bathrooms. "The density of the ground floor is flung to the perimeter of the house on the upper floor, creating a thickness to hold furniture and fixtures for bedrooms and bath," described the school. The team fitted the interior with concrete and bamboo flooring, white oak millwork and modern appliances. Several large windows, along with a skylight at the top of the core, enable natural light to fill the space. The project was honored with the 2015 Award of Merit for Student Design from the Connecticut Green Building Council. The Jim Vlock Building Project was started by Charles W Moore, the architecture school's dean from 1965 to 1971, in collaboration with faculty member Kent Bloomer." - Yale School of Architecture

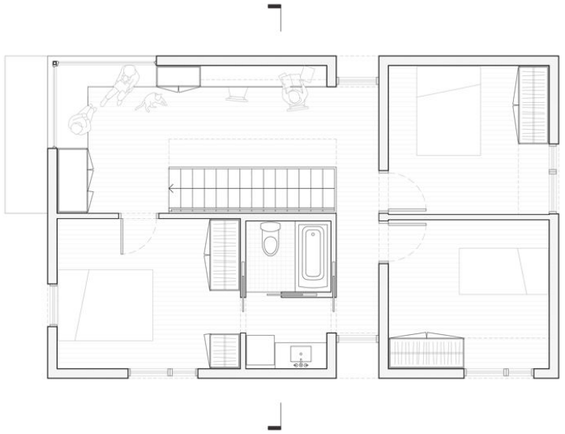
OBSERVATIONS: The scale, density, and contextualization of the house was integral to the conceptualization of the houses. The house is contextual and relates to the neighborhood but brings a modern interpretation with clean details and a mass/void relationship over the entry and windows to the overall form of the house. The house is very compact and has a clear core in the center for bathrooms, utilities, kitchen, stairs, etc. This is a clear strategy to keep the spaces clean and simple but also to keep costs down because the systems are compact. The kitchen, bath, and stair are integrated well into the central core to generate more public space along the perimeter and provide more access for views. This formal/ spatial strategy can be combined with the pre-fabrication of modules in the Float House precedent.

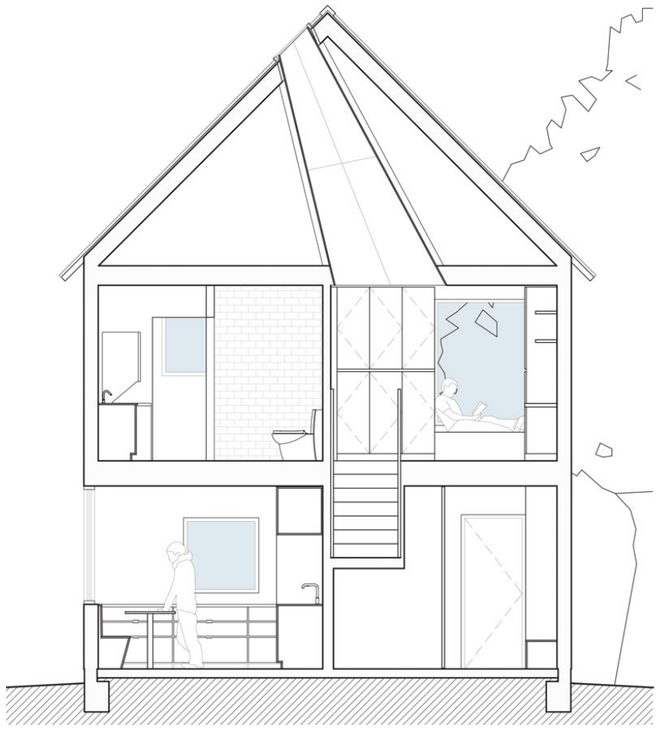
PRECEDENT

SINGLE FAMILY HOME TYPOLOGY

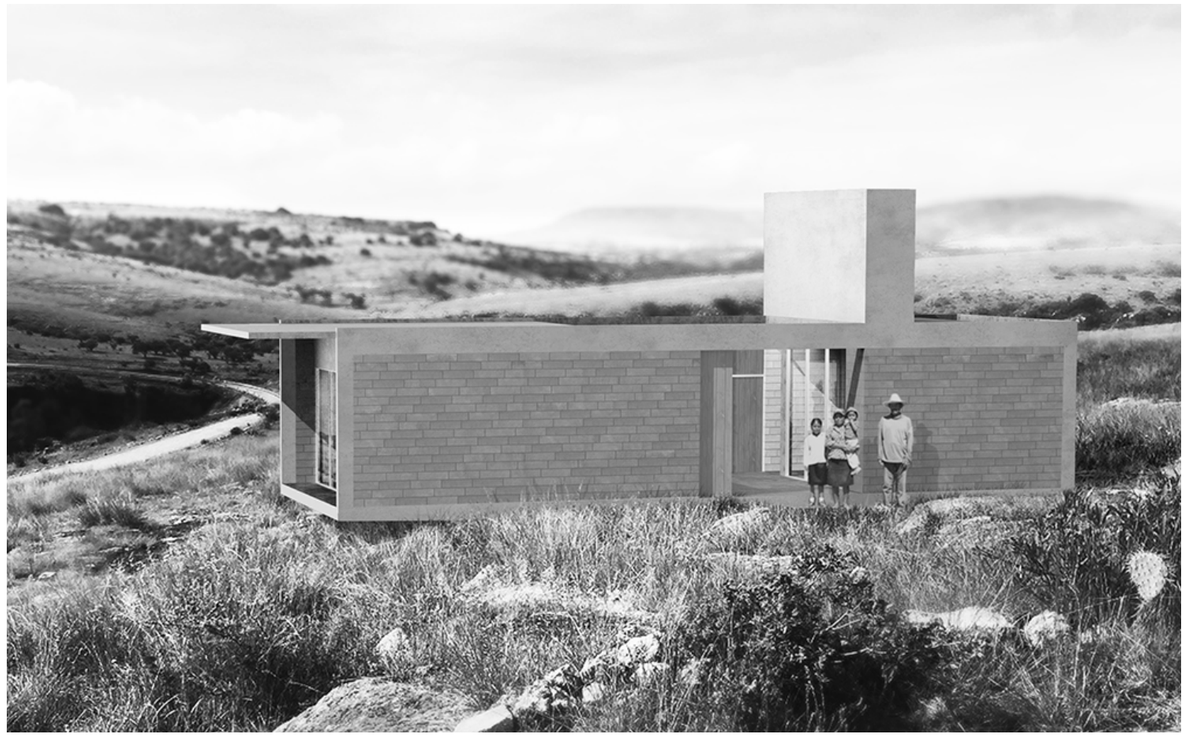








APAN
Querétaro, México,
RNThomsen ARCHITECTURE
2018



STRUCTURE:
Concrete frame, Block fill

FABRICATION:
On Site Construction

SF:
N/A

SF COST:
N/A

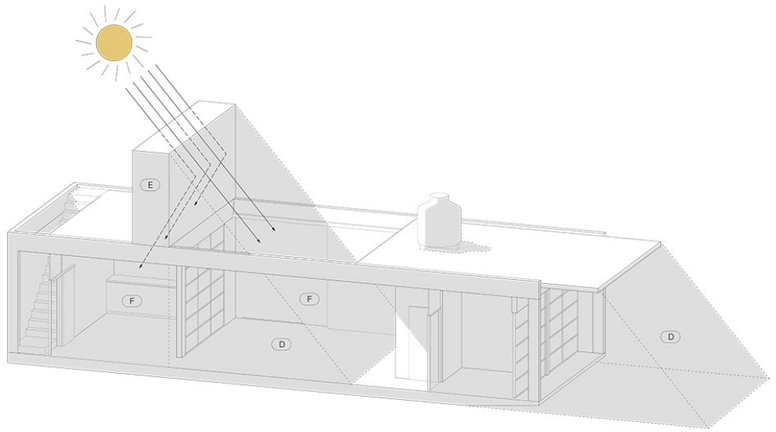
LINK:
http://rnthomsenarchitecture.com/2018/01/24/apan/

"Social housing is too often dealt with as a problem of efficiency and lifeless problem solving, devoid of the palpable qualities that only architecture can provide. Social housing is an opportunity, employing modest means and humble materials to provide an environment of quality and dignity for its inhabitants. It embraces a simplicity that speaks to the qualities of space, light and air coupled with intelligent problem solving. It enables the potential of the people who live there to form communities, provide humane spaces for the diversity of life, making room for an intense optimism. The design for a modest house in the countryside north of Mexico City is a response to the need for extremely inexpensive, single-family dwellings that dignify the lives of their inhabitants. Commissioned by Infonavit, an agency of the federal government in Mexico, the brief asked to explore how to make the most with the least. The house is currently under construction and will be used as a prototype for rural dwelling." - RNThomsen ARCHITECTURE

OBSERVATIONS: The quality of the APAN house is in its duplicity of functions for multiple elements. Its formal simplicity, relationship to the environment, and use of materials are explored in this project. The design calls for concrete masonry walls but leaves them exposed due to the continuous warm climate of Mexico. The overall form is simple but effective with the central courtyard to bring in light and to also ventilate the space. The double height bar adjacent to the courtyard provides additional public access to the roof but doubles as a vertical shaft to bring in light to the space below. The deep, modern overhangs create shadow in the high summer heat but also double as porch space to cool off in the summer. These are qualities intended to be replicated in the 'dry/arid' house typologies. Another feature to the house is the doubling of wall and storage/shelving space. This is a quality replicated in different capacities of the Syracuse Habitat Houses, where walls and shelter are doubled to become storage and threshold.

PRECEDENT

SINGLE FAMILY HOME TYPOLOGY



RESPONSES

A *BUILDING ORIENTED FOR SOLAR CONTROL*

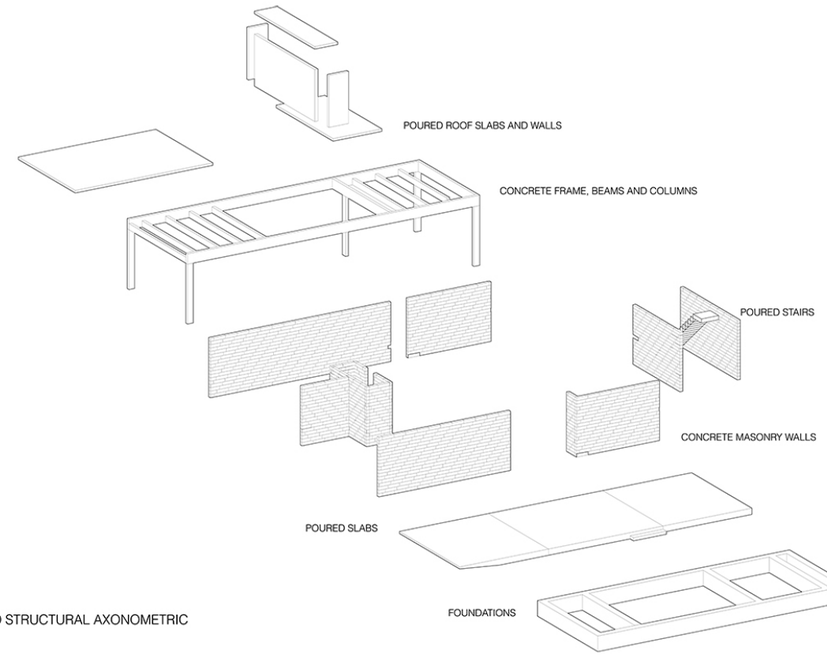
B *LIVING SPACES SEPARATED BY COURTYARD*

C *REFLECTED LIGHT CAPTURED FOR INTERIOR SPACES*

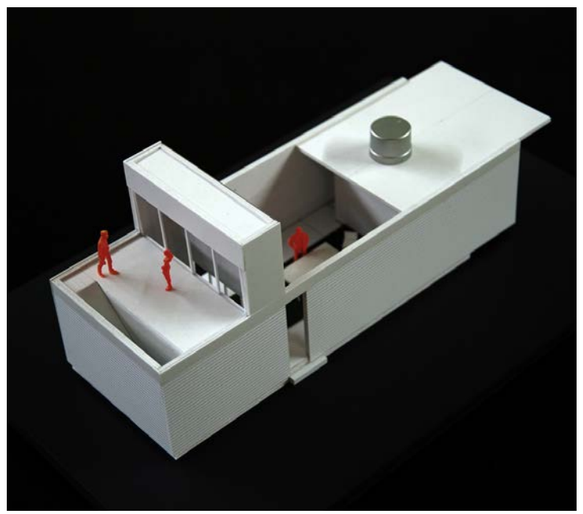
D *SHADED AREAS*

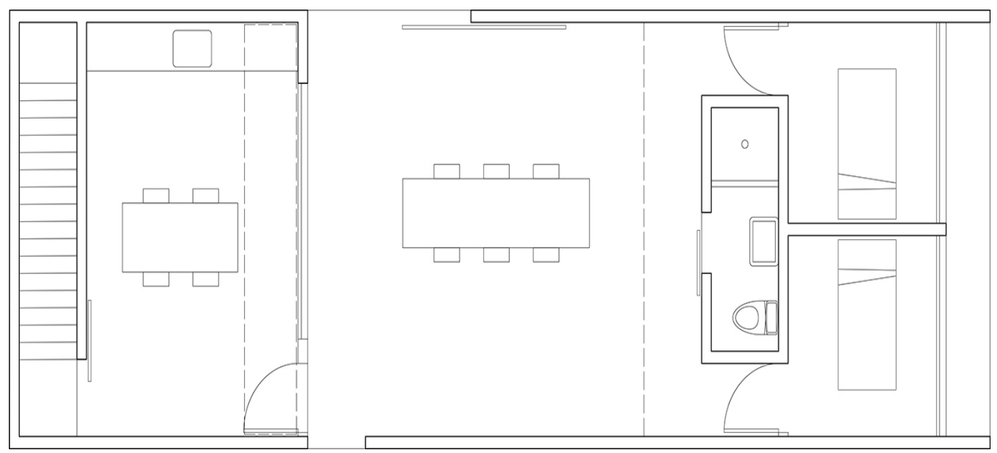
E *NAUTRALLY LIT AREAS*

CLIMATE AXONOMETRIC



EXPLODED STRUCTURAL AXONOMETRIC





SAWMILL RETREAT
Tehachapi, CA,
Olsen Kundig Architects
2014

Climate Zone 3	
Ceiling R-value	30
Wood Frame Wall R-value	13
Mass Wall R-value [i]	5/8
Floor R-value	19
Basement Wall R-value [c]	5/13[f]
Slab R-value [d], Depth	0
Crawlspace Wall R-value [c]	5/13
Fenestration U-Factor [b]	0.50[j]
Skylight U-Factor [b]	0.65
Glazed fenestration SHGC [b, e]	0.30

STRUCTURE:
Concrete Block, Steel deck roof

FABRICATION:
On Site Construction

SF:
4179 SF

SF COST:
N/A

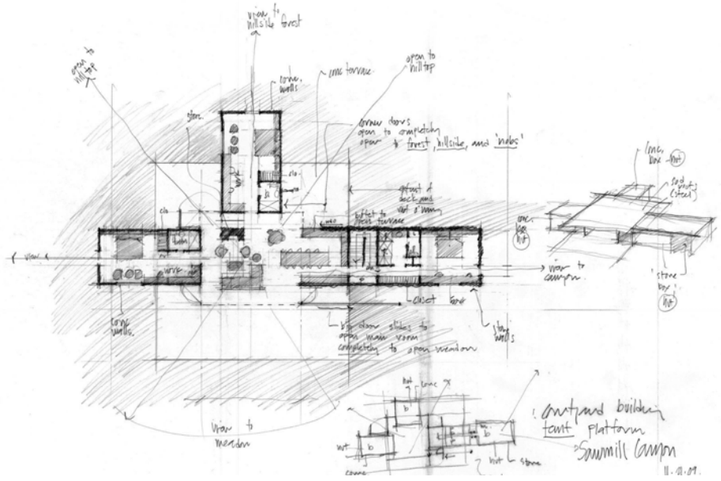
LINK:
https://www.olsonkundig.com/projects/sawmill-canyon-retreat/

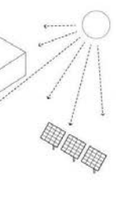
"Set in the harsh high desert of California, Sawmill is a family retreat embedded into the tough, scrubby landscape. Sawmill harnesses the challenges and opportunities of its remote site, emphasizing sustainable strategies and reclaimed materials. Demonstrating that high design can also be high performance, Sawmill is a net-zero home that operates completely off the grid. The client brief called for a self-sufficient home that maximized connection between architecture and nature, and between family members inside. Riffing on the tradition of tents around a campfire, the house is comprised of three wings connected by the central hearth in the living area. Here, a 12-by-26-foot window wall retracts with the turn of a wheel, transforming the outdoor patio into the fourth "tent" around the fire. Tough as nails, Sawmill is made from durable materials that can withstand the harsh climate, where fires are a major hazard in summer and winters are extremely cold. The design approach was driven by a scavenger mentality, seeking always to do more with less, including using salvaged and recycled materials whenever possible." - Olsen Kundig Architecture

OBSERVATIONS: While this is not a low-income house and offers a very luxurious program and layout, the house is a good precedent for the interaction between different constructive elements and their engagement with the environment. The project demonstrates a low impact design strategy that reflects in the well-oriented and organized spatial configuration of the house. The material expression of the different elements underlines the environmental design strategies, especially regarding strategies of passive cooling and ventilation. The massing strategy of the house requires a rather expansive site which is not ideal for our proposal but worth studying to encourage natural ventilation and passive cooling as much as possible within the volume of the houses.

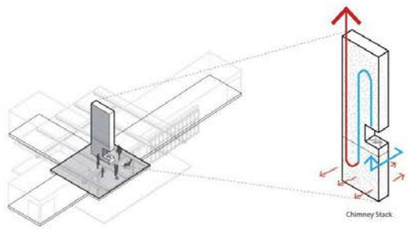
PRECEDENT

SINGLE FAMILY HOME TYPOLOGY

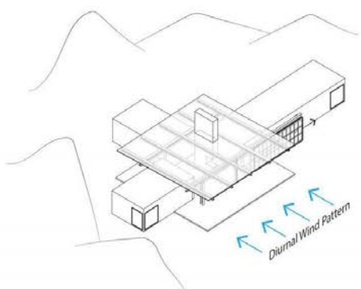




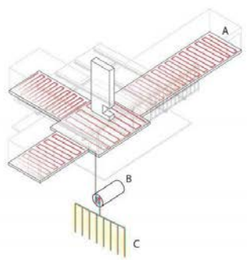
1. Expansive roof protects interiors from summer sun. 8.4 kW PV array with battery backup enables the house to be truly off-grid.



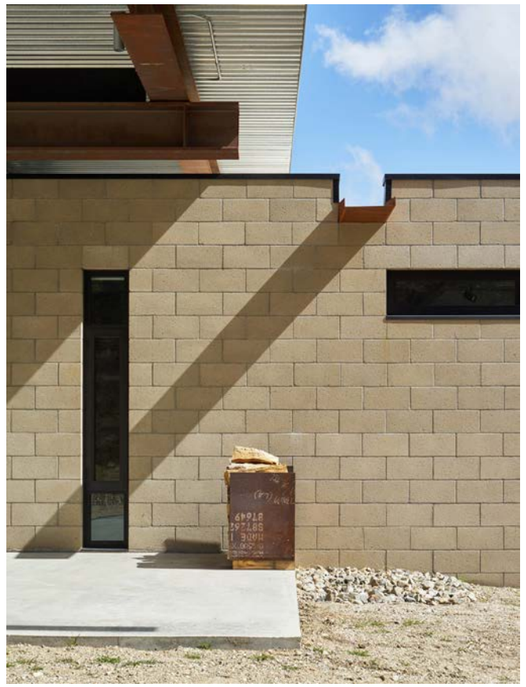
3. Fireplace works as lateral bracing for structure as well as gathering place for the families. Three air passes to maximize heat extraction and to provide heat to the basement. Concrete mass stores heat for many hours.

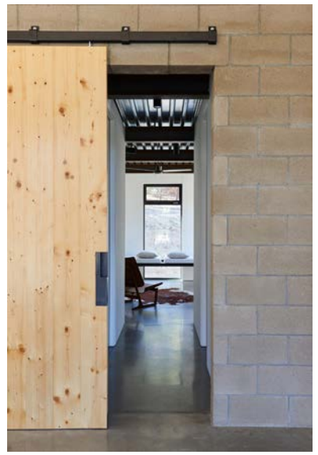


2. The house is oriented to take advantage of canyon wind patterns and diurnal temperature changes. Large openings allow for passive cooling.



4. A) Radiant slabs provide comfortable and efficient heating.
B) Water-water heat pump provides efficient heat source.
C) Ground coupled heat loop allows the building to pull heat from the ground.





Moonlight Duplex
Austin, TX,
Salas Design Workshop
2010

Climate Zone 2	
Ceiling R-value	30
Wood Frame Wall R-value	13
Mass Wall R-value [i]	4/6
Floor R-value	13
Basement Wall R-value [c]	0
Slab R-value [d], Depth	0
Crawlspace Wall R-value [c]	0
Fenestration U-Factor [b]	0.65[j]
Skylight U-Factor [b]	0.75
Glazed fenestration SHGC [b, e]	0.30

STRUCTURE:
Wood

FABRICATION:
(Platform Framing)

SF:
?

SF COST:
N/A

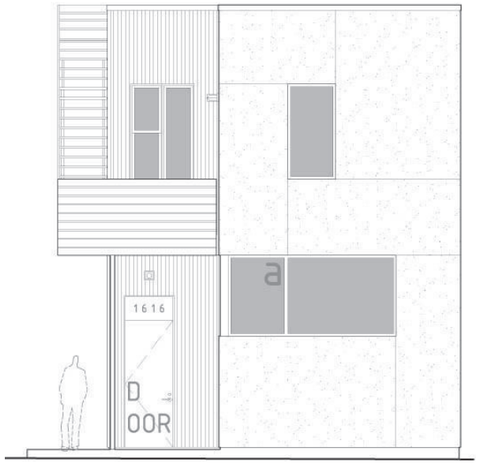
LINK:
https://wabisabimodern.com/section/332615_Moonlight_Duplex.html

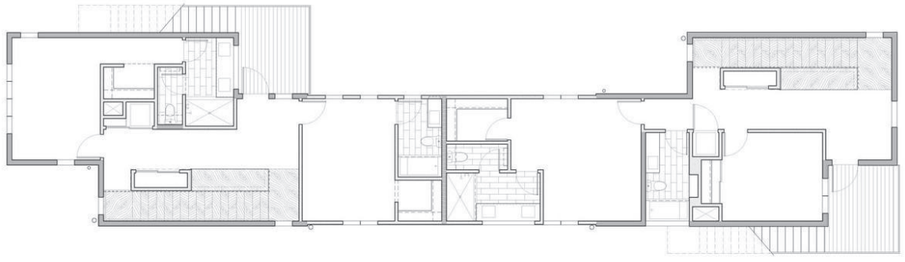
"A speculative development project that addresses the demands of rapid growth in Austin, Texas on a low budget, while being environmentally conscious and architecturally progressive. The project strives to be forward thinking and modern but sympathetic to its established neighbors in terms of scale and massing. The two unit project gives both units an independent and free standing ground floor footprint with clear and separate entrances to foster a sense of individuality and ownership of each unit. The project tries to achieve a balance of public and private space with private yards and a roof deck for additional outdoor space. The car is given special consideration and brought down the side of the site on a shared drive to the interior for security and to keep the street facing side of the project from becoming visually cluttered and overwhelmed by cars." - Salas Design Workshop

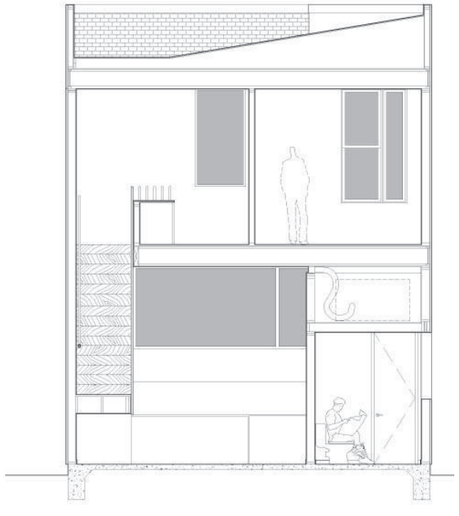
OBSERVATIONS: This is a helpful precedent because it is a relatively small duplex with a supposedly low budget. But this duplex is not perceived as a typical duplex because of its narrow situation on the site. The two units are not next to each other but one is set back behind, allowing each to have their own entry and more privacy. This is an appreciated feature, especially if a site is chosen in a narrow lot or in a denser neighborhood. The key will be to define the FAR ratio for the site and if the density is permitted in certain cities/towns. But it is beneficial to aim to have separate entries when possible. And due to the warmer weather of Austin, there are just carports with storage on the ground level with an entry tucked away and in close proximity to the carport.

