

A detailed historical map of New Castle, Pennsylvania, showing a dense grid of streets and property lots. The map is overlaid with a semi-transparent white box containing text. A north arrow is visible in the lower center of the map.

Affordable Housing with HempLime

New Castle, Pennsylvania

Healthy Materials Lab + Master of Architecture
Parsons School of Design | The New School
with DON Services

Acknowledgments

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Special Thanks
To our collaborators at DON Services for their insight, time, and financial support for travel. And to Villa Maria Education and Spirituality Center for providing accommodations.

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Fig 1.1 Wood mold assembly



Fig 1.2 Lime and Water Mixture

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Introduction

In Spring 2020, second year Master of Architecture Students at Parsons School of Design were given the challenge by Parsons Healthy Materials Lab to rethink the American Home by changing the material of construction to use healthier materials.

“Since WWII, home construction has been the result of a concerted effort by the petroleum and chemical industries, timber barons, real-estate developers, automobile manufactures, the US government and military to shape the form and organization of post-war America. Based on platform wood construction, the typical American home is an accumulation of standardized parts, systems, products and construction techniques that have sought to maximize short-term profit, leveraging global distribution chains, and low skilled labor.” (Lewis, David J, *Design Studio IV, Course Syllabus*, 2020).

Students developed their design proposals for affordable single family homes throughout two congruent courses, Design Studio IV and Construction Technology II.

Design Studio IV

Professor: David J. Lewis

“Design Studio IV is designated as the integrated studio, asking students to engage the integration of design, technology, materials and performance in the execution of the work of the studio. The key for this studio will be developing a design process where aspects of an architectural project are set in creative tension with each other, thus allowing the design to develop as an exchange between the contested requirements of the given architectural project. Toward that end, projects in this studio will engage issues of materials, energy, site, mechanical systems, thermal performance, structures and human health. We will be researching, exploring and examining the impact of using hemp-lime as a new building material. (Lewis, David J, *Design Studio IV, Course Syllabus*, 2020)

Construction Technology II

Professors: Marcus Carter + Eirini Tsachrelia

“This advanced construction course builds upon the fundamental concepts, elements/assemblies, and processes introduced in Construction Technology 1 to focus on more complex problems of building design in the context of contemporary trends towards integration, high-performance, and the advent of new technologies. It includes an extended, in-depth focus on the analysis, development, and integration of building systems that elaborate upon design intent from schematic, spatial organizations to the realization of a comprehensive design project. Throughout this exploration of the relations between conceptually-driven integrative thinking, design development, technical documentation, and construction/fabrication, the class will emphasize making as a creative practice and production process. To build is a deeply social and environmental act. It not only involves technical practices and implicates professional matters, but – quite literally (and profoundly) – is a resource-intensive endeavor that makes and remakes our world. As such, this class will study the construction of buildings as inseparable from the complex interconnected web of material, environmental, and human circumstances involved in architecture’s production and performance.” (Carter, Marcus, Tsachrelia, Eirini *Construction Technology II, Course Syllabus*, 2020)



Fig 1.3 Lime and Water being mixed with Hemp



Fig 1.4 Filling molds with Hemp and Lime mixture for pre-cast components



Fig 1.5 Tamping down Hemp and Lime into framework for a cast-in-place wall

HempLime

Exploring an Innovative Building Material in New Castle, Pennsylvania

The Healthy Materials Lab proposed a collaboration with the Master of Architecture program at Parsons to experiment with designs for affordable housing using HempLime as the primary insulation material. As a way to introduce students and faculty to HempLime, and to explore its future possibilities, a day long workshop was held in Industry City, Brooklyn where students and faculty gathered to build HempLime blocks. Students prepared the HempLime mixture and used molds to create blocks. It is a delicate balance to make a HempLime block which acts as a naturally fire-resistant insulator and a vapor-permeable surface for a wall because air pockets must be retained for the block to be an effective insulation material. This day-long experience fueled the design process for the spring semester as students returned to their desks to tackle the challenges of this semester—to design affordable housing using HempLime building products.

DON Services

“My Life, My Choice”

In order to investigate its potential in Affordable Housing specifically, students were introduced to a community partner from New Castle, PA, DON Services. DON Services is a consumer controlled, nonprofit organization in Western Pennsylvania, empowering people with disabilities to live as independently as they choose. The partnership between DON and Healthy Materials Lab (HML) began when Lori Daytner from DON Services met HML at US Hemp Building Association's inaugural conference in Ketchum, Indiana. Creating healthier, affordable and accessible homes is a mission shared by both DON Services and Healthy Materials Lab, so everything aligned. DON has been rehabilitating residences and building new homes in New Castle since 2018.

“I thought this is going to be a great way for us to elevate the status of the project. They thought ‘Wow you know this is everything we want to do. We want to work in a post-industrial city. We want to work with accessible affordable housing. We want to bring HempLime as a healthy building material into a national conversation.’ So everything aligned.”

Lori Daytner, DON Services

Fig 1.6 Students, Faculty and HML with newly made HempLime Blocks



Affordable Housing with HempLime



Student Research

At the beginning of the spring semester, students spent four weeks researching New Castle, PA and different aspects of the typical American Home with the objective of collectively understanding it's framework and history. In order to begin to challenge these norms, it was essential to study typical form, plan, materials, energy, construction, financing and zoning to see how those aspects inform the past, present and future of the American Home.

Zoning

As for any project, it is essential to understand zoning regulations and the surrounding context. The project site is R-2, Medium Density Residential which is zoned for a maximum of 35' building height and each lot had significant setback requirements from the street, back alley and houses on either side. Northwest of the site is zoned for C-2, Central Business District. Located across the street, is the Lawrence County Jail. The proximity of the jail to the residential community brought up questions about privacy and safety in and throughout the project. Providing private and protected outdoor spaces for each home became important. The 30' setback from the back of the property as per zoning allowed for generous backyards.

