DENHAY PROTOTYPE:
DESIGN AND PRODUCTION PACKET FOR REVIEW

IN PARTNERSHIP WITH BACH, RAISE THE ROOF AND UNIVERSITY OF PLYMOUTH

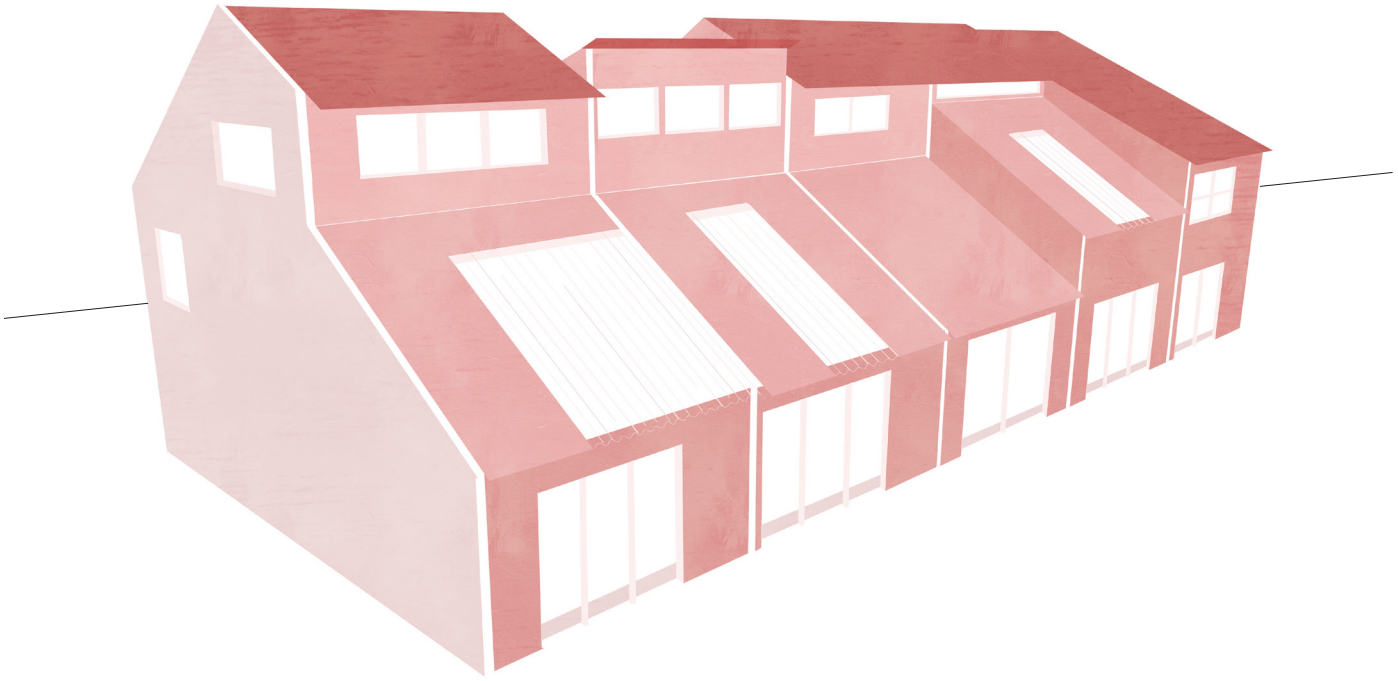
May 17 2022.

Supported by:

01. BUILDING SCHEMATICS

PROPOSALS FOR AFFORDABLE HOUSING IN BRIDPORT

A Bridport Area Community Housing and Raise the Roof Project.



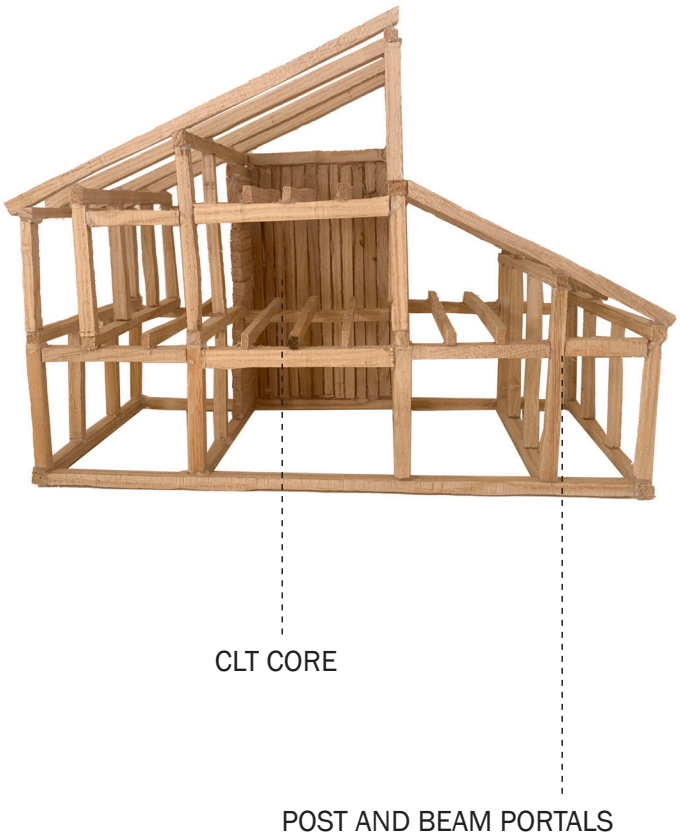
The row house begins with a standard footprint on a post and beam grid.

The logic of construction is post and beam frame with a mass timber core. The post and beam lends itself to an open floor plan within a shell, making self-finishing easier and more flexible, while the core houses more permanent fixings like kitchen and toilets.

