

**Six Projects on Accessory Dwelling**



## ACCESSORY DWELLINGS

Accessory dwellings—garage apartments, granny flats, backyard homes—have long been an important type of informal housing in the United States and are currently part of a growing national dialogue on affordability and sustainability. An accessory dwelling unit, or ADU, is a second dwelling on the same property as a single-family residence—though typically smaller and located in back. Until recently, such dwellings were mostly unsanctioned, constructed unlawfully by residents to provide additional space or added income as rental units. While still prohibited in many locations, some cities have begun to encourage their production as a way to provide affordable housing and increase urban density while maintaining the local neighborhood fabric and character.

Houston currently permits “secondary” dwellings limited to 900 square feet, each requiring an additional parking space. Despite a national image of affordability, much of central Houston is rapidly becoming less so. In this context, an ADU inherently increases density while providing lower-cost, rental housing. These smaller homes also respond to demographic shifts toward smaller households with more intergenerational families, single-parents and co-habiting individuals.

The accessory dwelling does pose challenges. Smaller spaces and tighter quarters test our cultural norms of comfort and privacy. Hidden away, they struggle to participate in the public sphere. ADU rentals can’t provide the economic benefits of home ownership or the efficiencies of mass-produced, conventionally constructed homes. Construct, Rice Architecture’s design-build program, has taken up these challenges. Six Projects on Accessory Dwelling presents two recent projects in that effort: +House and Accessory.

### +HOUSE

+House is an accessory dwelling prototype for two people. Construct developed the project for Agape, a non-profit that runs a Third Ward outreach program to assist young adults in transitioning from difficult living situations. Started in 2016, the project, designed and built by Construct students, just completed construction. Experience the scale of +House in the central space of the exhibit and imagine what it would be like to share a 360 square foot dwelling.

### ACCESSORY

Accessory is a set of five speculative garage apartments designed for Houston. The aim is to bring the accessory dwelling into the public sphere with qualities that balance a distinct visual presence against a sympathetic urban character, and with forms that encourage a community of interactions among the network of dwellings. Two of the five projects later served to test alternative, non-standard construction logics students developed with adaptable digital models, or paratypes, that automate quantitative analysis and fabrication. Peak through the exhibit walls and picture an ADU in your own backyard.

## CONSTRUCT

For more than twenty years, Rice Architecture has engaged the world by challenging students to contribute directly to the built environment. Construct designs and builds projects that produce lasting effects, creating resources for the communities they serve while building knowledge through research and experience.

Working at various scales and in diverse situations, students engage all facets of the creative process—conception through construction. Expanding their knowledge in the pursuit of novel solutions to real-world challenges, students work together to test concepts against practical realities, explore innovative means of design and fabrication, and translate forward-thinking projects into built works.

Construct is co-directed by Assistant Professor Andrew Colopy and Professor in the Practice Danny Samuels. It was founded in 1996 as Rice Building Workshop (RBW) by Professors Danny Samuels and Nonya Grenader.

## CREDITS

Six Projects on Accessory Dwelling was designed by Andrew Colopy and Eric Cheung, assisted by George Hewitt, Samantha Schuermann, Rose Wilkowski and Danny Samuels.

The exhibit has been supported by Rice Architecture and the Moody Center for the Arts.

Special thanks to: Alison Weaver, Joel Thompson, Robert Purvis, Connie McAllister, Sarah Whiting, Emily Stein, Lauren Kleinschmidt, Shawna Forney, Jennifer Judge, Jeremy Cross, Tami Andrew, Reto Geiser, Michelle Chang, David Costanza, Jack Hilchey, Ekin Erar, Robert Booth, Rice Design Alliance, and Agape Development.







### Single-Family Residential Space in Houston

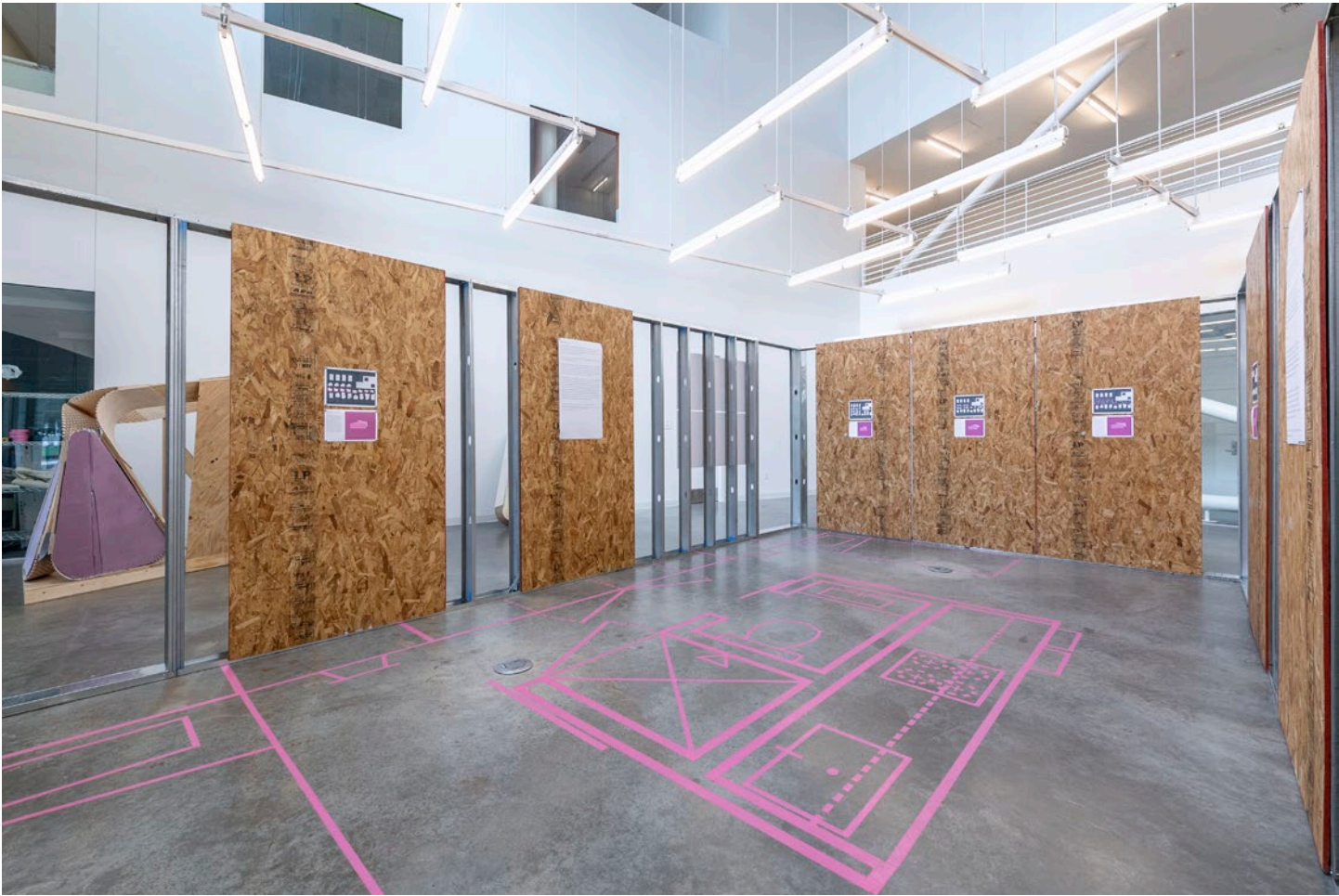
The map above captures about 1,200 square miles of Greater Houston. Dark areas represent land currently used for single-family dwellings (within Harris County). White lines are major highways and bayous.

Harris County is comprised of 1,024,243 single-family parcels<sup>1</sup> accounting for about two-thirds of the Houston metro area population: 4.7 of 7 million residents<sup>2</sup>. Imagine if each parcel had an accessory dwelling: Houston could add over a million residents without using a single additional plot of land.

<sup>1</sup> Houston County Appraisal District, 2017

<sup>2</sup> Texas Department of State Health and Human Services 2018 population estimates for Harris County and the Houston Metropolitan Statistical Area





**Accessory**

## Accessory

The five speculative designs for accessory dwellings presented here were completed in the fall semester of 2017 as part of Totalization, a series of advanced design studios at Rice Architecture that focus in depth upon a single research topic in the context of a complete building proposal.

Students were asked to consider the following conceptual prompt in the design of a new accessory dwelling type:

*An accessory is something added, its status dependent upon another, more primary condition. It is secondary but also supplementary. On one hand, it can be useful. On the other, ornamental. But the accessory enjoys greater autonomy—it is object, not appliqué. Secondary-ness is provisional, not a matter of subjugation. The accessory isn't necessarily part or whole, but remains open to circumstance.*

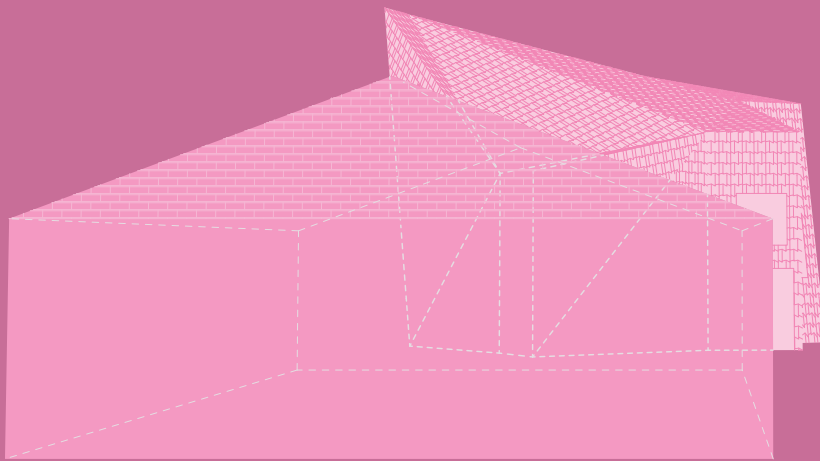
While the exhibit presents one ADU in detail, the aim was to think beyond the limits of a single structure. Using 35 different sites, students created flexible proposals using adaptive computer models. They designed new building types responsive to both the immediate context of each site and the neighborhood as a whole. Rather than a standard ADU for all locations, each dwelling can take full advantage of its unique circumstances. Simultaneously, students developed a building envelope system utilizing digitally fabricated plywood members that could be produced automatically from these same models. The result is an economy of scale through automated but non-standard production, as well as a neighborhood of buildings collective in their diversity as much as in their common cause.

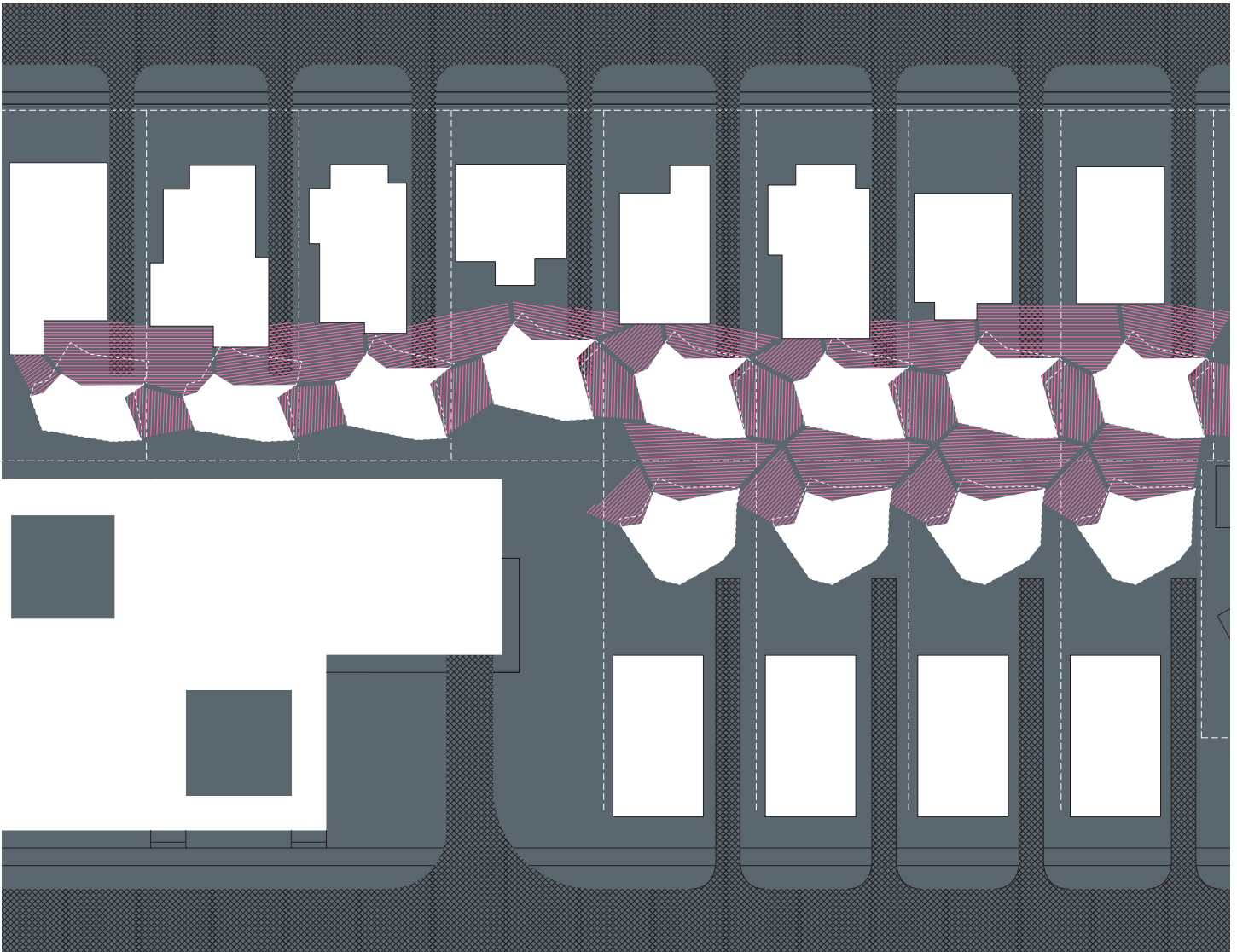
Accessory Projects: Dadu, Envelop/Unfold, Fremd Zone, Pillow, & Uncanny Incrementalism

Accessory Students: Francis Aguiard, Claire Chalifour, Hillary Davlin, Seth Defore, Jordan Gracia, Rachel Grady, George Hewitt, Younha Kim, Haotian Ma, Micah Piven, Lauren Turnage, Jiaying Yan

Studio Critic: Andrew Colopy, Assistant Professor



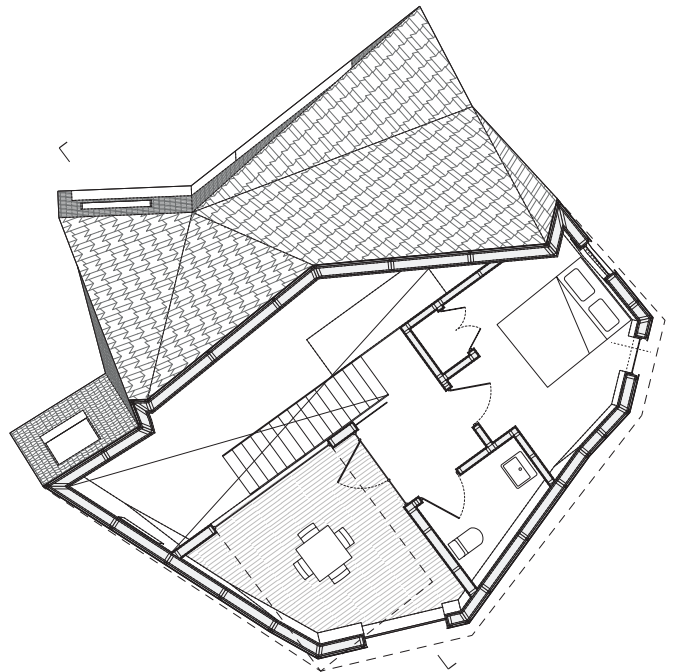
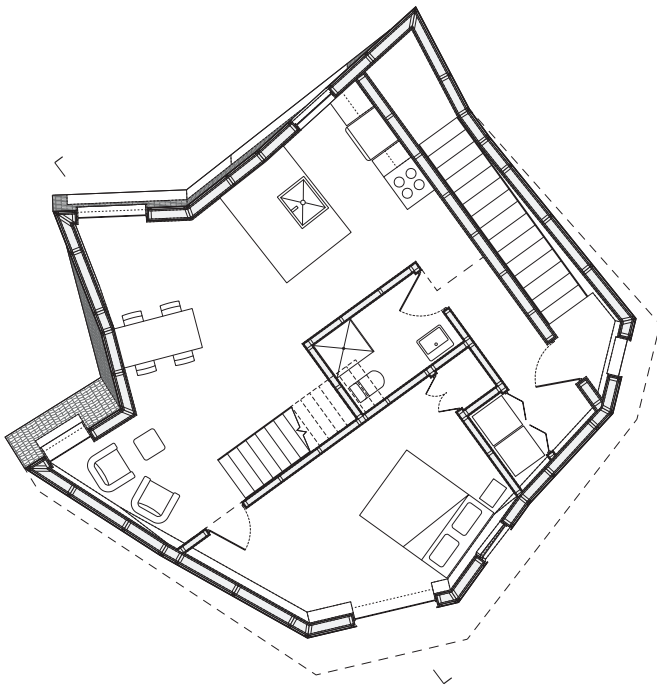
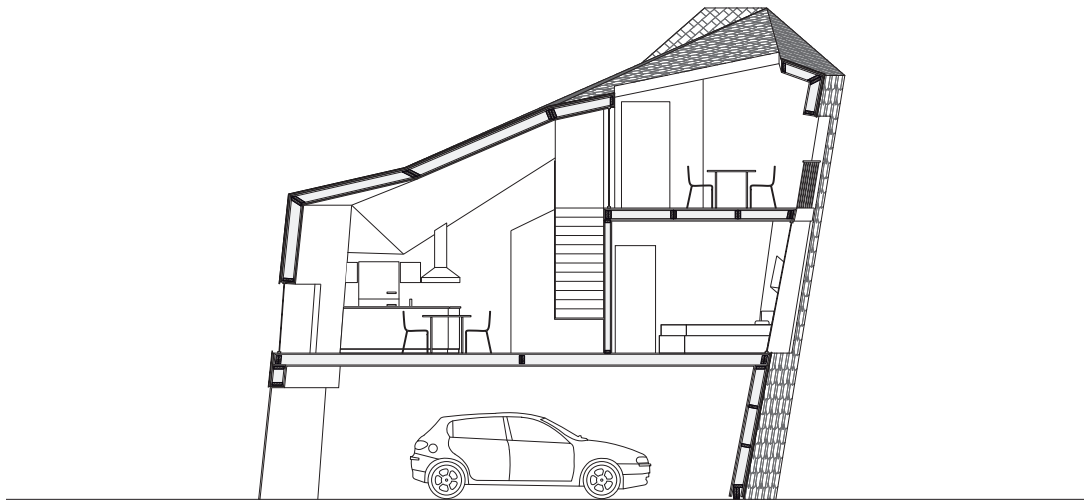




## envelop/unfold

Envelop/Unfold is withdrawn, deferential to both the bungalow in front and the neighborhood at large. The roof pitch and side wall are sympathetic in profile to the companion house. Fully shingled, it appears almost as a roof alone. Grey where street-facing, like much of the neighborhood, the color shifts to pink around the corner, making more vibrant the interior of the block. Spaces among dwellings are formed by the two halves of the ADU: a nondescript, convex side facing adjacent institutions that form a backdrop, and a crenelated side that shapes a tessellated set of small spaces for outdoor activities close to each dwelling.