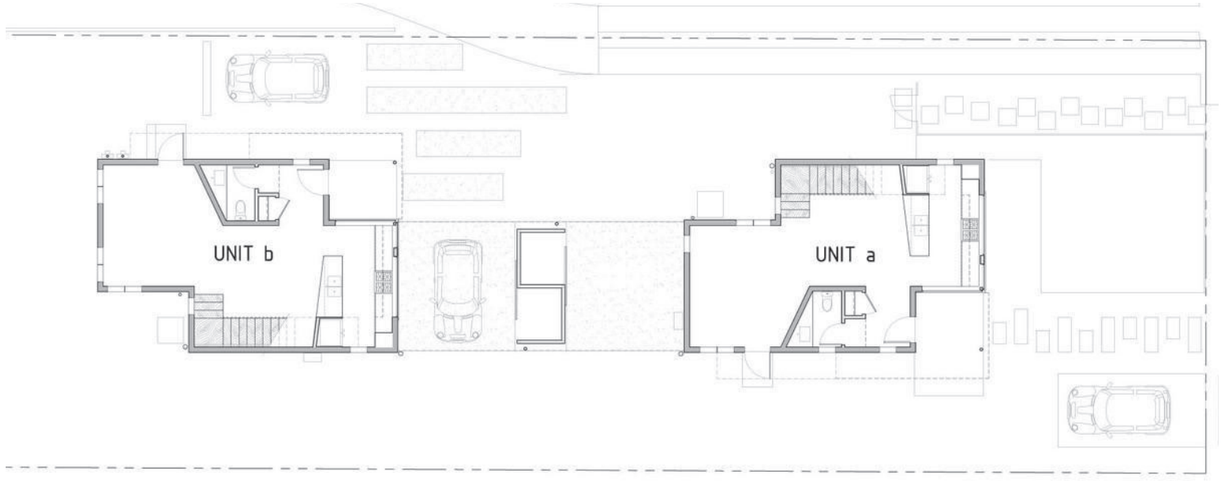
PRECEDENT

DUPLEX TYPOLOGY









Echo Ridge Duplexes
Topeka, TX,
El Dorado Inc.
2012

Climate Zone 4 (Except Marine)	
Ceiling R-value	38
Wood Frame Wall R-value	13
Mass Wall R-value [i]	5/10
Floor R-value	19
Basement Wall R-value [c]	10/13
Slab R-value [d], Depth	10, 2 ft
Crawlspace Wall R-value [c]	10/13
Fenestration U-Factor [b]	0.35
Skylight U-Factor [b]	0.60
Glazed fenestration SHGC [b, e]	NR

STRUCTURE:
Wood

FABRICATION:
(Platform Framing)

SF:
?

SF COST:
N/A

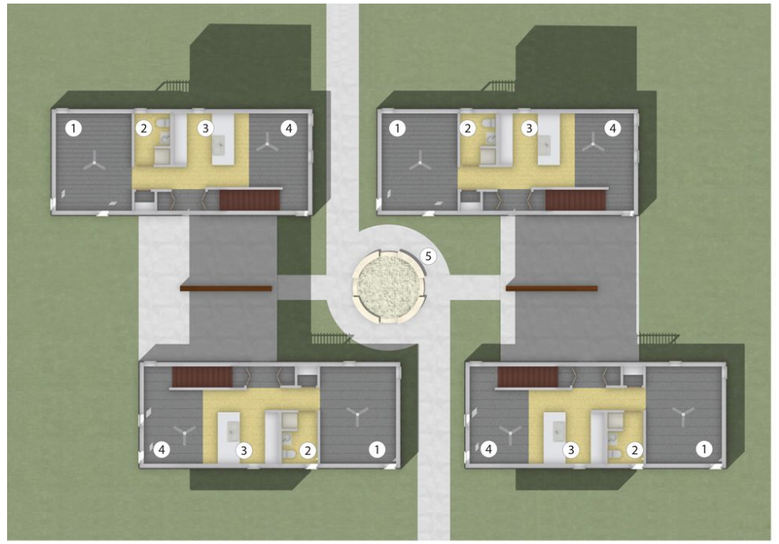
LINK:
https://www.archdaily.com/282076/echo-ridge-duplexes-el-dorado

"The typical duplex typologies were re-configured to provide natural cross ventilation for all major rooms of each unit. Designed with a focus on single mothers, the new configuration of duplexes creates a protected and easily supervised communal space for small children. The new duplexes also gain energy efficiency through the use of highly insulated envelope construction, fully ventilated rain screen systems, and a shared ground source heat pump system. Storm water management is achieved through planted rooftops and previous concrete sidewalk paving. Materials containing recycled content were specified throughout the design. The result, built for just $115 per square foot, is an energetic and optimistic re-thinking of a low-income housing typology that promotes sustainable living and a strong sense of community." - El Dorado Inc.

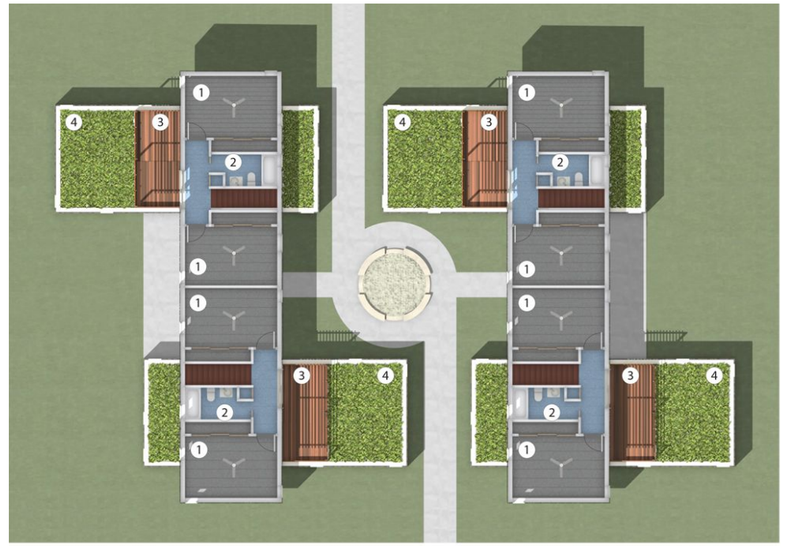
OBSERVATIONS: This is another precedent for a low-budget, affordable housing duplex development. The modular system of the project can grow beyond a single unit with the second level flipped by 90 degrees to connect to the next house. This, in turn, provides a covered urban space below. The challenge would be to have enough lot area to achieve this scheme. Compared to the previous precedent this scheme is ideal for a wide lot. The quality of the modern interpretation of 'siding' with vertical slats, creates an elongated facade that makes the buildings appear taller than they are and helps to compose the facade, even when there are minimal windows. The project is also a good example for a productive interrelationship between massing and passive cooling and ventilation.

PRECEDENT

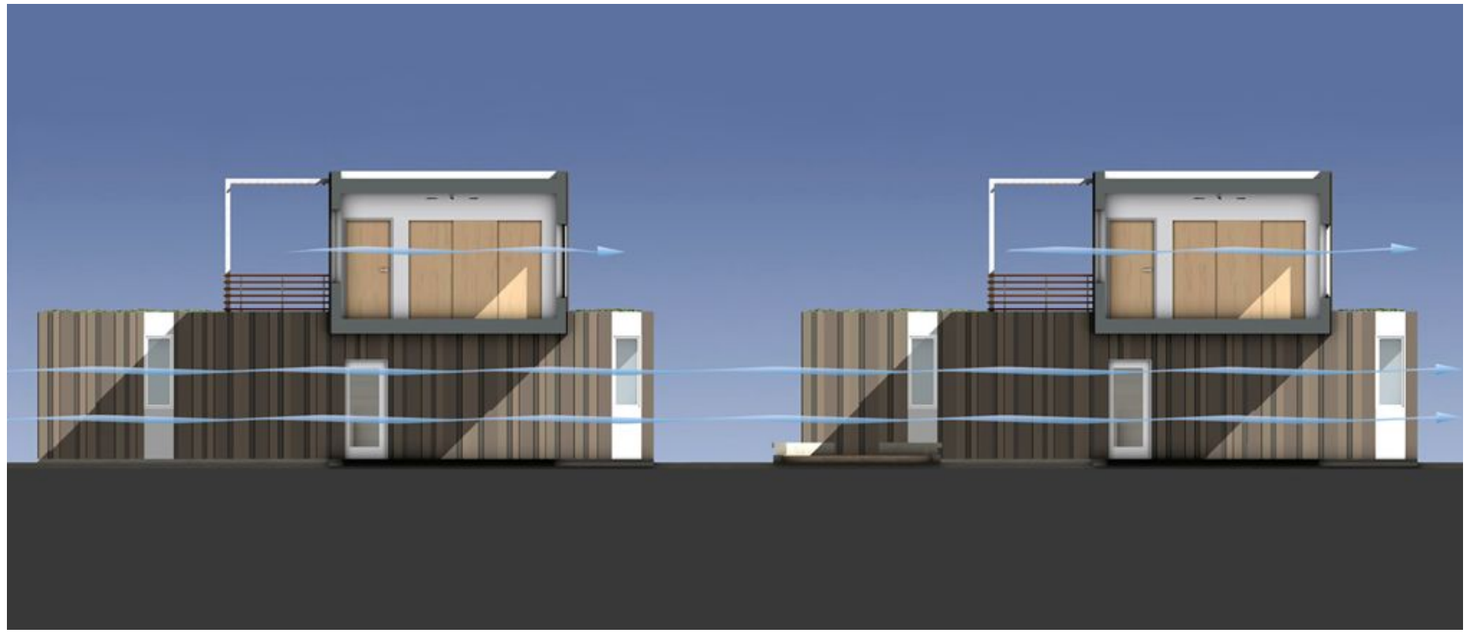
DUPLEX TYPOLOGY



1. BEDROOM
2. BATHROOM
3. KITCHEN
4. LIVING ROOM
5. COMMUNAL SPACE



1. BEDROOM
2. BATHROOM
3. BALCONY
4. PLANTED ROOFTOP



Waldo Duplex
Kansas City, MO,
El Dorado Inc., Kansas State University Design+Make Studio,
2017

Climate Zone 4 (Except Marine)	
Ceiling R-value	38
Wood Frame Wall R-value	13
Mass Wall R-value [i]	5/10
Floor R-value	19
Basement Wall R-value [c]	10/13
Slab R-value [d], Depth	10, 2 ft
Crawlspace Wall R-value [c]	10/13
Fenestration U-Factor [b]	0.35
Skylight U-Factor [b]	0.60
Glazed fenestration SHGC [b, e]	NR

STRUCTURE:
Wood, Steel, Corrugated Metal Cladding

FABRICATION:
Platform Framing

SF:
1500

SF COST:
$200

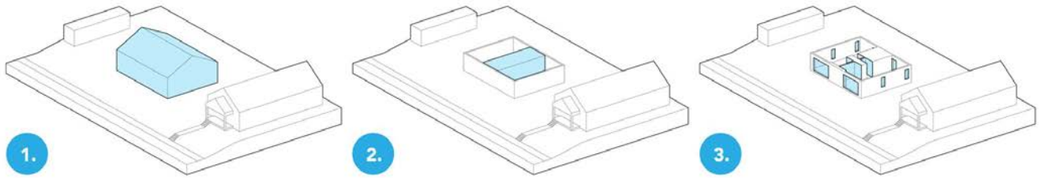
LINK:
https://www.ksudesignmake.com/the-waldo-duplex

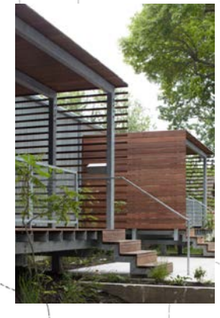
"Today, developers have co-modified the duplex, creating suburban neighborhoods with no distinctive identity whatsoever," the team said. "The Waldo Duplex looks to the inherent benefits of duplex construction, but works to redefine the building typology through a wholehearted embrace of pragmatic constructive and material constraints." The duplex is intended to be occupied by two low-income families. "This building type was conceived as a more compassionate way to meet housing needs in lower-income municipalities and neighborhoods without the density that is typical in affordable housing." Exterior walls, along with the pitched roof, are clad in corrugated metal. Each unit totals 725 square feet (67 square meters). The apartments have two bedrooms and an open-plan area zone for cooking, dining, and living. The rooms are illuminated through a careful balance of natural and artificial light. Despite a limited budget of $290,000, the team was able to incorporate high-quality finishes and custom cabinetry. The project was built for $200 per square foot, which is less than comparable projects." - El Dorado Inc.

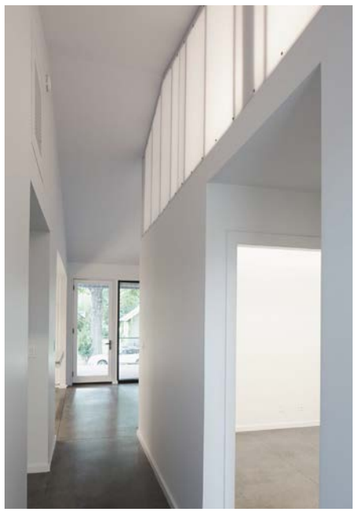
OBSERVATIONS: This duplex is extremely compact without losing the quality of space for each unit. The situation of the duplex towards the street is thoughtful in how one approaches the units with the individual stairs, which contextualizes the houses with the surrounding neighborhood. The front porches protrude out to signify entry and create a deep overhang for the porch to actually sit under a covered canopy. The units share a back porch but have their own entries which gives more the appearance of being a single family unit. In section, natural light is brought in to the hallway connecting the main public space to the back private rooms and bathroom. The spine of the hallway is flanked by bathroom and utility on one side and bedrooms on the other.

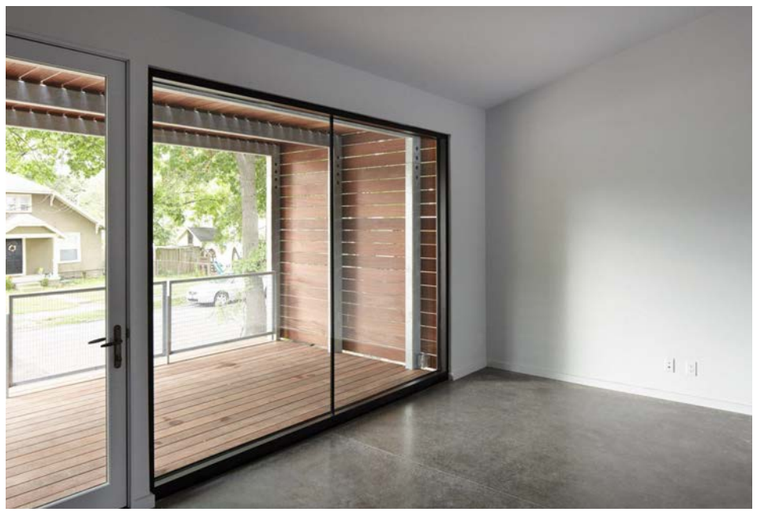
PRECEDENT

DUPLEX TYPOLOGY





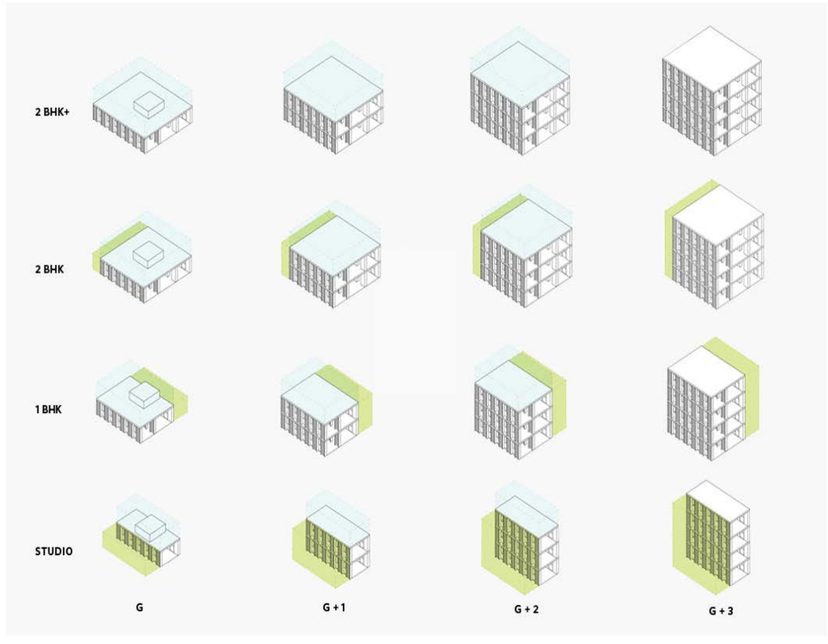




Ideal Choice Homes
Ahmadabad, India,
Kieren Timberlake Architects
Date: Ongoing

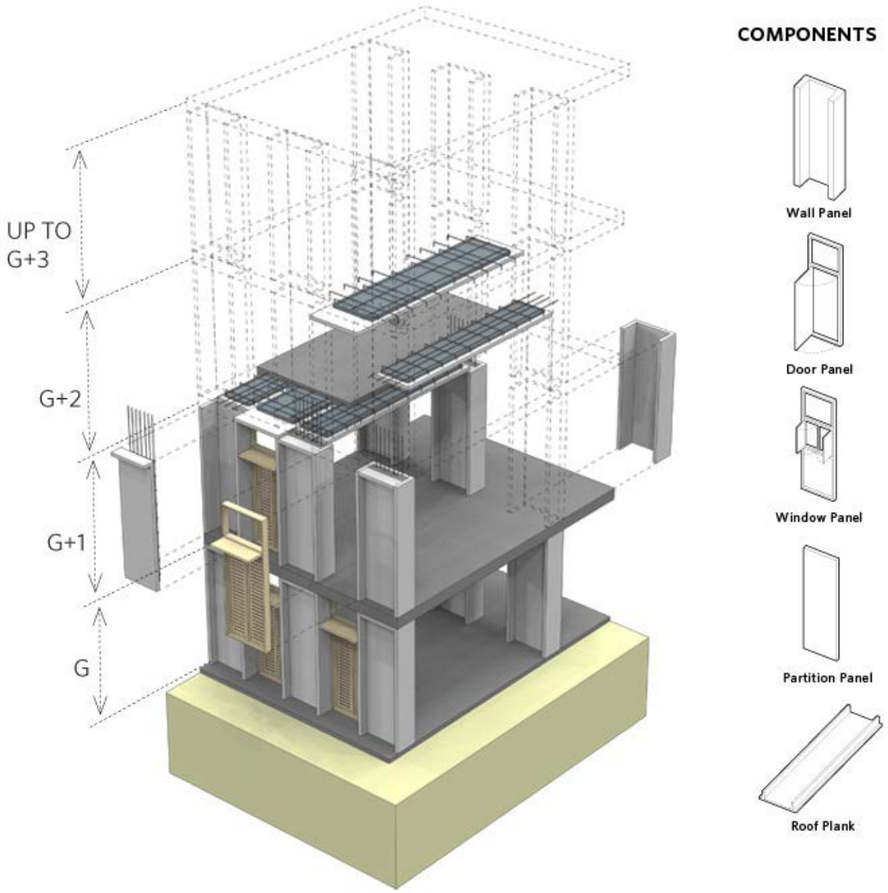
"The goal of the project was to develop a methodology that would promote sustainable growth by conserving resources throughout all building phases—from material supply chain to construction and habitation. The design is a holistic solution that leverages established knowledge of pre-cast concrete to satisfy a cultural preference for "pukka," or solid, construction (as opposed to movable, impermanent forms of construction). It is a clear departure from traditional construction in that it is engineered for off-site manufacture, delivery, and on-site assembly. The primary structural component is a concrete wall panel, shaped to self-shade in eastern and western orientations. The design significantly reduces construction time—from 24 months to an estimated 3 months. The design allows owners to manage thermal comfort, increase self-sufficiency, conserve water, and decrease the need for air conditioning. The house responds to a wide range of seasonal variation by minimizing solar gain through overhangs and shading during the summer, encouraging air movement through cross ventilation, and minimizing air infiltration during the winter." - Kieren Timberlake Architects

PHASE 1
STUDIES OF TYPE AND MASSING

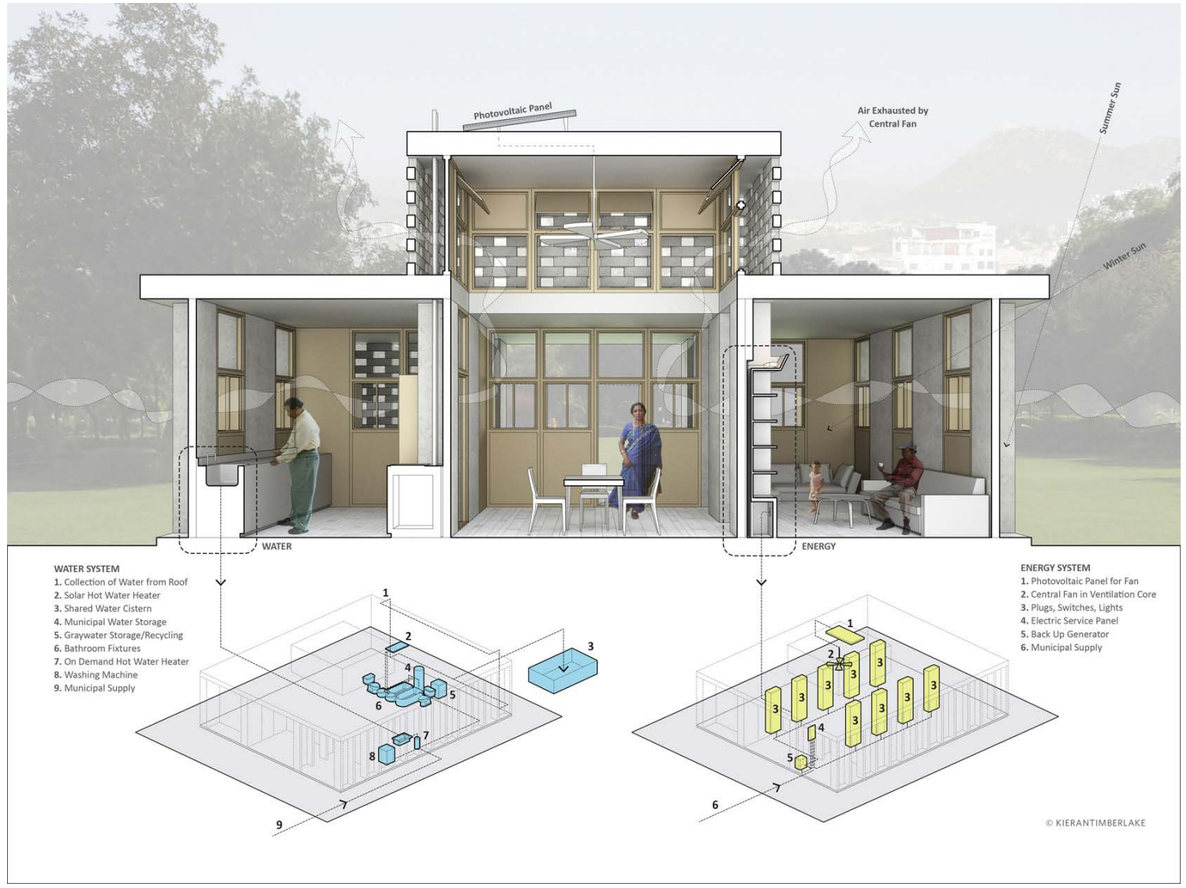


OBSERVATIONS: This project, using solid construction, serves as a strong reference in terms of its design development, phasing and holistic approach to the design and construction of the units. Looking at the project through the proposed phases of the grant serves to provide a clear approach to the development for this house design. The modularity allows for the project to conceptually expand to suit the needs of the users. The approach to the construction, to minimize on-site assembly, is of interest in order to control quality of construction as much as possible. The details of the construction allow the house to adapt to many different climates and sites, which is ultimately what we are trying to achieve with the current research and design of the houses(s). We will be using this project as a reference and strong example of how to achieve an overall strategy and bring it to a level of details that work at the scale of design, construction and management for the project. The images are also intended to provide a rough idea of the scale and scope of the final submission.