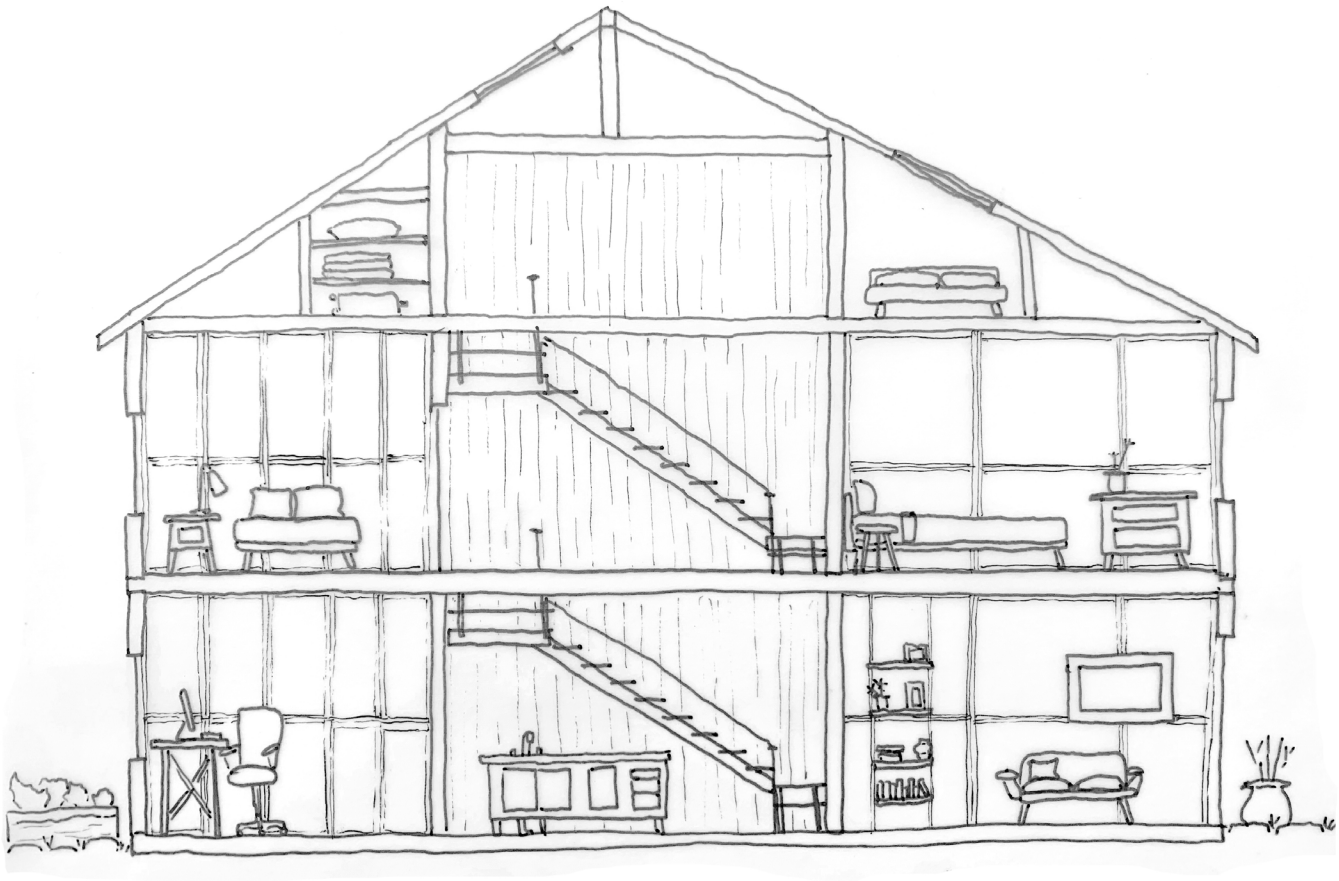
The CLT core acts a party wall shared between two houses, which provides stiffness to the global structure.

A series of post and beam portals are pre-fabricated and assembled on-site, either craned or tilted erect. The standard portal spacing can be enclosed with hemp-clay SIP panels, craned, or interlocking filled wooden cassettes.

Windows, doors and roofing are then added to complete a mortgageable shell.