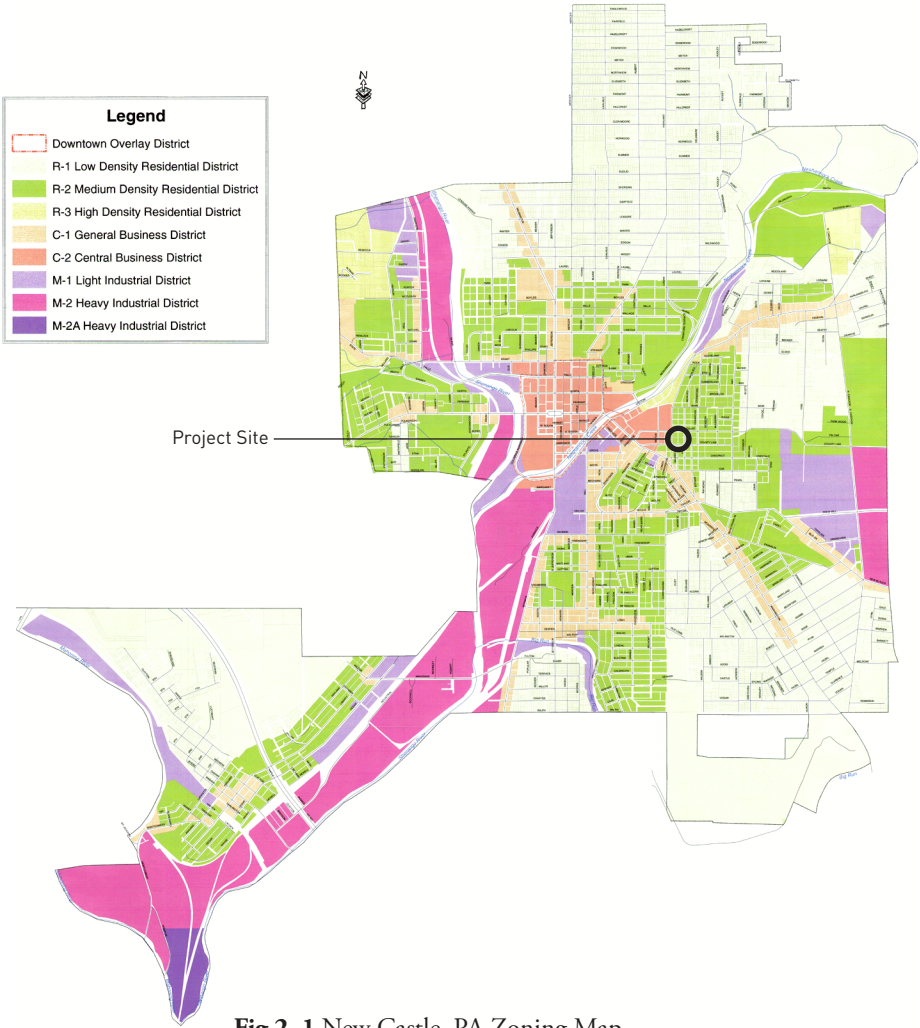


Fig 2. 1 New Castle, PA Zoning Map
Gingras, Frank "City of New Castle, Lawrence County, Pennsylvania, Zoning Map", 2009

Home Affordability

The median yearly income in New Castle is \$31,000. The average American home is 2,882 square feet, which would require an income of \$140,000 a year in order to qualify and purchase a home of that size. DON Services has been building new homes in New Castle, PA which range from 1200 - 1600 square feet. This size range is much more reasonable for the residents but a significant gap in affordability still remains.

a household with the median income of \$31,000, can afford

72% less sq ft

than the national average

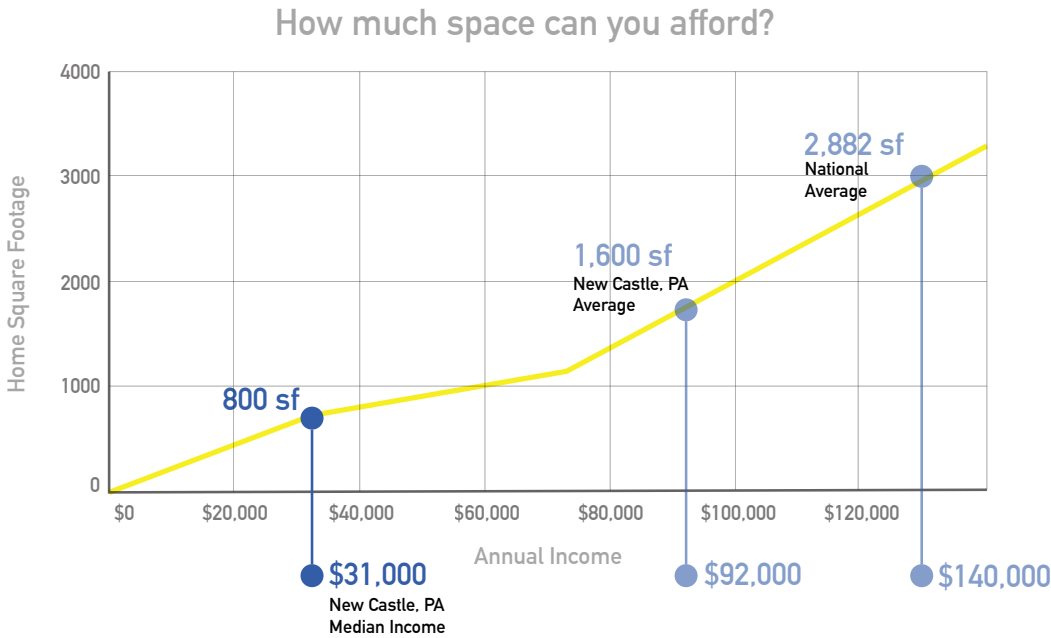


Fig 2.2 Buying a House - Annual Income and Cost per Square Foot
Freddie Mac, "Freddie Mac Mortgage Calculator," 2020
Fannie Mae, "Mortgage Insurance (MI) Plan Comparison, Questions and Answers," 2017

Architectural Plan Affordable Options

A dwelling unit is defined by providing adequate spaces for living, eating, sleeping, cooking and sanitation. Establishing that the average home is 2,882 square feet, and perhaps too large, students found options that provide efficient and generous space without excess by going back to the definition of a “dwelling unit” and eliminating wasted or unnecessary spaces, to achieve smaller and more affordable floor plan options.

Housing Program
**Living
Eating
Sleeping
Cooking
Sanitation**

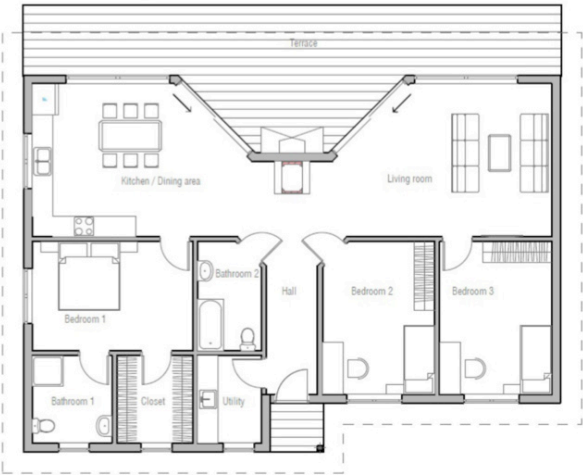


Fig 2.4 Single Story Home, 1500 sq ft
Schmitz, Holger, “25 Impressive Small House
Plans for Affordable Home Construction,” 2016



Fig 2.3 Single Story Home, 1500 sq ft
Schmitz, Holger, “25 Impressive Small House P
lans for Affordable Home Construction,” 2016

Construction Costs	% of construction budget
Site Work	5.6%
Foundations	11.6%
Framing	18%
Exterior Finishes	15%
Major Systems Rough-ins	13.1%
Interior Finishes	29.6%
Final Steps	6.8%
Other	0.5%
Total	100%
Key	
●	Renovation Savings
●	HempLime Allocation

Material Costs

To understand the affordability of constructing a new home, especially in regards to the use of HempLime, a breakdown of a construction budget is helpful to see how much money is typically allocated for materials and different aspects of home construction. When looking at renovating an existing home, one can eliminate 43% of the construction budget by reusing the Foundation, Framing/Structure and Major Systems. Additionally, this shed light on the affordability of HempLime. An exterior wall system using this material eliminates a lot of the layers of a typical assembly, and it was discovered that 15% of the construction budget can be allocated for the use of HempLime.