Project Team Claire Chalifour + George Hewitt





### **envelop/unfold**

The surrounding neighborhood is home to two distinct families of buildings, cultural institutions and bungalows. The institutions are object-like, facing multiple orientations, while the bungalows produce a single sided, neutral, grey backdrop. This project aims to negotiate that gap with a family of accessory dwellings. From the street, these new structures are sympathetic to the bungalow, with front facing entries, pitched roofs, a parallel profile and grey color. The form also permits the dwelling's convex side to face the institutions, again reinforcing the dwellings as part of a more neutral background. Within the block however, the surfaces transition to pink and movement unfolds along a more rotational, crenellated form that creates a small-scale set of spaces for outdoor activities. These crenellations perform similarly inside, pinching an otherwise open space into a series of small pockets for eating, food preparation, reading and other activities. The strategy is particularly well-suited for roommates and is furthered by lofting one of the two bedrooms within the roof volume for added privacy. The spatial sequence concludes with a shared, outdoor terrace. Construction is facilitated by structurally insulated panels, or SIPs, prefabricated to reduce construction time and increase quality. The exterior is clad with a custom pattern shingle of inexpensive fiber-cement.





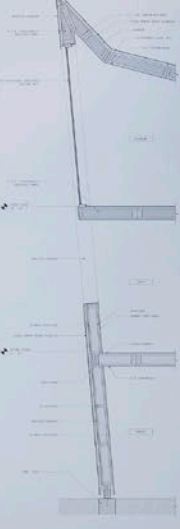
#### envelop/unfold

Project: Park House (2010-11) by a group of architects

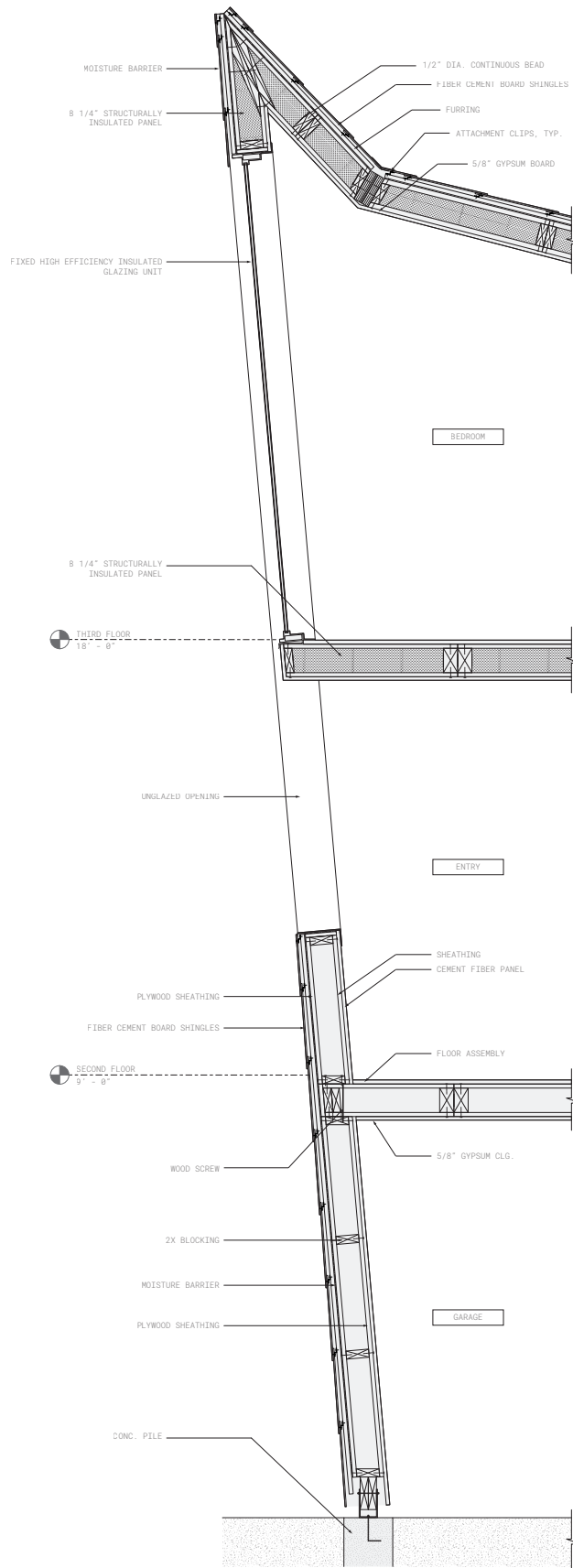
The building is designed as a series of interconnected volumes, creating a dynamic and fluid spatial experience. The design is based on the concept of 'envelop/unfold', where the building's form is defined by a series of interconnected volumes that can be opened or closed, creating a dynamic and fluid spatial experience. The design is based on the concept of 'envelop/unfold', where the building's form is defined by a series of interconnected volumes that can be opened or closed, creating a dynamic and fluid spatial experience.

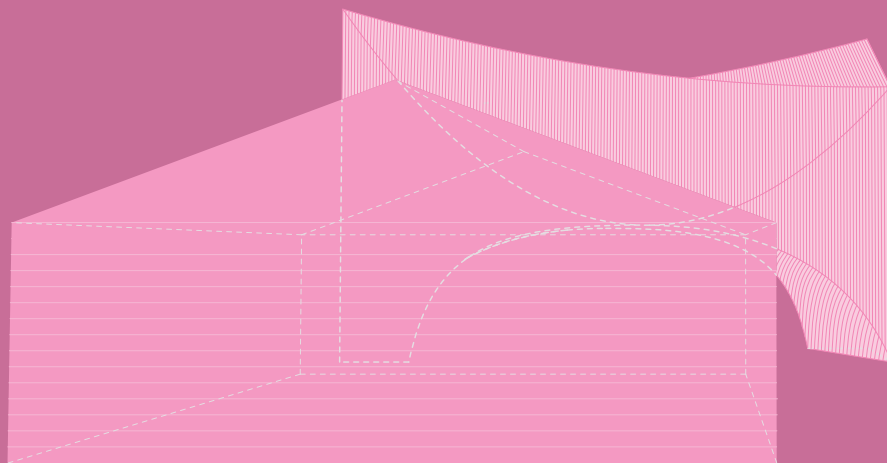
These interconnected volumes create a dynamic and fluid spatial experience, allowing the building to respond to the changing needs of its users. The design is based on the concept of 'envelop/unfold', where the building's form is defined by a series of interconnected volumes that can be opened or closed, creating a dynamic and fluid spatial experience.

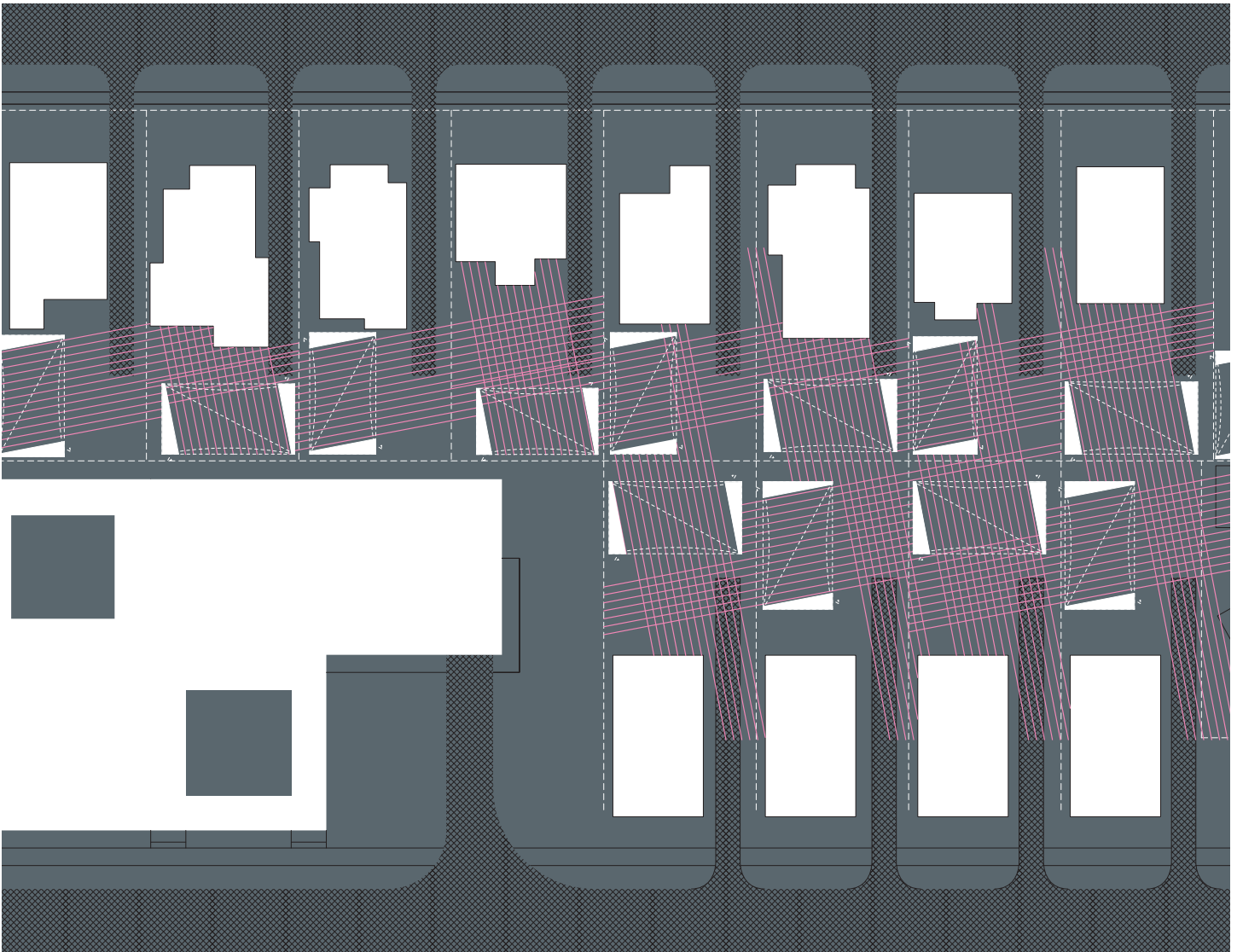
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1 TYPICAL WALL SECTION





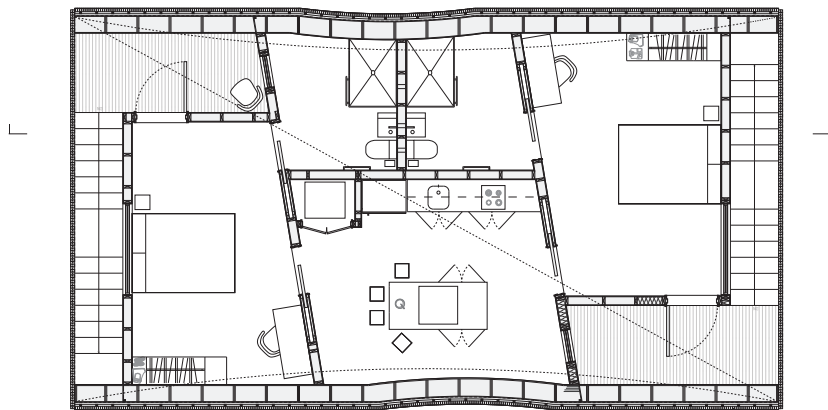
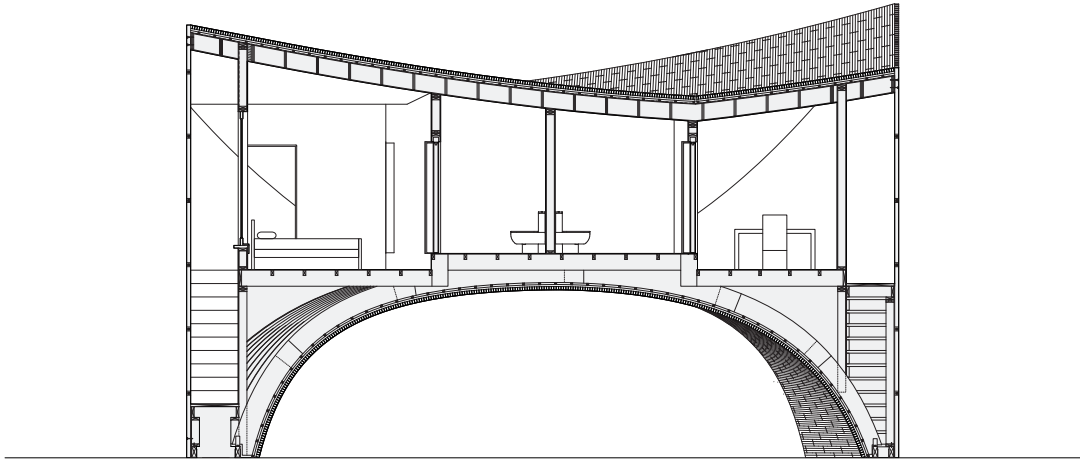


**dadu** (double accessory dwelling unit)

Dadu spans across the available width or depth of the site to provide a large, arched, outdoor area for parking or sheltered communal activities. The mass is made elegant through attenuation. An upturned parabolic arc traced along the broad side of the volume meets the arch below in a delicate point of tangency. Likewise, the alternating entry locations in each leg allow the point where dwelling meets ground to be expressed, quite literally, as a point, while opposing roof corners drape upward. The mass is vertically striated with thin strips of wood—opaque at the broad faces but an open screen at the ends. The grey weathering of wood is sympathetic in color yet varies with age, contrasting the consistency of the grey painted bungalows. Collectively, each ADU is rotated or mirrored to produce a tartan patterning of spaces, varied yet relatively open and connected to the neighboring dwellings at ground level.