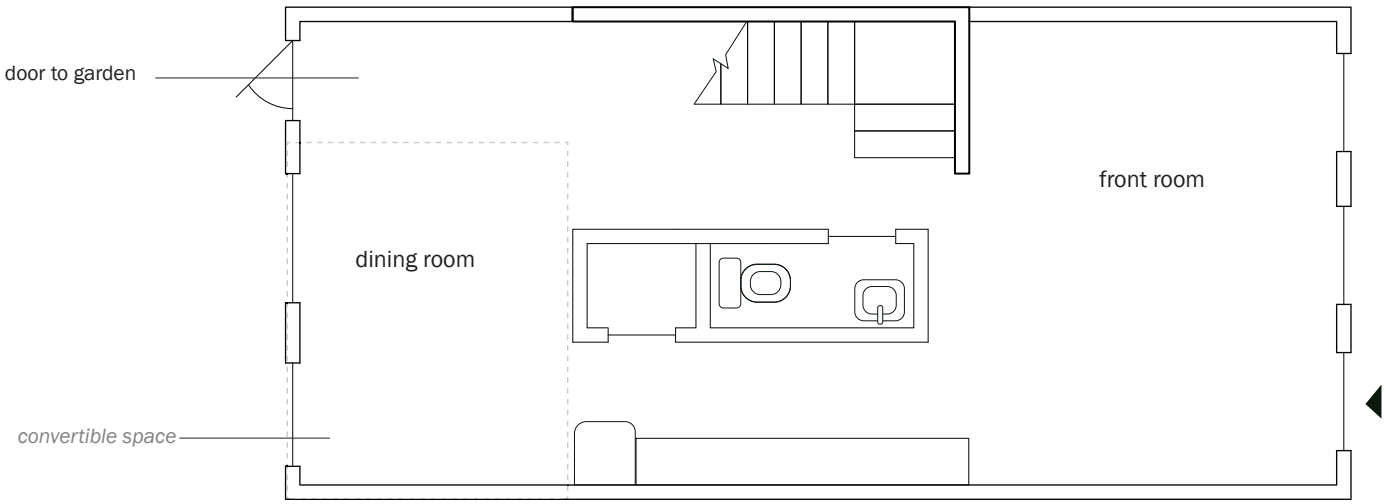
ROW HOUSE - BASIC



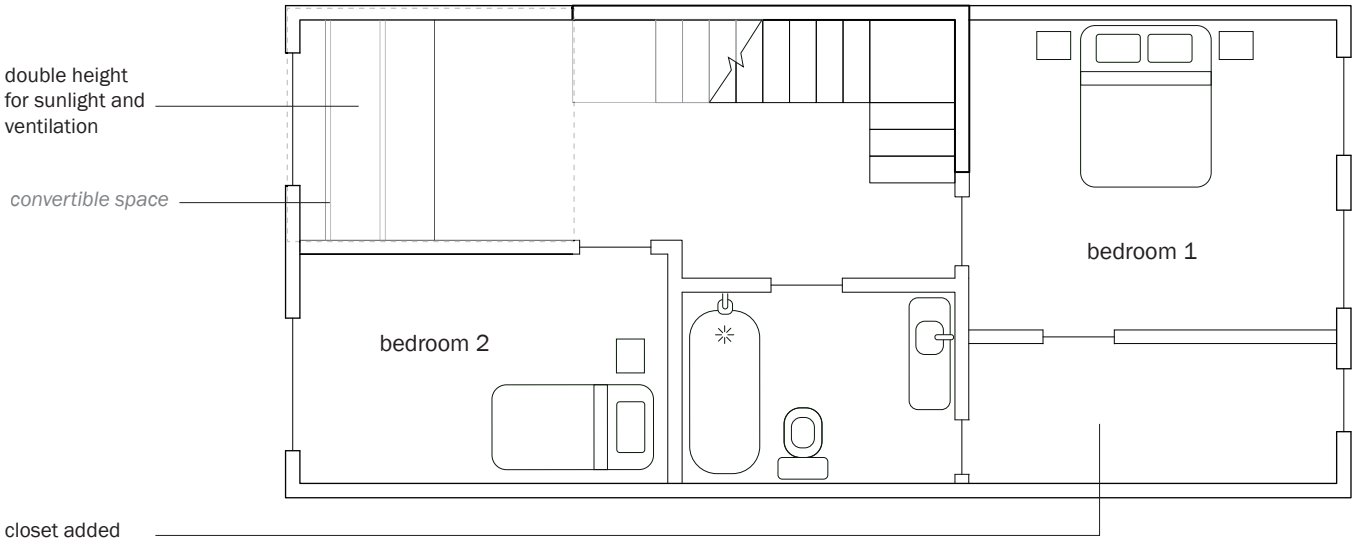
This layout provides the fastest route to a finished, mortgageable shell. Minimum partitions need to be added initially aside from toilets and optionally bedrooms. This offers the greatest flexibility for the home owners to decide spatial configuration throughout time.