Fig 2.5 New construction budget breakdown
*See Appendices for extended chart

Ford, Carmel, NAHB Economics and Housing Policy Group
“Cost of Constructing a Home,” 2020

43%

Minimum savings for
a renovation vs. new
construction

15%

of construction cost
can be allocated for
the implementation
of HempLime

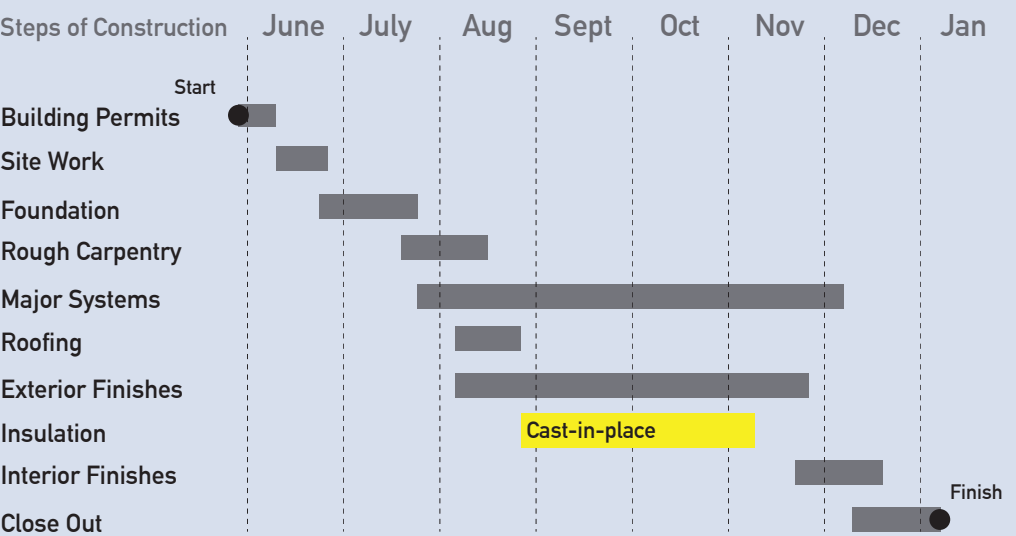
Construction Schedule

A typical and idealized six month construction schedule for an American home begins at the end of May and closes out at the end of November. When HempLime as a building material, it can be utilized in two forms; cast-in-place or pre-cast components. If cast-in-place HempLime walls are used, the minimum of two months that it takes for the material to cure will push the completion of construction into January of the following year. When HempLime is pre-cast into components, it does not add any significant time to the schedule. HempLime is not yet standardized or widely utilized as a building material and this research shed light onto how it might be efficiently integrated into typical construction methods.

1+ month

can be eliminated from construction time if HempLime pre-cast components are used

Cast-in-place HempLime



Pre-cast HempLime Components

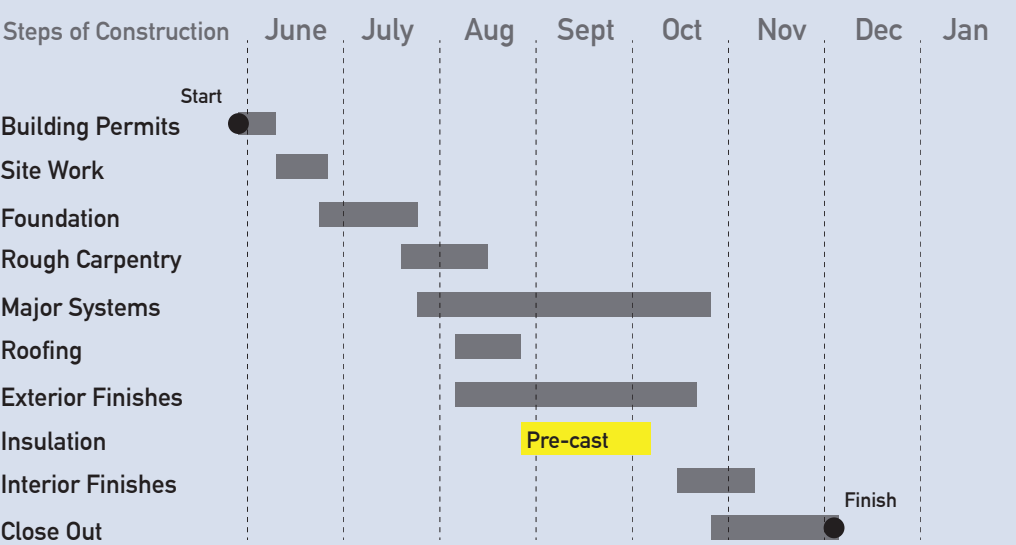


Fig 2.6-7 Construction Schedule, Cast-in-place vs Pre-cast HempLime
*See Appendices for extended Schedule

Site Visit in New Castle

Thanks to the generosity of DON Services and members of the community in New Castle, students visited the site at the beginning of March 2020 in hopes of better understanding the opportunities and challenges of the project. Students traveled from New York City where they spent a full day exploring the city and learning about its rich history with various members from DON Services, Arts & Education at the Hoyt Art Center, Eckles Architecture and the Lawrence County Historical Society. Transportation, Accommodations at Villa Maria and meals were generously provided for the students. The trip provided a wonderful opportunity to learn and engage with the community in order to more thoughtfully consider the city's history and design dwellings aligned with DON's mission.

“Up until this point, the students have not implemented their skills in a real community. But because of the collaboration with DON, the students will learn something, too — about real applications in an existing community. They will study how the architecture, neighborhoods, design and political decisions have affected how the city looks.”

New Castle News, “New Castle Becomes Architecture Graduates’ Semester Project, February 27 2020”



Figure 2.9 Kimberly Koller-Jones, Executive Director of Arts & Education at the Hoyt Art Center, conducting a tour of an historic home



Figure 2.8 Students meeting with David Esposito, President and Principal of Eckles Architecture



Figure 2.10 Affordable, accessible home under construction by DON Services



Fig 2.11 Visiting the project site with Lori Daytner from DON Services and Andrew Henley from the Lawrence County Historical Society

Design Solutions

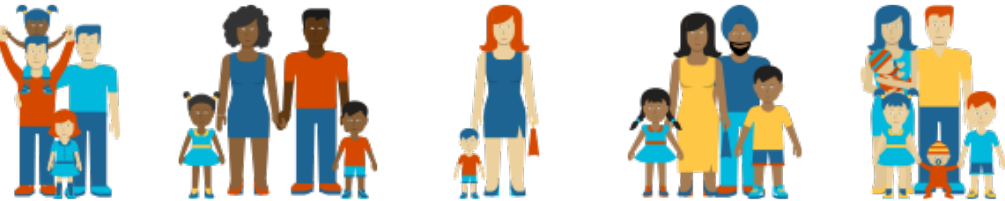


Figure 3.1 Possible Family Structures

Multi-generational Living Considerations

Students designed homes to accommodate the reality of contemporary life, including one parent or split parent households, grandparent pods or suites, and sublease arrangements as well as an emphasis on accessibility and aging in place.

Approaches:

1. Two separate wings for generations with shared entrance, kitchen and dining.
2. Main house with detached apartment for different generations with shared garden.
3. Fully accessible first floor apartment with two stories of livable space with shared backyard.
4. Single home with interior courtyards to provide private outdoor space.