Project Team: Micah Piven + Younha Kim

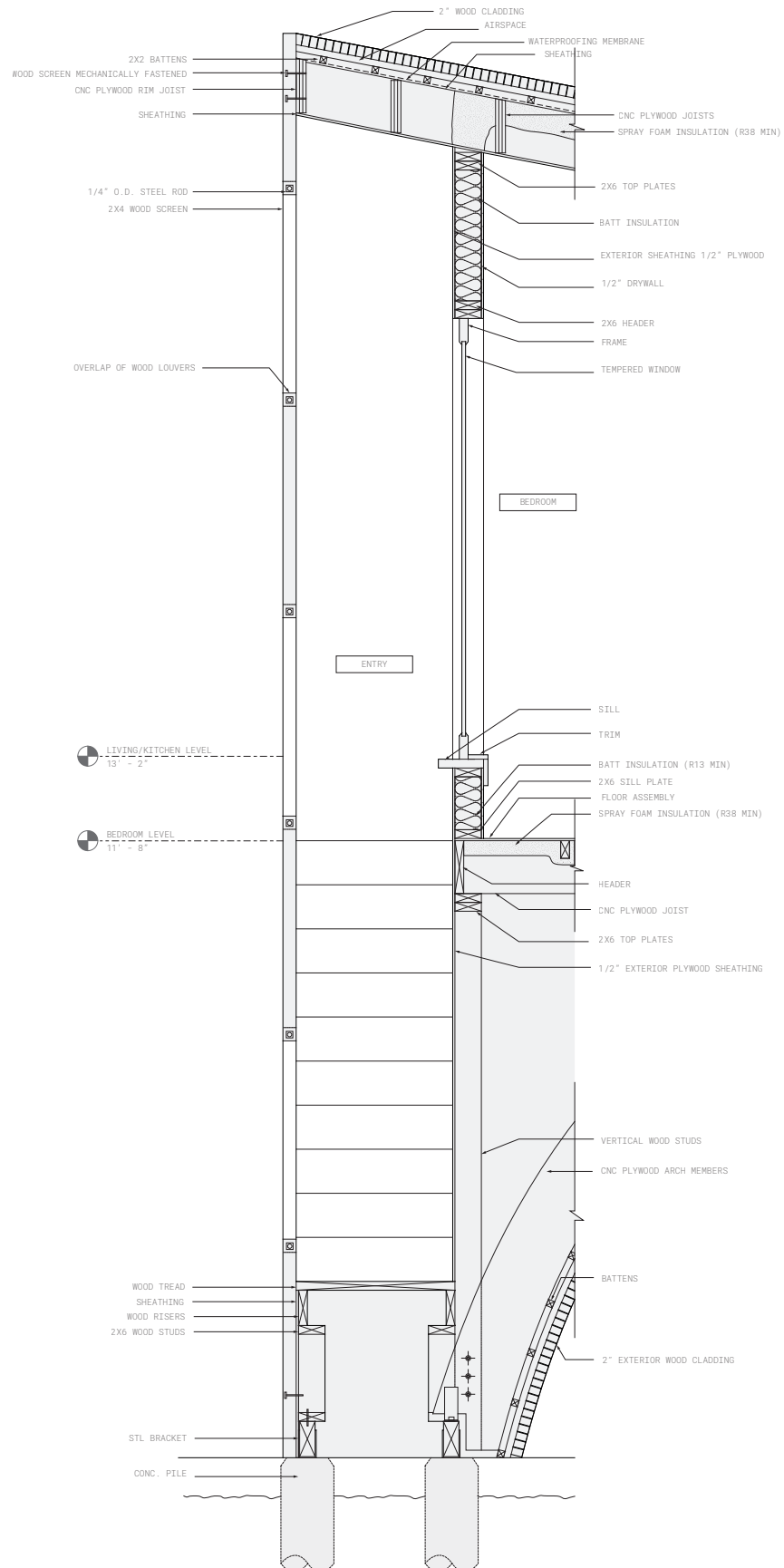




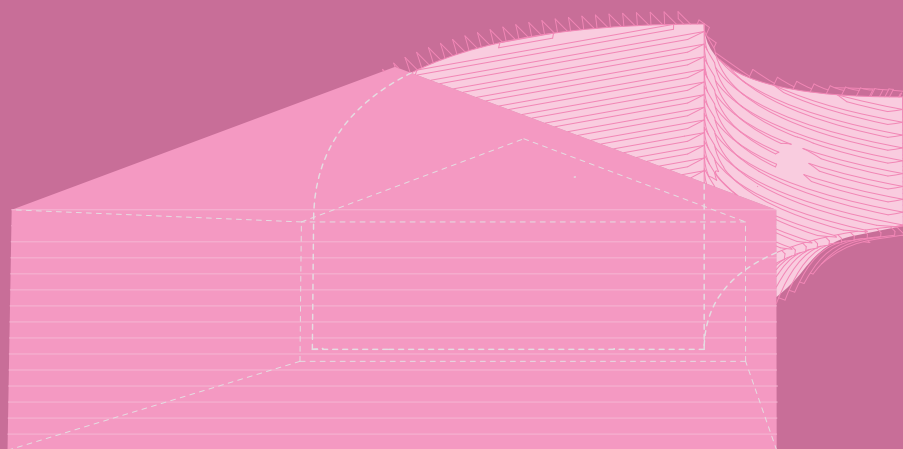
## **dadu**

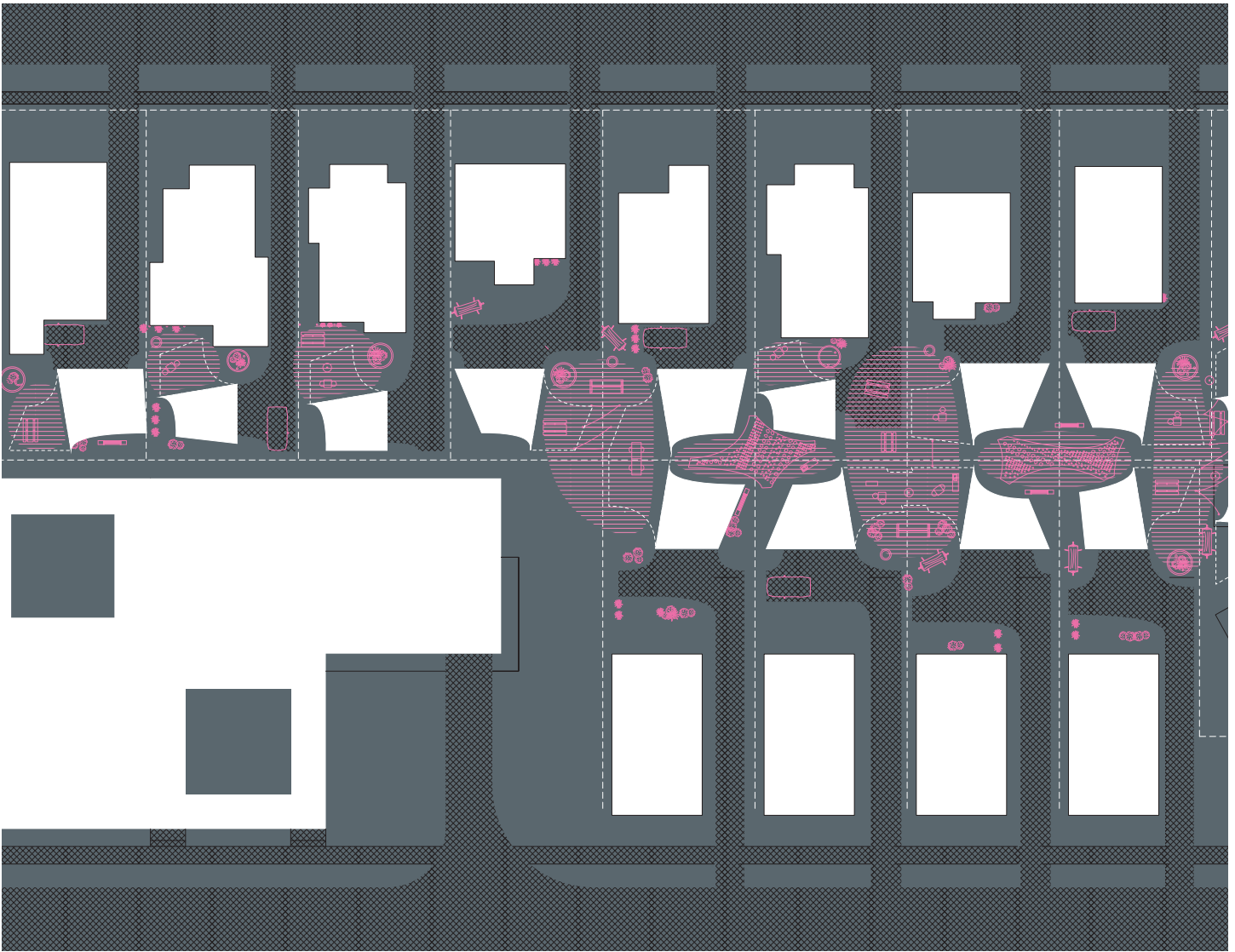
This project maximizes the separation between individual inhabitants. With separate entries, generous bedrooms, private baths and even separate outdoor spaces, only the kitchen is shared among renters. Working within the definition of a single dwelling, Dadu achieves a condition similar to a duplex. Perfect for roommates or perhaps even two couples, the scheme takes advantage of both the diminishing importance of the kitchen and its status as the most communal of spaces. The overall volume of the project stretches to meet the limits of the site as it touches down on two legs. Entry occurs in each leg at opposite corners, again maximizing privacy, with exterior but screened entry stairs and porches that increase the amount of living space while staying under Houston's ADU area limitations. With fenestration occurring only at each end, the projects rotate from one site to the next to increase privacy. The strong separation is countered at the ground with a large, covered space used either for parking or sheltered outdoor activities. These spaces expand at a slight oblique into the adjacent drive or neighboring yard, maximizing collectivity in contrast to the strong separation above.







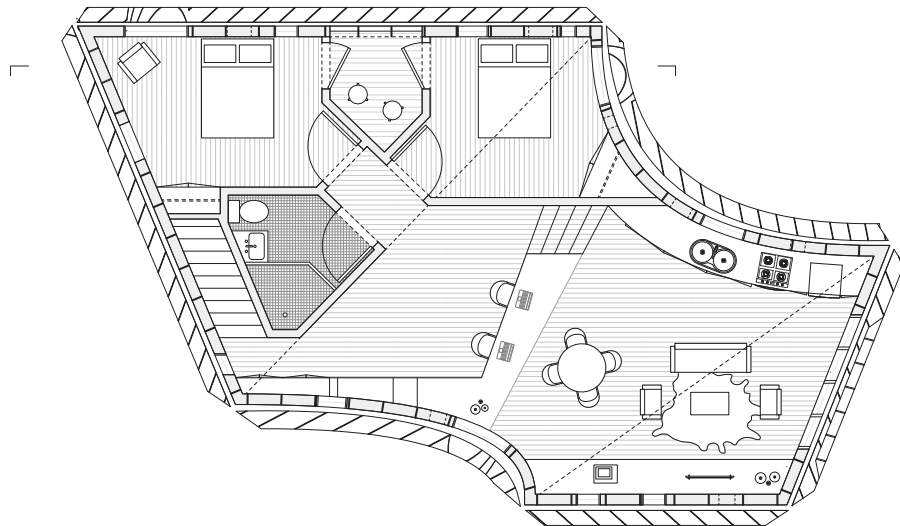
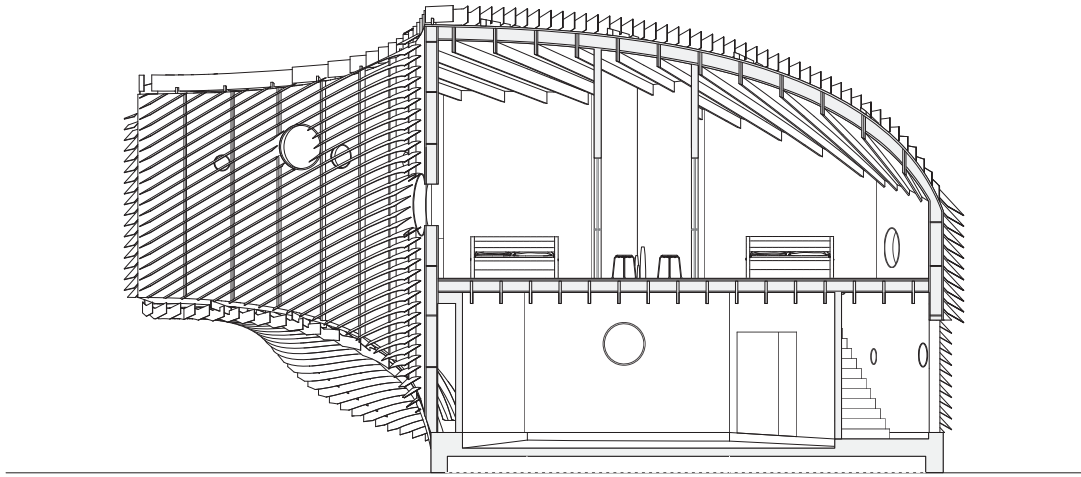




### fremd zone

Fremd Zone's playful form peaks around corners, cantilevering over the drive or side yard to make a carport or covered terrace. In most instances, the bulk of the building mass sits comfortably behind the existing bungalow and draws the attention of passing pedestrians to the smaller, lifted volume above. At the neighborhood scale, the units puzzle together with pairs of curved walls that form courtyard-like spaces between dwellings for communal actives such as gardening. Some cantilevers also pair overhead to create larger, shared communal areas protected from the elements. The exterior is clad in grey, diagonal louvers, similar to the grey siding common to the neighborhood though at more attention-seeking angles. The louvers also help to transform a mostly opaque, mute but curious background object by day into a softly glowing lantern at night.

Project Team: Jordan Garcia, Hillary Davlin, Seth Defore + Hoatian Ma





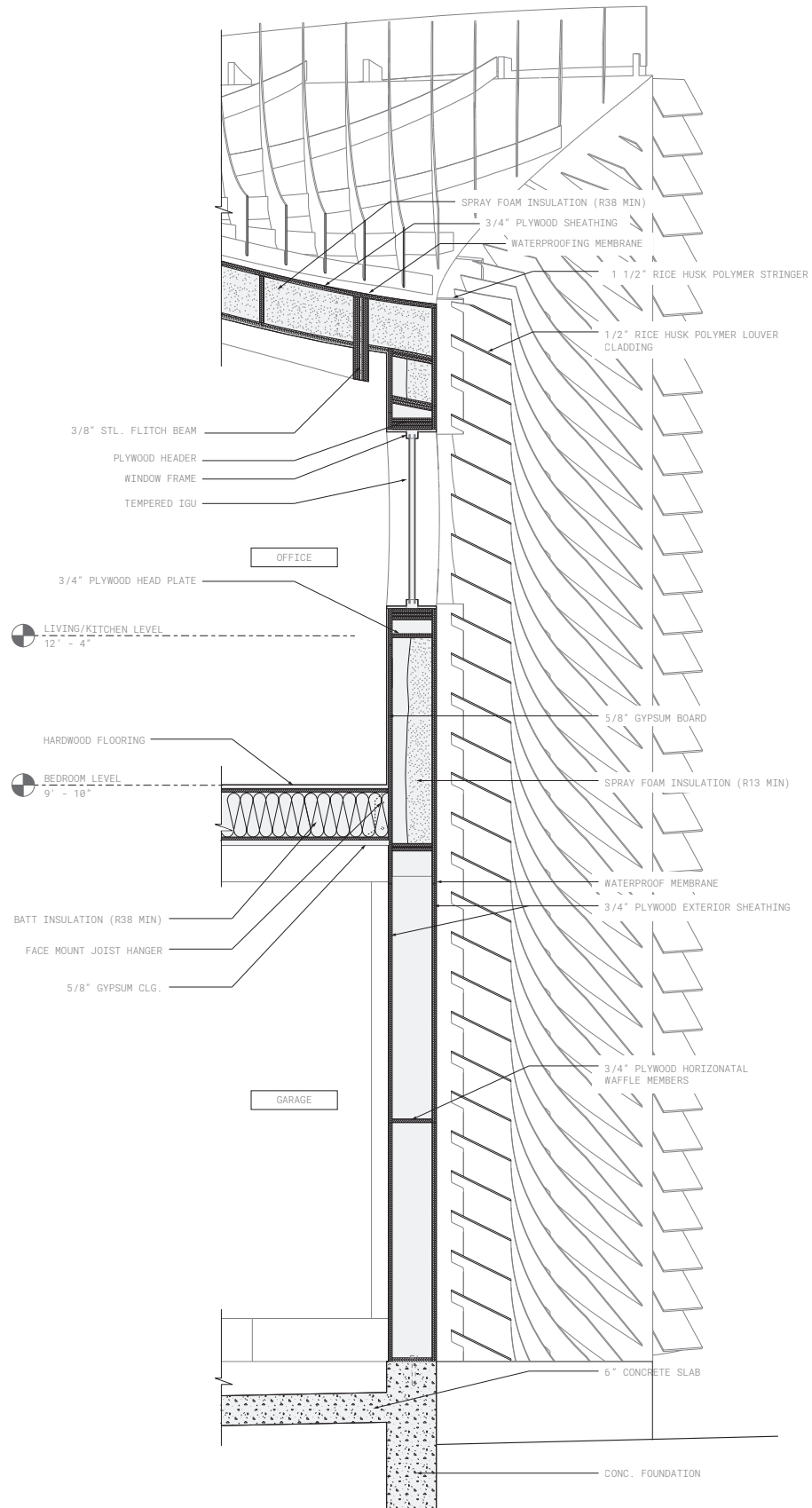
Fremd Zone Detail Model, 1:16  
Detail model demonstrating the construction and assembly logic of the building envelope.