ROW HOUSE - BASIC

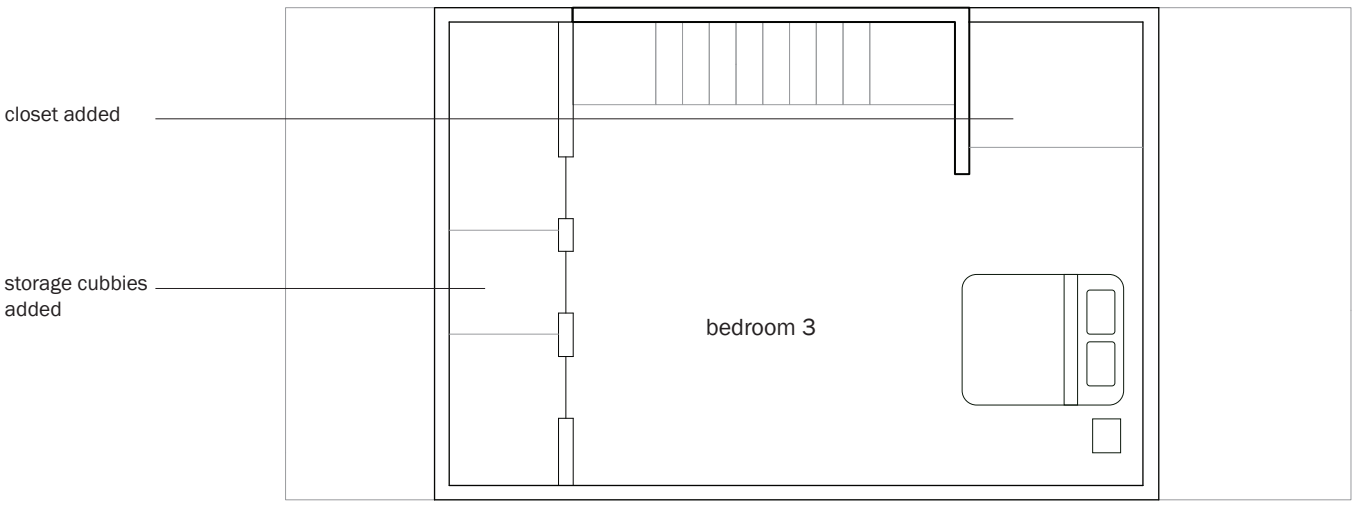
GROUND FLOOR



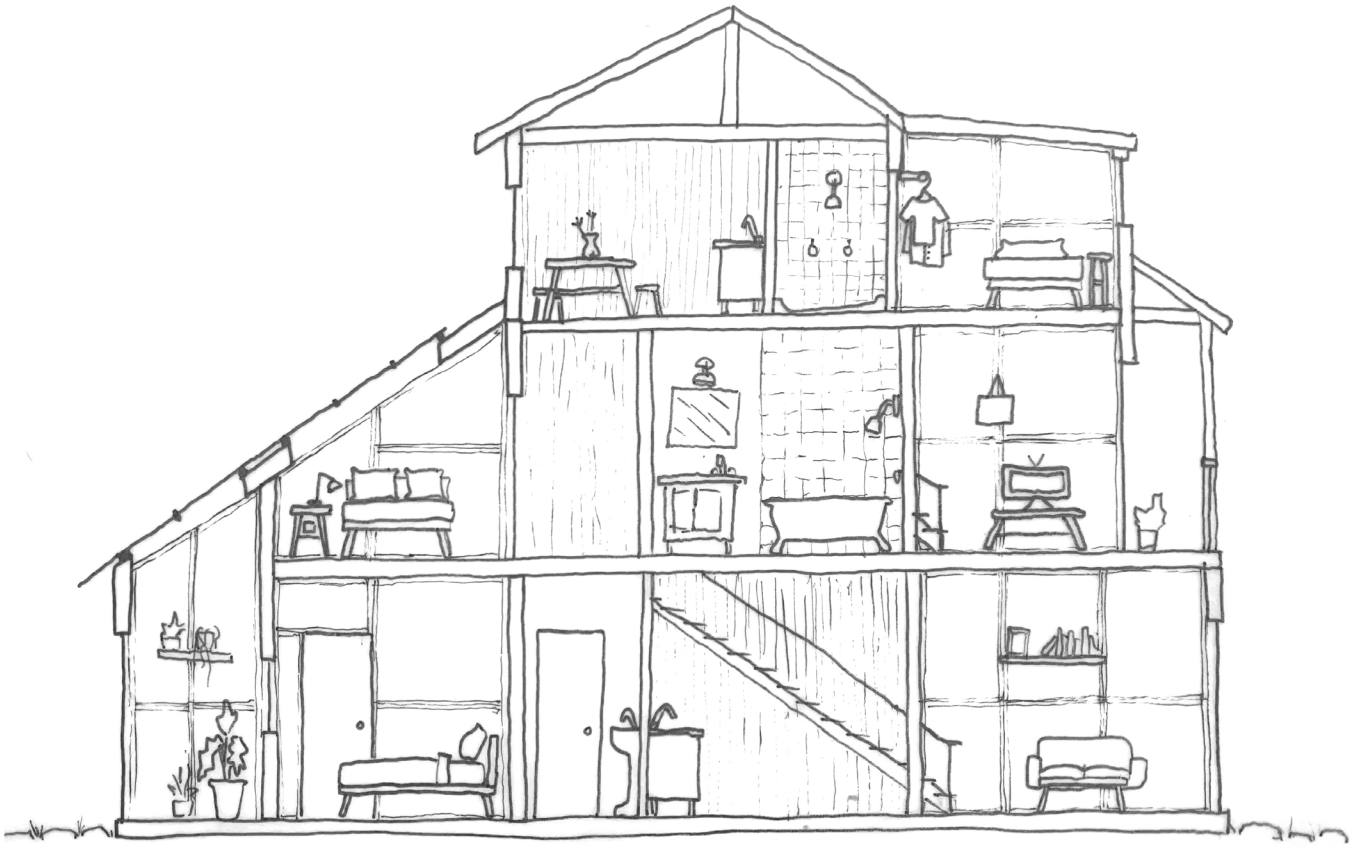
FIRST FLOOR



SECOND FLOOR



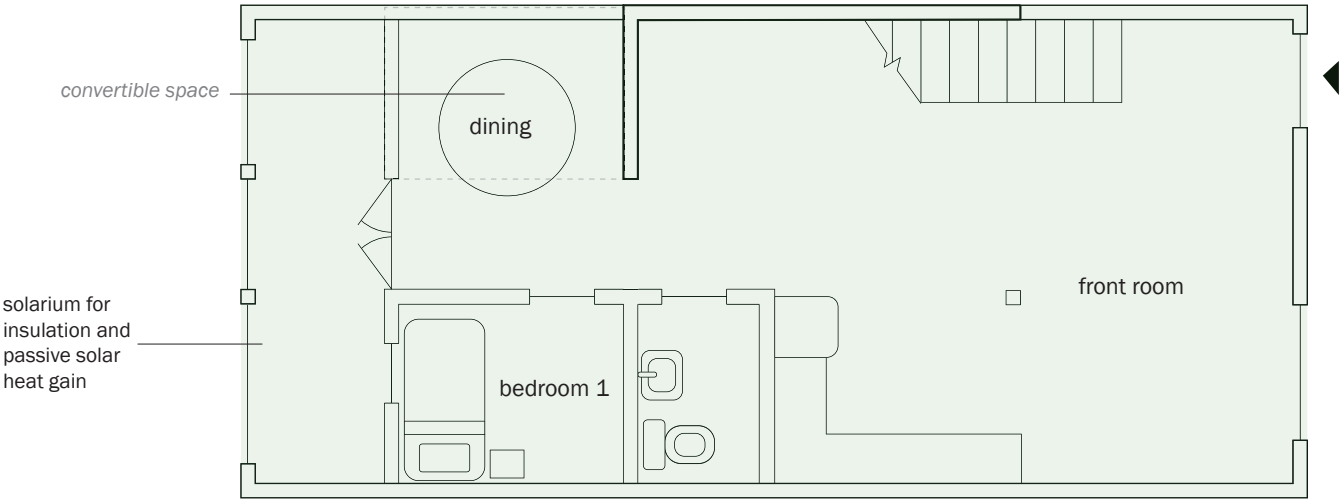
ROW HOUSE - SPLIT UNIT



The split unit offers diverse types of dwelling, from families to single dweller. This recognizes Bridport's needs to provide for both families and young individuals in their 20's and 30's.
This layout could work as an end cap to a terrace of houses where the second floor has it's own stairs, or in a series of the same layout with a continuous walkway.