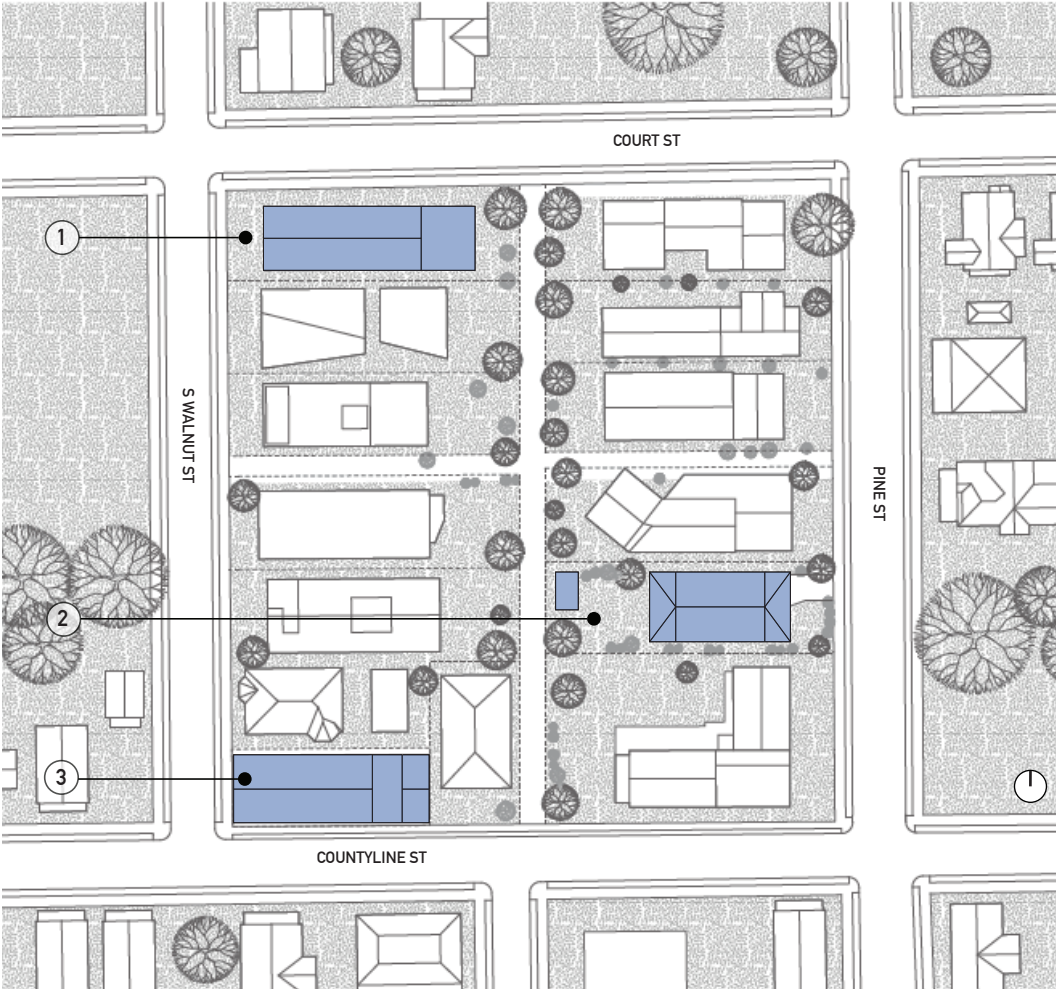
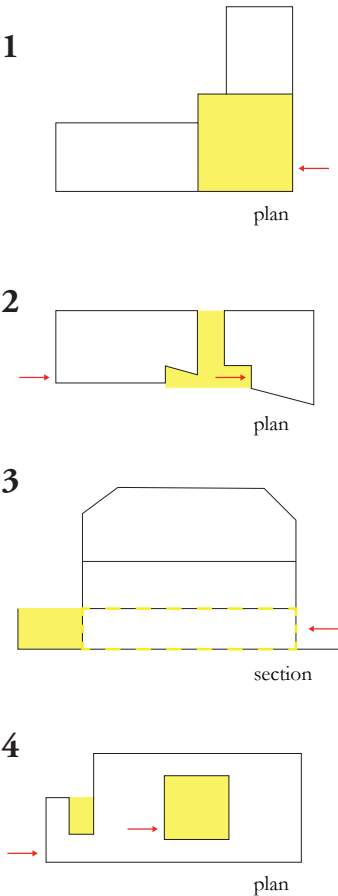
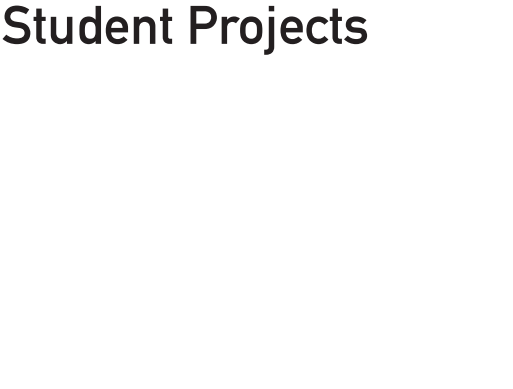


Figure 3.2 Site Plan - Fifteen students of the design studio worked on fifteen different plots

Student Projects

Affordable Housing with HempLime



May Rantanachiwapong



Meryl Smith



Ashely Lam



Jenya Uzhegova



Youcong Li



Victoria Frederick



Chase Hodge



Karolina Vargas



Peter Vos



Jack Chiu



Samuel Vilson



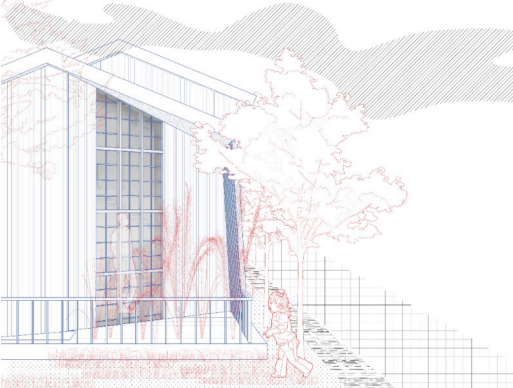
Rita Baboujian



Jen Kwan



Darina Keane



Maggie Li

Rafter House

Meryl Smith

This project takes the typical anonymous roof lines that are seen throughout suburban America and dilutes it down to a simple form extruded along the narrow site for a fully accessible first floor with subtracted elements. These create generous outdoor spaces that engage with the odd site to allow for multiple opportunities to be alone, or together. Where the subtractions are made, the rafters are revealed using a three-layer structural system with loose fill HempLime insulation to bring light into the home and make the most of the southern exposure.