PHASE 1/2
STUDIES OF PROGRAMMATIC AND CONSTRUCTIVE COMPONENTS



PHASE 2
STUDIES OF SYSTEMS INTEGRATION

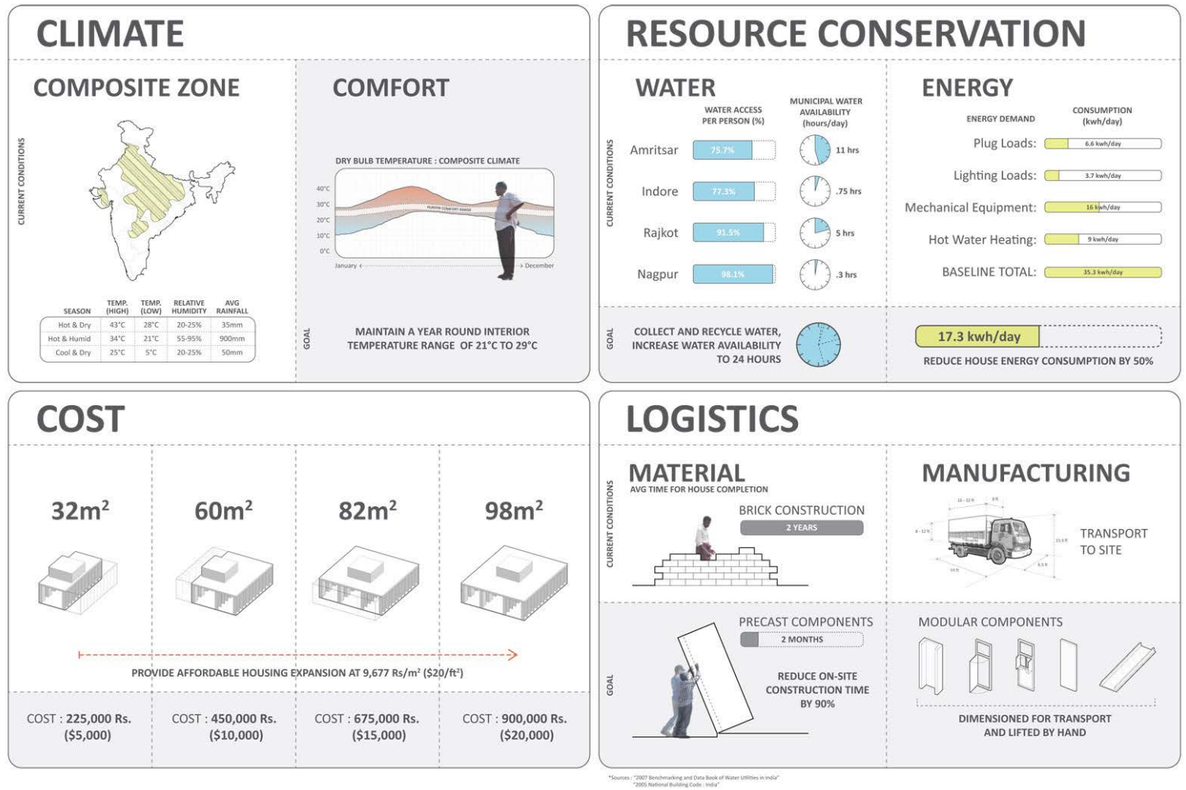


REFERENCE PROJECT

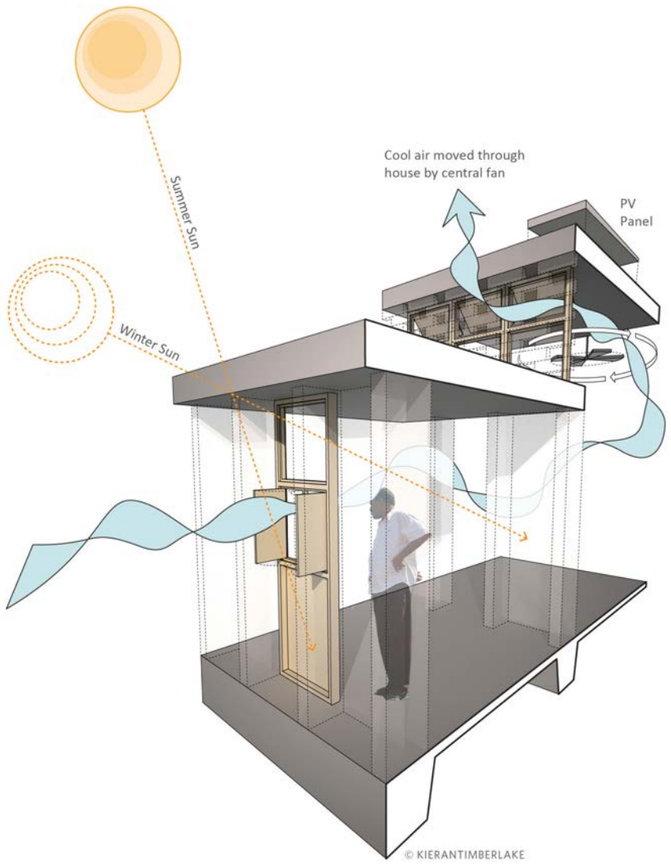
DESIGN METHODOLOGY AND OUTPUT REFERENCE

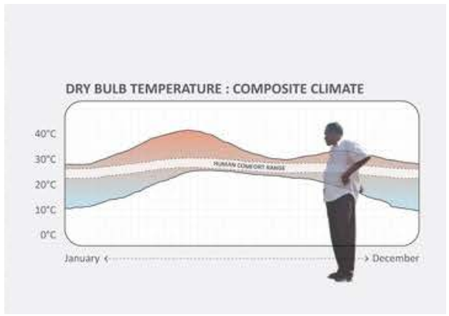
PHASE 2/3
CONSTRUCTION SEQUENCE / STRUCTURE / BIM

PHASE 2/3
STUDIES OF ENERGY PERFORMANCE AND COST

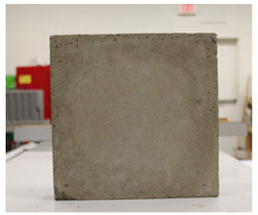


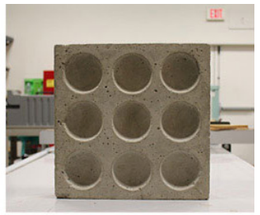
PHASE 3/4
ENERGY MODELING

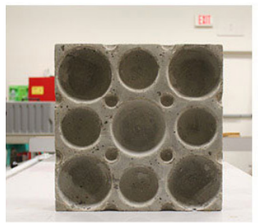


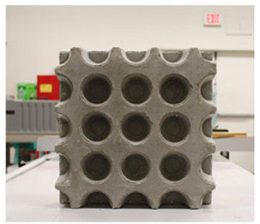


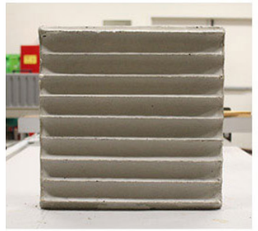
PHASE 3/4
PHYSICAL PROTOTYPES

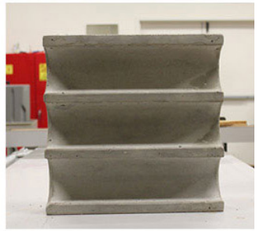


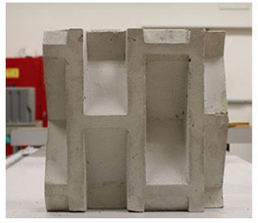


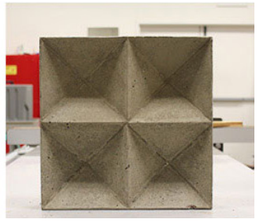












SITE

PROPOSED SITES - CLIMATE AND WEATHER

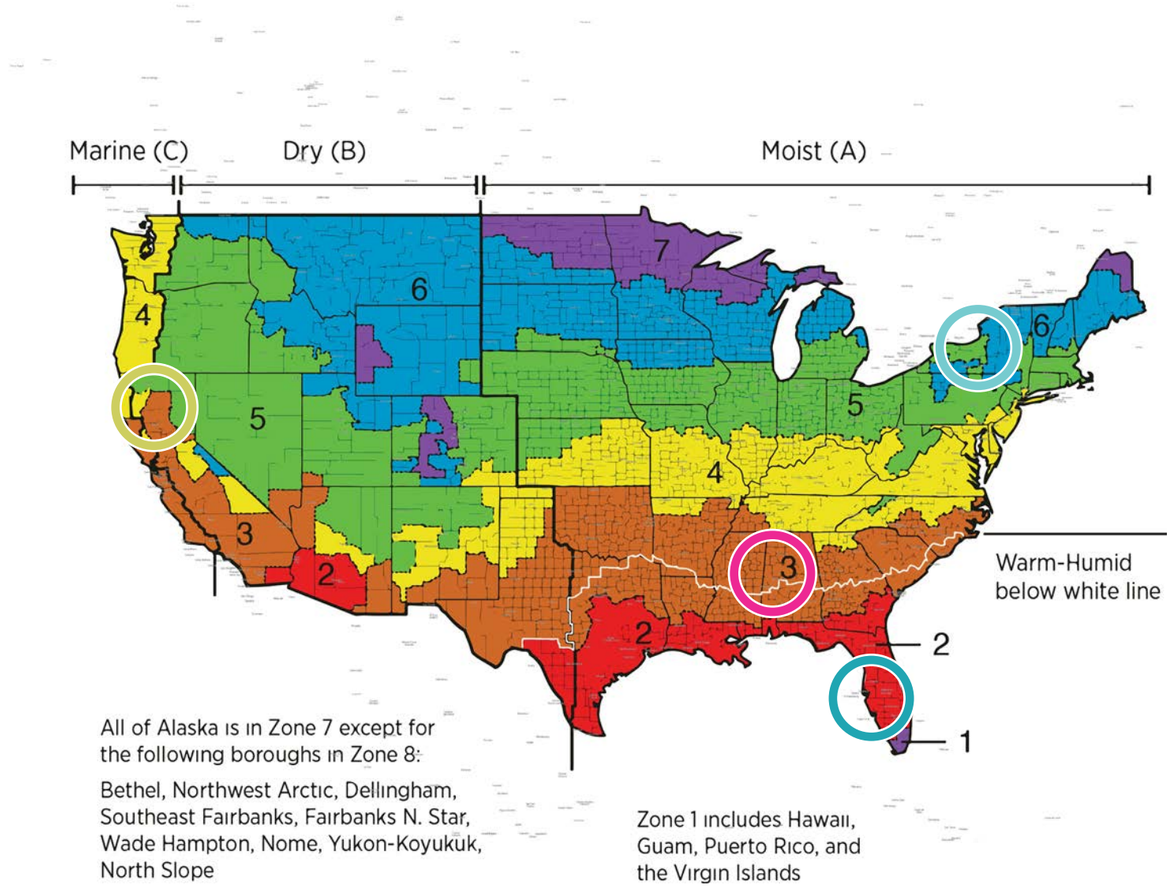
A prototypical project might be best located in areas where the structural and performative benefits of CMU are most prevalent due to its strength, fire and flood resistance, as well as its capacity to retain energy. The following maps suggest potential sites in four distinct climatic zones - 1. Desert/Semi- Arid, 2. Humid/Subtropical, 3. Temperate / Midwest and 4. Continental/Cold. These sites include a variety of different building code requirements, depending on the climate zone they are in. These zones require consideration of different orientations, massing, as well as details for the project; enriching the potential range of implementation of the prototypes. While some of these needs are reflected in the preliminary massing, plans, sections and elevations, they will be worked out in more detail in the subsequent phases. This overall strategy allows for the development of a series of tactics that can be deployed at a variety of scales (i.e. orientation to massing to construction details) while the overall formal, structural and compositional qualities of the modules remain the same.

1. Desert/Semi- Arid

2. Temperate / Midwest

3. Humid/Subtropical

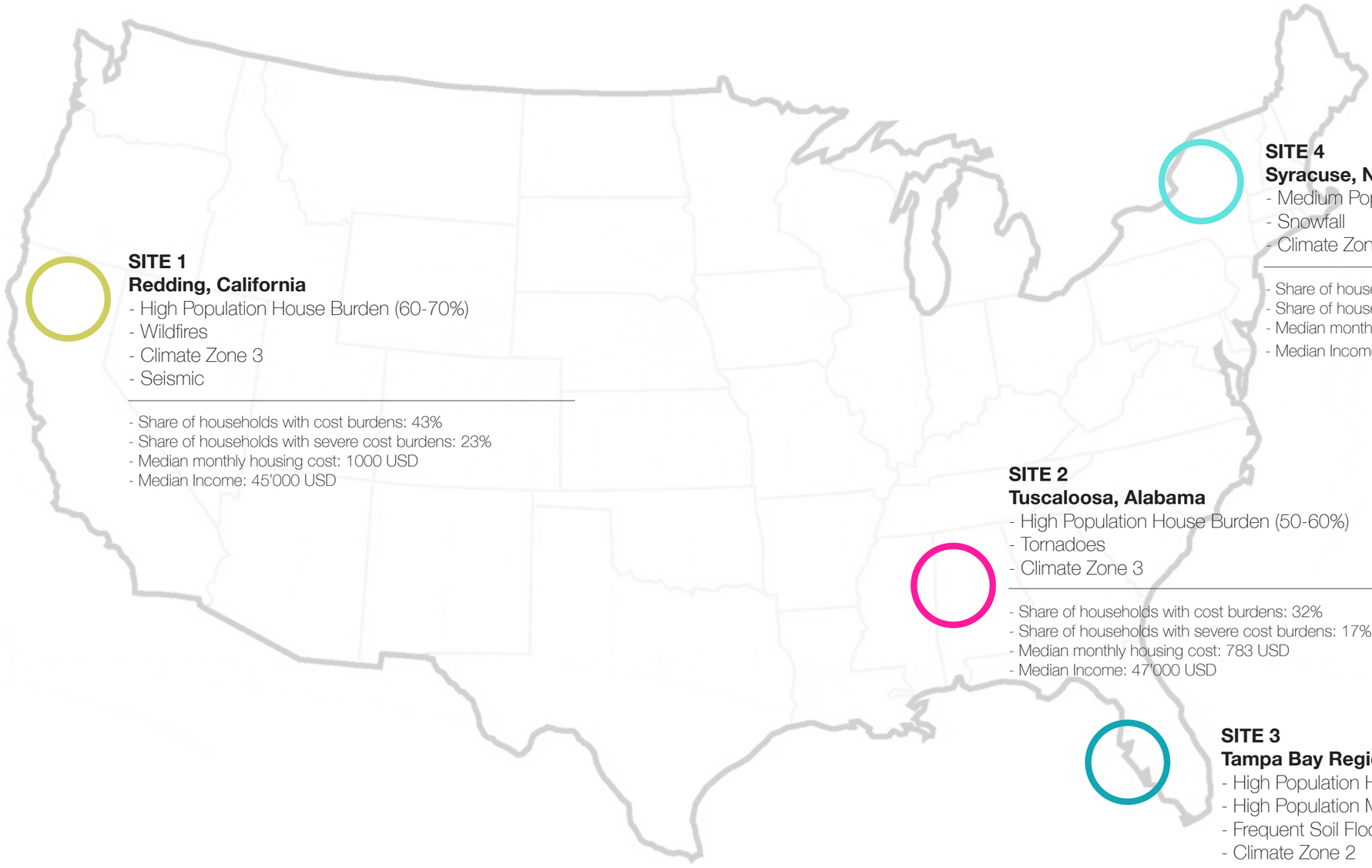
4. Continental/Cold



Climate zones according to the International Building Code

SITE

PROPOSED SITES - LOCATION



SITE 1
Redding, California
- High Population House Burden (60-70%)
- Wildfires
- Climate Zone 3
- Seismic

- Share of households with cost burdens: 43%
- Share of households with severe cost burdens: 23%
- Median monthly housing cost: 1000 USD
- Median Income: 45'000 USD

SITE 2
Tuscaloosa, Alabama
- High Population House Burden (50-60%)
- Tornadoes
- Climate Zone 3

- Share of households with cost burdens: 32%
- Share of households with severe cost burdens: 17%
- Median monthly housing cost: 783 USD
- Median Income: 47'000 USD

SITE 3
Tampa Bay Region, Florida
- High Population House Burden (60-70%)
- High Population Mobile Homes
- Frequent Soil Flooding
- Climate Zone 2

- Share of households with cost burdens: 34%
- Share of households with severe cost burdens: 17%
- Median monthly housing cost: 980 USD
- Median Income: 50'100 USD

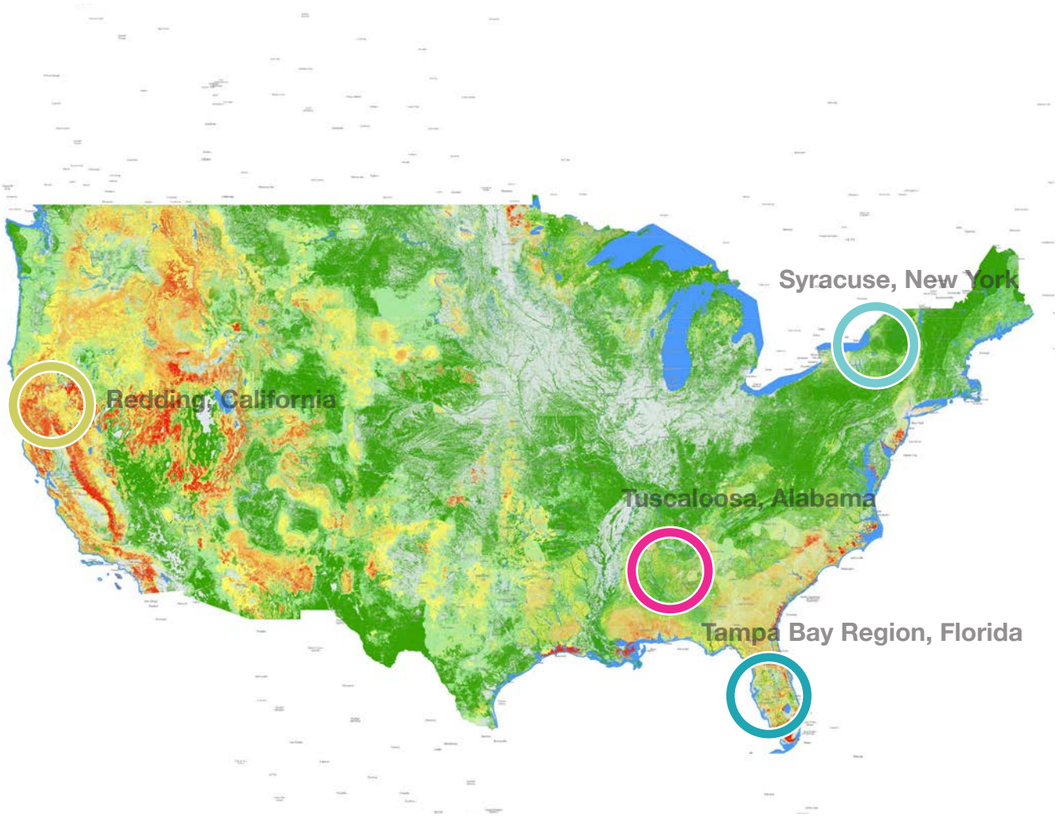
SITE 4
Syracuse, New York
- Medium Population House Burden (40-50%)
- Snowfall
- Climate Zone 5

- Share of households with cost burdens: 27%
- Share of households with severe cost burdens: 14%
- Median monthly housing cost: 870 USD
- Median Income: 55'000 USD

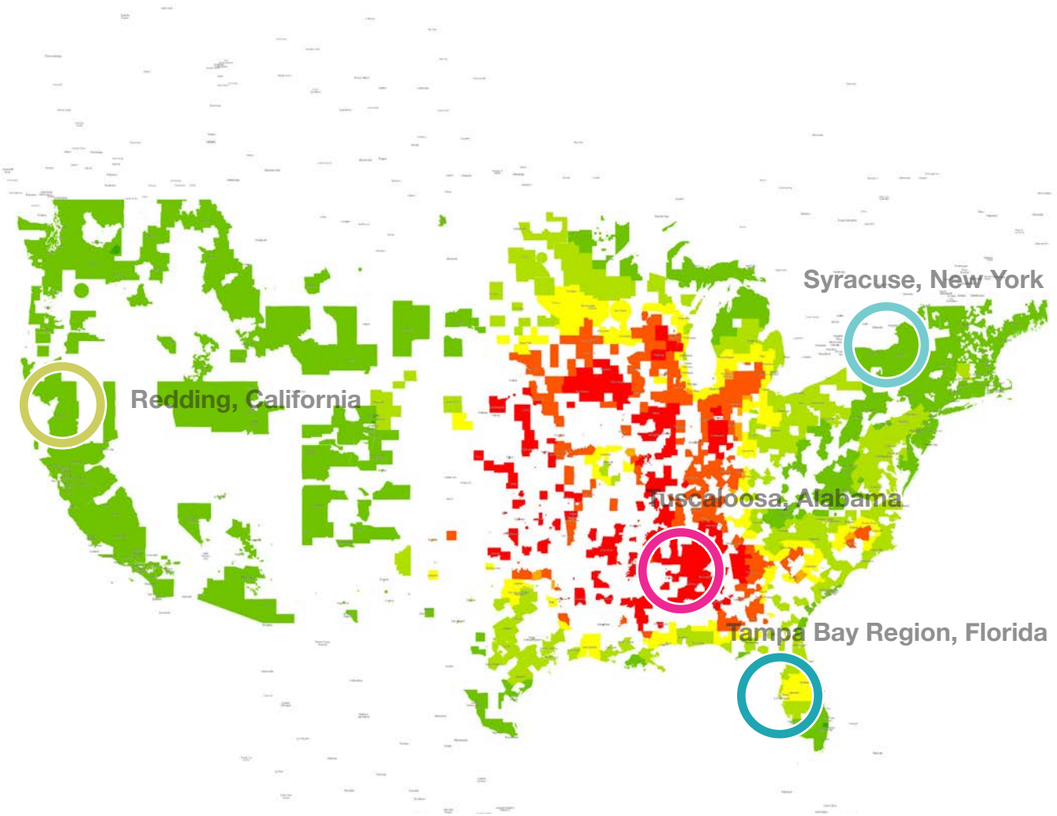
Income and household statistics source: http://www.jchs.harvard.edu/many-households-burdened-housing-costs-2016with cost burdens: 34%

SITE

MAJOR NATURAL DISASTER ZONES



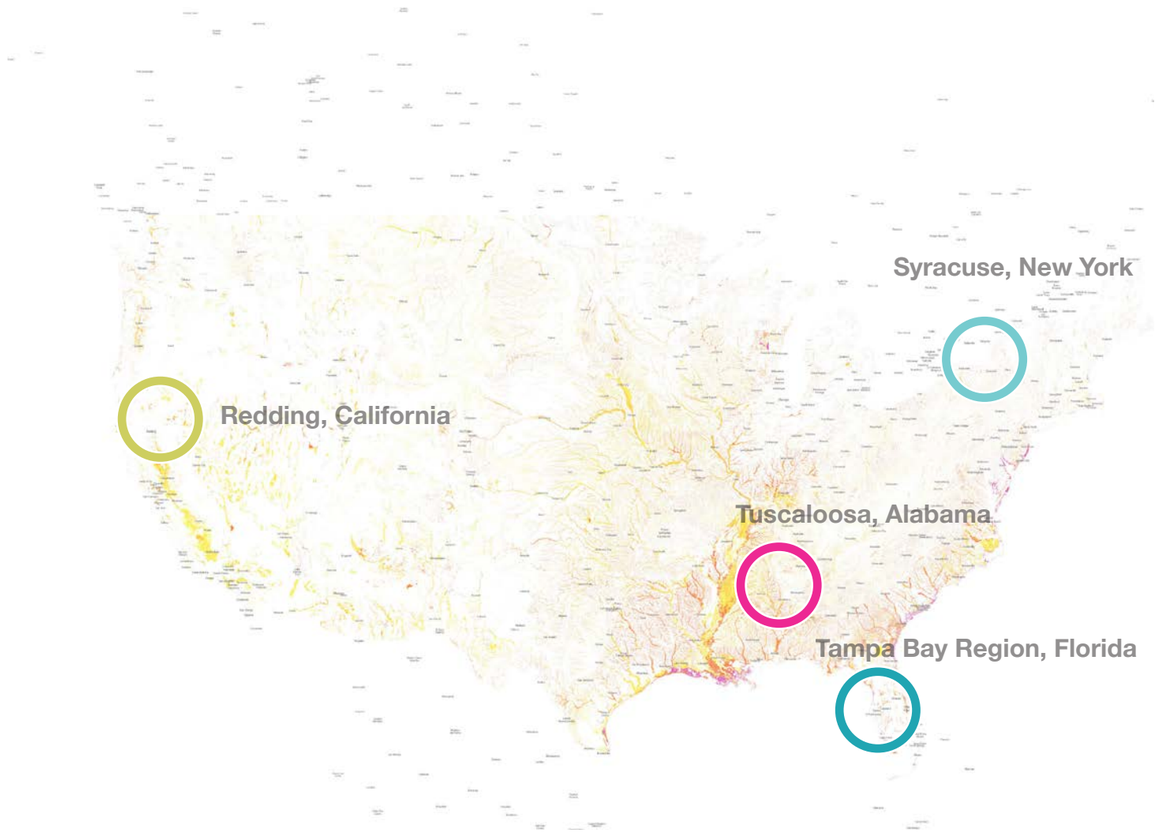
Wild fire frequency in the United States