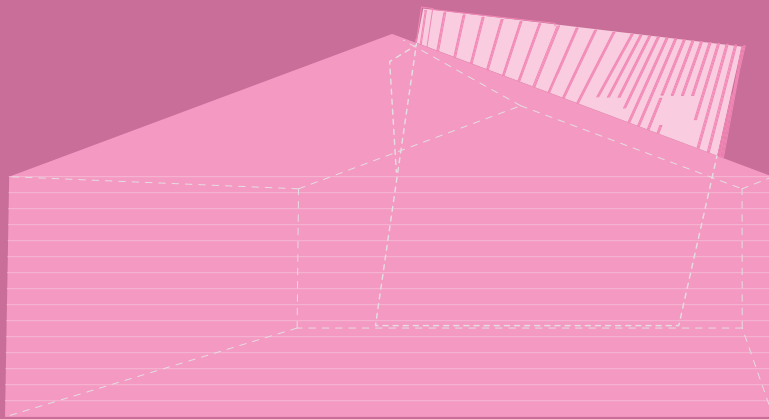
### **fremd zone**

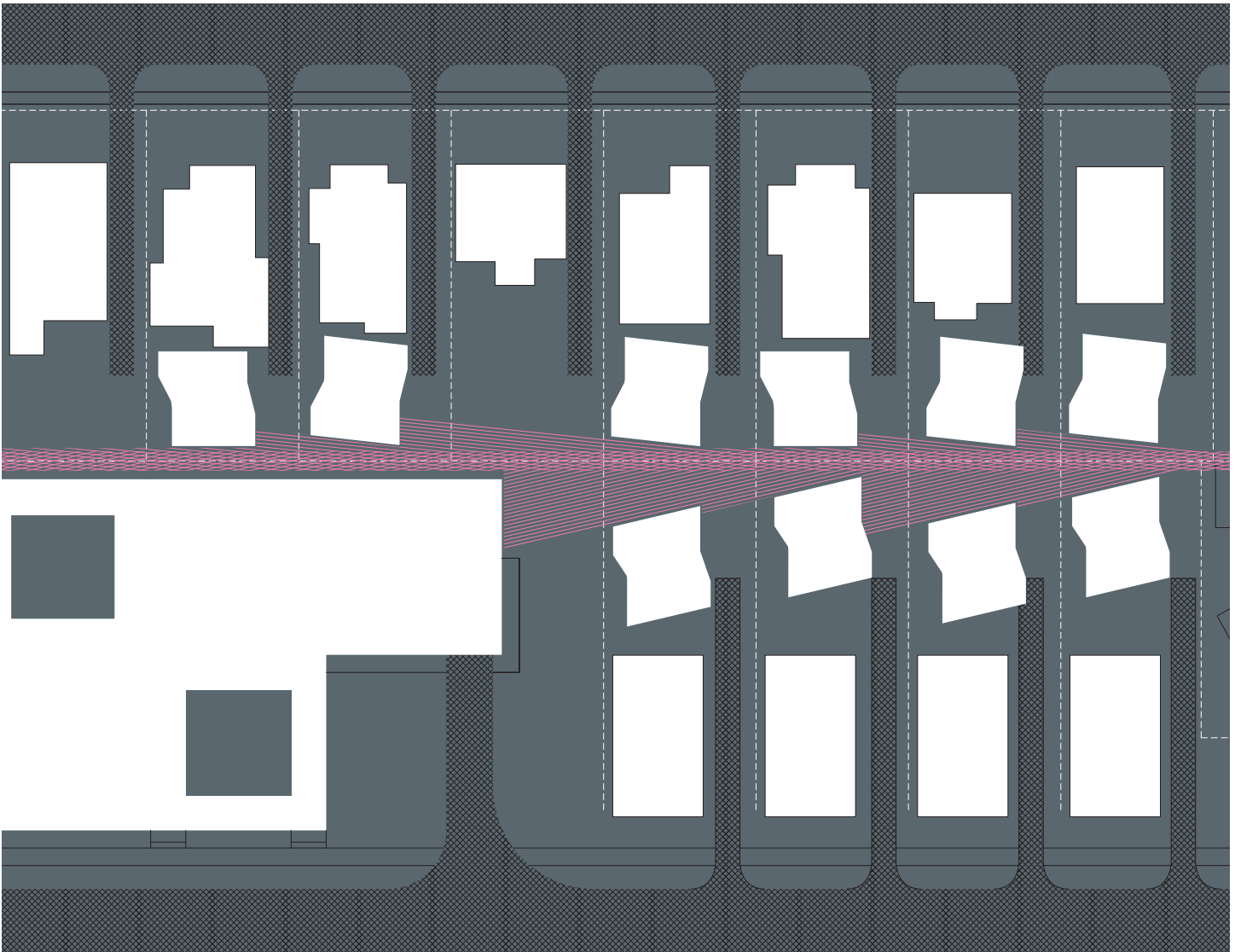
This garage apartment is oriented around the local population of young professionals and college roommates. Inside, spaces are terraced between day and night with living areas lifted just a few steps up from spaces of rest. The distinction is made by a parallel set of convex walls that softly pinch the volume in two. Ample work space connects the two levels, and a tiny terrace makes space for conversation between roommates. Outside, the playful form peaks around corners with its more public, lofted living spaces cantilevering over the drive or side yard to create a carport or covered terrace. Multiple dwelling units puzzle together to form large courtyard-like spaces for communal actives. The exterior of grey, diagonal louvers bring to mind elements familiar to the neighborhood, albeit in a more eye-catching orientation. The louvers' performance also reflects the split activities within. During the day, a mostly opaque, mute but curious object sits in the background. At night, as nearby cultural institutions close, apertures hidden behind the louvers transform the dwelling into a softly glowing lantern, lit from the activity within and now more visibly a part of the residential community. The unique form is created using a laser-cut plywood waffle structure, stiffened by expanding foam insulation. The louvers are easily site-bent along the curved surface of the dwelling using a flexible biopolymer.









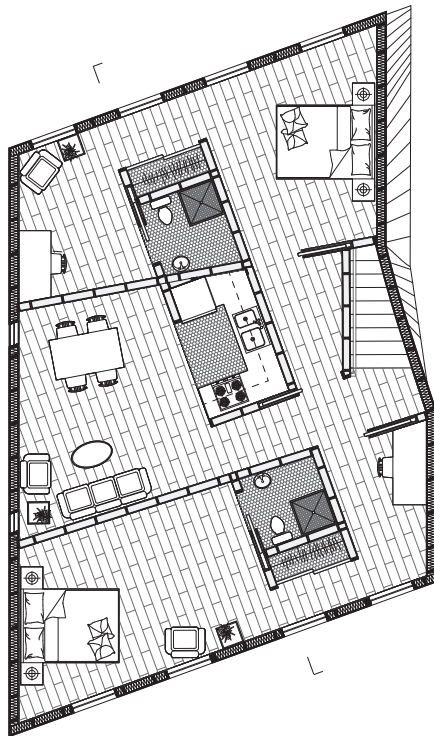
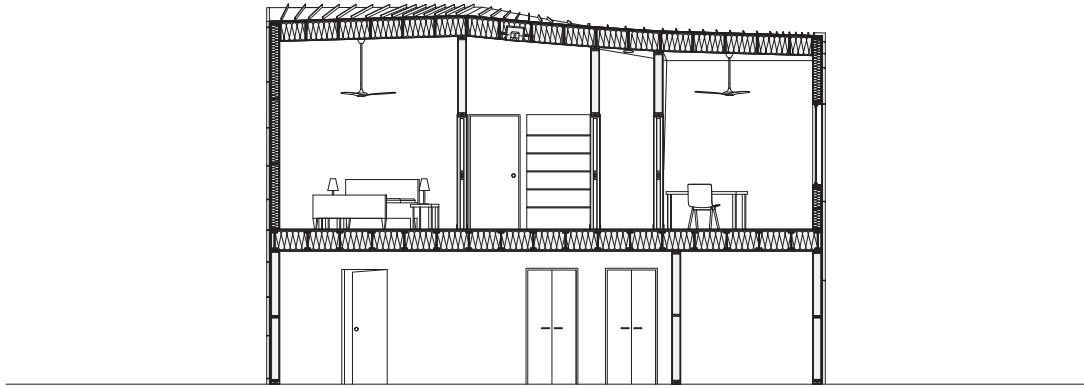


**uncanny incrementalism**

Uncanny Incrementalism takes its cue directly from context. Sitting squarely behind each bungalow, these dwellings tilt slightly side to side to make their presence known from the street. Like an accordion, they expand variably front to back, and angle in plan to guide entry from drive to door at one end and from a new mid-block pedestrian walkway at the other. The angle also reduces the perceived mass from the walkway, flattening the visible face as side becomes front. The volume is further articulated by vertical banding set against a two-tone grey, light over dark—like their environment, an artificial, repeating horizon that structures the sense of depth along the walkway.

Project Team: Lauren Turnage + Rachel Grady





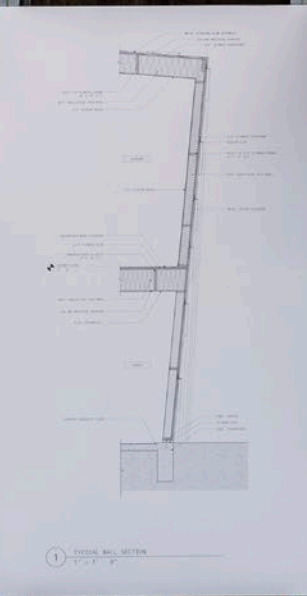
### **uncanny incrementalism**

The interior exhibits a simple subdivision into thirds with bedrooms at either end and common area between. Each bedroom is generous, with an internal study and private bathroom, and occupies the full width of the opposing ends to maximize both privacy and daylight exposure. The arrangement is ideal for cohabitating individuals who want private quarters within a shared dwelling. The two ends are pinned together by a service core including kitchen, and a separate entry sequence opposite the communal space. Externally, the project takes its cue directly from the context. Sitting squarely behind each bungalow, the ADU tilts slightly from side to side to make its presence known from the street. Like an accordion, it expands variably front to back, adapting to each site. The angled plan guides entry from the drive to the ADU's front door. At the opposing end, the angle leads pedestrians along the edge of one unit to another from a new mid-block pedestrian walkway shared among the accessory dwellings. That same oblique angle reduces the perceived mass of the building from the walkway side, reducing the volume to a planar face. The mass is further articulated with vertical banding and by a two-tone grey, light over dark—an artificial, repeating horizon that structures the sense of depth along the walkway. Construction utilizes a series of laser cut, composite plywood frames, and small areas of surface curvature discretized through the use of standing seam cladding.

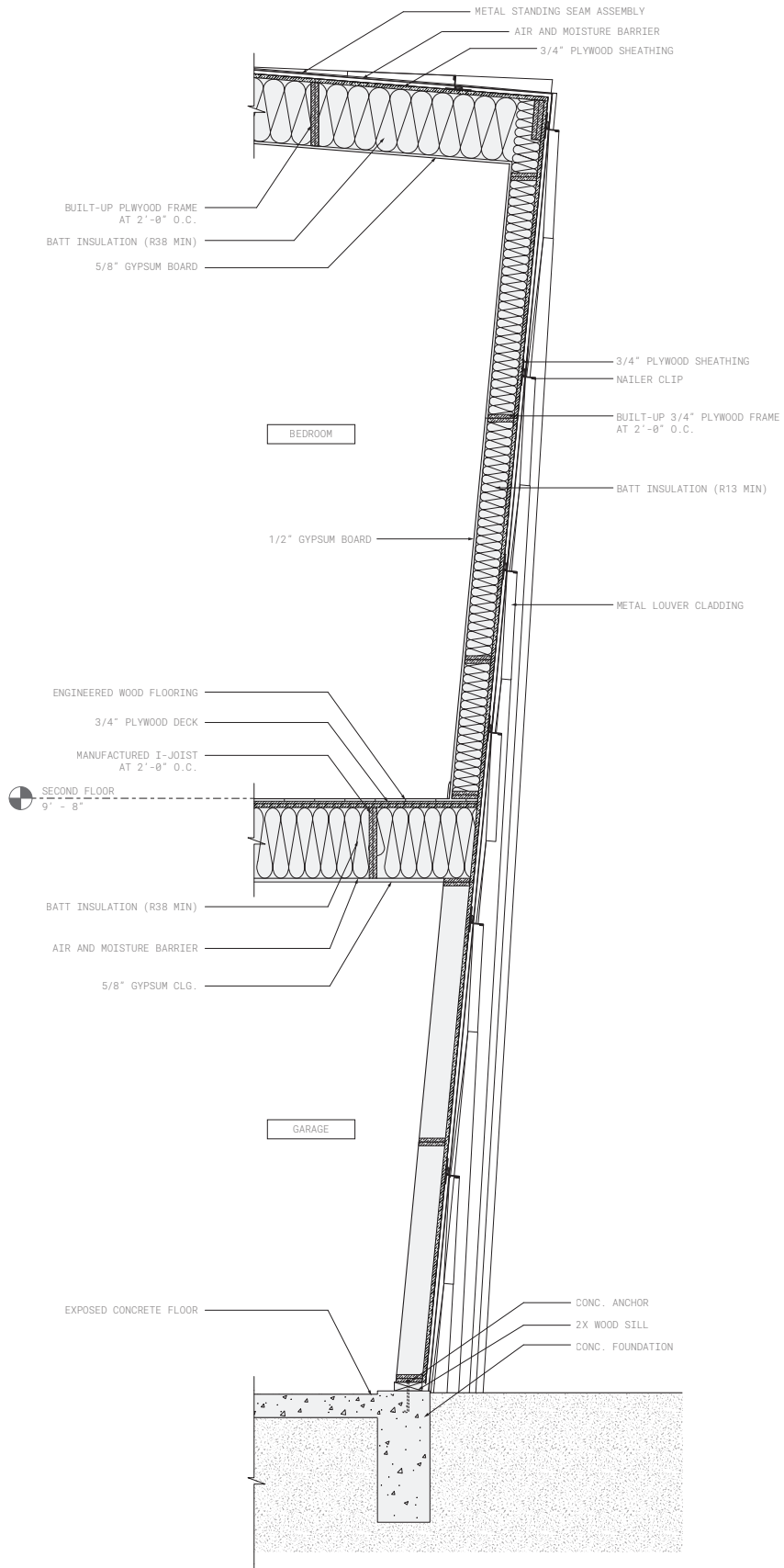


### uncanny incrementalism

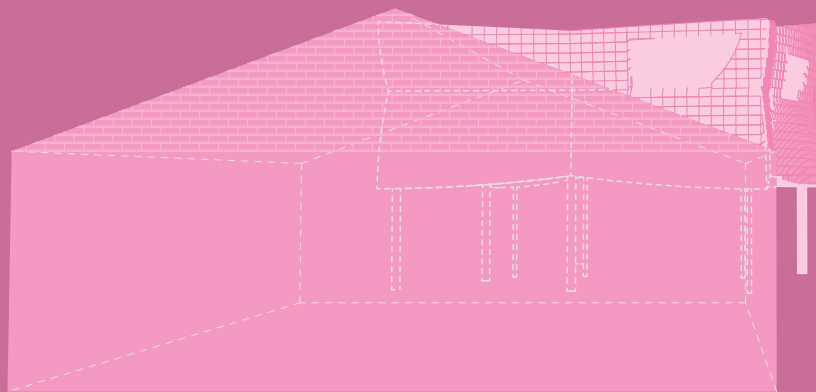
The phrase uncanny incrementalism describes the process of incremental change and the way in which it can be used to describe the way in which a building is built. It is a process of incremental change, where a building is built in a series of small steps, each step adding a new element to the building. This process is often used to describe the way in which a building is built, where a building is built in a series of small steps, each step adding a new element to the building.

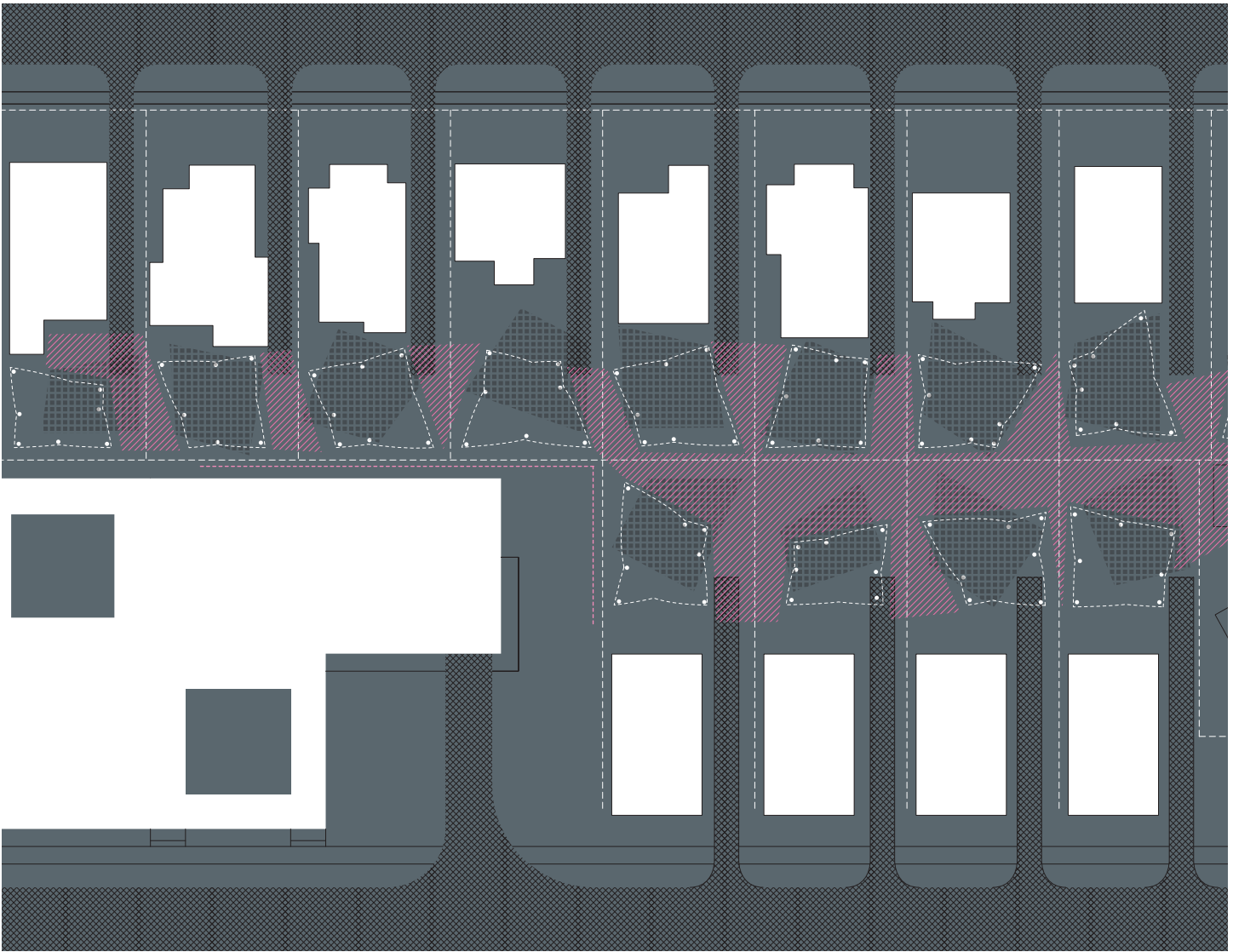


1 DIVISION: BUILDING SYSTEMS





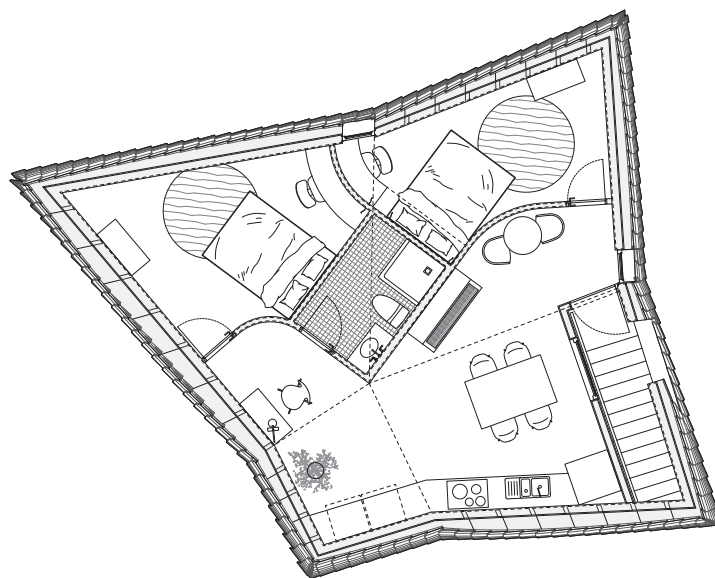
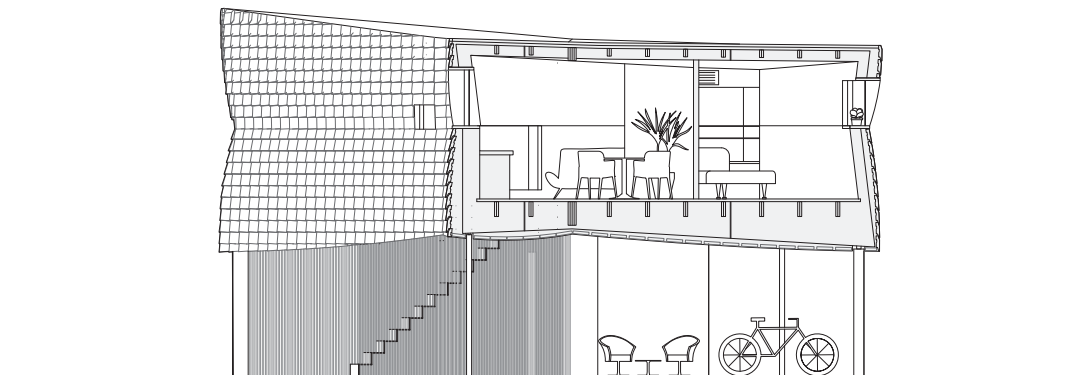




**pillow**

Pillow adds a layer of soft contrast to the neighborhood in both form and materiality. First, the building mass is lifted upon a thin forest of columns to maximize exterior space at ground level. The ground isn't free, per se, but is variably programmed. A shadow of hardscape slips against the figure overhead and shapes an informal set of interconnected landscape conditions among dwellings. The billowing form above flattens against neighboring institutions while stretching to further delineate this rich spatial network. Clad in terracotta shingles of earthen and grey hues—an accessory material language of the neighborhood—the color distribution varies relative to position. At the neighborhood center, where grey dwellings predominate, pillows are mostly orange. At the periphery, they're mostly grey. The inversion provides local contrast yet greater consistency of the neighborhood as a whole.