Fig 3.3 Exterior View, North

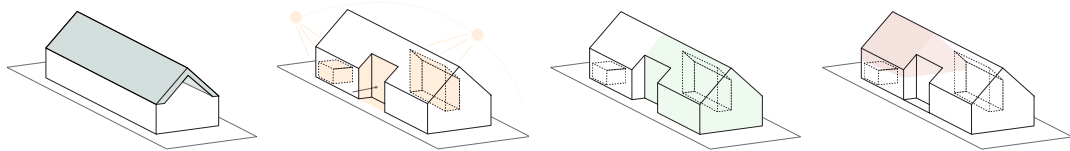


Fig 3.4 Roof Diagrams

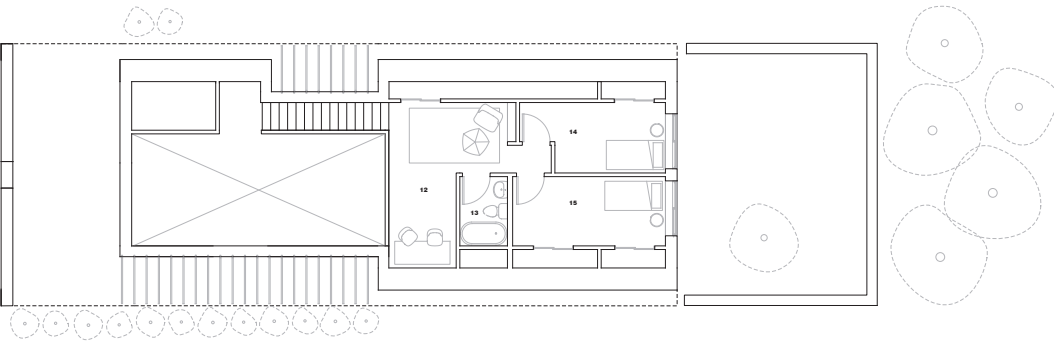


Fig 3.5 Second Floor Plan

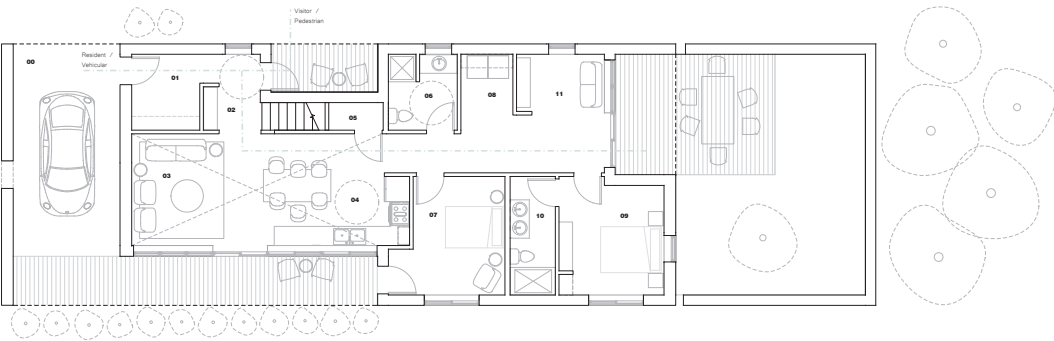


Fig 3.6 First Floor Plan



Fig 3.7 Living Area, Kitchen & Dining (Left) Private Porch that maximizes southern exposure (Right)

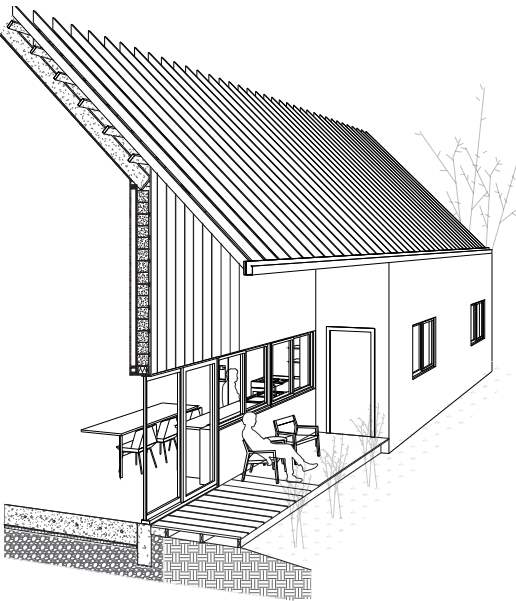


Fig 3.8 Wall Section, private side porch

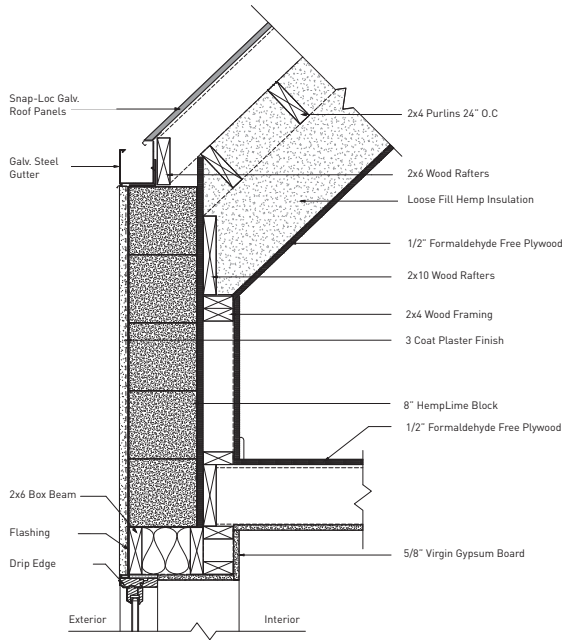


Fig 3.9 Concealed Gutter and Roof System detail

House with Two Porches

Samuel Vilson

How do we create affordable detached houses well-prepared for an unknown future? This project demonstrates a compact interior layout that adjusts to fit various types of household constellations. The shape of the house is kept simple in order to achieve a generality that makes the house possible to fit into various types of plots. The house minimizes utilization of petroleum-based products: the exterior walls are insulated with HempLime blocks applied on the outside of a 2x4 wood frame covered with plywood sheathing. The exterior finish is lime-plaster applied directed to the HempLime.



Fig 3.10 Exterior View, East



Fig 3.14 Flexible space between rooms can connect or separate to allow for multiple uses

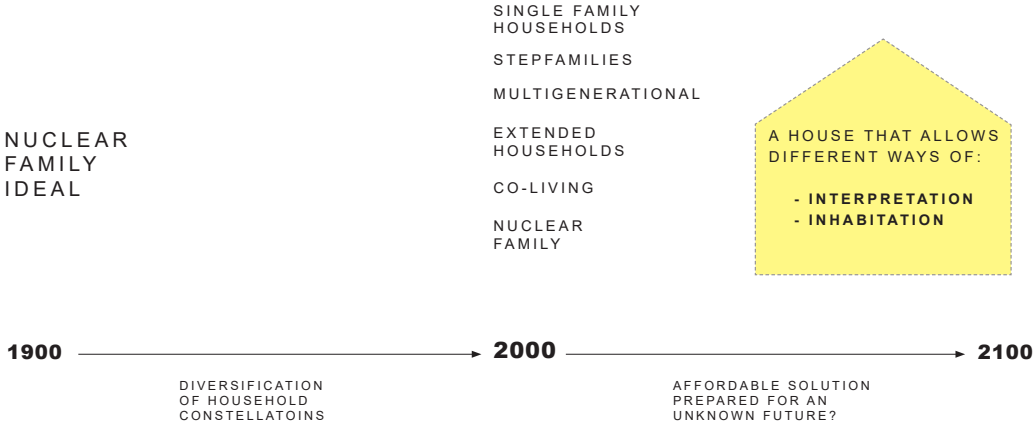


Fig 3.11 Changing Family Structures informed the planning of the compact, 2 story home