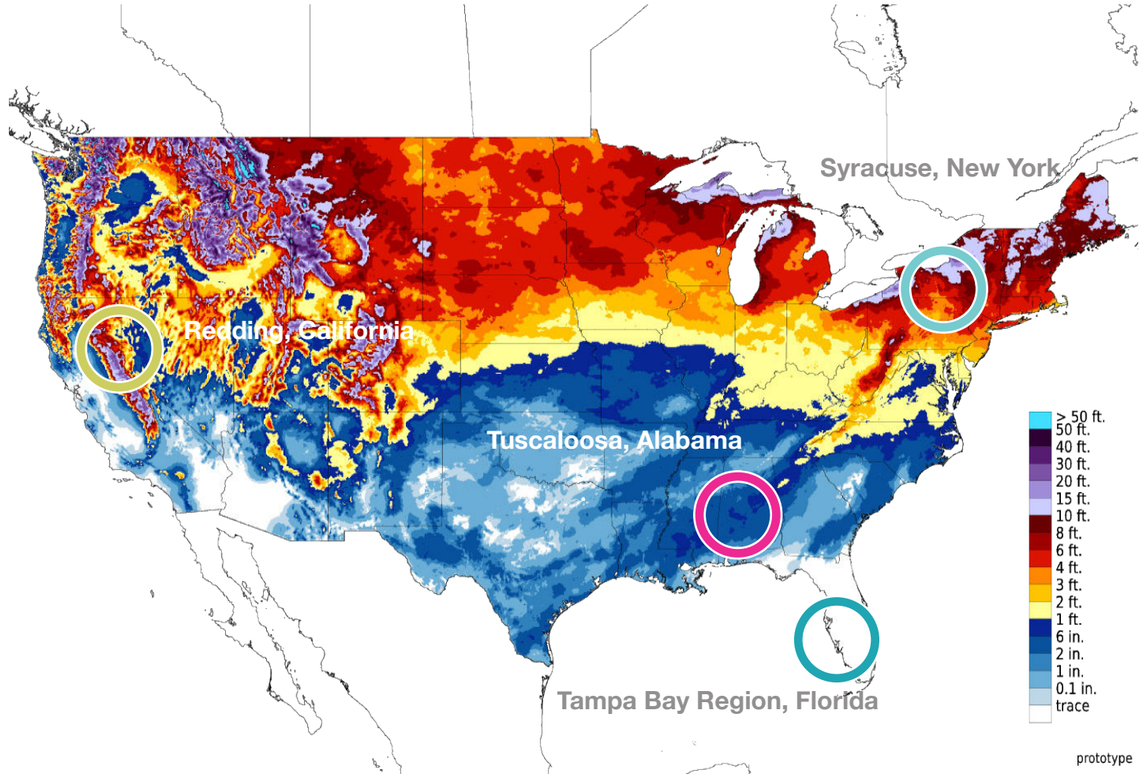
Tornado frequency in the United States

SITE

MAJOR NATURAL DISASTER ZONES



Soil flooding frequency in the United States



Seasonal Snow Fall 2017-18 in the United States

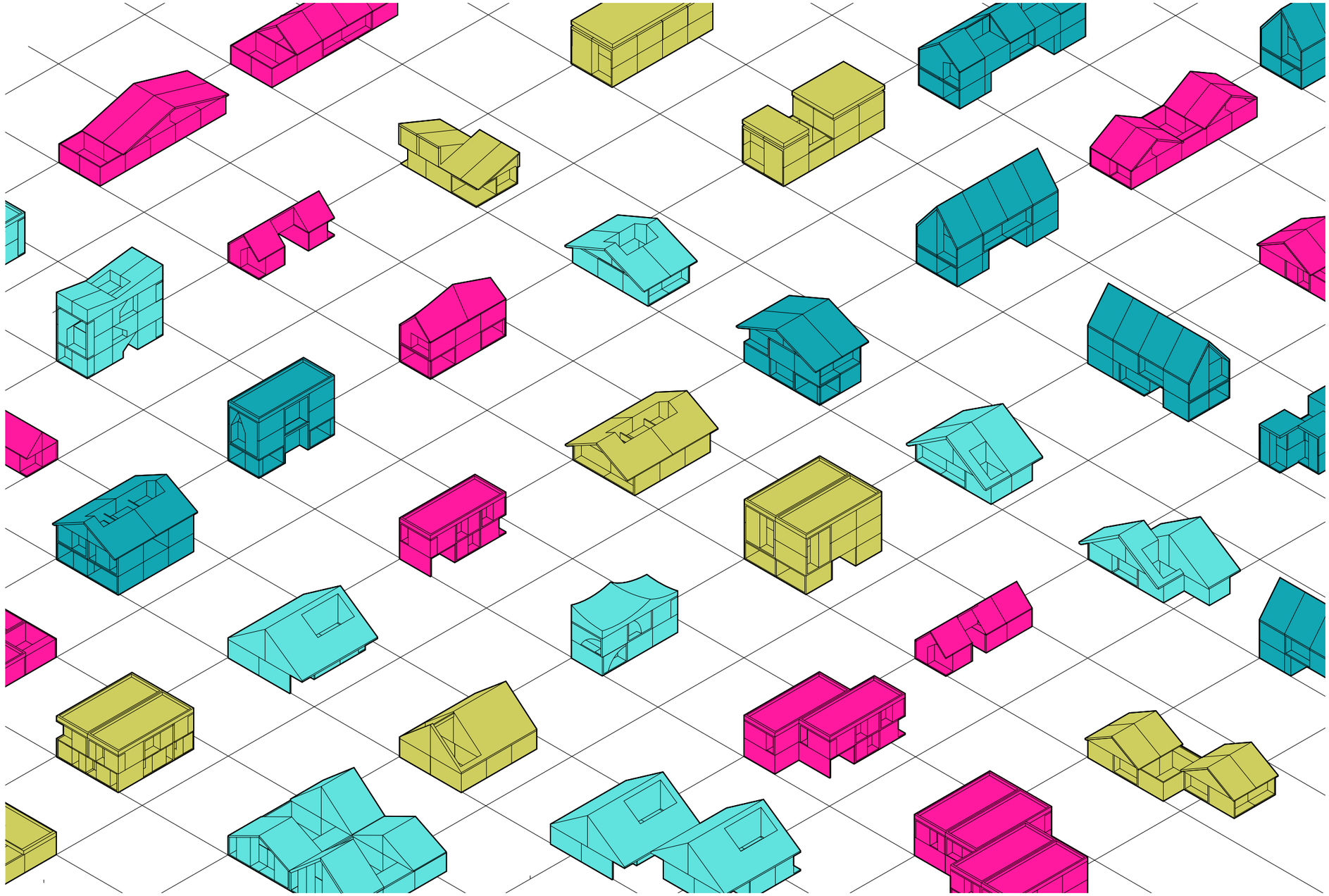
HOUSING TYPOLOGY

SITE AND TYPOLOGY

The goal is to develop house types for each of the different site / climatic conditions. There are a series of types configured from the same design modules in order to respond to the specific needs of that site.

While the spatial and structural conditions of the modules remain the same, the construction layers of the modules change according to the climatic zone. (For example, roof modules in areas of higher risk for wild fires are clad in clay tiles rather than with the typical roof shingles). See page: 45-46 for diagrams that showcase initial consideration on the configuration and construction of the modules .

The catalog of different houses shown on the right reflect the variety of formal expressions that the modules can generate. However, these will be further explored and refined through the further development of the modules in the next phase of the research. Allowing for an iterative design process that plays out the reciprocity between the technical needs of the modules for the different sites and the expression of the houses.



SITE 1

SITE 2

SITE 3

SITE 4

SITE 1

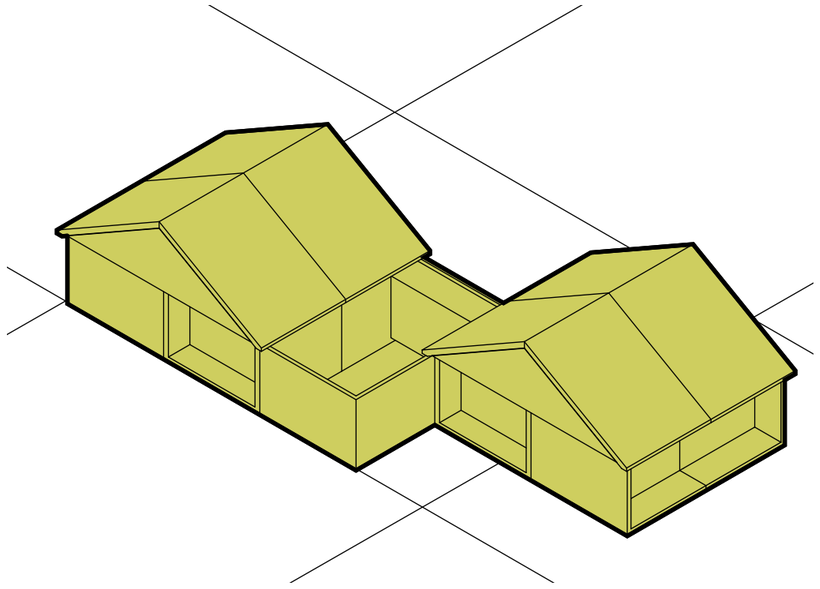
Redding, California
Desert / Semi-Arid / Hot Climate (forest fires, seismic)

Basic characteristics:

- No external wood inserts
- Compact massing
- Pitched tile/ceramic roof
- Insulated at inside
- Cross ventilation
- “Safe-room” area with crucial services (bathroom/kitchen/storage)

Challenges:

- Might look like a bunker
- No exposure of flammable details
- Fire prevention relies on site strategy and not just the structure



SITE 2

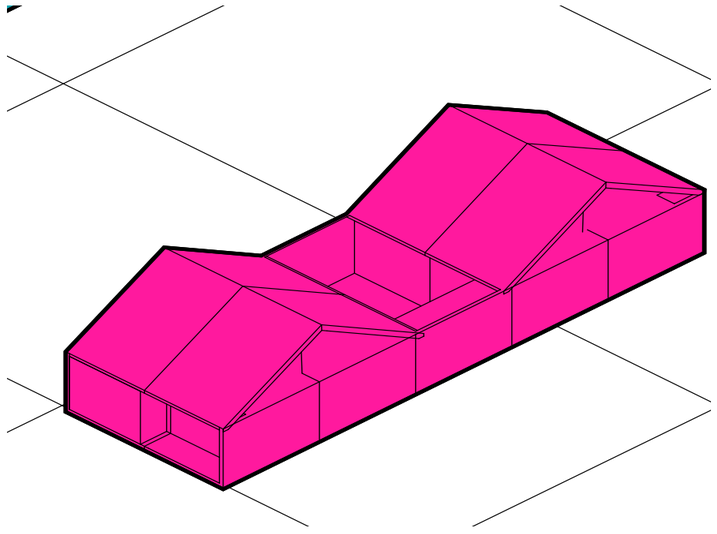
Tuscaloosa, Alabama
Temperate / Midwest Climate (tornadoes/high winds)

Basic characteristics:

- “Safe-room” area with crucial services (bathroom/kitchen/storage)
- Compact massing
- Lower pitch roof
- Courtyard
- Protected windows (i.e. shutters)

Challenges:

- Might look like a bunker
- Roof details that prevent dislocation of roof
- Wind force directions unpredictable



SITE 3

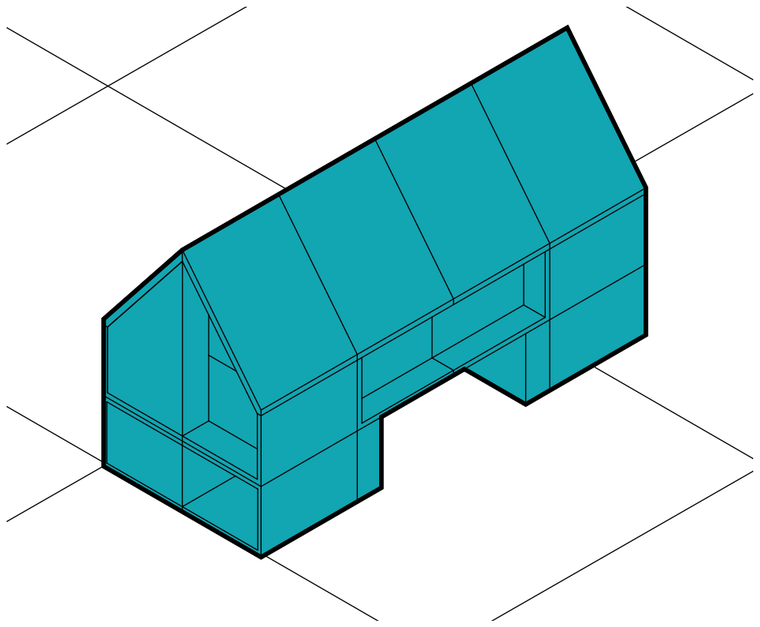
Tampa Bay Region, Florida
Humid / Subtropical Climate (flooding/hurricanes):

Basic characteristics:

- Main living area off ground
- Massing can be fragmented
- Protected windows (i.e. shutters)
- Areas of refuge (i.e. easy roof access)
- Cross ventilation
- Off ground storage areas

Challenges:

- Very little ground access for living areas
- Handicap accessibility is limited
- Details to ensure water shedding
- Minimize wood construction near ground



SITE 4

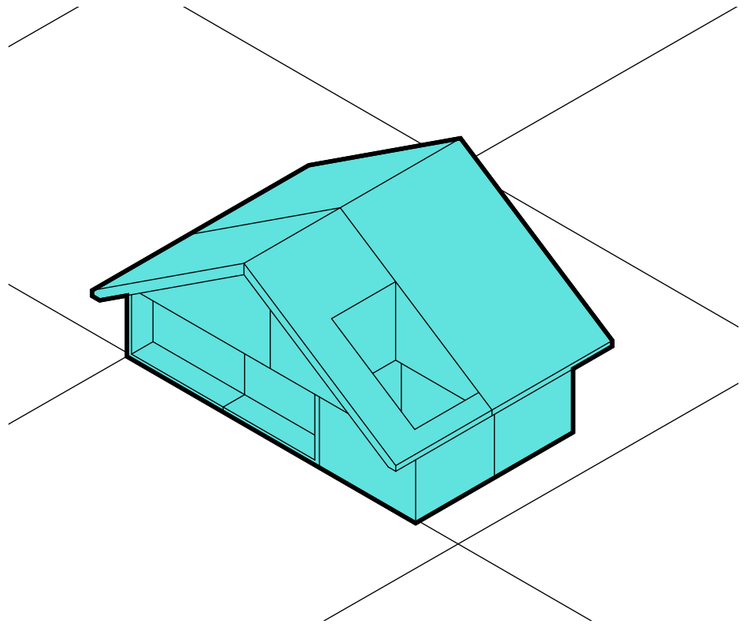
Syracuse, New York
Continental Cold Climate (freezing temperatures):

Basic characteristics:

- High external insulation
- Compact massing
- Cross ventilation (for humid summer)
- Details for roof (pitched or flat) to shed water/snow

Challenges:

- Shedding of rain and snow
- Snow loads
- Freeze / Thaw cycle

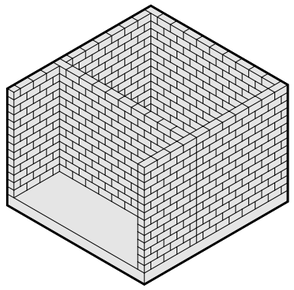


MODULE TYPOLOGY

MODULE CATALOG

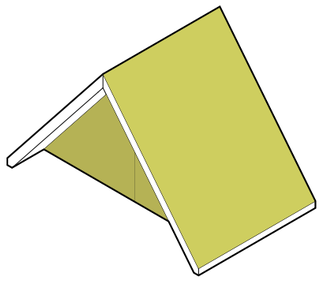
CMU ‘Structural/Spatial Modules’

CMU ‘Structural/Spatial’ Modules



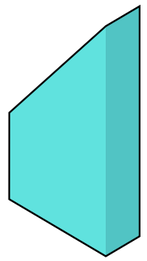
The load-bearing structure of all proposed projects consists of CMU and is formed by a series of pre-configured modules. While parts of these elements could be prefabricated they are intended to be modular ‘planning’ tools more than as constructive elements. The module exists as a base element that then is further detailed according to the climatic zone of the site. I.e. the exterior walls of these modules will be highly insulated in a cold climate, while in a warmer climate the insulation might be reduced or not needed at all.

Roof Modules

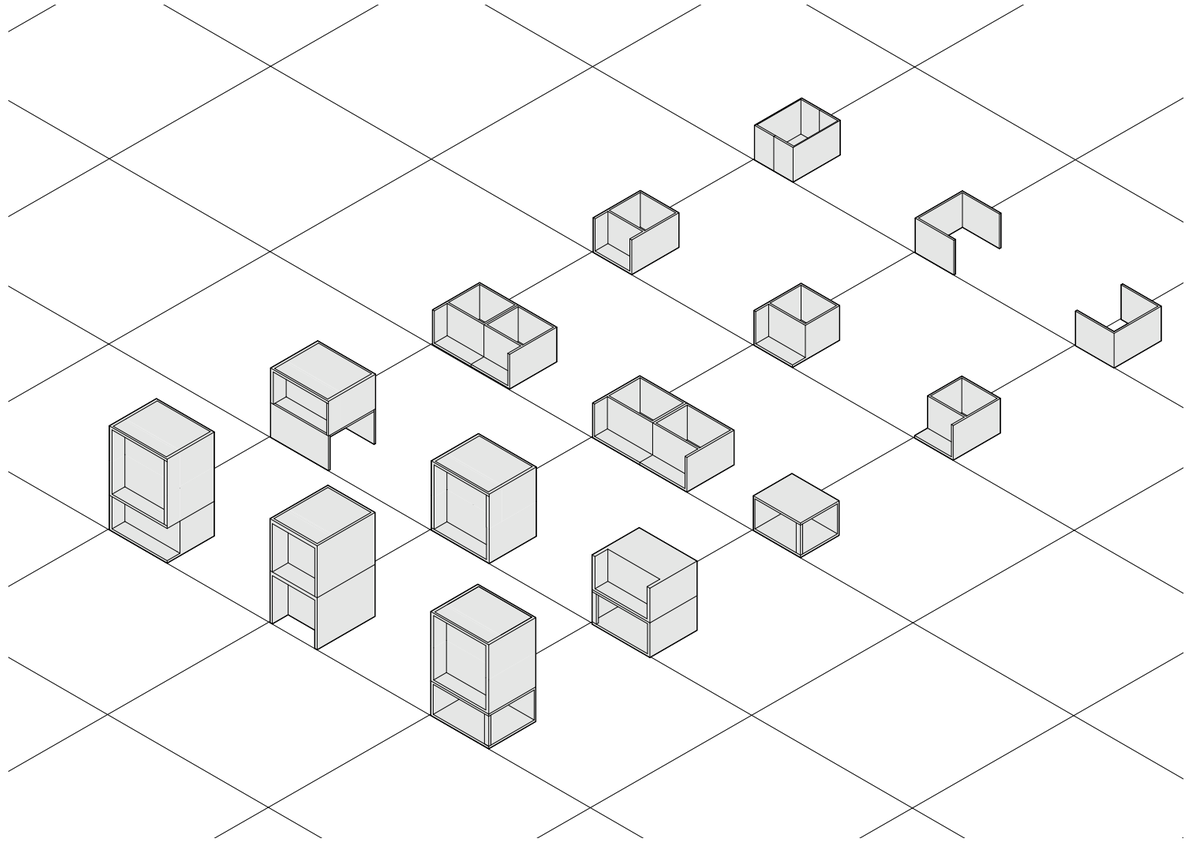


The CMU structure is capped by a series of pre-configured roof systems. These are constructed with typical wood frame construction. The construction details in Phase II will outline specific connections between the wood roof and the CMU wall construction. The highly insulted roofs will adapt to the individual needs of the site and climate the house(s) are in. Close attention will be made to accommodate issues of high winds, fires, etc. in terms of how to detail and materialize the roof systems.

Functional Wood Inserts



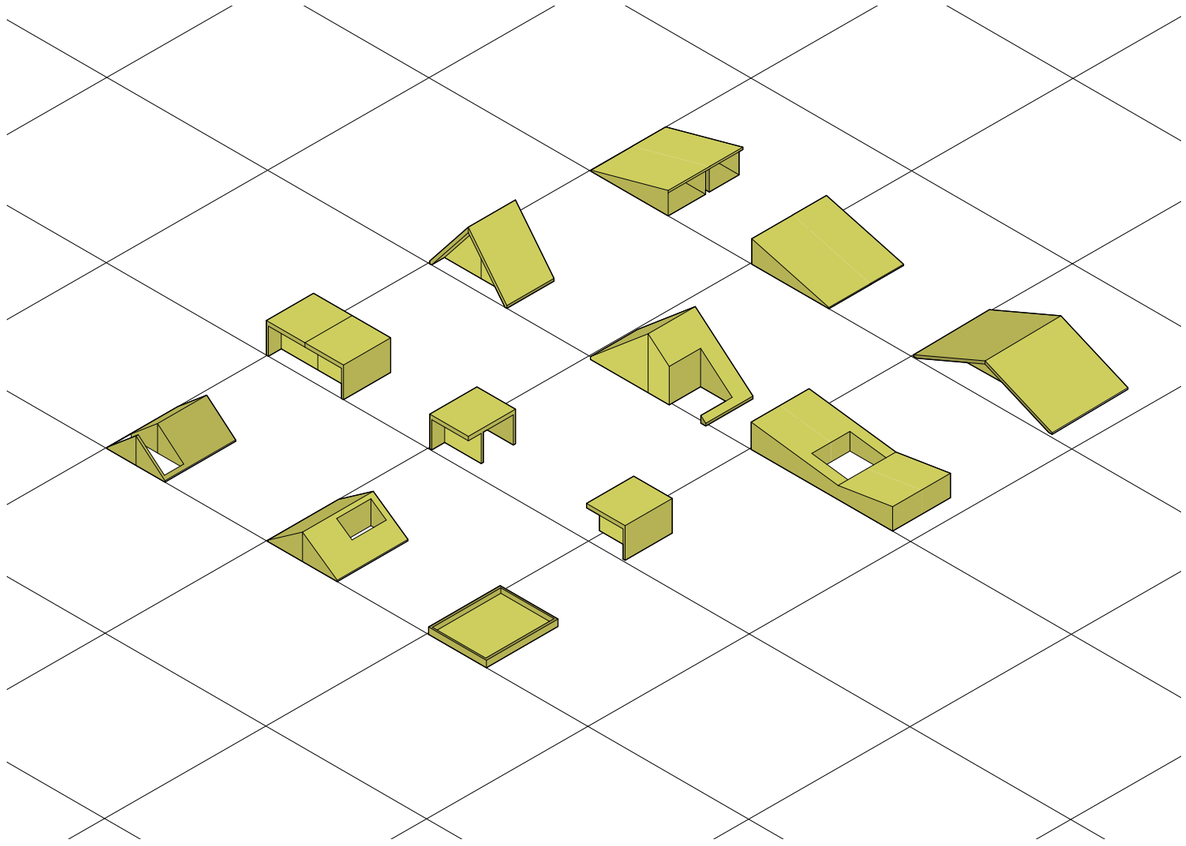
In addition to the load bearing walls, and roof modules the system is supplemented by a series of “soft” wood structure insert modules that are typically placed within porches or balconies or serve as cores with utilities. These Inserts allow for additional exterior storage space and contribute to the composition of the exterior of the houses and the spatial and functional organization in the inside of the house. The external spaces are not insulated and clad in a variety of materials (i.e. wood siding, cement board, shingles, etc.).