ROW HOUSE - SPLIT UNIT

GROUND FLOOR



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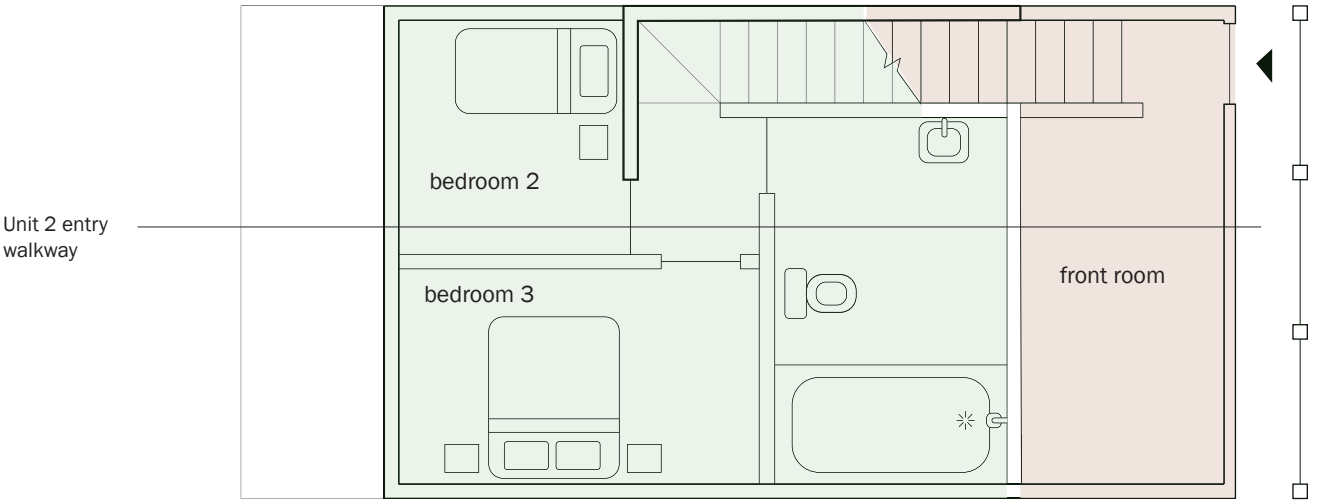
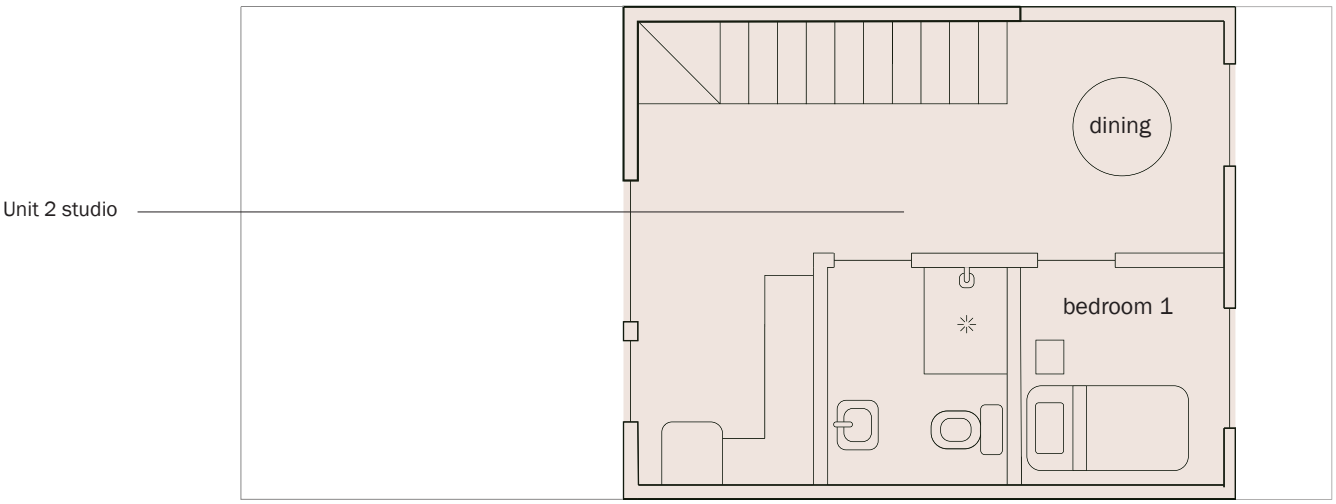