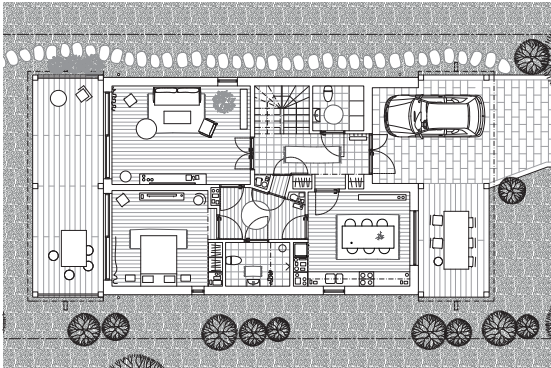


Fig 3.12 First Floor Plan

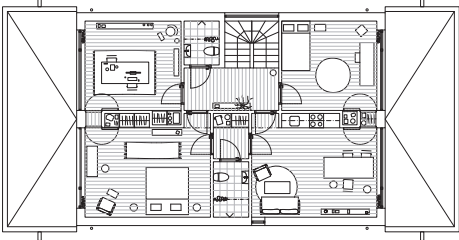


Fig 3.13 Second Floor Plan

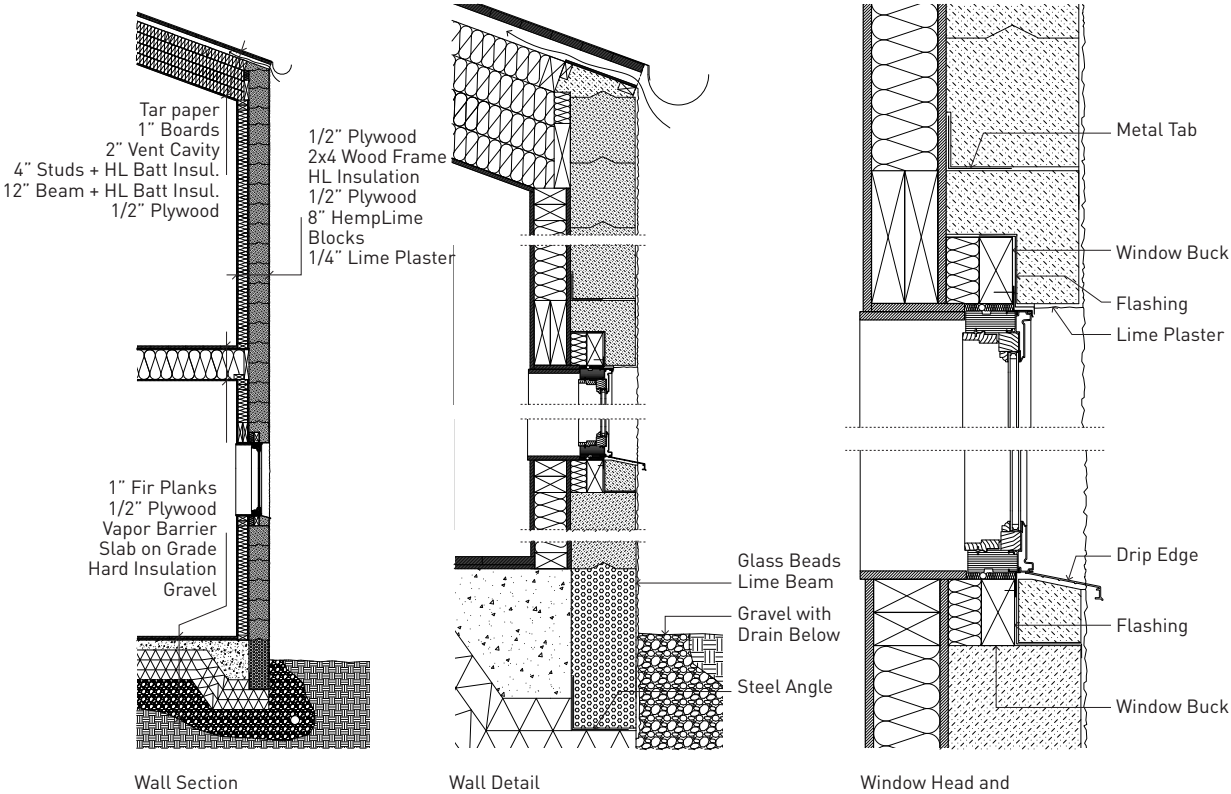


Fig 3.15 HempLime Details

Cabinet House

Chase Hodge

When the “single” family can no longer be confined to the “nuclear” family definition, a single family house should provide a flexible and healthy living space allowing the family to age in place. This project demonstrates the use of an adjustable interior, made of pre-fabricated HempLime Panels, to raise questions about flexibility and change. Exterior walls are composed of HempLime, plywood, a wood rain screen and lime plaster finish. The interior partitions are made from wood with a thin layer of hemp lime at the base to provide added acoustical dampening to the interior spaces.