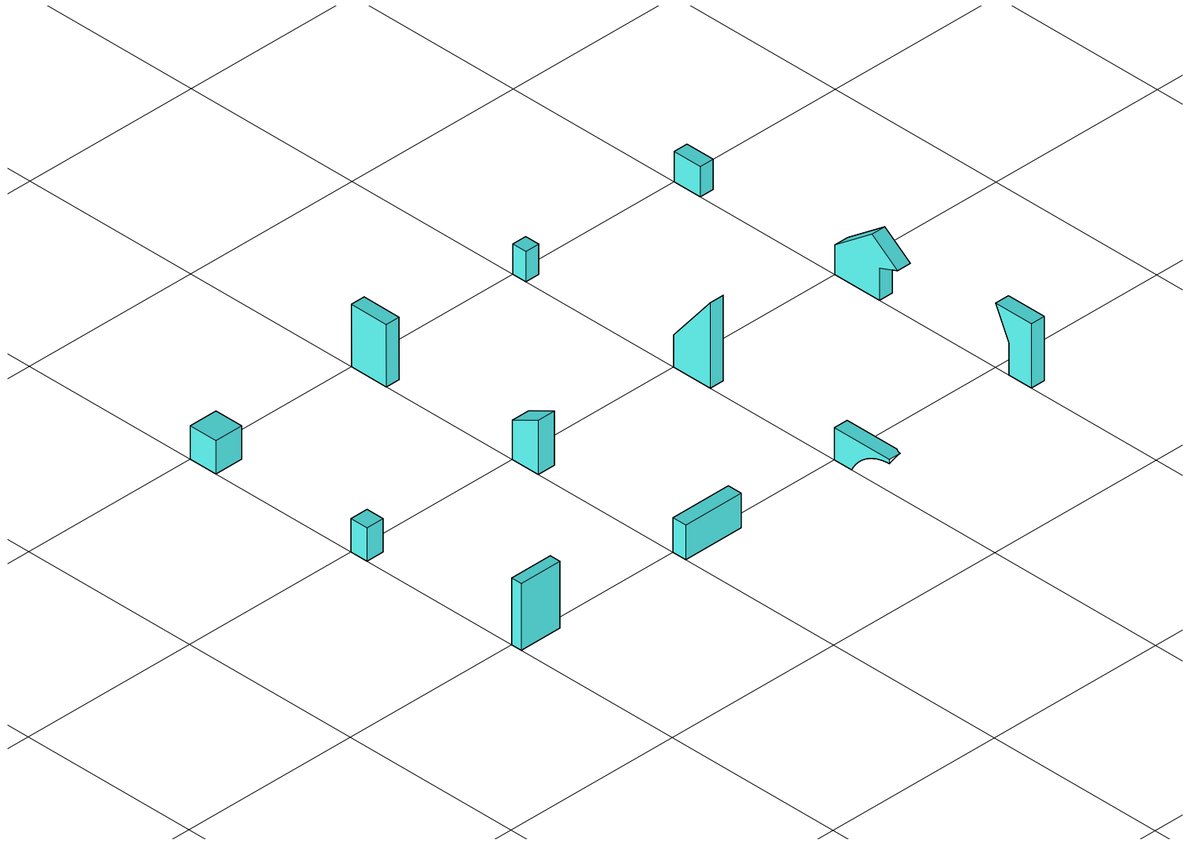
CMU ‘Structural/Spatial’ Module Catalog

MODULE TYPOLOGY

MODULE CATALOG



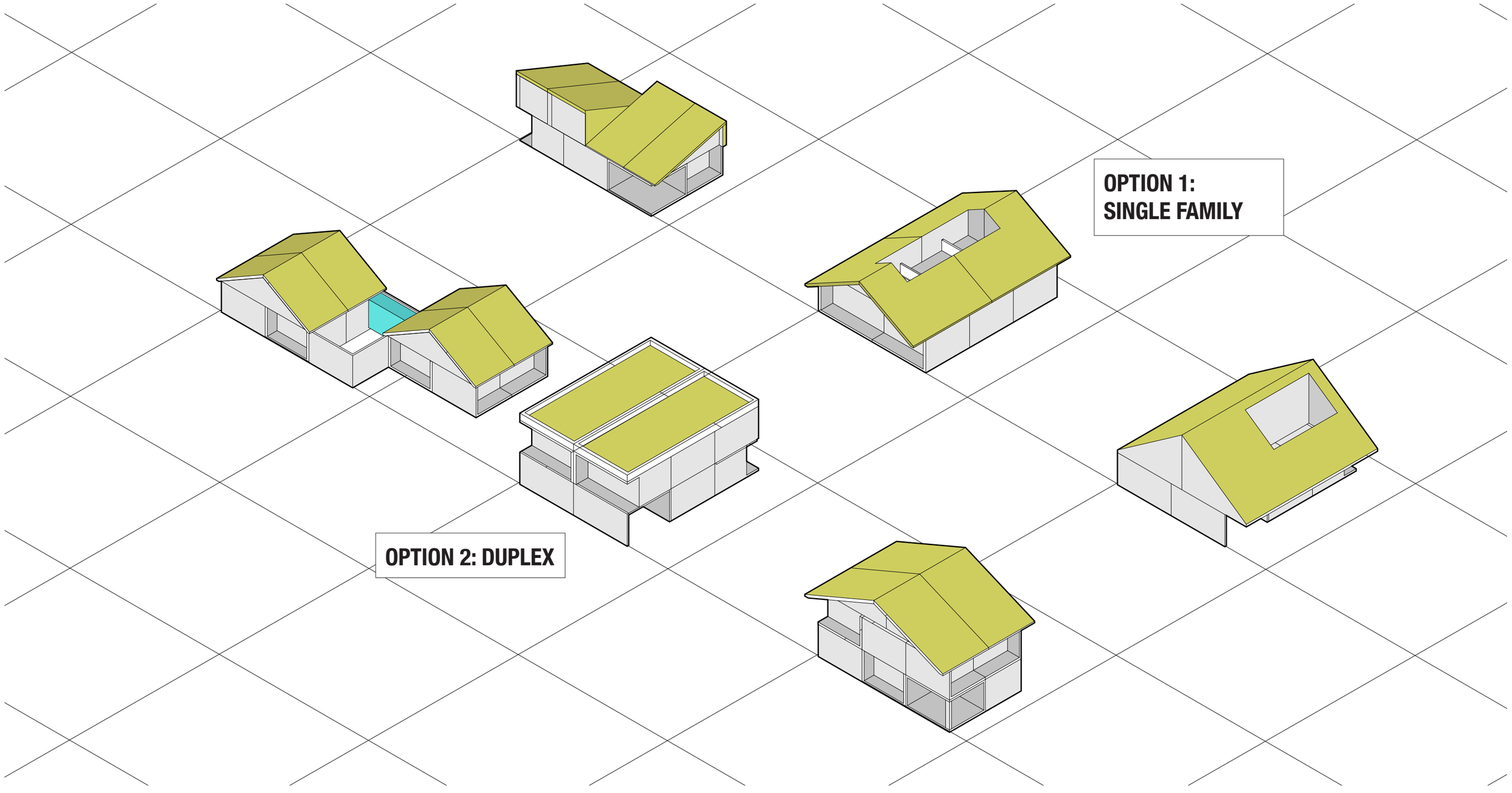
Roof Module Catalog



Functional Wood Inserts Catalog

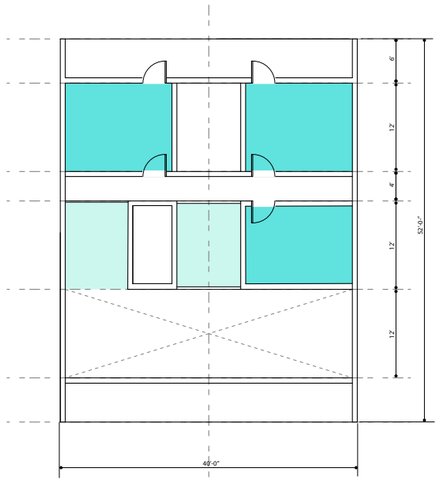
PRELIMINARY PROJECT IDEAS

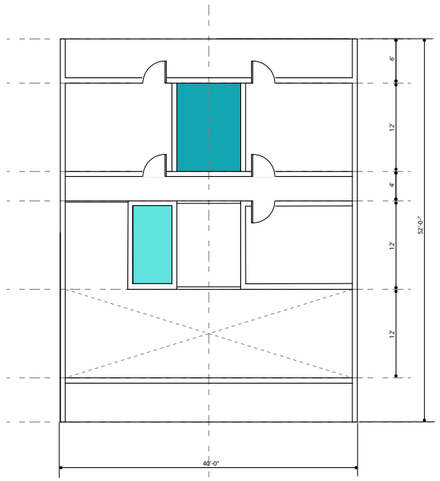
MASSING STUDIES SITE 1, REDDING, CA

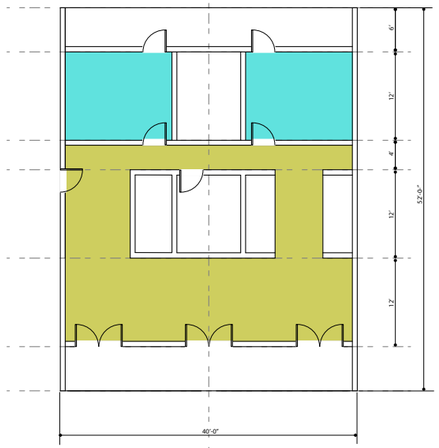


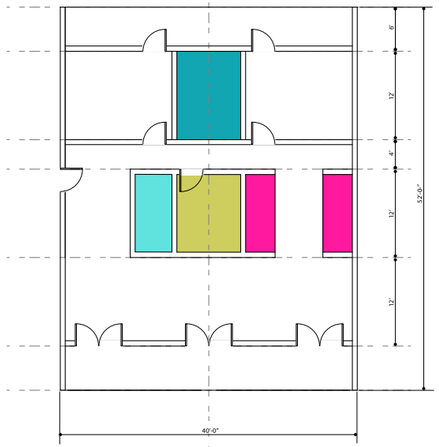
PRELIMINARY PROJECT IDEAS

SITE 1 - PLANS



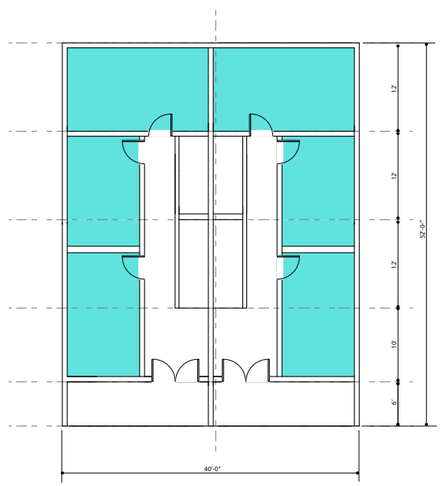


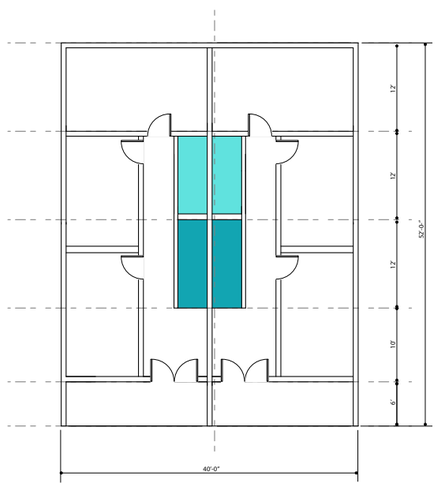


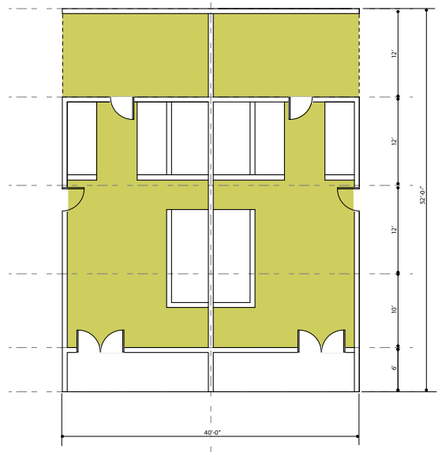


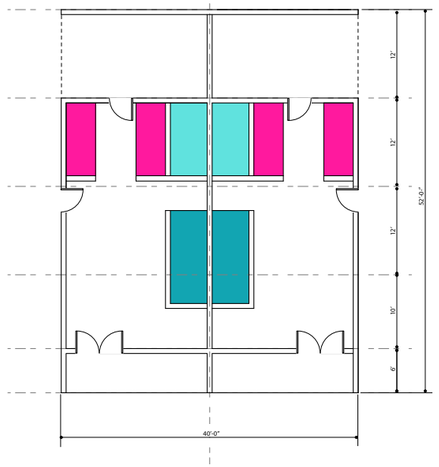
PUBLIC
PRIVATE
STAIR
BATH
SAFE ROOM
KITCHEN