Project Team: Francis Aguiard + Jiaxing Yan





Pillow Detail Model, 1:8

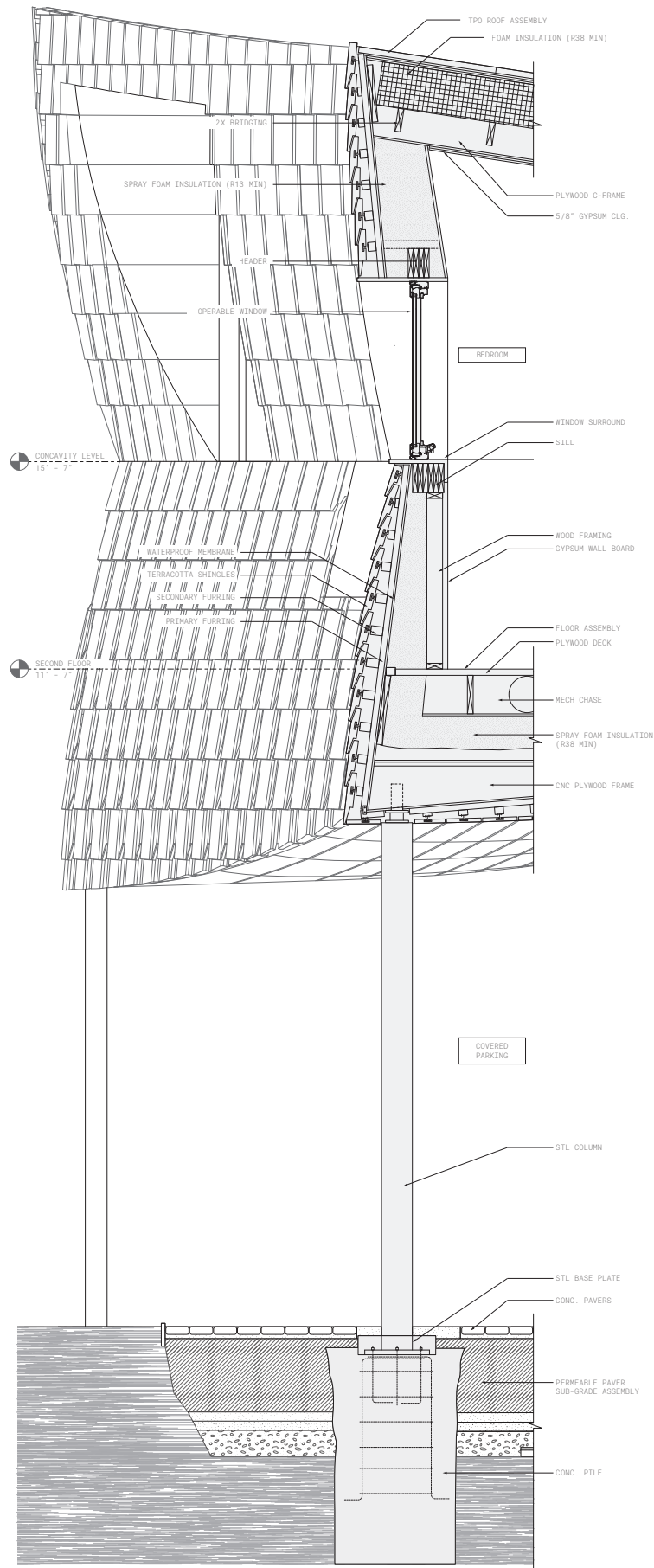
Detail model demonstrating the original construction and assembly logic of the building envelope.

## **pillow**

Pillow provides a soft contrast to the neighborhood with its subtle curvature and a sympathetic color and material palette. The geometry derives from four hyperbolic curves that organize a four-lobed figure with an asymmetrical core and corner stair. By varying the attenuation of the lobes, or “pinches,” both program and structure are reconfigured. Bedrooms pair along any edge, split by shared bath and opposite common spaces and entry. The pinch inverts the structural logic of an otherwise cubic mass-ing by coordinating the main structural frame and columns at the center of each wall rather than the corners. The strategy frees the corners to attenuate, or billow, in various directions to define the space among dwellings and coordinate issues of privacy. In more restricted locations or against neighboring institutions, the curvature can flatten to provide a backdrop—more curtain than pillow. Lifted above the ground, a rich network of landscape spaces is created using permeable pavers, grassy areas and plantings. The planar structure is clad in terracotta shingles of earthen and grey hues to create the appearance of curvature, and the color distribution varies depending on its location. At the neighborhood center, where grey dwellings predominate, pillows are mostly orange. At the periphery, they’re mostly grey. The inversion provides local contrast yet greater consistency for the neighborhood as a whole.







**Paratype**

## Paratype

Two of the five speculative designs from Accessory were workshopped in a subsequent seminar in the spring of 2018. As part of Rice Architecture Construct, students worked to test ideas with large-format constructions utilizing the makerspace at the Moody Center.

Students were first asked to consider the following conceptual prompt:

*Prototypes are real objects that aid in concept definition. However, the implied emphasis on a single result, i.e., a product, ontologically favors mass production—protos begets telos. A paratype, by contrast, aims to articulate multiple, parallel, but no less definitive results.*

The aim of the course was twofold. First, students focused on the digital model, creating a more developed computational framework that could serve as a quantitative analytical tool and point of comparison for the original proposed design. Then, students proposed an unconventional building envelope assembly aimed at achieving a defined, speculative benefit. Finally, students set about testing through iterative physical models the technical resolution and potential challenges of their alternative proposal.

Paratype Projects:

### Envelop/Unfold

This project considers the possible benefits of inverting the logic of a conventional SIP (structurally insulated panel). A typical SIP has two plywood faces and a foam insulation core. By flipping the configuration—a plywood edge and sprayed foam core—weight of the SIP is greatly reduced. Along with the tectonic differences from the use of plywood edges rather than surfaces, the strategy permits much larger panels, possibly speeding assembly and reducing labor costs.

### Pillow

This project examined how the underlying structural geometry might be brought more in line with the curved geometry of the original design, making better use of plywood's inherent ability to bend. Exchanging a logic of rectilinear frames and T-connections for a set of larger-scale, bowed plywood members achieved entirely through lamination, the aim is to reduce the number of overall components (including columns) and expedite on-site construction.

Paratype Students: Claire Chalifour, Eric Cheung, Ekin Erar, George Hewitt, Jack Hilchey, Illy Rakhlin & Yixin Zhou

Instructor: Andrew Colopy, Assistant Professor





## **pillow paratype**

paratype assembly, 1:10

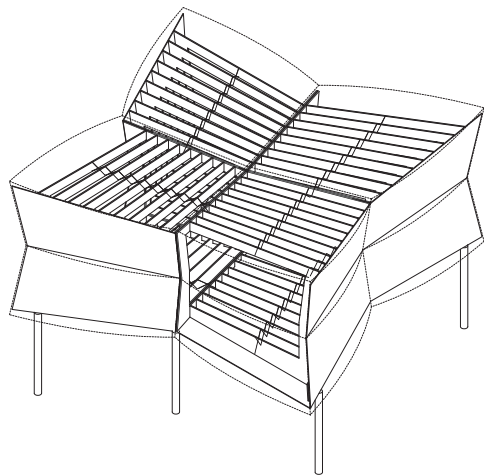
This model demonstrates the basic assembly logic of the principal plywood structural members. Each bay is formed by two sets, top and bottom, of long members bent alongside one another to form a bow from laminated connections. A secondary bay rests upon the primary. The strategy aims to reduce the overall number of members, including the necessary number of columns, by reordering the structural logic.

paratype unit, 1:3

Here, a single bow is constructed using the center bow limb and two outer chords. These components envision the use of plywood at a new scale, making use of long, linear but principally 2D members for easy transport. Chords would be bent on-site and each bow lifted into place. During the process, mechanical fasteners were necessitated as part of the testing along the length of each chord to approximate the conditions of fully adhered components—these fasteners would not be necessary as part of the intended construction logic.

Project Team: Eric Cheung, Ekin Erar, Jack Hilchey, Yixin Zhou

# original

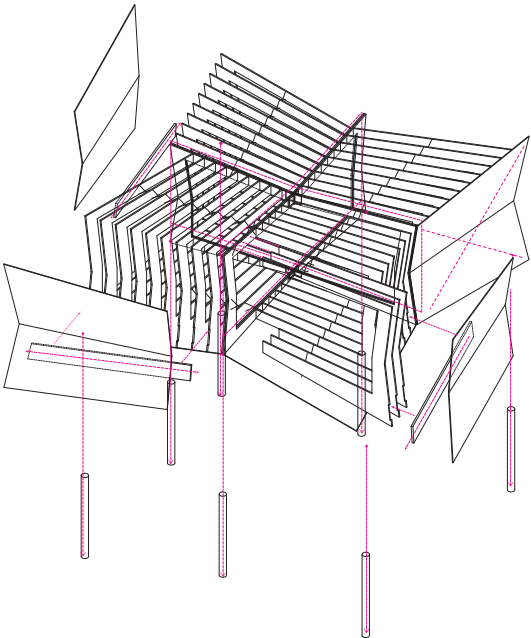
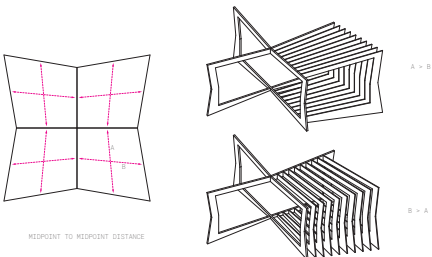


scale: 3/16" = 1' - 0"

## composite assembly

The original structural system is based on a hierarchal set of frames in each of the four quadrants. These quadrants are derived from constructing a set of axes connecting the points at which the pillow "pinches" inward with an independent center. These axes are the primary structural members [axial frames, a flitch beam] on which the secondary frames ["C" frames] connect to discretize the volume of each quadrant.

By using custom shaped frames and a quadrant system, the structure is able to conform to the convex and concave moments in the pillow form. The "C" frames splay to reach the corners and a furring system allows for the cladding to structure the curvature inherent to the pillow's outermost surface.

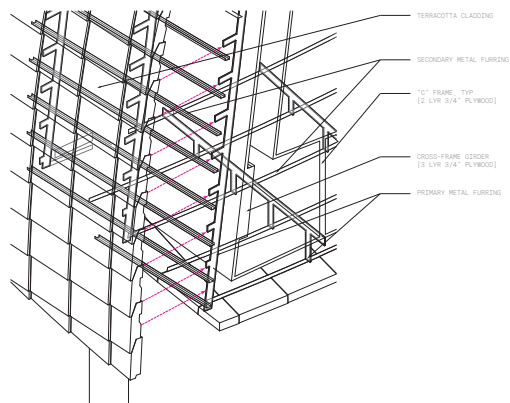


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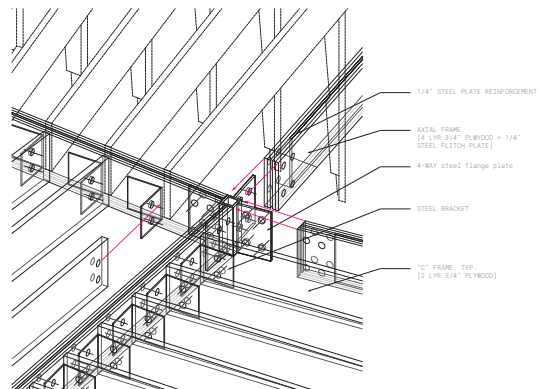
## structural concept

To determine the direction of the "C" frames, a parametric analysis of the form compares the distances from the midpoints of the axes to the edges of the form (within each quadrant). The frames then span the shorter of the two--the more structurally efficient. These "C" frames are then connected to two additional main components: the axial frames and the cross-frame girders, which carry the load to the seven columns.

The 4-way flange plate connects at members the center, redirecting loads to the outer edges of the axial frames and allowing the interior space to be free of structural columns. The "C" frames are reinforced by bridging and outer sheathing and hence are able to resist lateral loads. This system allows for a logical structural discretization that can adapt to changes in the form.



BAY CORNER LAMINATION CONNECTIONS  
scale: 1" = 1' - 0"

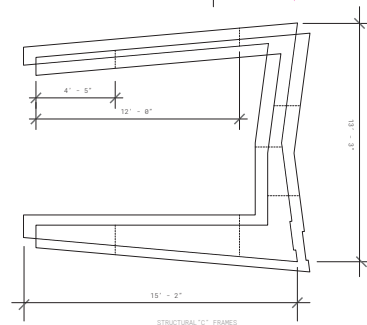
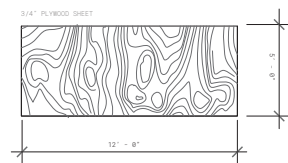
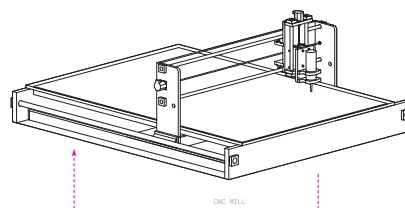


COLUMN TO BEAM CONNECTIONS  
scale: 1" = 1' - 0"

## schematic detail

Due to the flat faces of the sheathing and framing system, the cladding strategy is responsible for creating curvature. Double curvature is accomplished by a primary and secondary furring system, each running in a different direction. Custom terracotta tiles are then attached as the final exterior element.

A steel, 4-way flange plate connects the four axial frames at the center of the structure. The frames slide onto the flange plates. 'C' frames are attached to the axial members with steel brackets; because each member is splayed to meet the form, the angle of connection is variable.



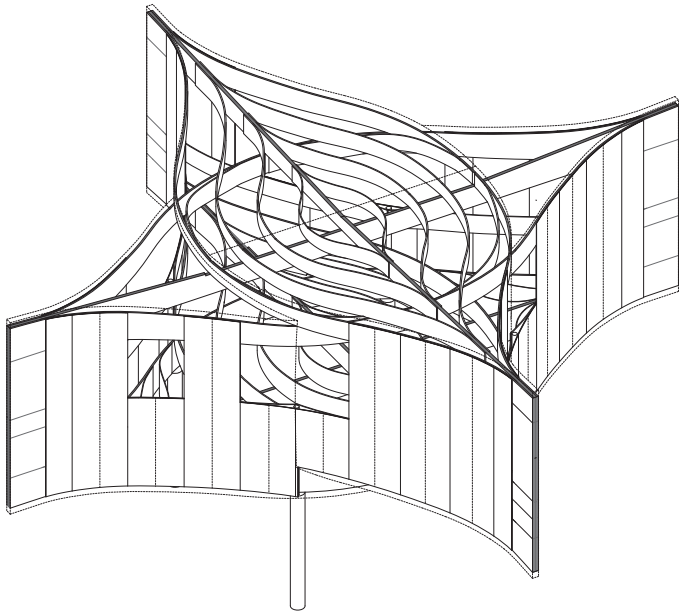
CNC MILLING PRODUCTION  
scale: 3/8" = 1' - 0"

## fabrication

The structural 'C' frames consist of two laminated layers of standard 3/4" plywood. These can be cut from standard sheets and overlapped to create a single member. With the specific and varied shape of each frame, production is made possible by a large 3-axis CNC mill or laser cutter.

Axial frames consist of four layers of 3/4" plywood with one 1/4" layer of steel plate "sandwiched" between to create a flitch beam.