Fig 3.16 Exterior View, West

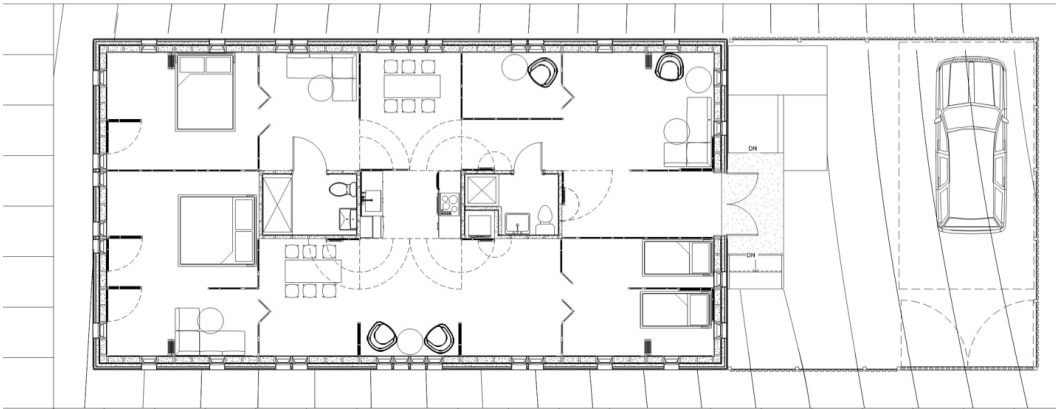


Fig 3.17 First Floor Plan, Option 1, 4 Bedroom

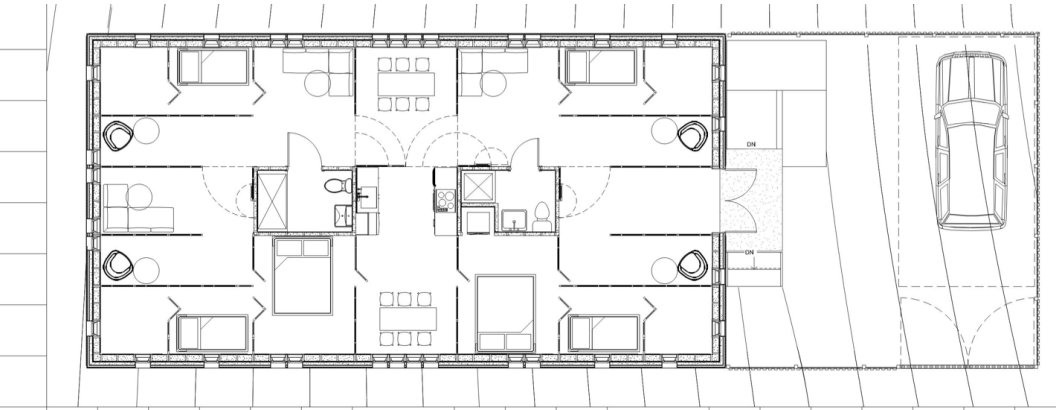


Fig 3.18 First Floor Plan, Option 2, 6 Bedroom



Fig 3.19 Interior View



Fig 3.20 Pre-fabricated Wall, Interior

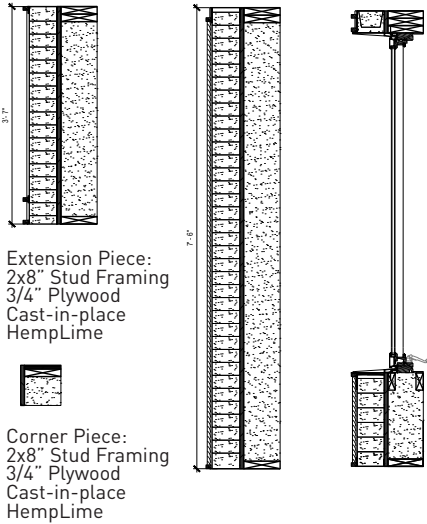


Fig 3.21 Pre-fabricated Wall, Exterior

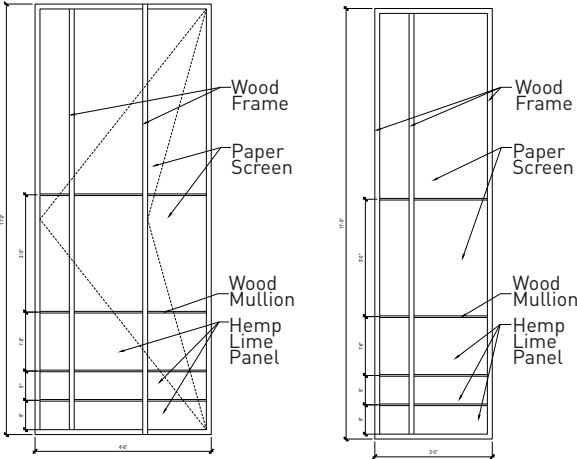


Fig 3.22 Pre-fabricated Wall, Interior

Additional Insights

Renovating with HempLime Panels

One student was presented with the challenge of beginning with an existing home on their assigned site. Rather than proposing to demolish the derelict home, she asked the question, “What if you renovate a home using HempLime?” This project keeps the existing structure to re-use as much as possible and implements HempLime panels, which are exposed on the interior, to emphasize the contrast between old and new. The exposed HempLime gives a visual cue to the intervention and drastically transforms the health of the home. Replacing the old vinyl siding with corrugated metal panel minimizes the use of petroleum based products.

“One student realized there is no need for additional interior finish material, other than natural coating. Her insight was, “When left exposed, the texture of HempLime is naturally rich and aesthetically appealing”.”

Eirini Tsachrelia, Construction Technology II

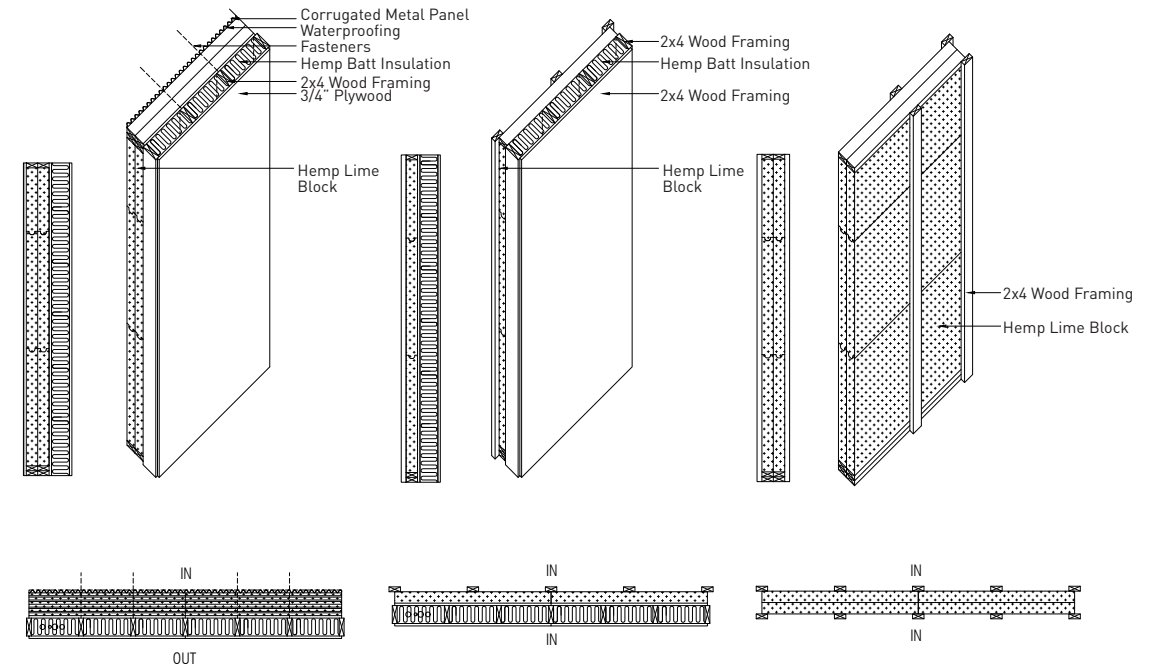


Fig 4.3 Panelized HempLime System for renovation



Fig 4.1 304 Pine Street, existing home



Fig 4.2 Interior View - Exposed HempLime in home addition

Faculty Insights and Course Outcomes

Since there are very few precedents and the use of HempLime in residences has not yet been standardized, the faculty are learning along with the students. Construction Technology II (taught by Marcus Carter and Eirini Tsachrelia) taught in conjunction with Design Studio IV (taught by David J. Lewis) provided support for technical detailing while investigating potential uses of HempLime for affordable housing in the design studio. It was a challenge for students to build up knowledge and background of standard practices in order to propose variations of those standards. The learning curve was steep, but it was a team effort between faculty, students and the Healthy Materials Lab to better understand the material and its capabilities for affordable housing applications in a post-industrial city.

“We have to find ways of building that use elegant naturally derived materials in monolithic configurations, that are cost-effective and durable. Reducing the number of materials is simultaneously the key to resolving the numerous performance liabilities associated with the multi-layered construction systems that dominate the housing market today.”

Professor David J. Lewis, Design Studio IV

Next Steps with DON Services

Representatives from DON Services sat in on the virtual final review, where all of the final design proposals were presented by the students. Inspired by the creativity and considerations for DON's mission, DON Services purchased an 800 square foot home located at 506 Spruce Street in New Castle on June 15th. The home will be renovated using HempLime. The insights and discoveries made by the students had a large impact on this decision and will inform the renovation process.

“Graduate students from the Parsons School of Design’s Healthy Materials Lab presented their architecture thesis projects through a virtual day-long session linking the students with representatives of DON Enterprises and designers located in the U.S. and Europe. DON will consider the design ideas for inclusion in the Blueprint Community neighborhood revitalization project, “Building New Castles”, on the east side.”