OPTION 1: SINGLE FAMILY



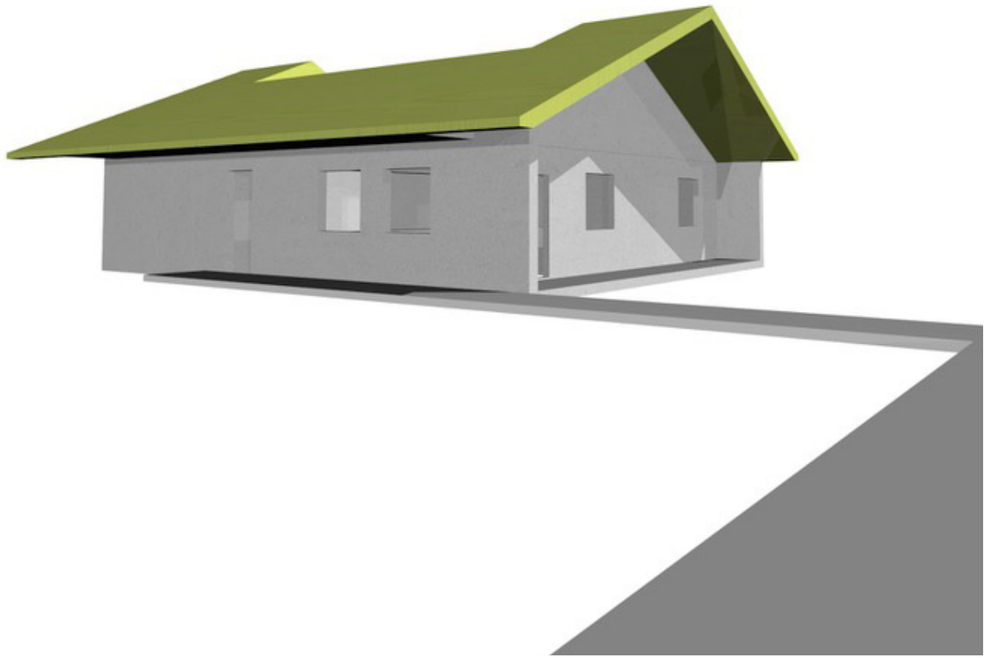


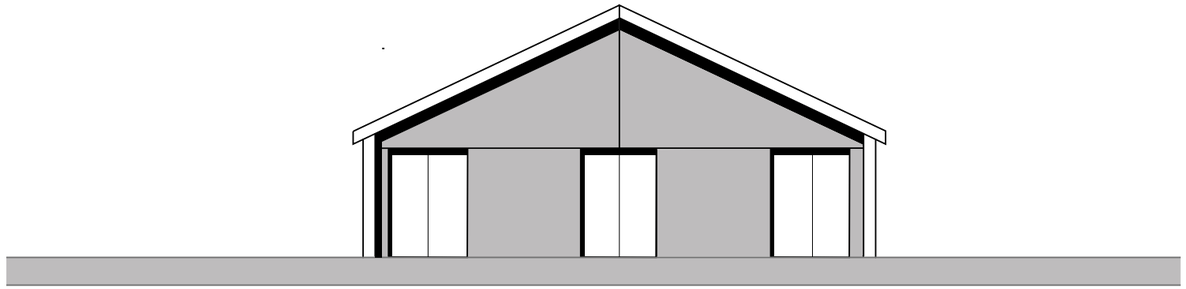




PUBLIC
PRIVATE
STAIR
BATH
KITCHEN

OPTION 2: DUPLEX

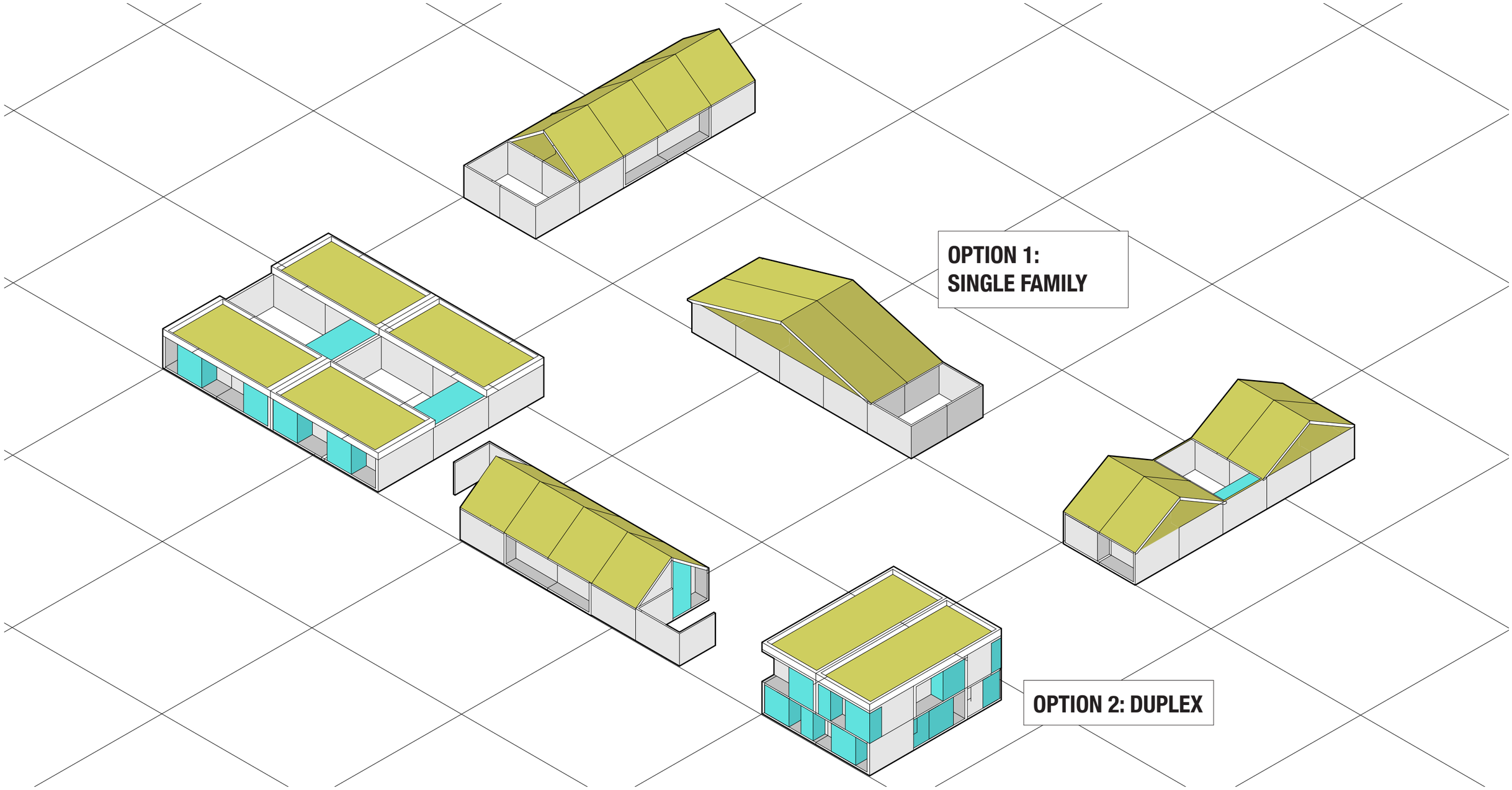




OPTION 1: SINGLE FAMILY - PERSPECTIVE, SECTION, ELEVATION

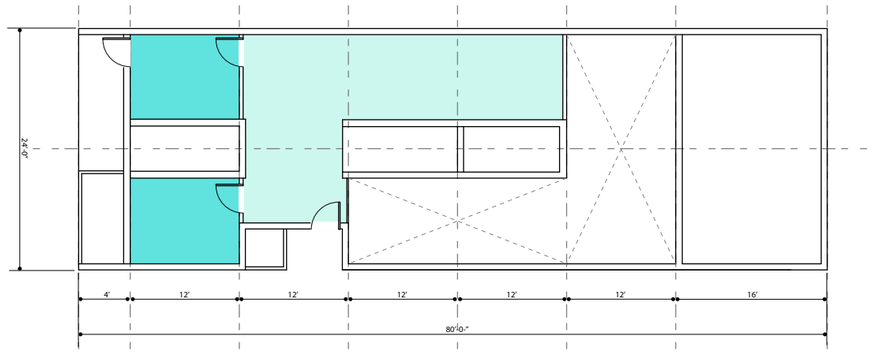
PRELIMINARY PROJECT IDEAS

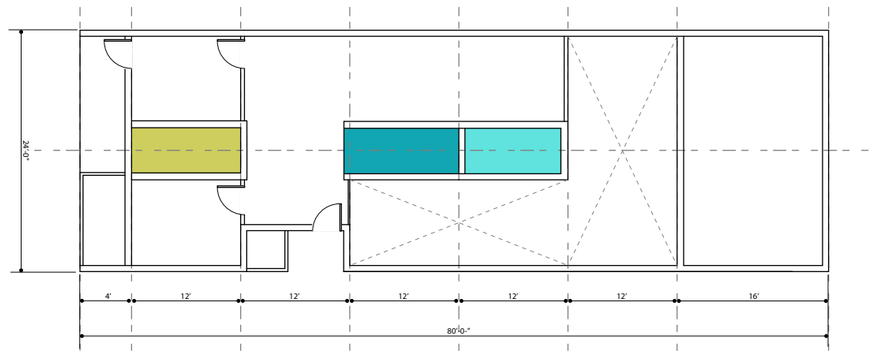
MASSING STUDIES SITE 2, TUSCALOOSA, AL

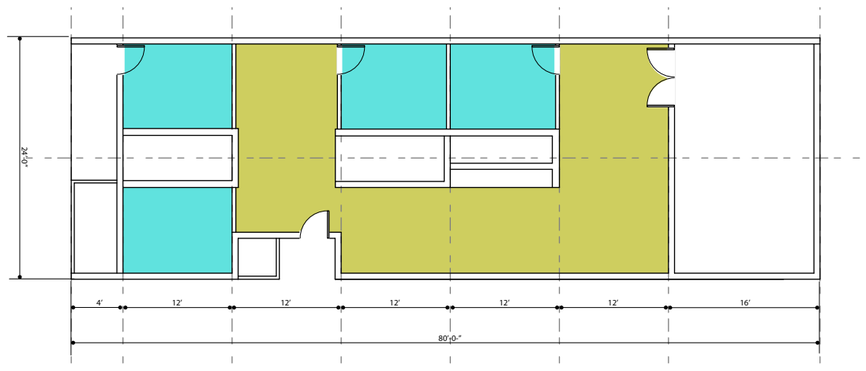


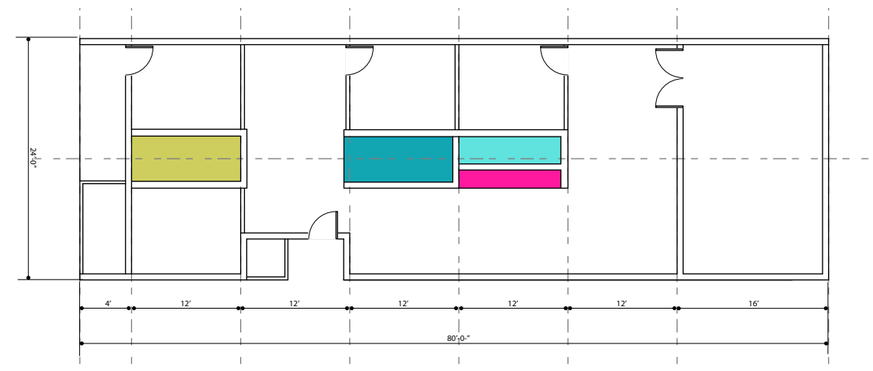
PRELIMINARY PROJECT IDEAS

SITE 2 - PLANS









PUBLIC

PRIVATE

STAIR

BATH

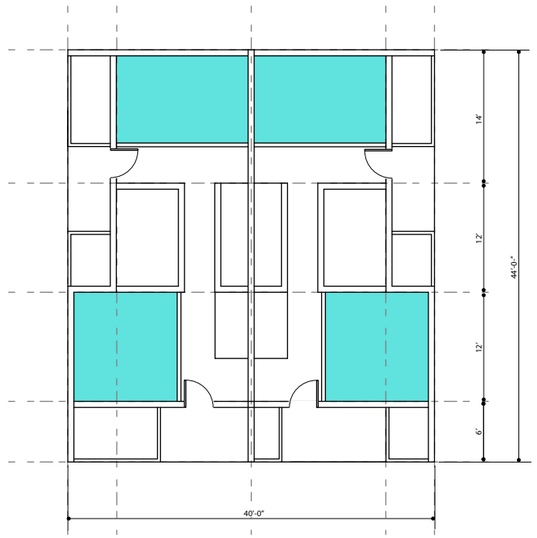
SAFE ROOM

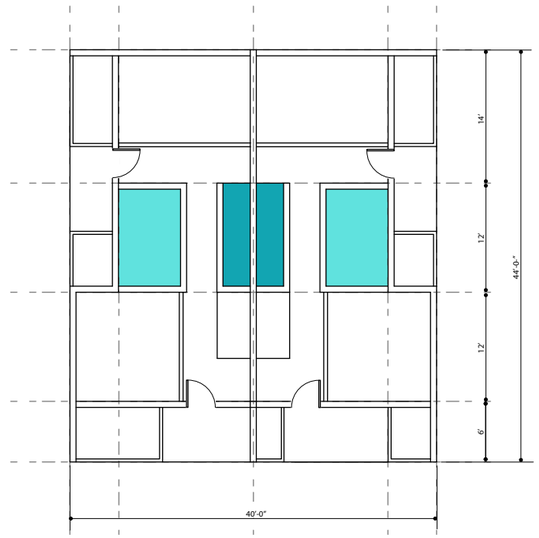
KITCHEN

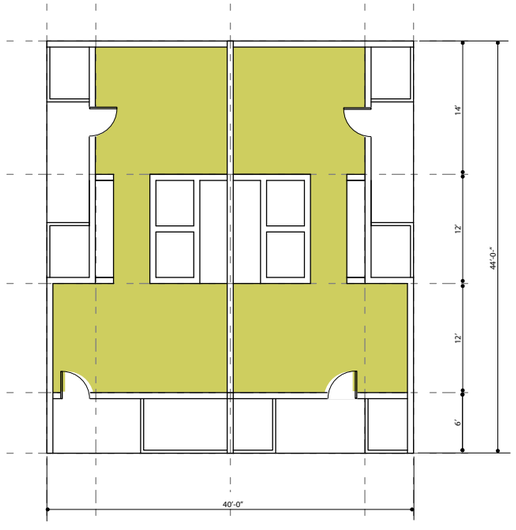
OPTION 1: SINGLE FAMILY

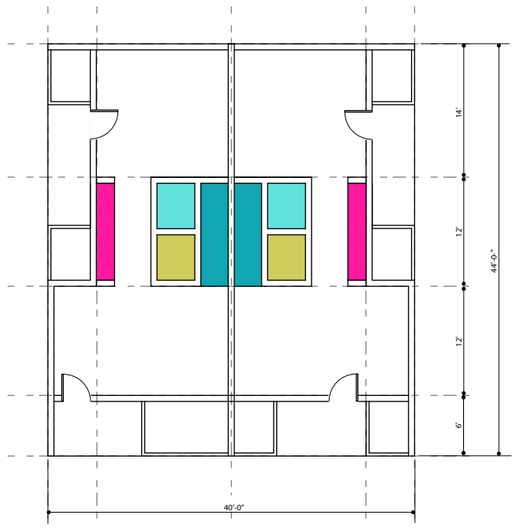
PRELIMINARY PROJECT IDEAS

SITE 2 - PLANS









PUBLIC

PRIVATE

STAIR

BATH

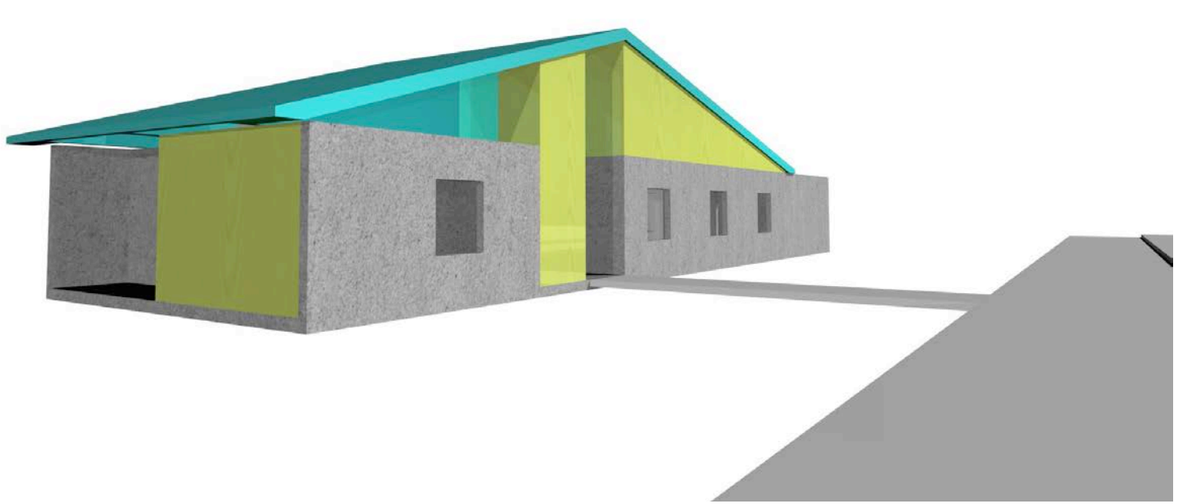
SAFE ROOM

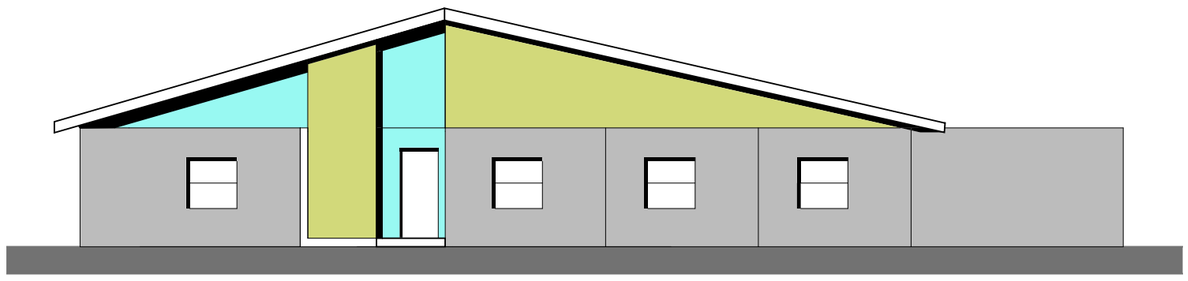
KITCHEN

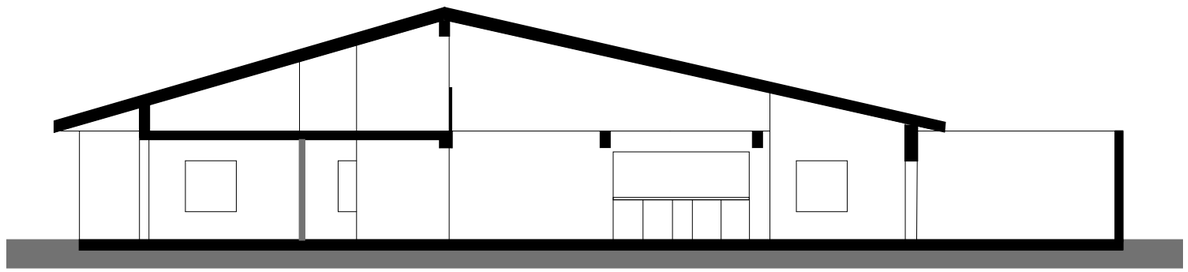
OPTION 2: DUPLEX

PRELIMINARY PROJECT IDEAS

SITE 2 - PERSPECTIVE, ELEVATION, SECTION



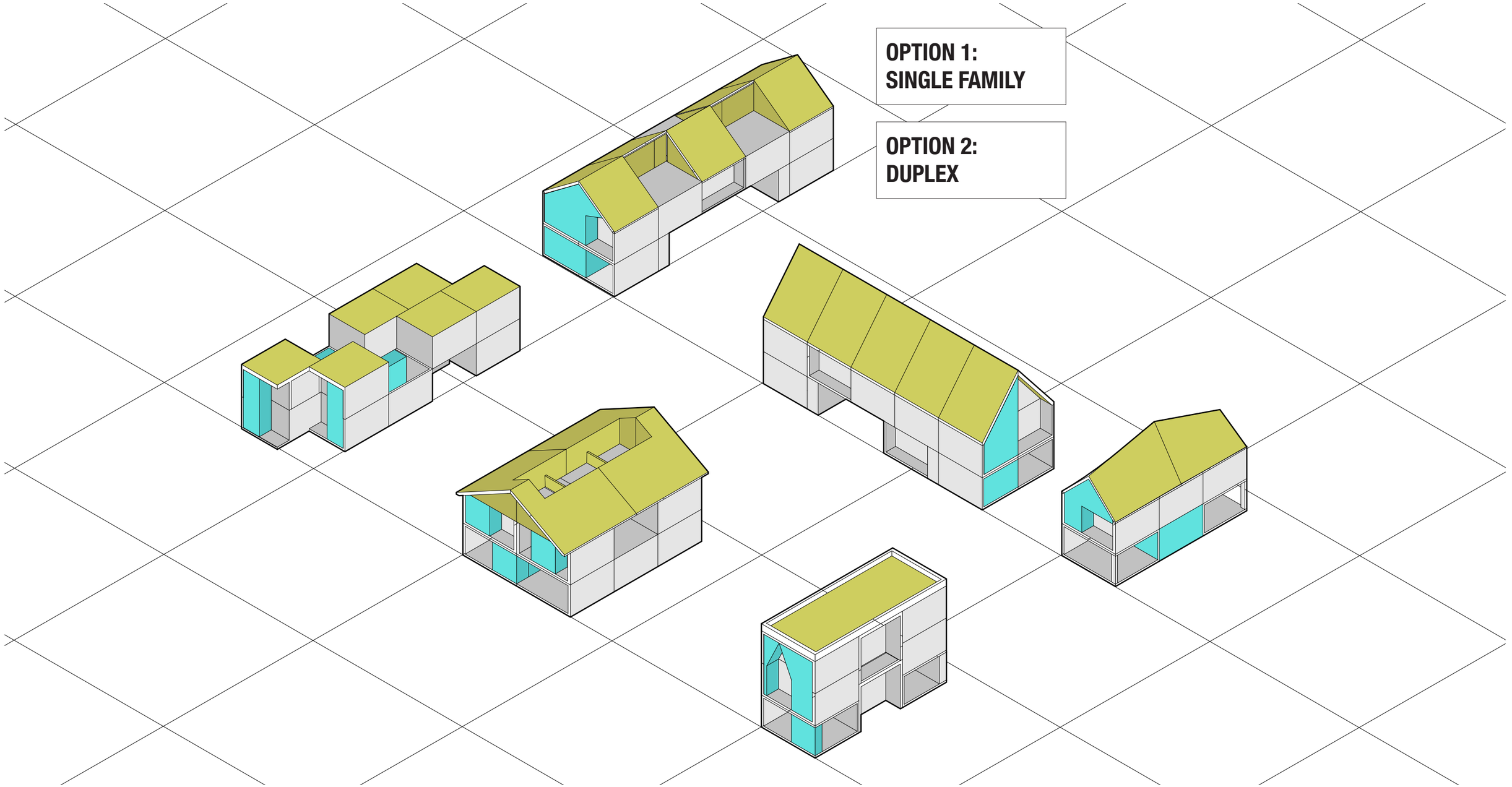




OPTION 1: SINGLE FAMILY - PERSPECTIVE, SECTION, ELEVATION

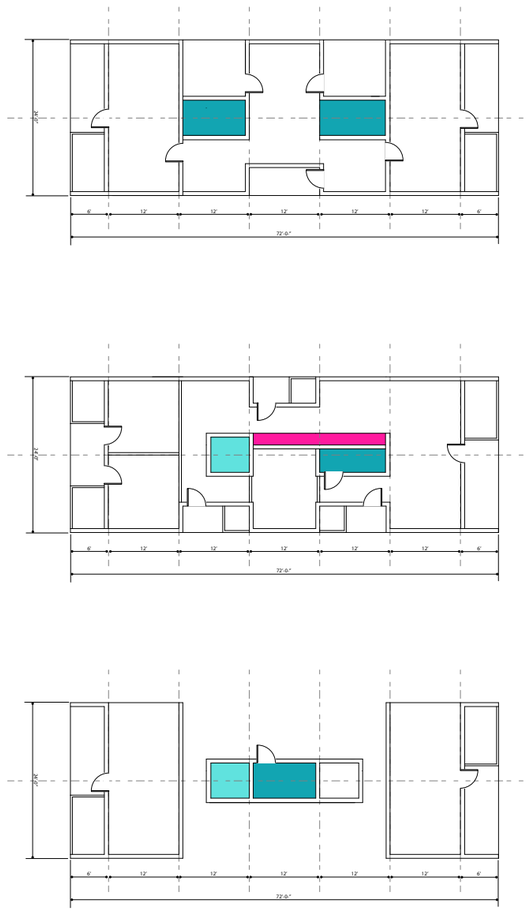
PRELIMINARY PROJECT IDEAS

MASSING STUDIES SITE 3, TAMPA BAY REGION, FL



PRELIMINARY PROJECT IDEAS

SITE 3 - PLANS



PUBLIC

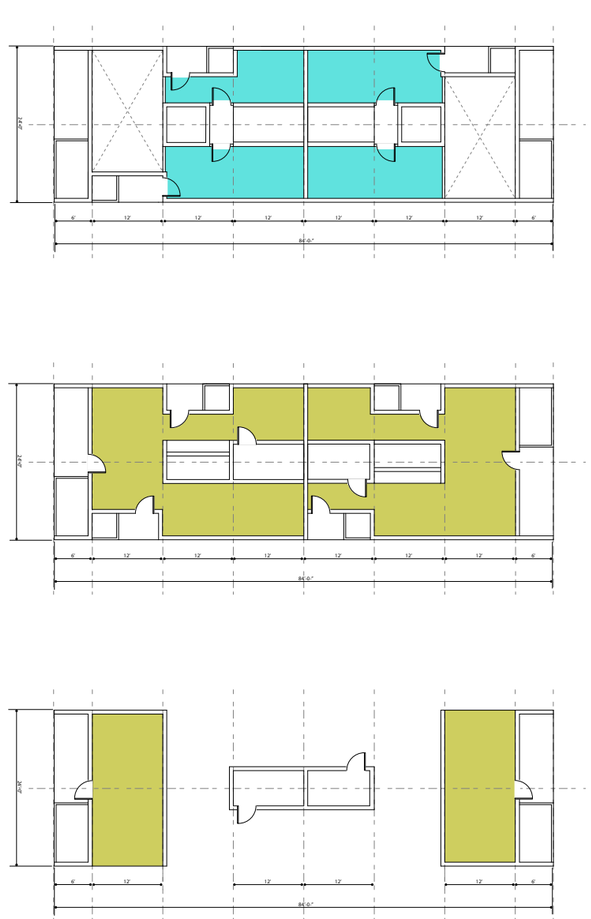
PRIVATE

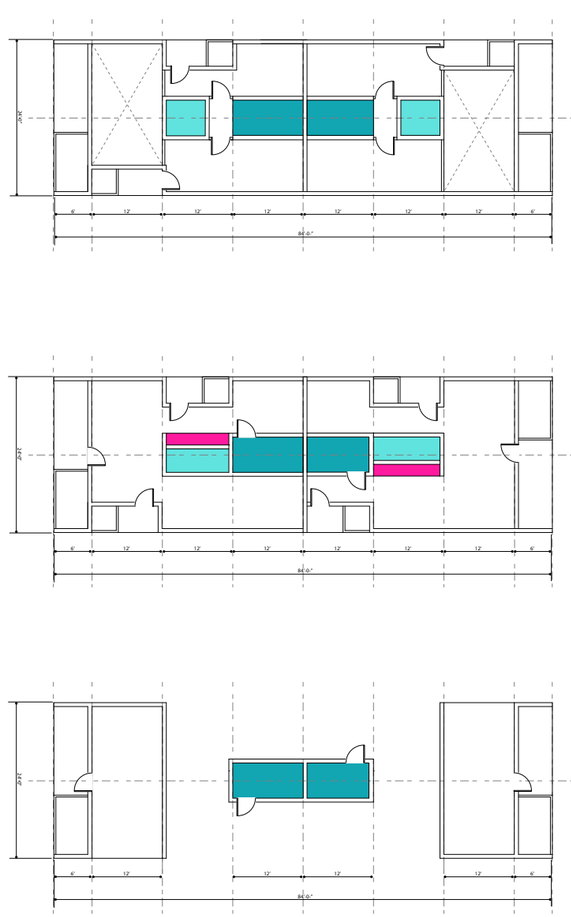
STAIR

BATH

KITCHEN

OPTION 1: SINGLE FAMILY





PUBLIC

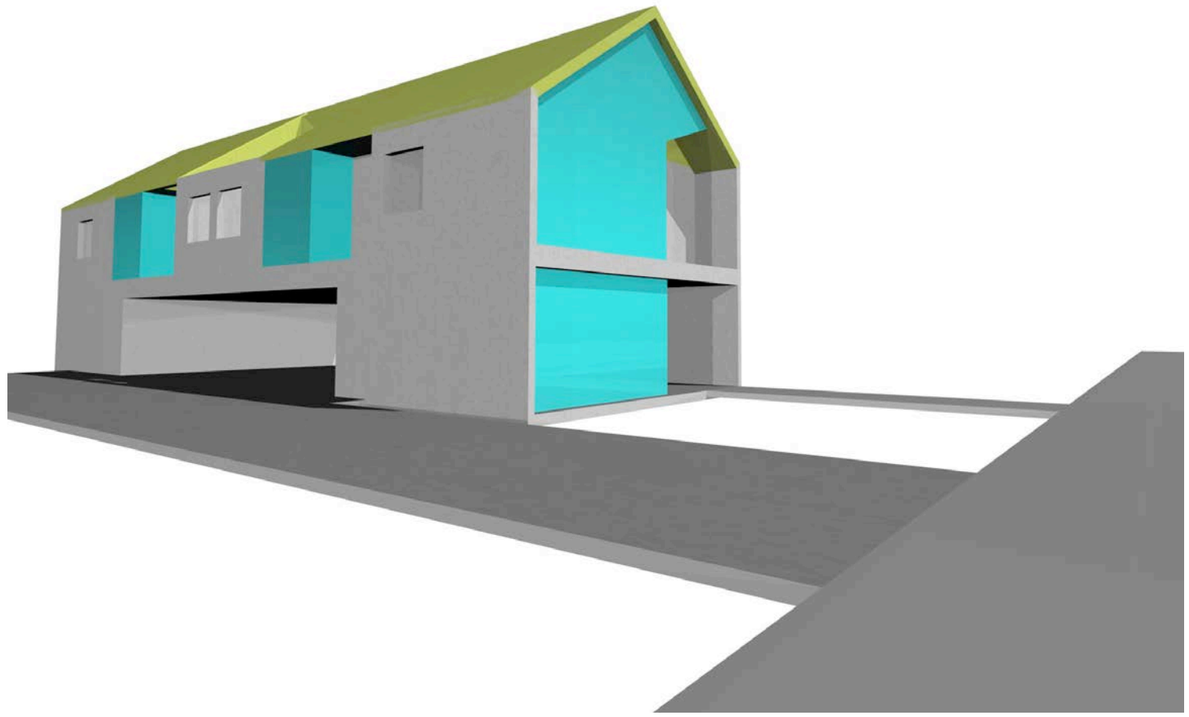
PRIVATE

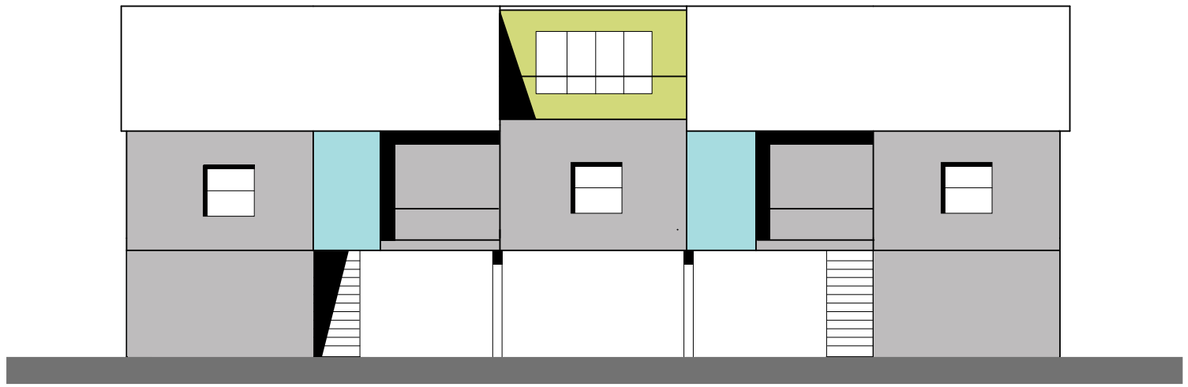
STAIR

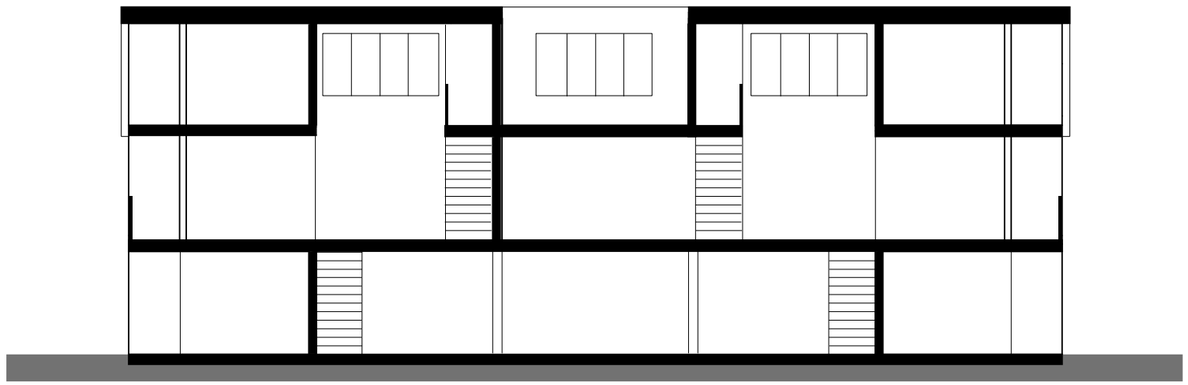
BATH

KITCHEN

OPTION 2: DUPLEX



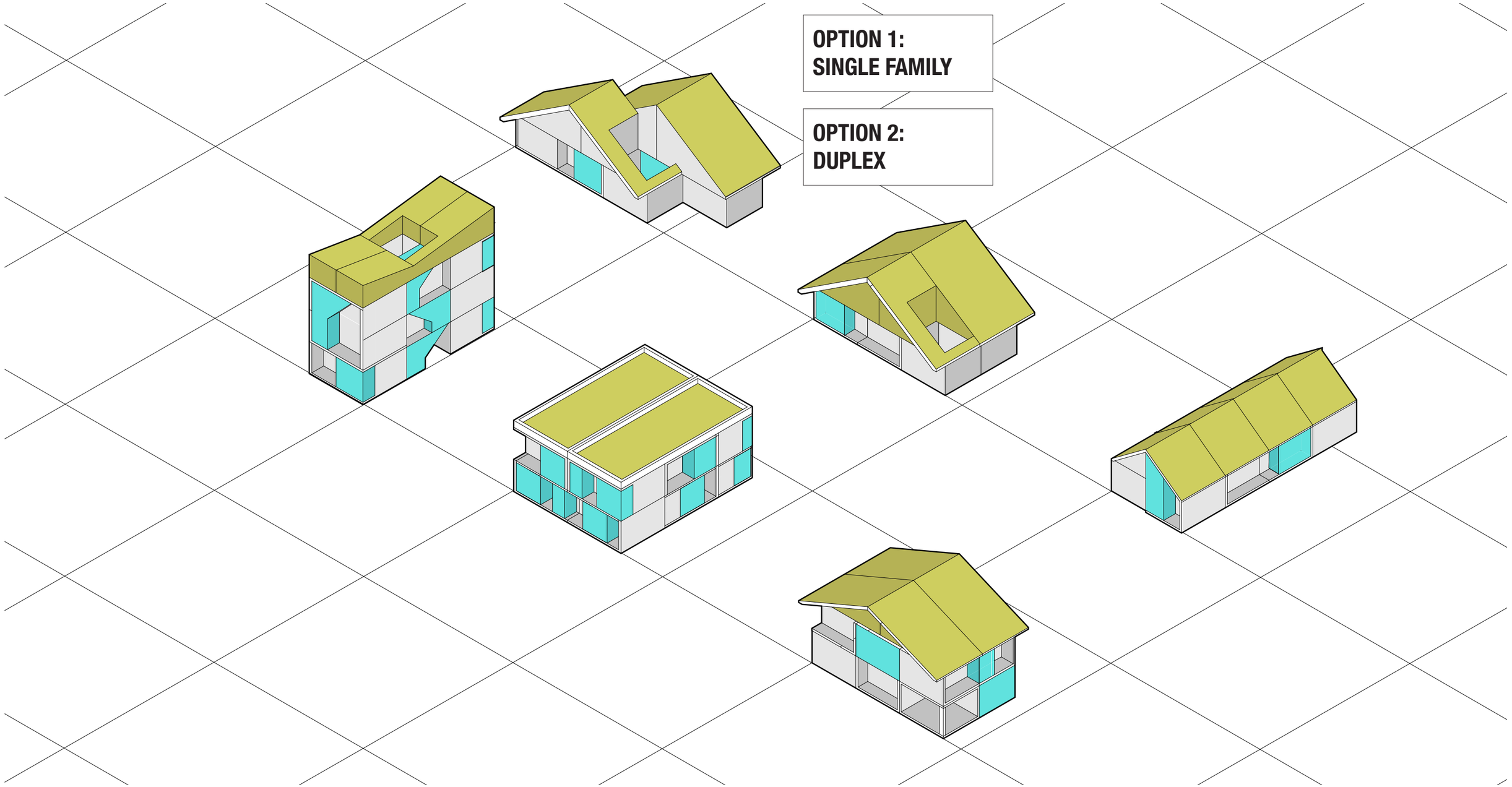




OPTION 2: DUPLEX - PERSPECTIVE, SECTION, ELEVATION

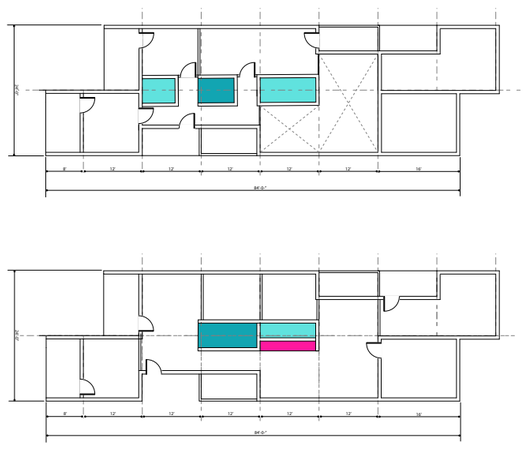
PRELIMINARY PROJECT IDEAS

MASSING STUDIES SITE 4, SYRACUSE, NY



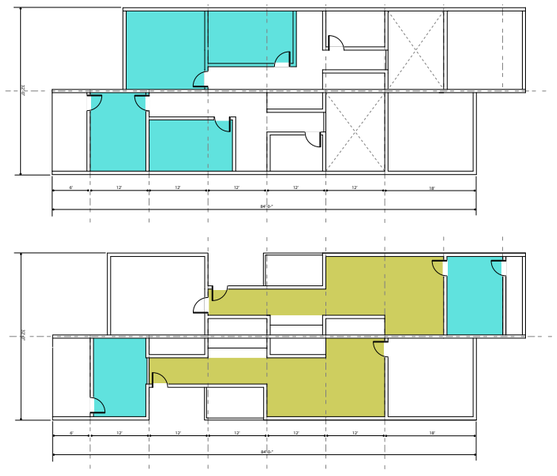
PRELIMINARY PROJECT IDEAS

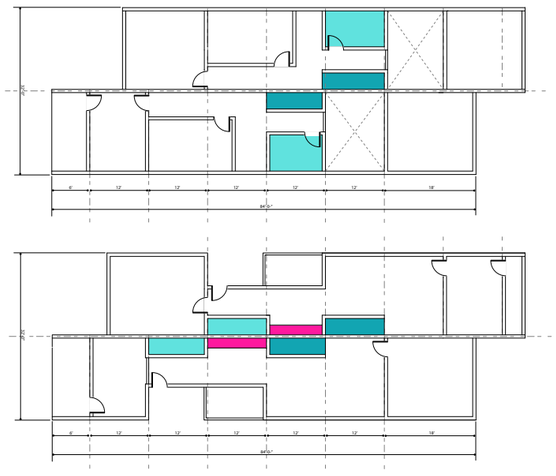
SITE 4 - PLANS



PUBLIC
PRIVATE
STAIR
BATH
KITCHEN

OPTION 1: SINGLE FAMILY



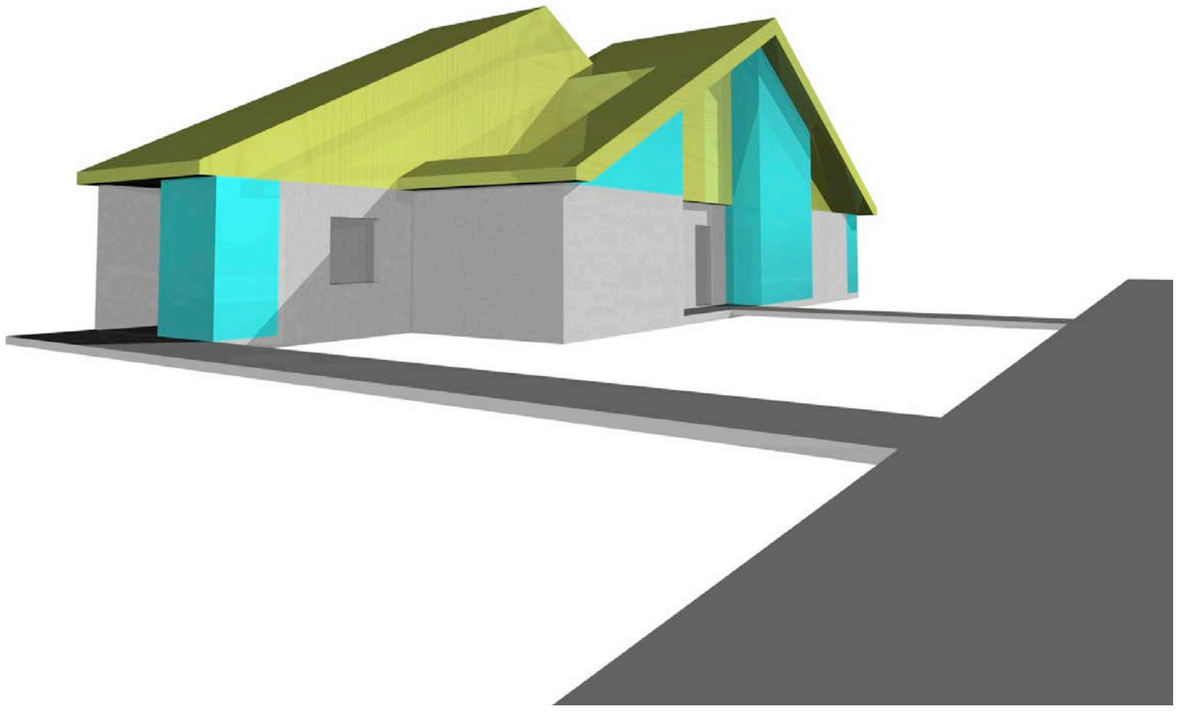


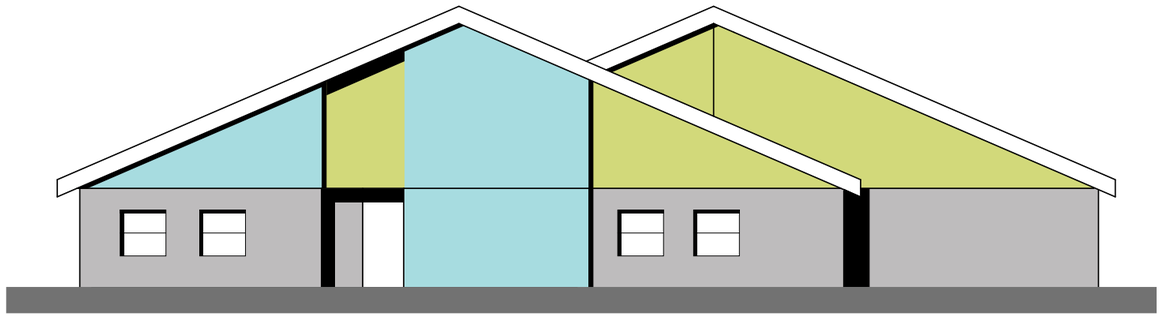
PUBLIC
PRIVATE
STAIR
BATH
KITCHEN

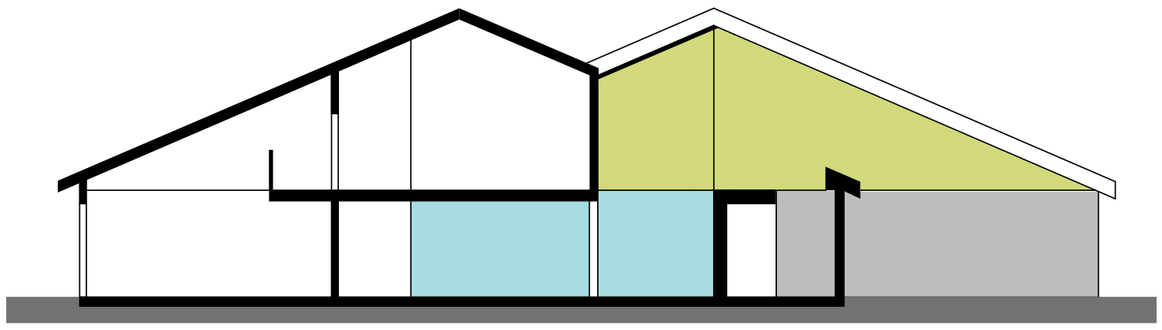
OPTION 2: DUPLEX

PRELIMINARY PROJECT IDEAS

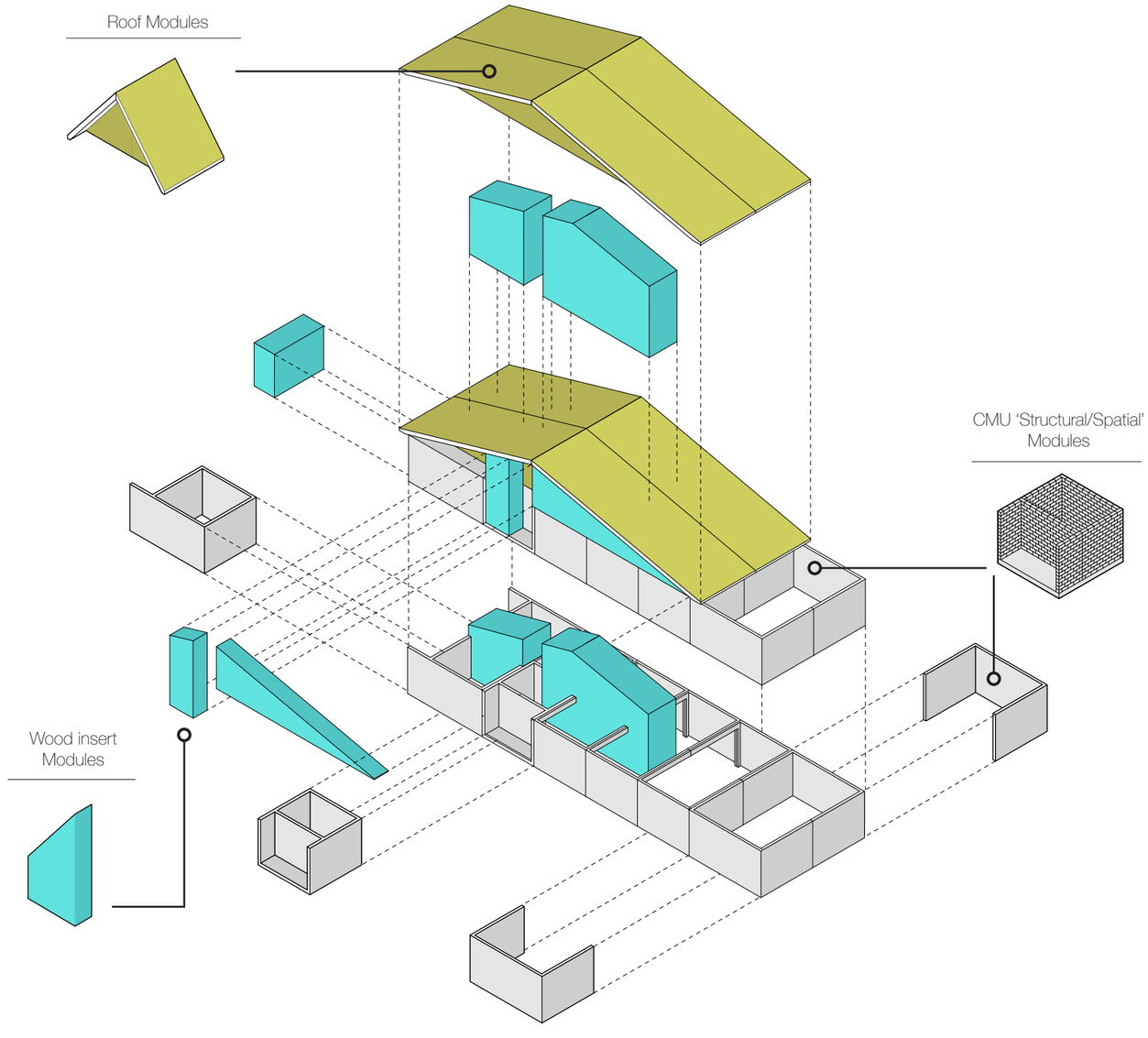
SITE 4 - PERSPECTIVE, ELEVATION, SECTION



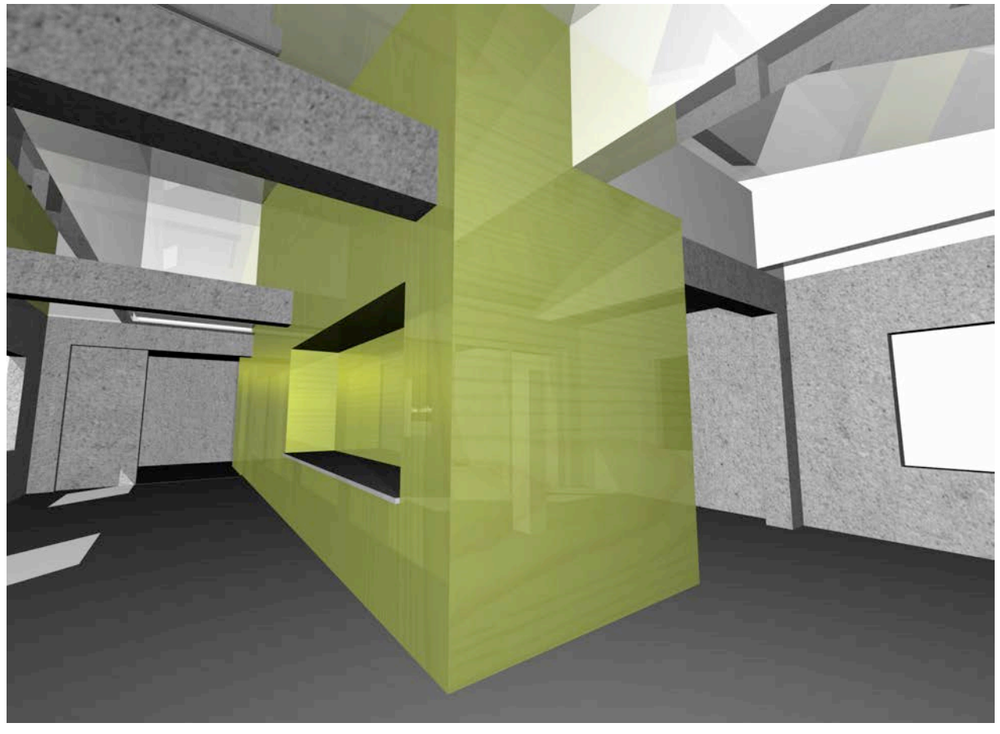




OPTION 1: SINGLE FAMILY - PERSPECTIVE, SECTION, ELEVATION



TYPICAL MODULAR SYSTEM