SECOND FLOOR



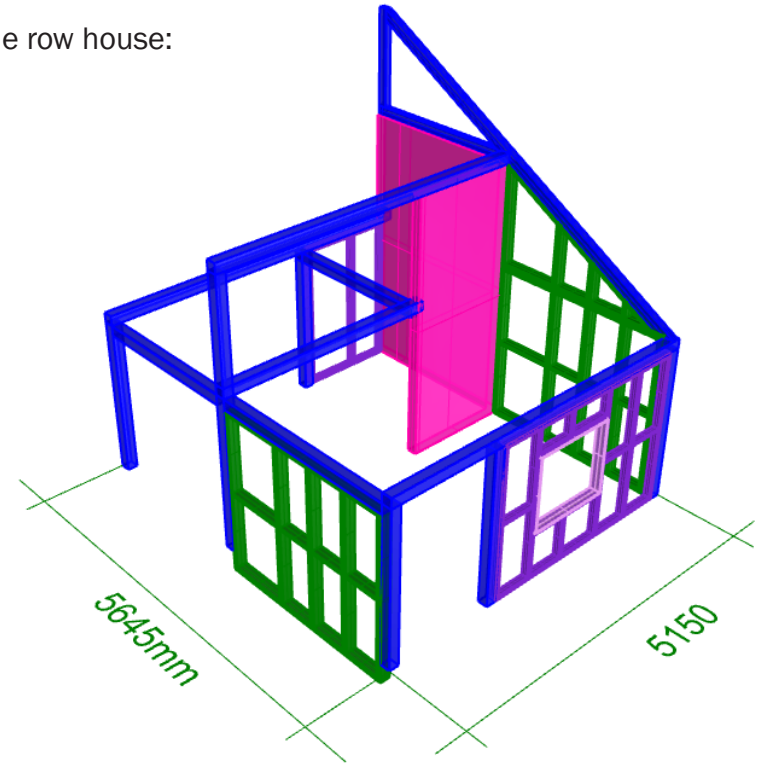
02. TECHNICAL DEVELOPMENT

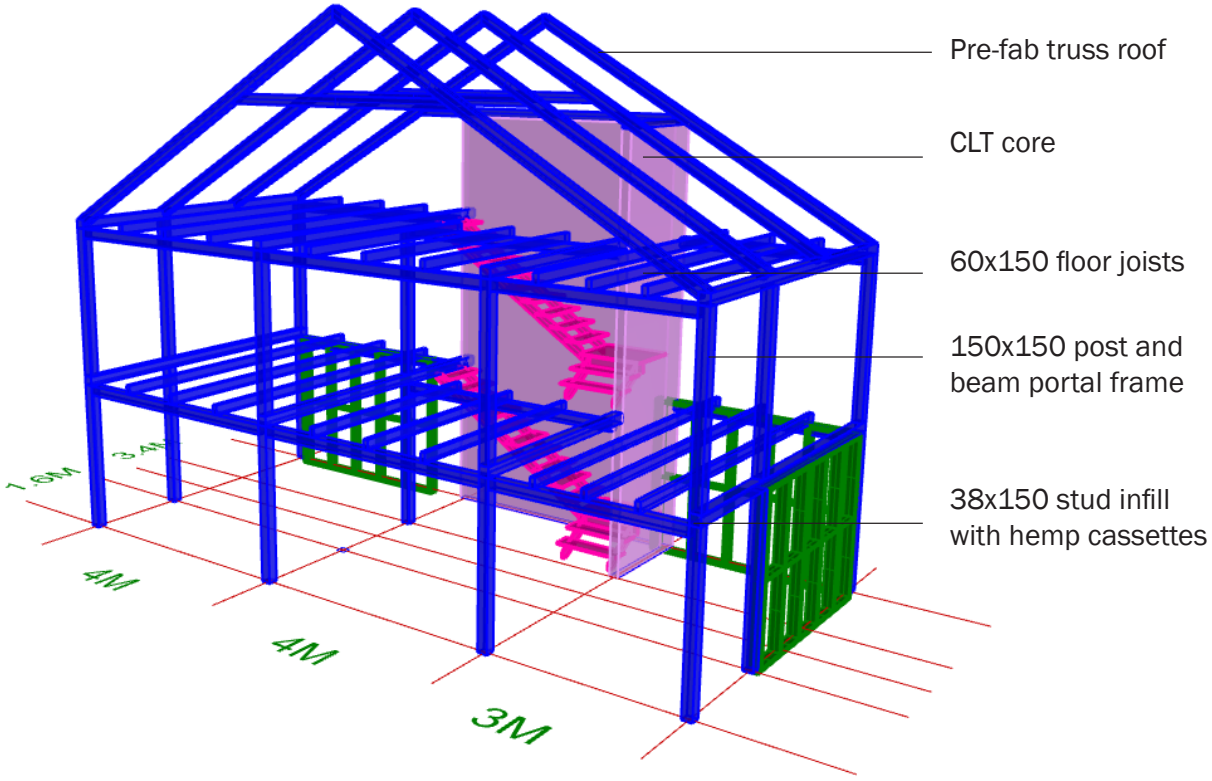
1:1 Demonstrator

Post and beam construction allows more versatility with how the walls are filled within and is easier to introduce partition walls inside as a part of self finishing.

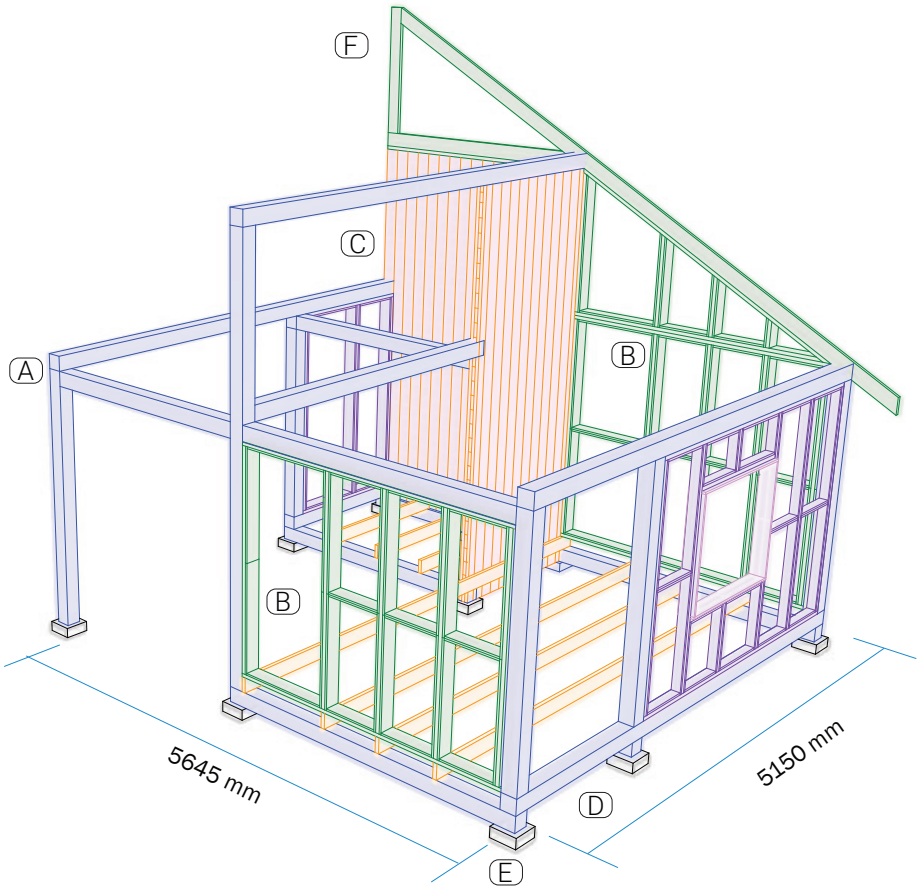
We'll use a CLT element (pink) to demonstrate the element of the core, housing those elements unlikely to change while structurally stiffening the system.