# paratype

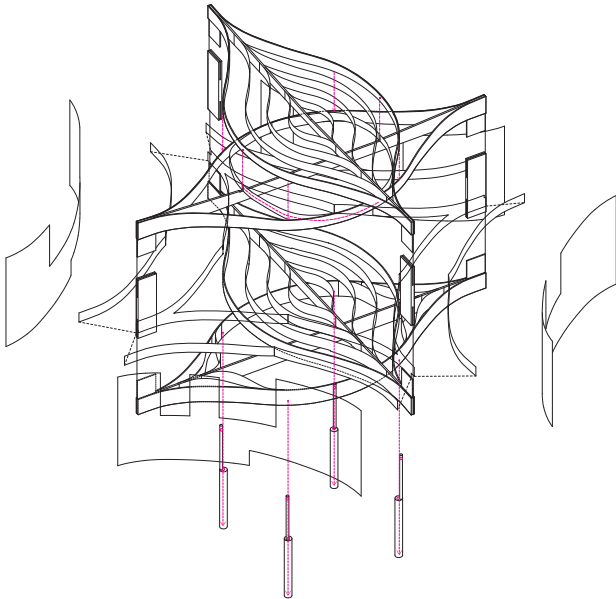
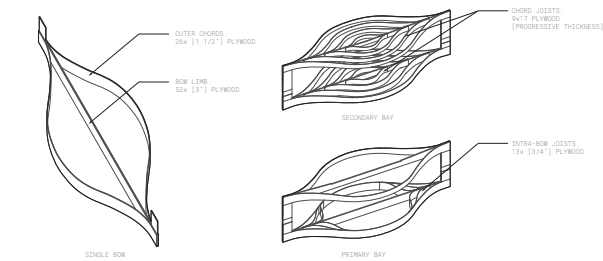


scale: 3/16" = 1' - 0"

## composite assembly

This alternative structural approach to Pillow speculates on the possibility of creating a load-bearing framework from the project's base geometry. As the original shape was derived from 2 pairs of curves to create an 8-sided "pillow," the new concept grounds itself in reproducing similar curves as structural members through lamination.

By using four "bows," each constructed by laminating two bent chord members on either side of a stiff bow limb to create a structure that can span across the ADU, this paratype recalls the pillow form while reducing the number of columns and variable angle connections. The system makes use of longer plywood spans made possible by the lamination and varies member strength by the number of plies, taking full advantage of the inherent logic of plywood. These four bows are paired vertically, then set on different axes to be pinned at various points to create rigidity and sheathed to resist lateral loads.

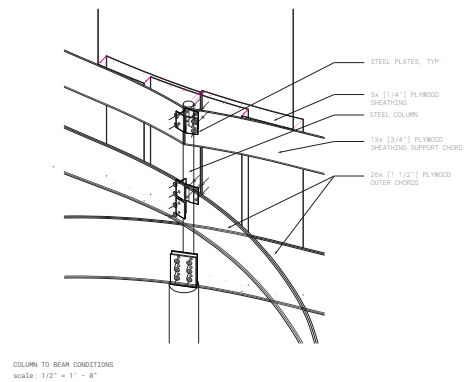
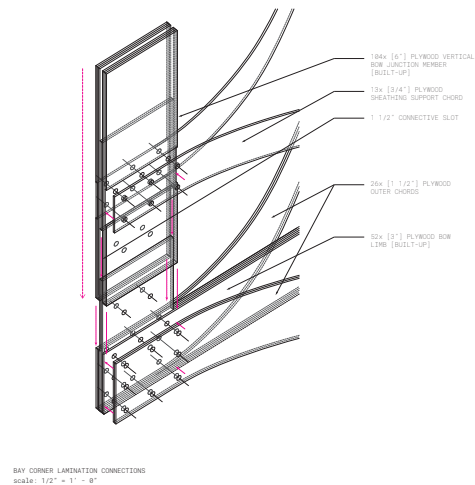


scale: 1/8" = 1' - 0"

## structural concept

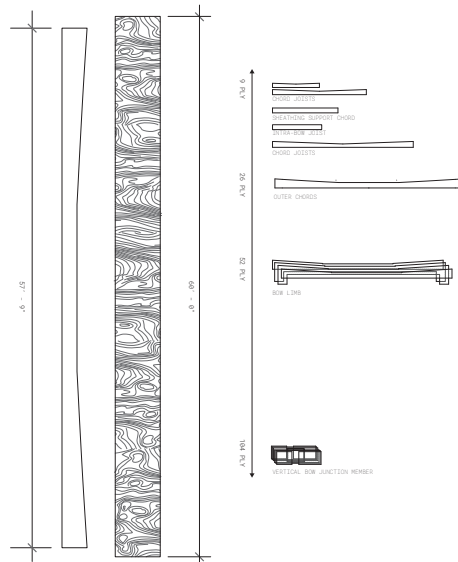
Two single bows are connected with a vertical member to create a bay, which encloses a volume. The two bays are interlocked, creating the hierarchy of primary and secondary bays: the secondary's two bows sit on top of the primary's respective bows, transferring the loads down to the steel columns. As the secondary bay accounts for a majority of live and interior dead loads, it is discretized using more laminated "bow joists," whereas the additional area provided by the primary bay are discretized using different but also laminated joist members.

The structure becomes rigid through the connections along the two bays. These include pinned joints to the steel columns, two layers of sheathing that bend to create shear planes stretching across both bays, and laminated members that pin the midpoints of the two upper bows.



## schematic detail

Two important concepts reinforcing this scheme are lamination and the pinning of the intersection points of the two bays. The former becomes a way to reduce connections requiring specific and variable angles, opting instead for a unidirectional method that uses standard bolts. This approach incorporates a slotting system for on-site construction to assemble the interlocking bays. The latter provides the vital framework for forces to transfer and create a robust structure: the steel columns are located at the intersection points of the chords on either bay.



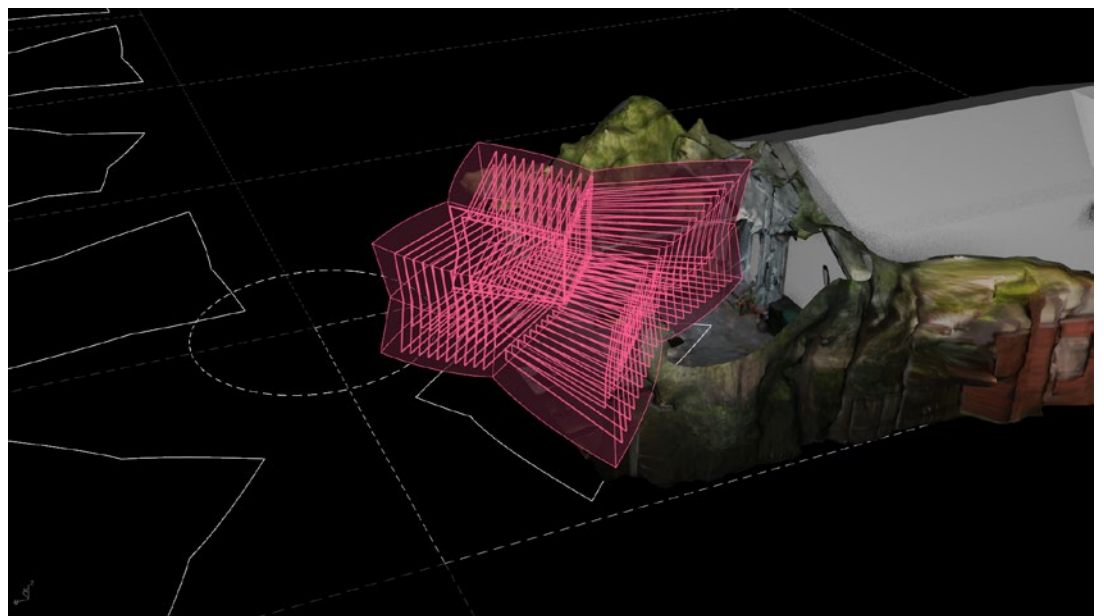
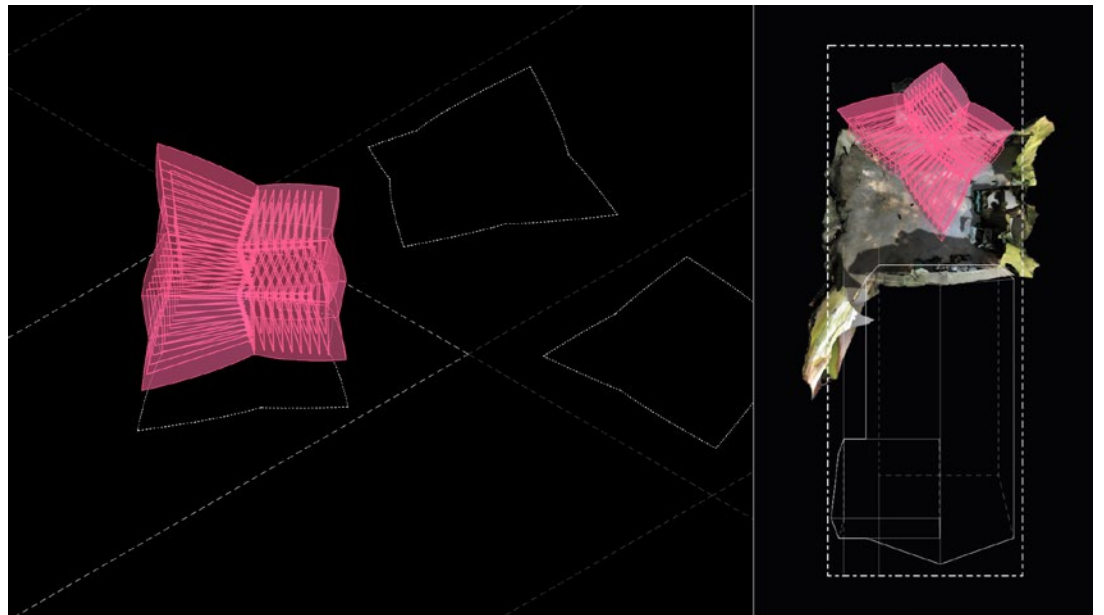
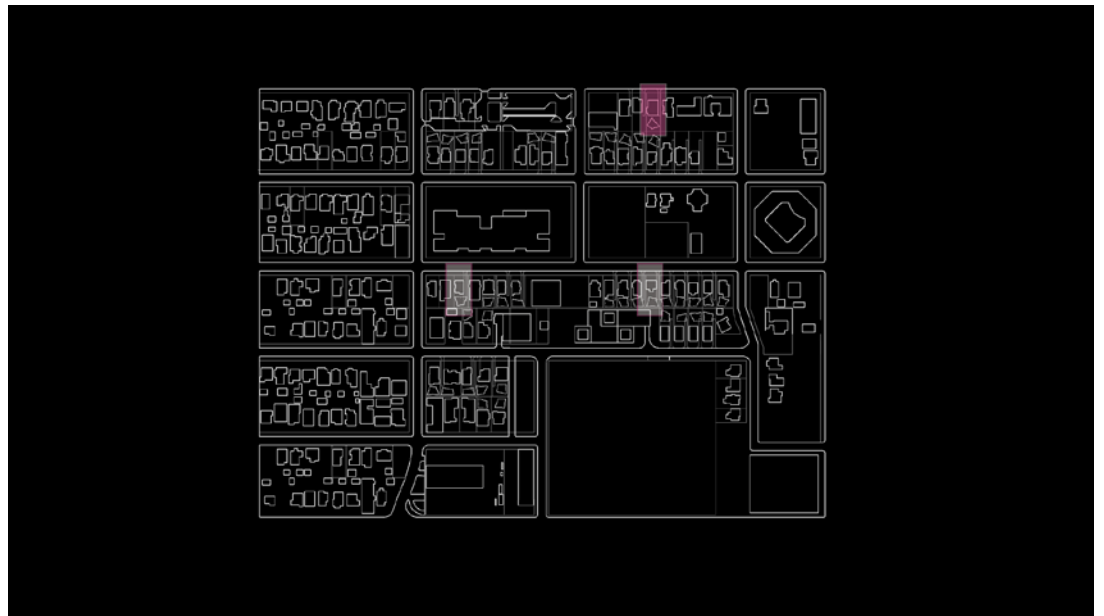
## fabrication

While the plywood members do not align with current standardized sheet sizes and thickness, the paratype suggests a new possible type of plywood production to assist in creating structural members. Reimagining the standards without going beyond the limits of current manufacturing technology involved an adaptation of current Baltic Birch ply thickness to a variable number of plies and the implication of rolling longer, thinner sheets.

The plywood members in this alternative proposal are therefore able to be bent on site as single long chords to create bows and bays, with variable numbers of plies to account for different radii and structural capacity.







animation stills



## envelop/unfold paratype

paratype assembly, 1:2

This first, large-format test demonstrates the assembly of individual SIPs (structurally insulated panels), and is shown partially sheathed and clad (using a substitute material for visualization). In the final assembly, each triangular unit would be filled with expanding foam insulation to produce a stiffened panel. The milled, rigid foam (purple) was substituted here to reduce testing costs, and some units were left unfilled for visualization purposes. In some locations, the forces when assembled without insulation to resist compression proved too great for the “kerfed” corner plywood parts. More durable (though less rigid) plastic components were substituted here to complete the first test.

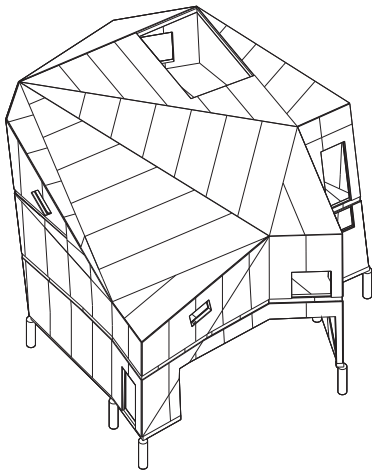
paratype unit, 1:2

This single unit demonstrates the inverted logic of the triangular SIP (structurally insulated panel). A plywood frame is formed using a “kerfing” pattern at the corner units and then filled with expanding foam insulation that resists compression (integrating insulation and structure). The inversion reduces the weight of the initial unit, allowing for larger and fewer panels to be installed on site and subsequently sheathed.

Project Team: Claire Chalifour, George Hewitt, Illy Rakhlin



## original

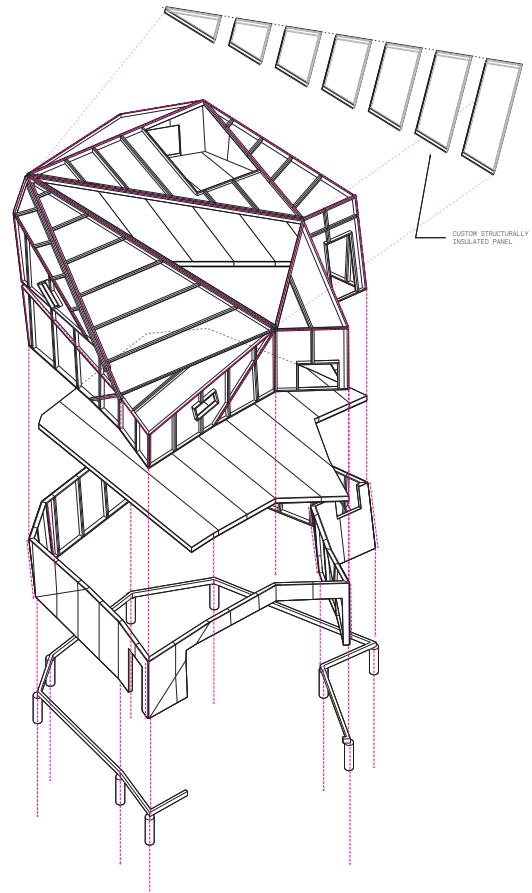


COMPLETE MODEL, WITH CLADDING REMOVED  
scale: 3/16" = 1' - 0"

### composite assembly

The original structural system uses the large triangular facets in the form as a starting point for a shell-like structure. The facets are broken down into quadrilaterals with two parallel lines, 4 feet apart. Each of these smaller facets is a custom produced SIP (Structurally Insulated Panel) with high thermal efficiency and enough flexibility to be adapted on site.

If the triangular facets have an edge greater than 8 feet, the SIPs are oriented perpendicular to that edge. Framing for the windows, doors and openings are built into the custom SIPs providing a fast construction time on site. Three fitch beams provide additional support along the large spans at the top of the form.

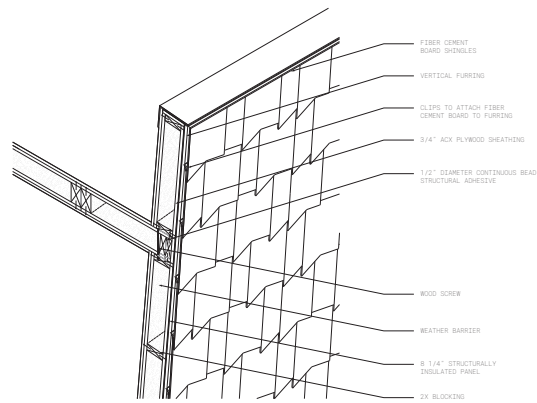


DISTRIBUTION OF FORCES  
scale: 3/16" = 1' - 0"

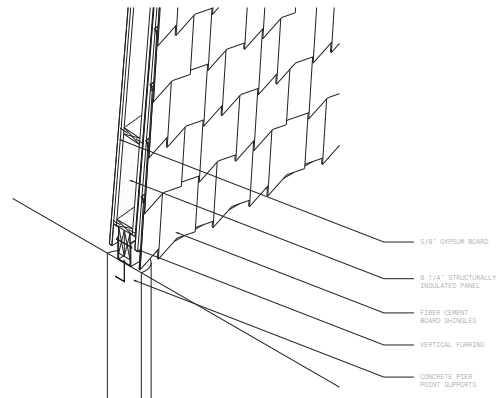
### structural concept

The shell structure formed by the SIPs treats the envelope on the first and second floor separately, similar to a platform framing logic. Forces on the second floor are distributed towards the edges of the floor plate and are translated vertically to the first floor. The floor is also constructed from SIPs which are oriented parallel to the wall with the front entrance. This orientation allows for the greatest number of panels spanning from edge to edge as possible. A system of concrete piers at each bend in the perimeter of the floor forms the foundation. The piers lift the house up from the ground to minimize flood damage.