New Castle News, “DON to Consider Thesis Ideas for East Side Project, May 14 2020”

Conclusion

The collaboration between DON Services, Healthy Materials Lab and Parsons’ Master of Architecture provided an important opportunity, for all involved, to explore uses of HempLime uses in affordable housing. The hands-on workshop and the students’ visit to New Castle inspired a range of innovations that prompted the student designs. It was inspiring to visit the community and to meet with people who are passionate about the city’s history. There is a possibility that DON Services will incorporate student ideas into a realized application of HempLime, that will exist beyond student’s pencils and computers. A “Big Idea” starts as just that, an idea. Healthy Materials Lab has a hunch about HempLime as a building material for use in affordable housing, DON Services has a mission to provide healthier, accessible and affordable homes in the New Castle Community, and students have a thirst for knowledge and innovation. Combined, these “Big Ideas” may soon become reality.

Special Thanks

To our collaborators at DON Services for their insight, time, and financial support for travel. And to Villa Maria Education and Spirituality Center for providing accommodations.



Fig 4.4 506 Spruce Street, New Castle, Pennsylvania

Appendices

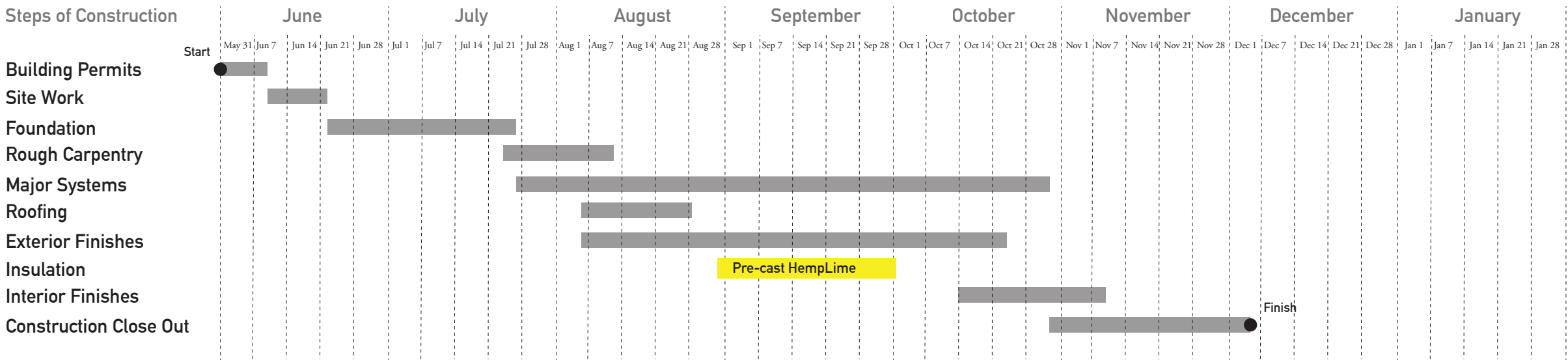
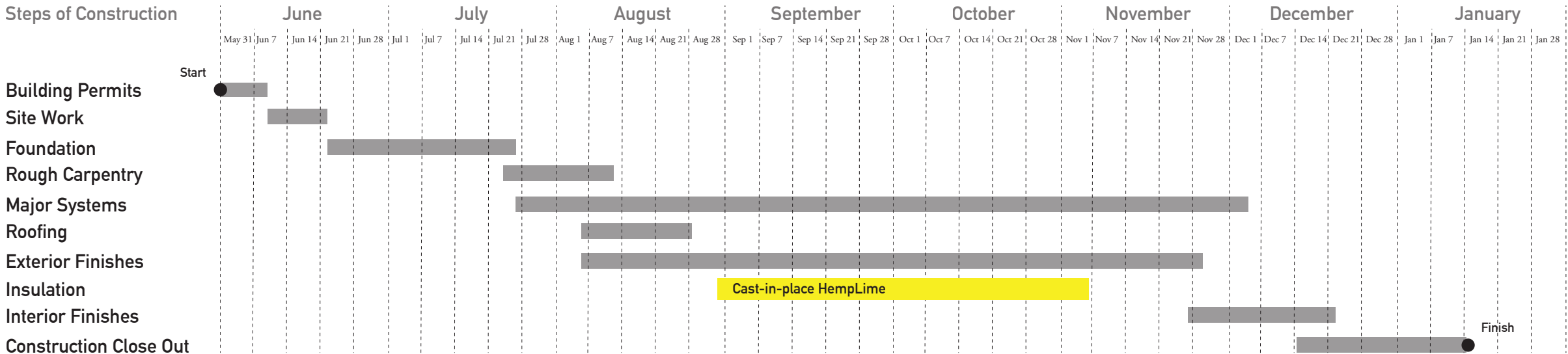


Fig 5.1 Extended Construction Schedule, Cast-in-Place vs. Pre-cast HempLime

Steps of Construction	% of construction budget allotted
I. Site Work	5.6%
Building Permit Fees	1.2%
Impact Fee	0.6%
Water & Sewer Fees Inspections	1.4%
Architecture & Engineering	1.6%
Other	0.7%
II. Foundations	11.6%
Excavation, Foundation, Concrete, etc.	11.3%
Other	0.3%
III. Framing	18%
Framing	15.4%
Trusses	1.3%
Sheathing	0.4%
General Metal Steel	0.4%
Other	0.3%
IV. Exterior Finishes	15%
Exterior Wall Finish	7.2%
Roofing	3.5%
Windows and Doors	4.2%
Other	0.2%
V. Major Systems Rough-ins	13.1%
Plumbing	4.3%
Electrical	4.2%
HVAC	4.4%
Other	0.2%
VI. Interior Finishes	29.6%
Insulation	2.2%
Drywall	4.1%
Interior Trims, Doors and Mirrors	4.3%
Painting	3.1%
Lighting	1.2%
Cabinets, Countertops	5.5%
Appliances	1.5%
Flooring	4.6%
Plumbing Fixtures	1.5%
Fireplace	1.0%
Other	0.5%
VII. Final Steps	6.8%
Landscaping	2.1%
Outdoor Structures	1.5%
Driveway	2.2%
Clean Up	0.7%
Other	0.3%
VIII. Other	0.5%
Total	100%

Fig 5.2 Extended Budget Breakdown
Ford, Carmel, NAHB Economics and Housing Policy Group “*Cost of Constructing a Home*,” 2020

References

Fig 1.1-5 Photograph by Michelle Claire Gevint
Fig 1.6 Photograph by Healthy Materials Lab
Fig 2.1 Map by City of New Castle
Gingras, Frank “*City of New Castle, Lawrence County, Pennsylvania, Zoning Map*”
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Fig 2.2 Graph by Meryl Smith
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Fig 2.3-4 Small and Affordable Floor Plans
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Fig 2.5 Chart by Meryl Smith
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Fig 2.6-7 Schedule by Chase Hodge, Drawn by Meryl Smith
Fig 2.8-11 Photograph by David Lewis
Fig 3.1 Family Structures
Townes, Lorraine M “*Diverse Family Structures*”
Fig 3.2 Drawing by Samuel Vilson
Fig 3.3-9 Drawing by Meryl Smith
Fig 3.10-15 Drawing by Samuel Vilson
Fig 3.16-22 Drawing by Chase Hodge
Fig 4.1-3 Photograph by Darina Keane
Fig 4.4 Photograph from Google Maps
Fig 5.1 Schedule by Chase Hodge, Drawn by Meryl Smith
Fig 5.2-3 Chart by Meryl Smith
*See Fig 2.6 Source