TYPICAL INTERIOR UTILITY CORE INSERT

PRELIMINARY PROJECT IDEAS

ASSEMBLY & CONSTRUCTION DETAILS

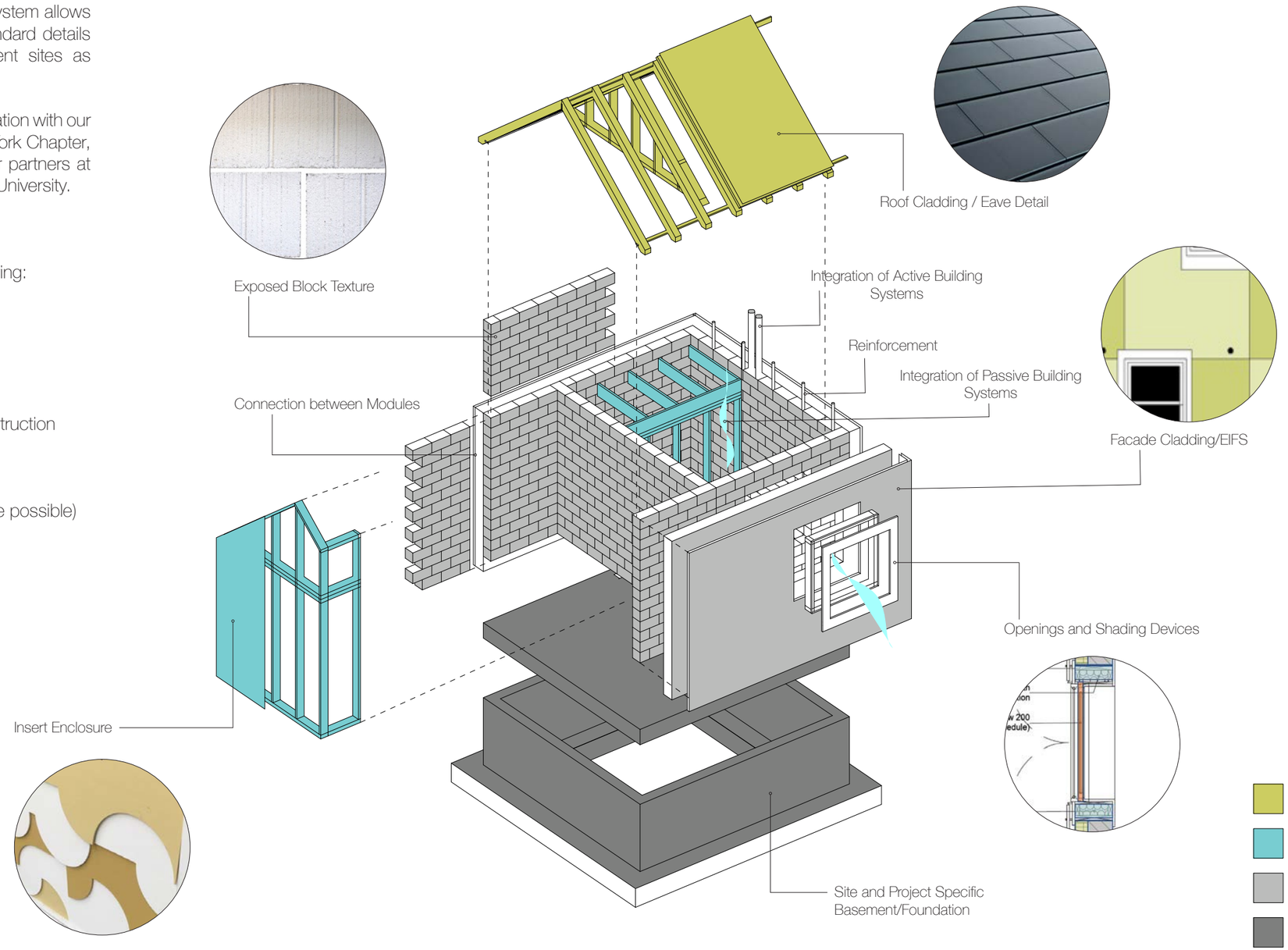
The development of the details will be a main focus in Phase 2 of the grant. The modular system allows for the development of a series of standard details that each can be adapted for different sites as outlined above.

The details will be developed in collaboration with our grant partners at MCAA Upstate New York Chapter, the structural engineers, as well as our partners at the School of Engineering at Syracuse University.

The details will be developed in BIM.

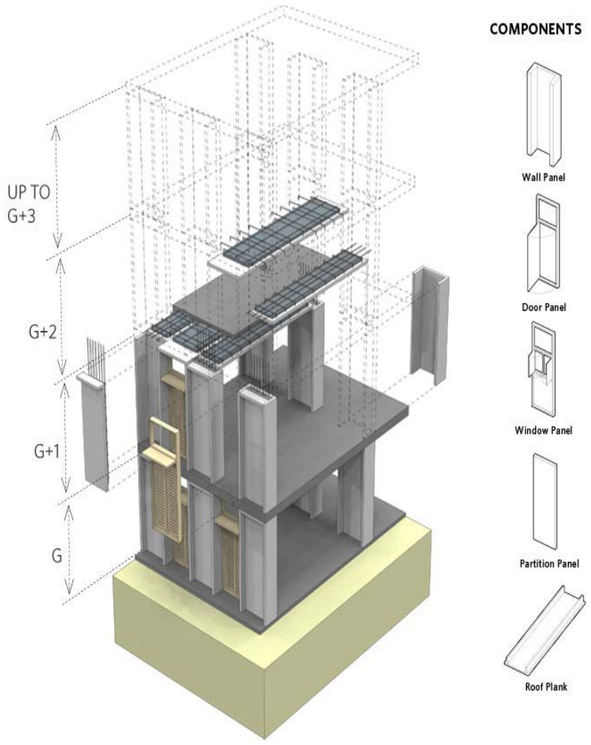
Main attention will be given to the following:

- Connection between modules
- Quality/Durability of materiality
- Ease of assembly
- Coherent Aesthetic
- Availability of Material
- Maximizing the benefits of Mass Construction
- Recyclability of assembly
- Energy conservation
- Passive energy systems
- Minimal mechanical technology (where possible)
- Affordability

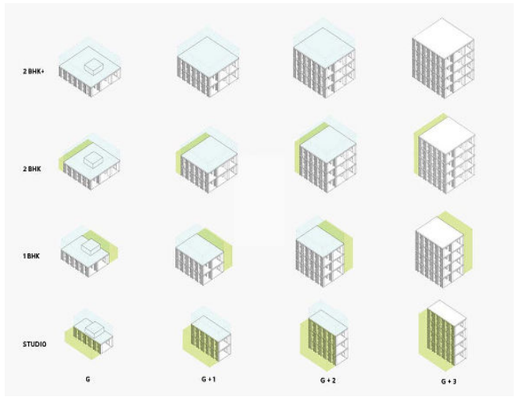


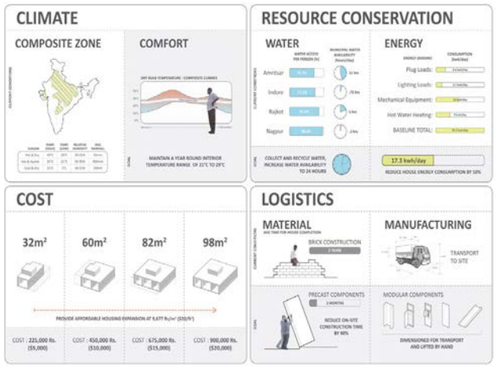
PROJECT OUTLOOK AND NEXT STEPS

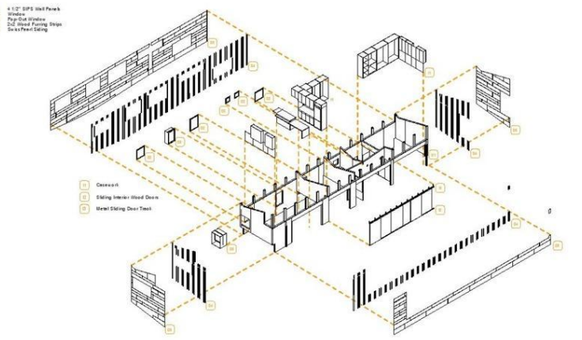
PRECEDENTS AND AIMS



Ideal Choice Homes, Kieren Timberlake Architects







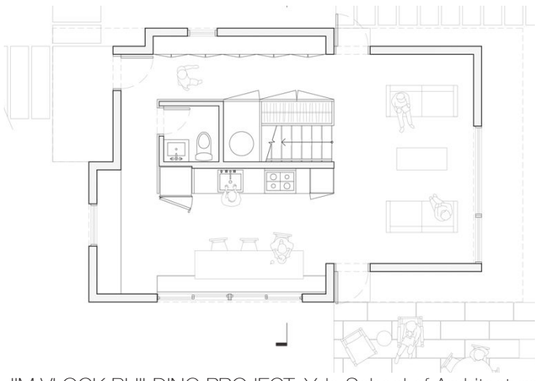
Float House - Make It Right, Morphosis Architects

MODULARITY AS SYSTEM - The goal of the next phase is to develop the toolbox + manual from the level of 'conceptual modularity' where the system is applicable in many different configurations and sites, to defining the constructive details that can be applied universally or specifically in different regions. Taking cues from Ideal Choice Homes by Kieren Timberlake, their modularity allows for the project to conceptually expand to suit different needs and users as well as allow the house to adapt to many different climates and sites. We would like to approach the manual and toolbox to provide clear assembly and details that can be adapted to different users and applied to the different regions outlined on page 23. We will comprehensively develop the modules as shown above (upper right drawing) to show how they can expand to different sites configurations and densities. We will also use construction drawings, as shown in the upper left axonometric drawing, to outline assembly of parts and to demarcate clear layers of materials. This will serve as the Basis for a larger BIM model that allows to reconfigure these elements and uses the Plug-In for CMU construction.