This drawing hides the plywood exterior on the second floor and the plywood interior on the first floor for clarity. Additionally, one of facets in the form is removed to show the SIP assembly.



STORY TO STORY CONNECTION  
scale: 1" = 1' - 0"

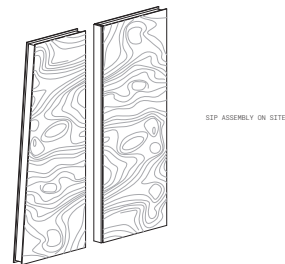
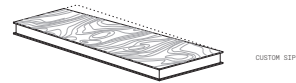
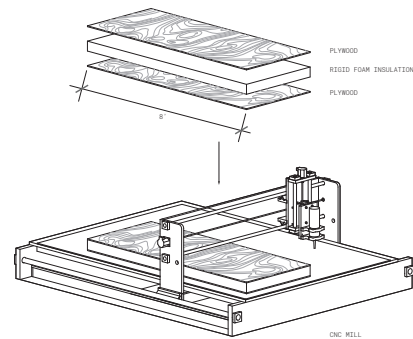


FOUNDATION TO GARAGE CONNECTION  
scale: 1" = 1' - 0"

## schematic detail

Each SIP is composed of two plywood sheets sandwiching thick rigid foam insulation. Between the SIPs are wooden studs that translate the loads of the form and provide a surface to attach the panels to one another with glue and screws. A horizontal SIP (forming the floor) connects to a SIP on the building's envelope using large wood screws.

Cladding is attached to the exterior of the SIPs using vertical furring. The fiber cement board is cut with a variable edge and scored to create the appearance of shingles.



SIP MANUFACTURING AND CNC MILLING PRODUCTION

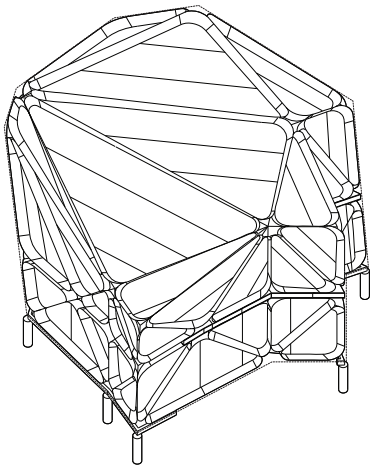
## fabrication

This set of diagrams outlines the production of a custom structurally insulated panel (SIP) within a shop rather than on the construction site. After two plywood sheets are laminated to the rigid foam insulation, a CNC mill customizes the profile of the form, in this case, removing a corner.

After the milling, a portion of the panel's foam sides are scooped out with a foam cutter to provide room for the wood studs that will provide additional structure when assembled on site.



## paratype

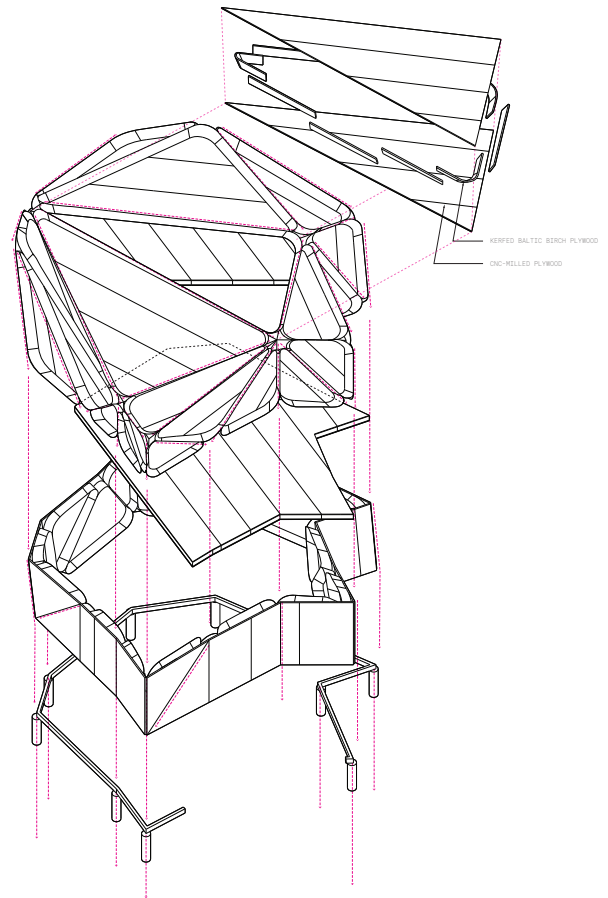


COMPLETE MODEL, WITH CLADDING REMOVED  
scale: 3/16" = 1' - 0"

### composite assembly

This structural scheme takes the triangular facets of the original form and translates them into triangular panels. Rather than using the more traditional SIP (Structurally Insulated Panel) logic, these panels use entirely custom cut materials using plywood rather than wood studs. Within each panel, a layer of plywood wraps the edge of the foam insulation, creating greater thermal efficiency, greater efficiency of materials, and lighter panels.

The cladding strategy is fairly independent of the panels since the plywood exterior is applied on site after the triangular panels are in place. Sometimes the plywood cladding spans multiple panels for greater efficiency.

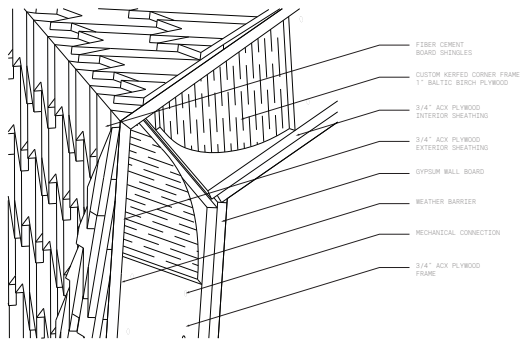


DISTRIBUTION OF FORCES  
scale: 3/16" = 1' - 0"

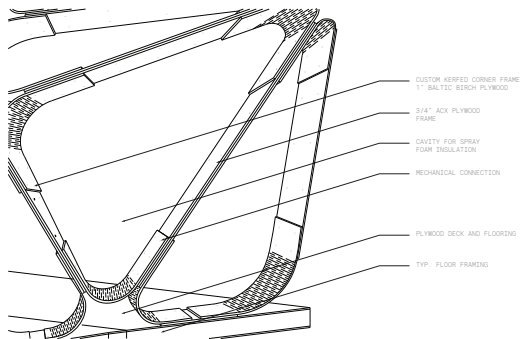
### structural concept

Similar to the previous scheme, this shell structure is formed by insulated panels that distribute loads through their edges. Forces on the second floor are distributed towards the edges of the floor plate and are translated vertically to the first floor. This strategy uses far fewer panels, which expedites on-site construction time. The floor is made of standard SIPs that are oriented parallel to the wall with the front entrance. A system of concrete piers at every bend in the perimeter of the floor, form the foundation. The piers lift the house up from the ground and minimize flood damage.

This drawing removes the plywood exterior on the second floor and the plywood interior on the first floor for clarity. Additionally, one of the facets is removed to show the assembly of pieces that form a single panel in lieu of the seven in the previous scheme.



WALL LAMINATION DETAIL  
scale: 1" = 8" - 4"

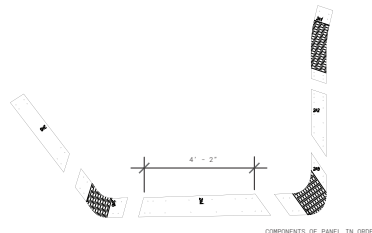
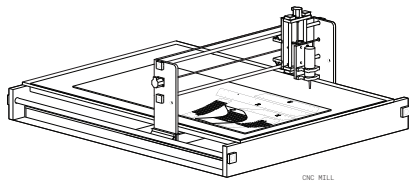


PANEL TO PANEL CONNECTION DETAIL  
scale: 1" = 1' - 0"

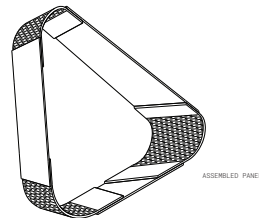
## schematic detail

These details show the connections between panels and construction of a wall using custom components. Each segment of the plywood that wraps the panels is cut differently according to the severity of the angle and the number of connections it makes. Each connection between segments within a panel is made with a least four screws. Completed panels are joined to one another before they are filled with spray foam insulation. Additional spray foam insulation is added to the open forms once assembled on site.

Cladding is attached to exterior of the SIPs using a system of vertical runners. The fiber cement boards are cut with a variable edges and scored to create the appearance of shingles.



COMPONENTS OF PANEL IN ORDER



ASSEMBLED PANEL

PANEL ASSEMBLY AND CNC MILLING PRODUCTION  
scale: 3/8" = 1' - 0"

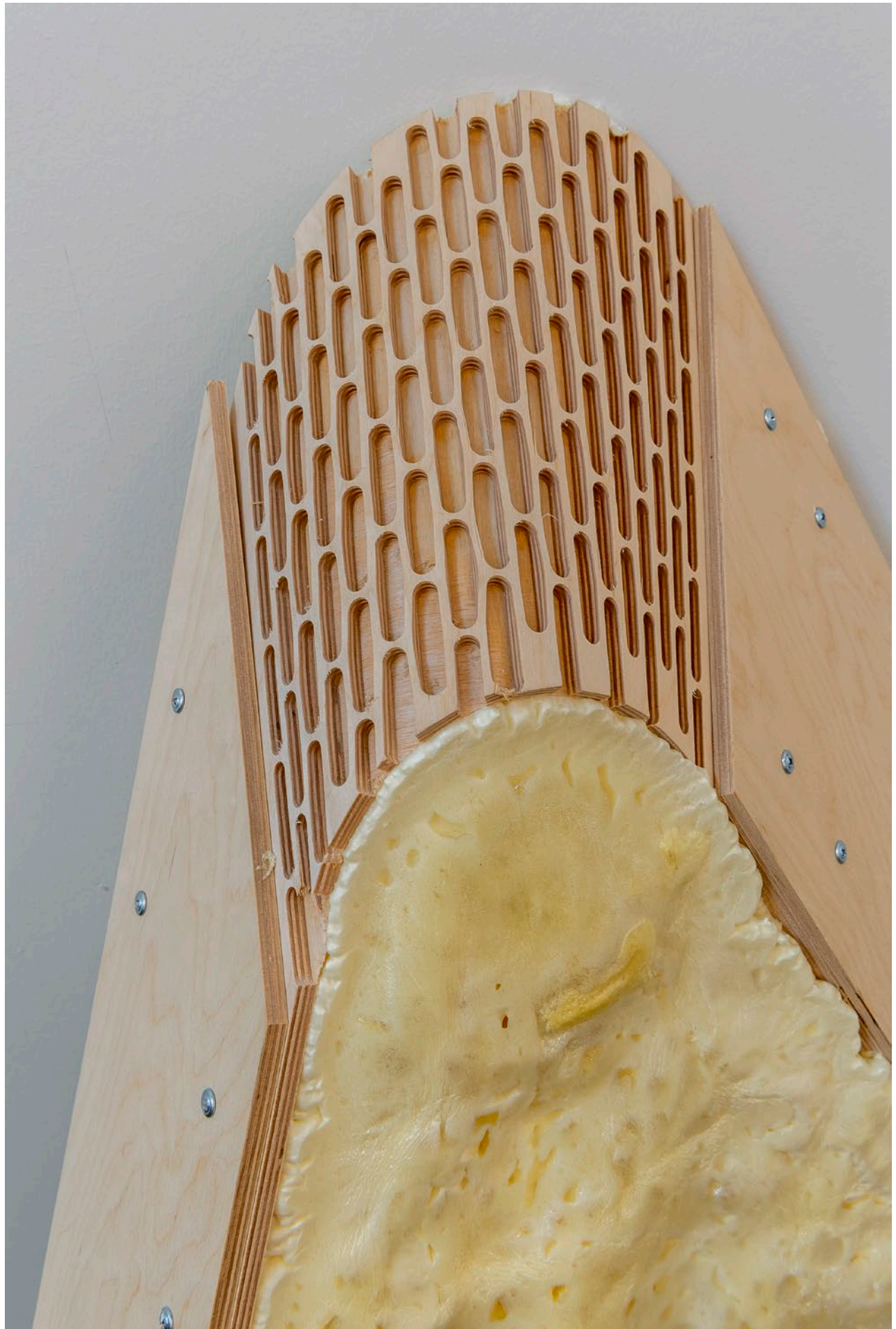
## fabrication

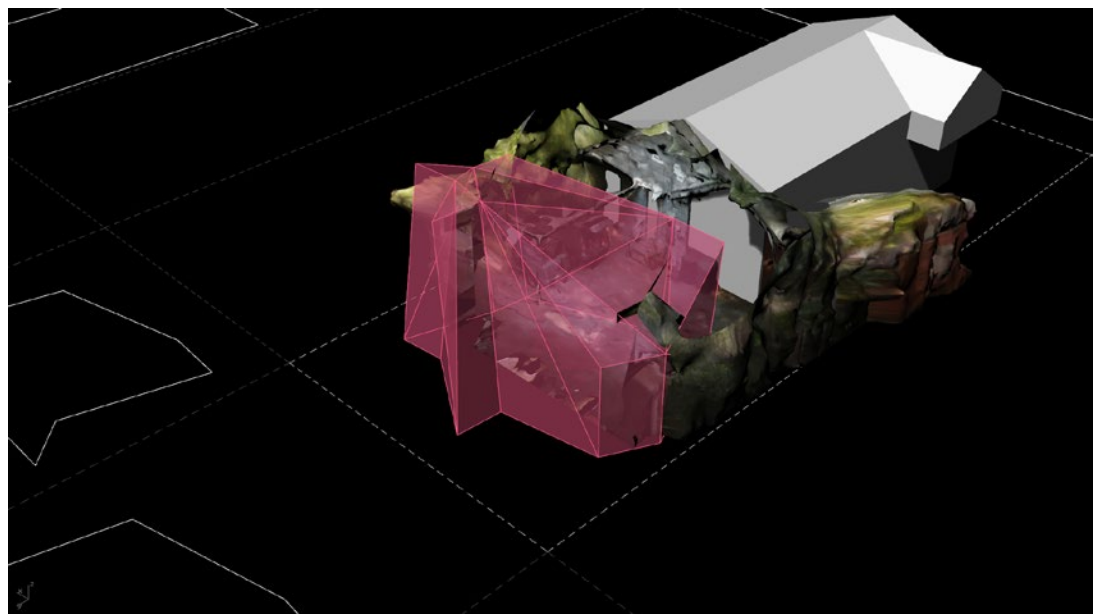
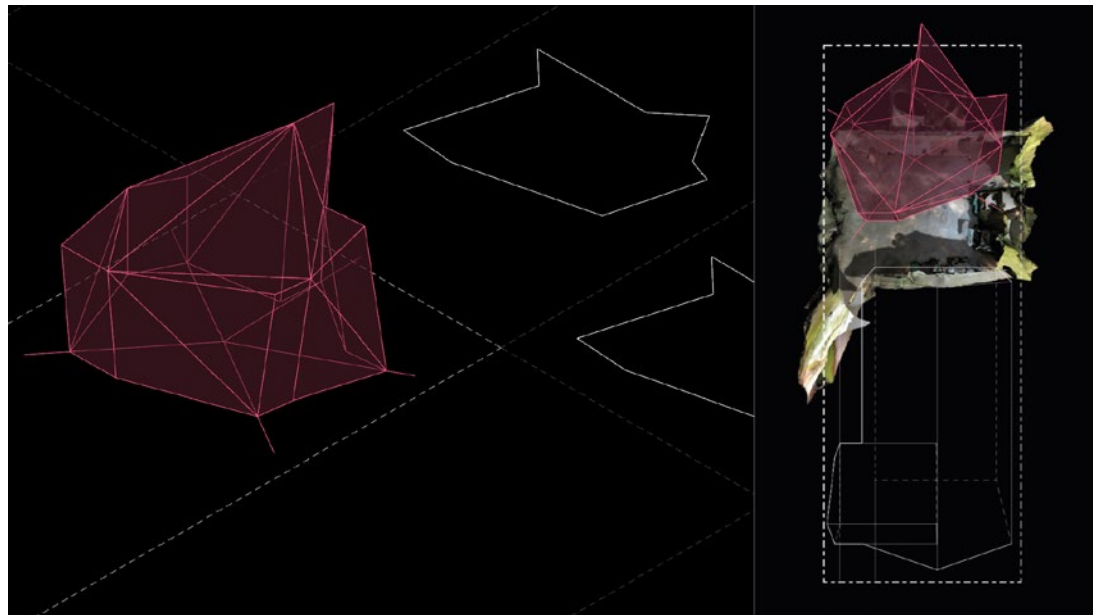
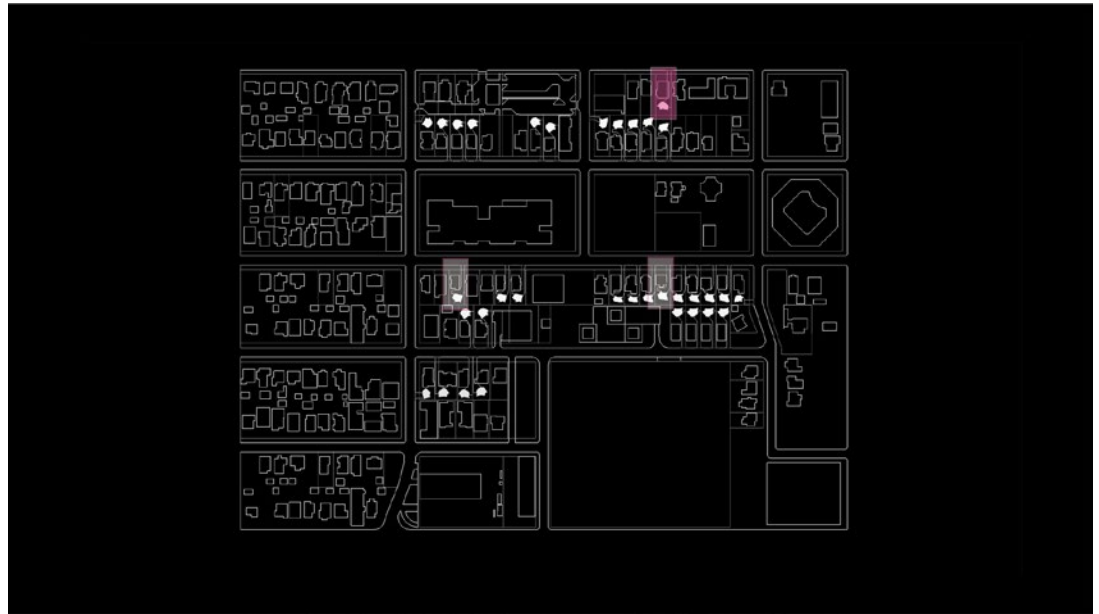
The fabrication process for the triangular panels is fairly fast since pieces for many panels can be cut at once. The corners of the panels are cut out using a 'kerfing' pattern of alternating slots that allows the rigid plywood to bend. Each piece of the panel includes labels and marks indicating the location of necessary fasteners.