This would demonstrate scenarios of the row house:
- exterior envelope
- interior partitions/self-finish
- party wall
- system compatibility





Plymouth and BACH Systems Demonstrator



A. 150x150 post and beam framing.

Joined either with traditional joining techiniques i.e. mortise, tenon and pegs (more skillful and time consuming) or hardware, bolts and straps (faster but less natural)
**Oak (traditional but expensive!) or other hardwoods, but spruce or similar is fine.*

B. Stud framing with hemp cassettes.

38x150 studs framed either within post and beams or substituting as structure. 20x150 cassettes with hemp and clay infill.
**Spruce *4 screws per stud*

C. CLT core

38x150 studs cross laminated with wood dowel guns. 4 layers would give a 150mm thickness to match the beam connections but to save timber the CLT is 3 layers here.
**Spruce *Assembly logic needs thought, i.e. in modules or as one *Beam connection- notched into CLT or use of hardware *Likely cannot build this all*

D. Flooring

150x150 beams and 38x150 joists
**Spruce *Check that they can span 5.1 M, if not continue the middle floor beam*

E. Footings

Concrete or stone blocks can be shimmed to level. If a more robust foundation is necessary, we can look into buying or making concrete footings with a shoe.

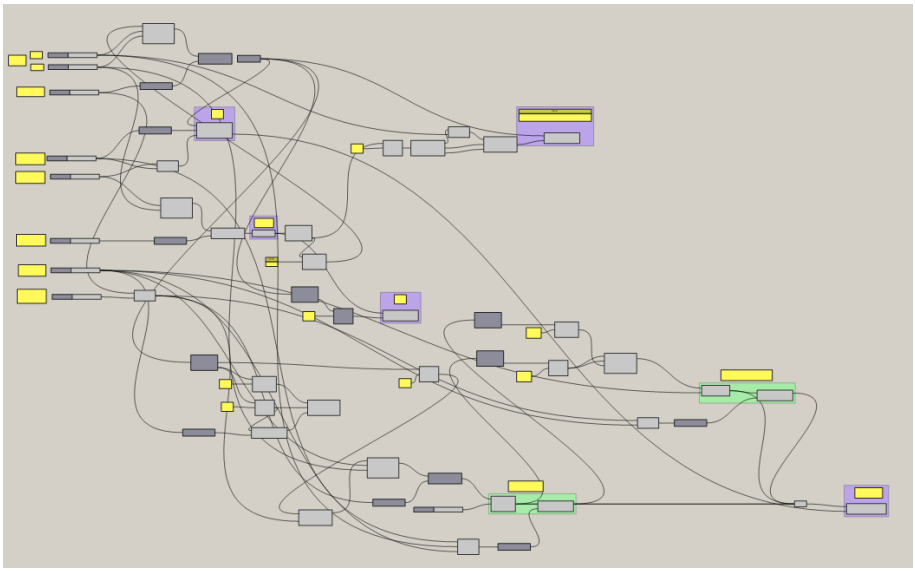
F. Roof truss

38x150 studs. Shown here as an internal roof truss, i/e there is no wall depth to it. This saves material and time but shows the system.
**Metal straps could be necessary, as well as hardware*

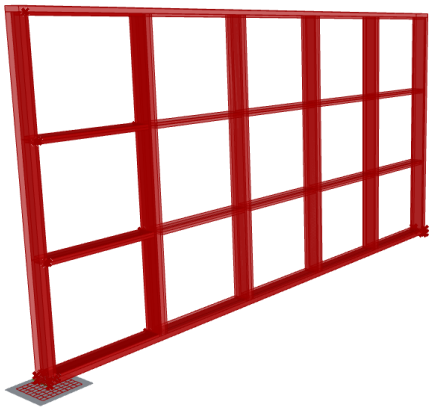
PARAMETRIC CASETTE SYSTEM

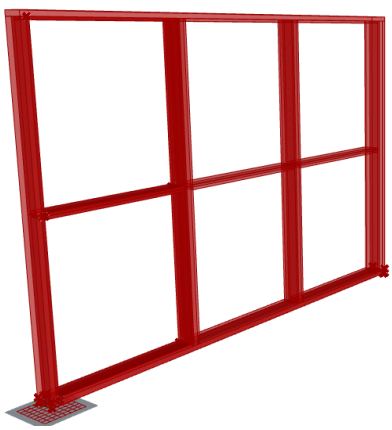
Material inputs and construction parameters are inputs for a grasshopper script to quickly model and give a cut list, i.e. 20 meters of 38x150 section timbers, or (8) 2.4 meter 38x150 timbers.