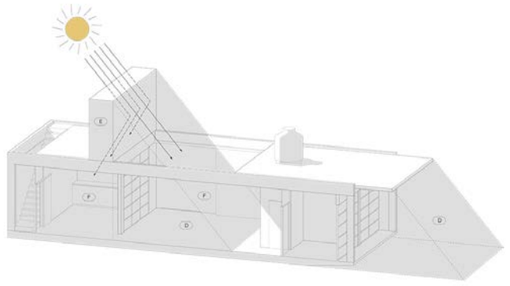
ASSEMBLY AND INTEGRATION - We will further develop the toolbox using Ideal Choice Homes and Float House as case studies for clear integration of systems, environmental analysis, assembly and logistics, as well as costs. The innovative base of Float House, or the "chassis," integrates all mechanical, electrical, plumbing and sustainable systems, while also providing a secure floating surface in case of flooding. This system of assembly is beneficial to thinking holistically about all the systems that will need to be integrated into the house design. Ideal Choice Homes also is a clear case study to reference ways for the manual to be developed and become a useful tool when developing the house holistically from planning to implementation. Focus will also be given to how these assemblies can be designed to be done in the context of a living class room that includes apprentices as much as volunteer labor.

PROJECT OUTLOOK AND NEXT STEPS

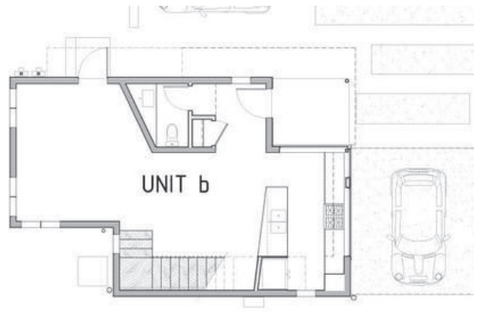
PRECEDENTS AND AIMS



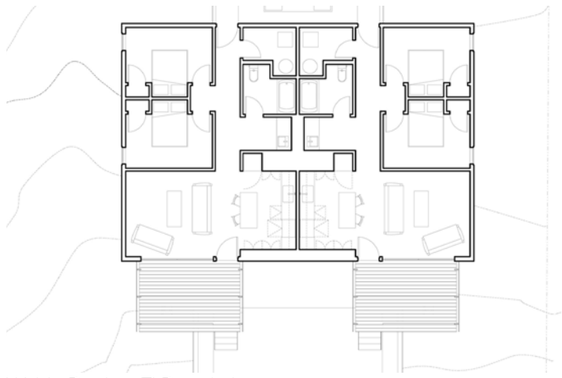
JIM VLOCK BUILDING PROJECT, Yale School of Architecture



APAN, RNThomsen ARCHITECTURE



Moonlight Duplex, Salas Design Workshop



Waldo Duplex, El Dorado Inc.

DENSITY AND COMPACT PLANNING - We will further develop the toolbox and house designs with the intention to create a clear assembly using a modest material palette that can be explored for its full potential. Similarly to the APAN project (above right), the simple plan was effective in section to maximize natural ventilation and daylighting. The core of the Jim Vlock House is a clear precedent as to how to create a dense core that houses all utilities (plumbing, electrical, HVAC, etc.). The cores can also be a clear spatial marker for the houses with a distinct volume that houses the kitchen, bath and stair. We intend to take these precedents, along with the Ideal Homes project (previous page) and use them to develop the toolbox from the interior outwards; from the overall framework of the unit composition to the details and constructibility to create a modular planning systems that allows the development of compact, affordable houses at multiple scales and sizes.

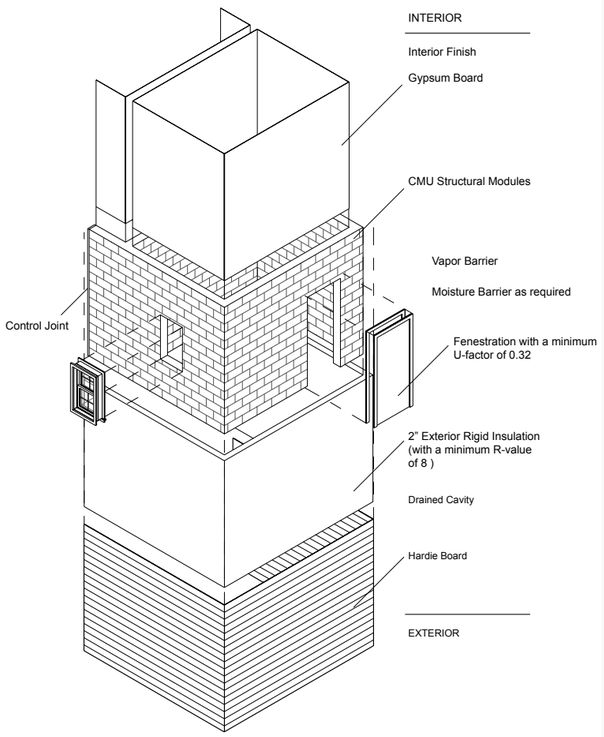
MULTI-FAMILY / DUPLEX HOUSING - Since we are developing housing units for more compact, urban neighborhoods, the ‘duplex’ as a type will be developed in more detail for the manual and toolbox. This offers additional flexibility to provide for many different types of users (extended family, renters, co-op housing arrangements for families) and many different densities of urban sites (duplex units can be more slender and taller). The conceptual modularity of the toolbox and manual will allow for the design of the units to expand and contract to suit these variations of needs and potentially unusual lot sizes, as seen in the Moonlight project in Texas (upper left) that has a very narrow but deep lot. The Waldo project (upper right) is a wide but shallow lot so the duplex is compact but very spacious at only 750 SF per unit.

PROJECT OUTLOOK AND NEXT STEPS

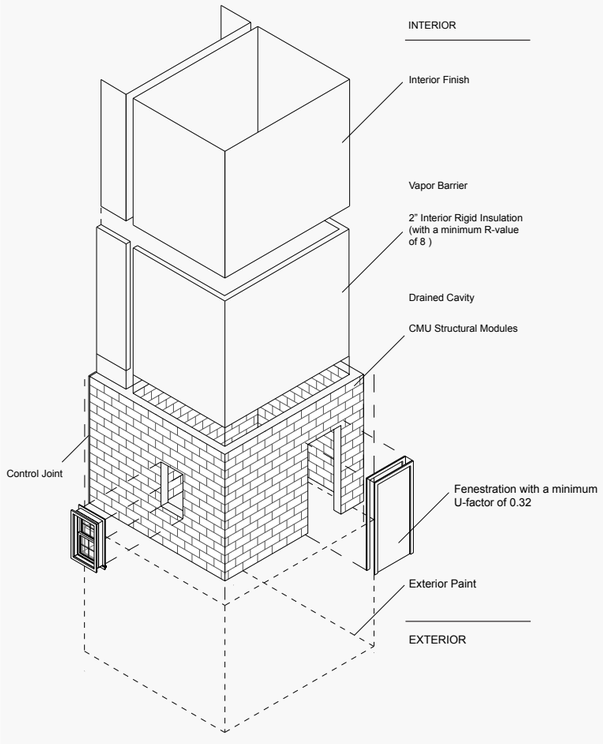
DEVELOPMENT OF MODULES (SAMPLES)

In the next phase, the different spatial modules will be further developed to recognize the different technical needs regarding climate, construction, economy and aesthetics as well as their function as part of a larger integrated system. The drawings on the next three pages show the initial draft diagrams of how we imagine the integration between the modules and house will be developed. Each space in a typical house is being developed as a series of spatial modules that can be assembled and re-configured into the various housing types in their respective regions.

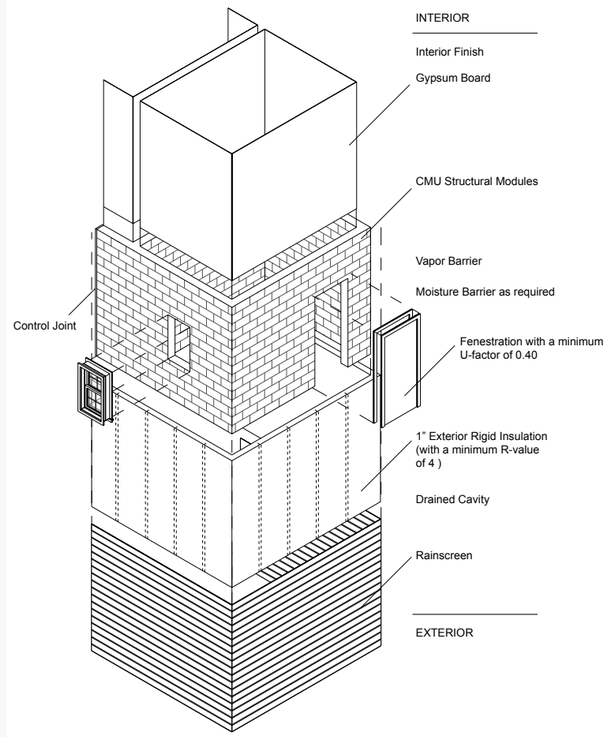
SITE 1
Redding, California



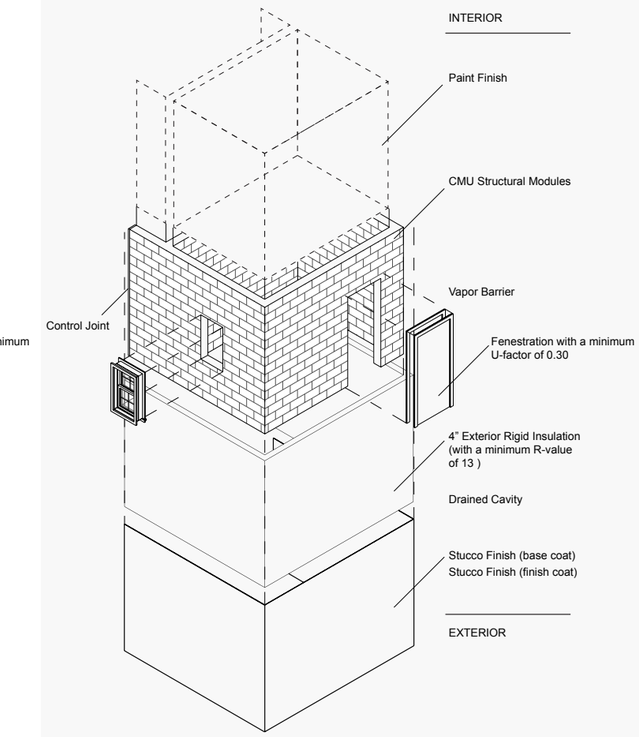
SITE 2
Tuscaloosa, Alabama



SITE 3
Tampa Bay Region, Florida



SITE 4
Syracuse, New York

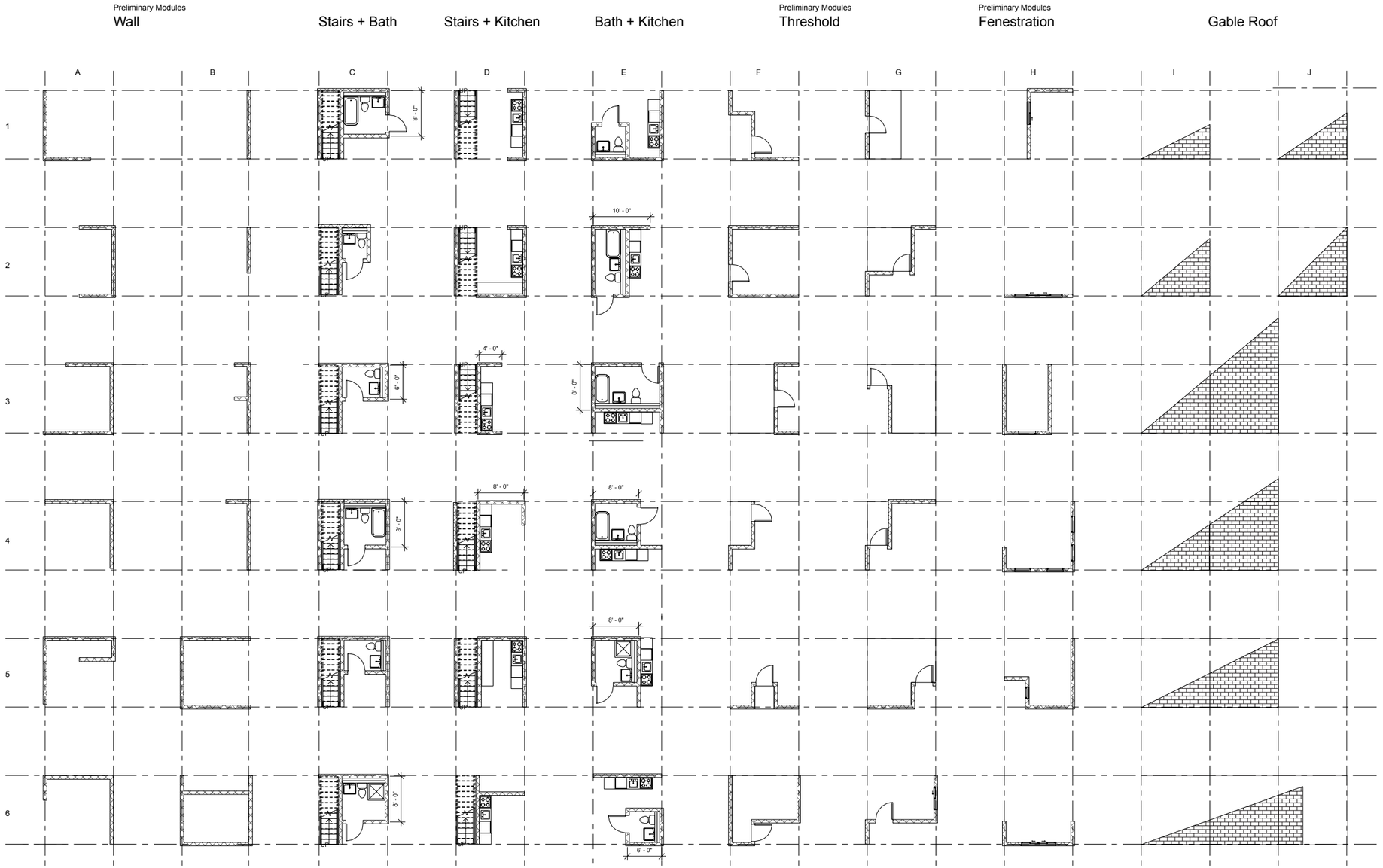


PROJECT OUTLOOK AND NEXT STEPS

DEVELOPMENT OF MODULES (SAMPLES)

Each space in a typical house is being developed as a series of spatial modules that can be assembled and re-configured into the various housing types in their respective regions. The next page articulates an example of how to configure a series of the spatial modules into an overall strategy for a house.

CMU Structural/Spatial Modules



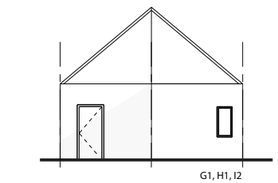
PROJECT OUTLOOK AND NEXT STEPS

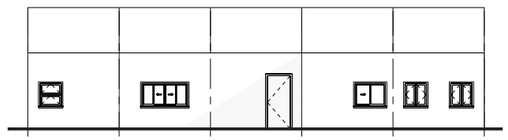
DEVELOPMENT OF MODULES (SAMPLES)

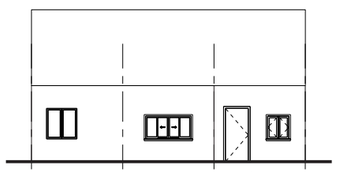
This is an example of how the spatial modules can be reconfigured into a single family housing unit and a multi-family low-rise duplex. The letters and numbers correspond to the spatial units on the previous page.

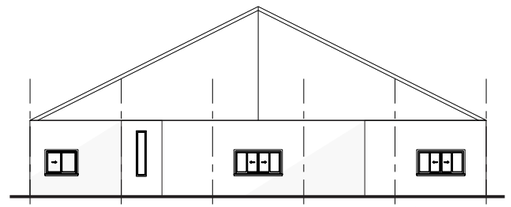
The sample plans and elevations will be resolved in the next phase and merely serve to illustrate our process at this stage.

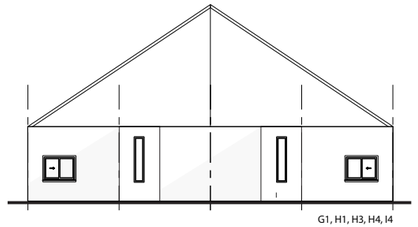
Elevations

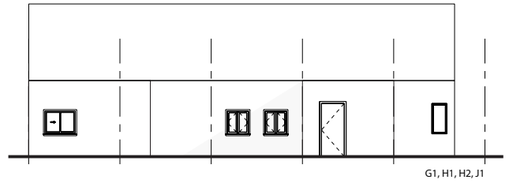

G1, H1, I2

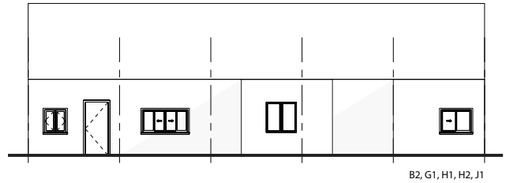

G1, H1, H2, H4, I1

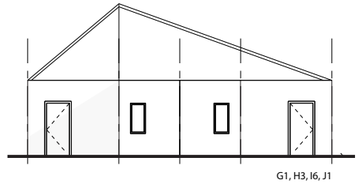

G1, H1, H2, I2

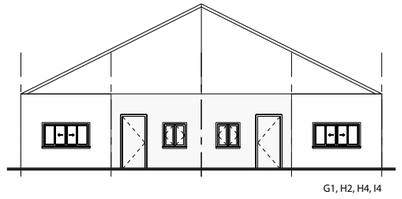

G1, H1, H3, H4, I6

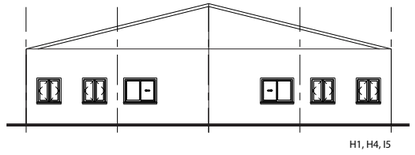

G1, H1, H3, H4, I4


G1, H1, H2, J1


B2, G1, H1, H2, J1


G1, H3, I6, J1

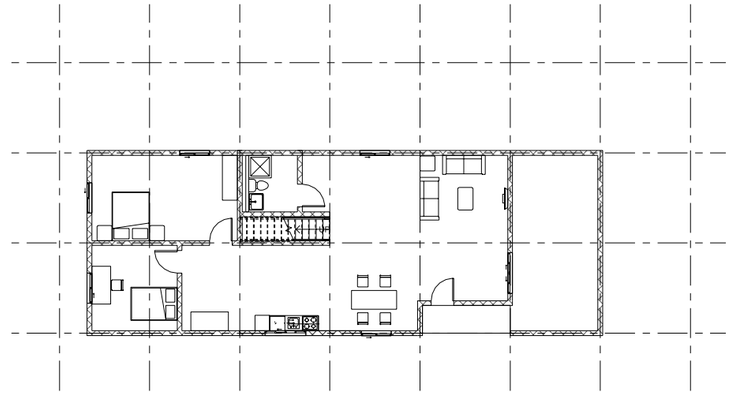

G1, H2, H4, I4


H1, H4, I5

Floor Plans

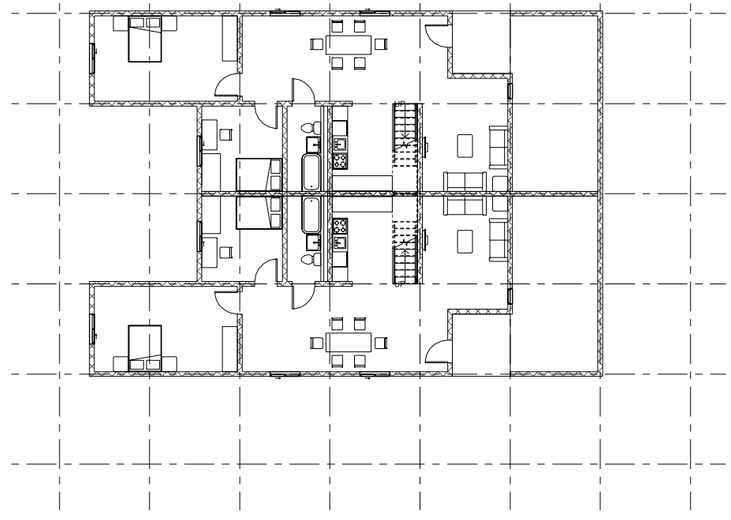
OPTION:
Single Family

A4, B2, C4, F2, G6, H2



OPTION:
Duplex

A4, D4, F1,F2,H2



PROJECT OUTLOOK AND NEXT STEPS

GRANT SCHEDULE OVERVIEW

PHASE 1

Schematic Design
Fall Semester 2018
(September ‘18 - Mid-January‘19)

Description:
Survey of precedent projects. Definition of typical site conditions and constraints. Development of basic design schemes (massing/partie/principle of modularity). Survey of relevant material and construction precedents. Initial studies of key construction details. Initial cost comparison to wood frame construction and other equivalent residential CMU houses.

Deliverables:
- 11x17 booklet (physical and digital as PDF) containing the following:
Project Precedent, Site Plan and Site Descriptions (With indication of Relevant Climate/Zoning/Code Information), Massing, Elevation, Plan/Section, Preliminary Details

CONCLUDED JANUARY 2019

PHASE 2

Design Development
Spring Semester 2019
(January ‘19 - End May ‘19)

Description:
Development of design in Plans, Sections, Elevations. Including typical wall sections with construction details. Initial BIM Models and Energy Models. Energy Model comparison between CMU and Wood for different construction systems. Probable cost estimates. Physical models (architectural).

Deliverables:
- 11x17 booklet (physical and digital as PDF) containing the following:
Site Plan and Site Descriptions (With indication of Relevant Climate/Zoning/Code Information), Elevation, Plan/Section, Wall Sections with Typical Details.
- Initial BIM Model
- Synopsis of Energy Modeling identifying key details and assemblies for final modeling

FUNDING SECURED

PHASE 3

Construction Documentation
Summer 2019
(End May ‘19 - End August ‘19)

Description:
Development of full construction set, comparative energy models and cost estimates. Construction of mock-ups of key details that will serve as part of the educational videos.

Deliverables:
- Digital Project Set as PDF including Architecture, Structural, HVAC, Plumbing, Electrical.
- Comprehensive BIM Model
- Comprehensive Energy Model and documentation of performance of key assemblies
- Specifications (separate or as part of Project Set)
- Cost Estimate
- 3 CMU Educational Videos
- Documentation of Test Mock-Ups

PHASE 4

Documentation for Distribution
Fall 2019
(September ‘19 - Mid-January ‘20)

Description:
A manual that is a collection of all design work and construction documents and energy performance predictions, collaboration details and strategies, coordination information between architects, engineers, and trades, coordination information between Habitat for Humanity volunteers and local trades.

Deliverables:
- Manual (Digital and Print).
- Accessible online and available to all Habitat chapters and local CMU trades.

Syracuse, NY, January 15th 2019