Spray foam insulation is added before the panel leaves the shop, providing rigidity through the building insulation.









animation stills



**+ House**

## + House

+House was designed to be an accessory dwelling unit prototype with a minimal footprint for two, independent occupants. It includes space for sleeping, bathing, food preparation, work, and storage in a mere 360 square feet, with a generous porch that expands the dwelling out and into the exterior. This compact and efficient plan demonstrates one viable strategy to provide new, energy efficient housing in Houston while maintaining the existing urban fabric.

The project will provide much-needed housing for Agape Development's Gateway Residential Program, a Third Ward outreach program that assists youths 18-25 years of age in the transition from a difficult living situation to healthy, independent adulthood.

Over the course of four semesters, the project provided students the opportunity to research structural and envelope systems, materials and fabrication technology, and renewable energy and resource efficient strategies. Construction began in the spring of 2017, first with fabrication of the core, a 6x10 foot unit that includes the kitchen, bathroom, and MEP systems. Completed in Ryon Lab at Rice, the core was then relocated and stored for the summer. In the fall of 2017, students constructed the envelope on-site in southeast Houston, and in December, introduced the core into the house. In 2018, after working to complete interior and exterior finishes, the project was handed over to Agape. In all, Construct spent approximately 70 working days (less than four months) on construction and fabrication, involving the efforts 25 students.

### Project Team

#### Rice Architecture Construct Students

James Carr, Ningxin Cheng, Hillary Davlin, Nell El Sour, Leyla Hepsaydir (2 semesters), Michael Hernandez, JP Jackson, Daniel Kleeschulte (2), Julie Klosterman (4), Yu Kono (2), Keija Lu (2), Xi Luo, Eleanor Ma, Haotian Ma, Edna Otuomagie, Alex Palmer, Jonathan Pan, Rui Qi, John Rudd (3), Shiori Sageshima, Sebastian Torres (2), Claire Wagner, Rose Wilkowski (4), Xiangcheng Xing, Jiaying Yan

#### Rice University Faculty and Fellows

Danny Samuels, FAIA, Professor in Practice, Co-Director, Rice Construct  
Andrew Colopy, Assistant Professor, Co-Director, Rice Construct  
Jason Fleming, Construct Fellow  
Eric Hester, Construct Fellow  
Roque Sanchez, Construct Fellow  
Rose Wilkowski, Construct Assistant

#### Agape

Kirk Craig, Executive Director and Co-Founder  
Carl Winn, Director of Operations

#### Consultants

Bradley Doherty, Insight Structures  
Vladimir Berka, Insight Structures

### Special Thanks

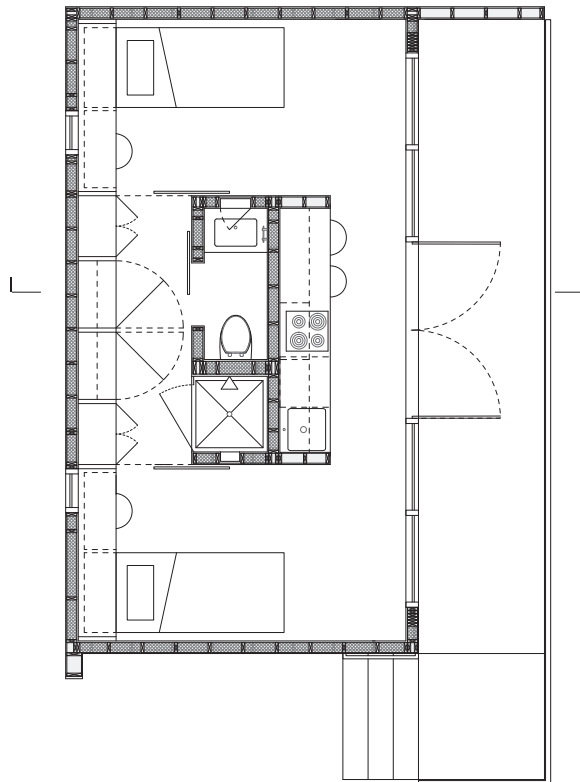
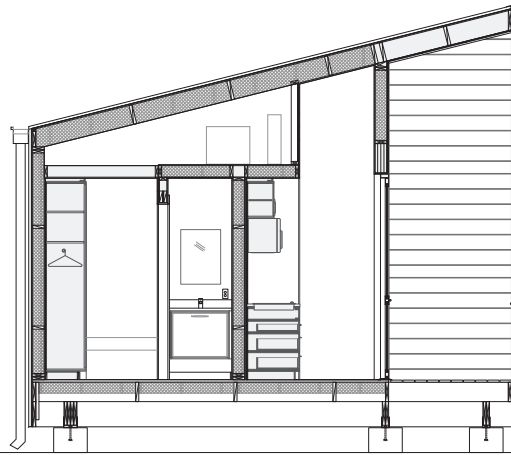
Carroll Blue, Ryn and Russell Bowers, Jodie Foster, Jo and Jim Furr, Jonathan and Nonya Grenader, Royce Hassell, Paul Hester, Lonnie Hoogetboom and Betsy Strauch, Aubrey Karr, Joe Meppelink, David Morris, Onezeime Mouton, Larry Richmond, Emily Stein, Robert and Amy Taylor, Larry Troups, Sarah Whiting, Gordon Wittenberg, Brett Zamore, and The Susan Vaughan Foundation.

### Material Support

Anchor Drilling, Anworth Services Air Conditioning & Heating, Assa Abloy, W.S. Bellows, Cangelosi, Daltile Houston, Diversified Thermal, Dixieply, Ferguson Supply, Floor Zone, James Hardie, Huber Engineered Woods, Icynene, Image Electric, Insight Structural, Kohler, Lesco Lighting, Madden Galvanizing, Marek Brothers, Mission Air Conditioning and Plumbing, Ram Windows, Larry Richmond, RootLab, Roppe Flooring, Schluter Systems, Southern Window Concepts, Stahlman Lumber Company, & Valli and Valli





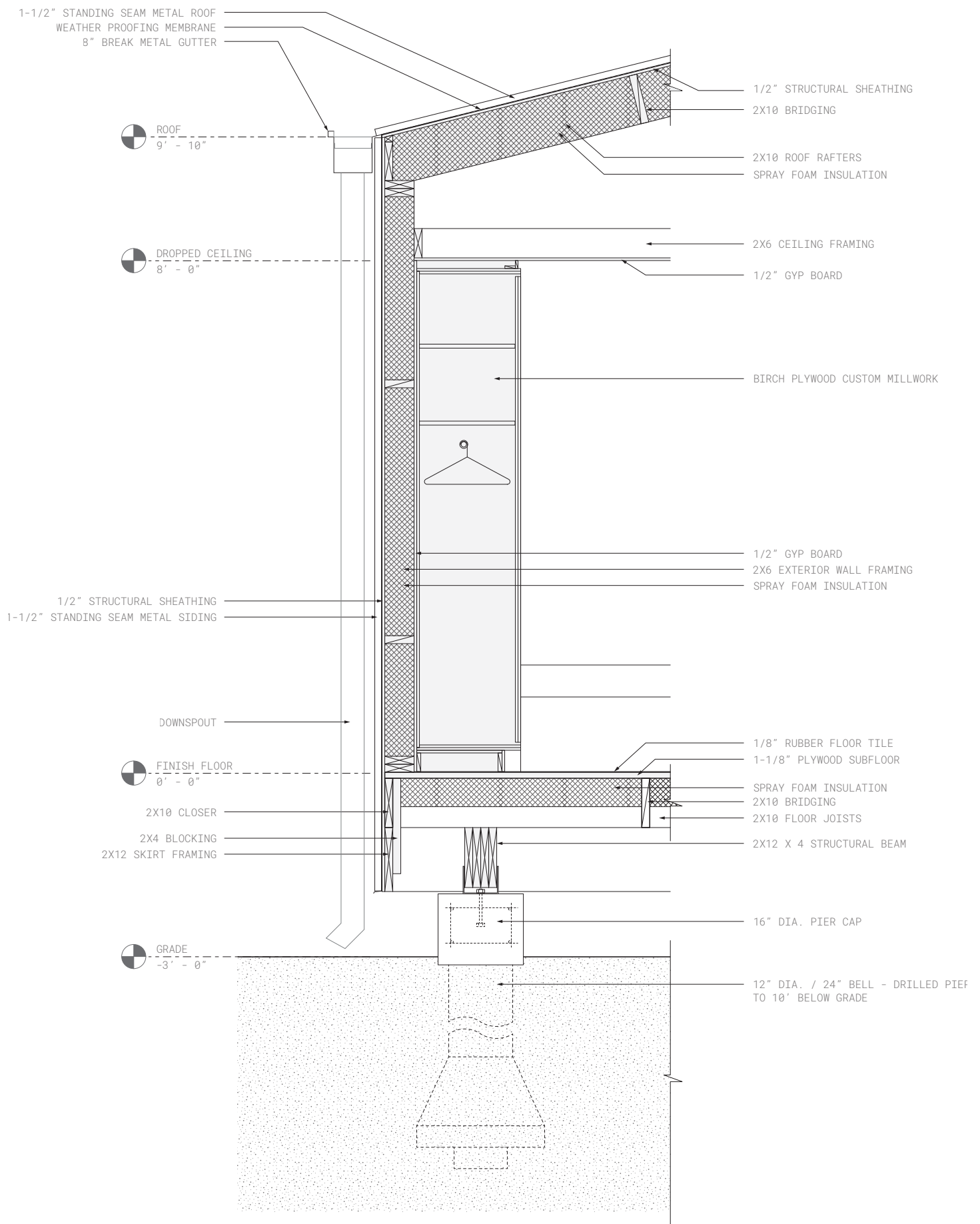








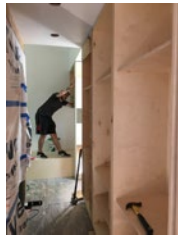
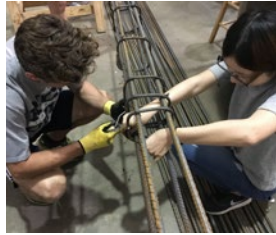










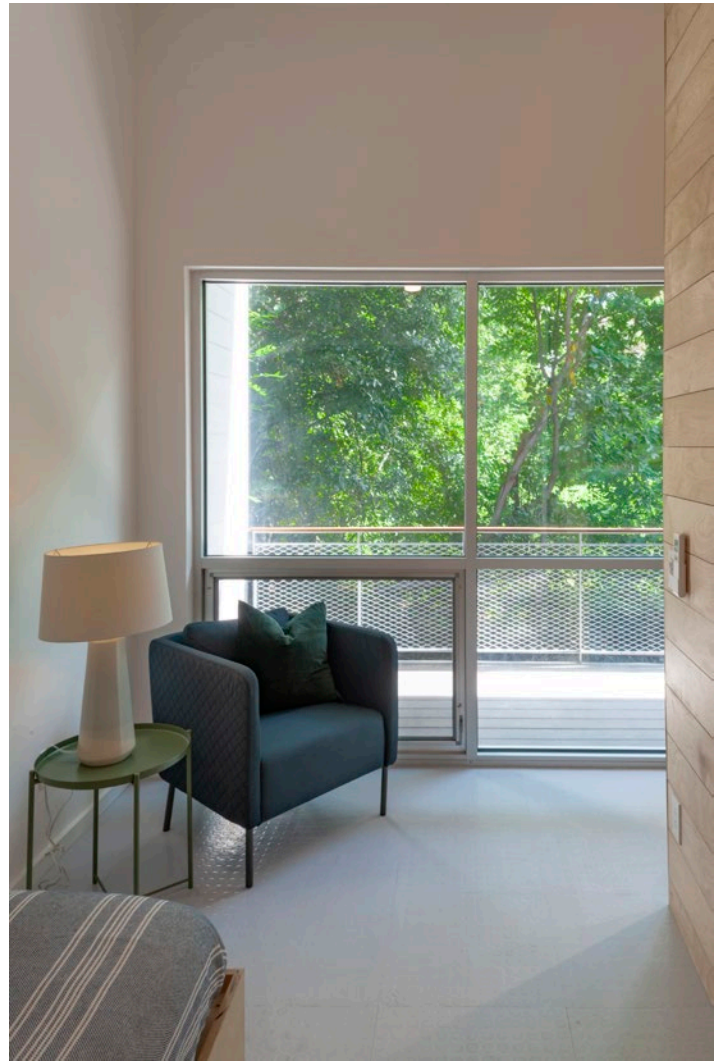




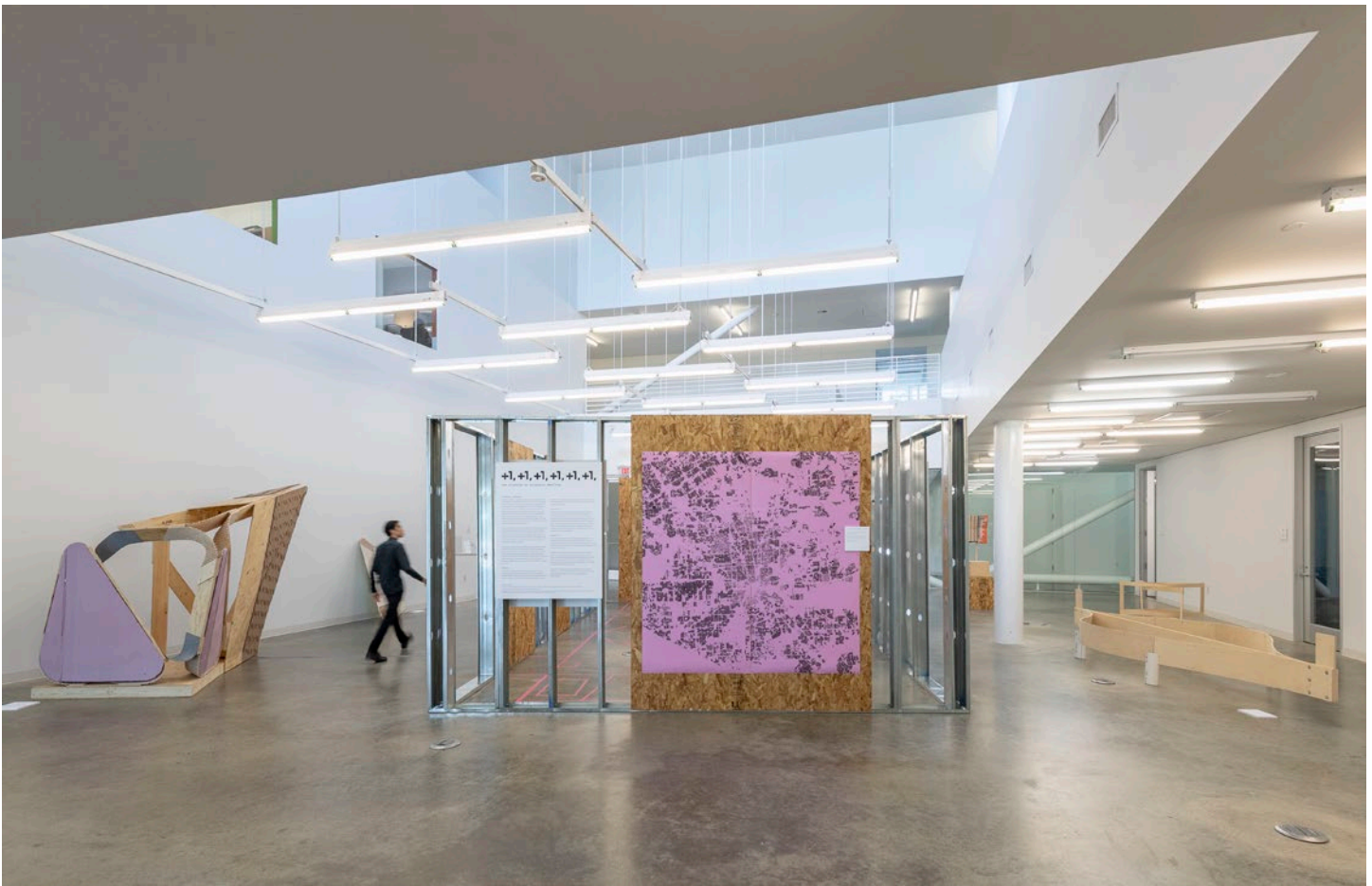












Catalog edited by Andrew Colopy

Photography by  
Nash Baker Photography (exhibition)  
Paul Hester, Hester + Hardaway (pg 65-67)  
Brandon Martin, Rice News (pg 58)  
Rice Architecture Construct (pg 46, 53, 63-64)