The purpose was to make the translation between fabrication specs and timbers available easier, anticipating changes and fluidly place Plymouth's system in any given design.



INPUTS:
- Stud section and height
- Stud spacing
- Length of wall
- Thickness of casette planks
- # of cassettes stacked





BRIDPORT AREA COMMUNITY HOUSING
+
RAISE THE ROOF
+
UNI OF PLYMOUTH

A Prototype construction at Denhay Farm near Broadoak in a retired dairy barn.

What are we building?

A 4x5 metre section of a terrace house developed for Bridport Area Community Housing's plans to support a series of affordable homes.

The system has been developed in partnership with a University of Plymouth research group for a grant project Connected Everything, which looks at off site digital production and codesign in housing manufacture.

What is this demonstrating?

An approach to affordable housing that aims to quickly construct a "mortgageable shell" through off-site construction.

At the core of this system are locally sourced natural materials like timber, hemp and clay which seek to create healthier and more sustainable environments.

Why hemp and clay?

Hemp is an historically prevalent material once widely grown in Dorset for the rope industry.

New applications for hemp that use the "shives" or woody refuse have been found to provide a high performing, natural building insulation.

The shives are often mixed with lime to create what's called "hempcrete," but lime has a high embodied carbon due to its extraction and processing. Instead, we use clay as the binding agent to create an insulating thermal mass. Dorset soil is rich in clay, making it an ideal regional resource that is natural and local.

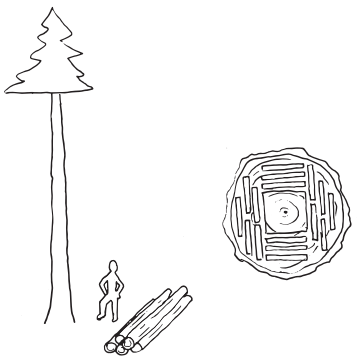
What next?

The prototype will be used as a centre for hemp processing in Denhay, one of three Bridport area farms piloting hemp crop this year.

Within the next year, the structure will be disassembled and reconstructed as a skills training center in Bridport's Foundry Lea development, where BACH hopes to pilot a portion of affordable terrace homes.

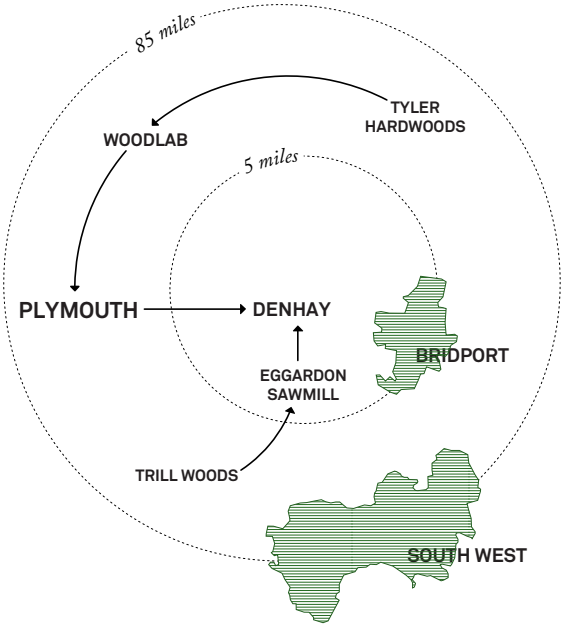
TIMBER PROCESS MAP

From forest to frames

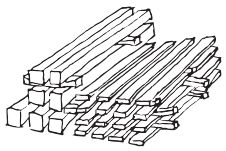


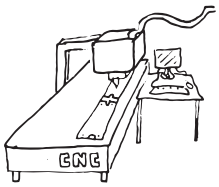
Local Timber

Douglas Fir from a Dorset Devon woodland was milled to order at Eggardon Sawmill for the structure. English Ash from a Wiltshire mill was processed in Devon's Woodlab.



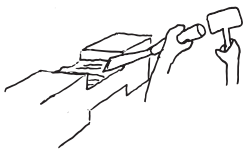
Stock Timber





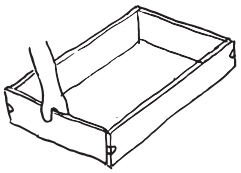
Digital Manufacture

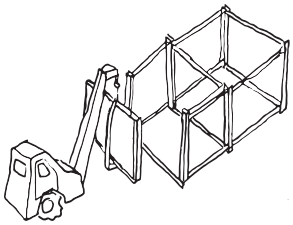
Planed Ash planks are milled at University of Plymouth to design specifications using the CNC.



Manual Fabrication

Timber posts are given kerf cuts and chiseled out to make joints.



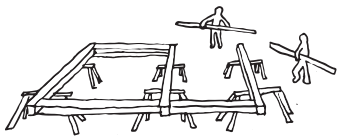


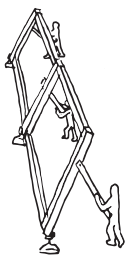
Cassette Casting

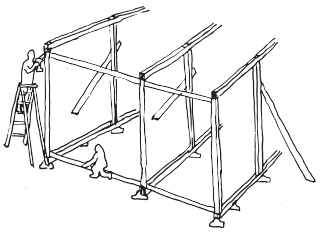
Pre-fab cassettes are assembled at smaller modules and wall scale.

They are filled with a mixture of clay from Denhay farm and hemp.

Cassettes are placed into the timber frame.



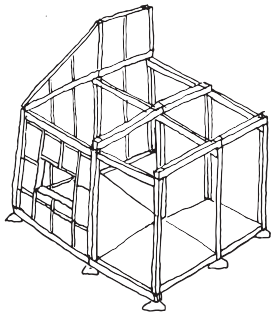




Timber Frame Portals

Portal frames are made flat and raised onto pad foundations, then the cross joists are added.

Prototypical Section

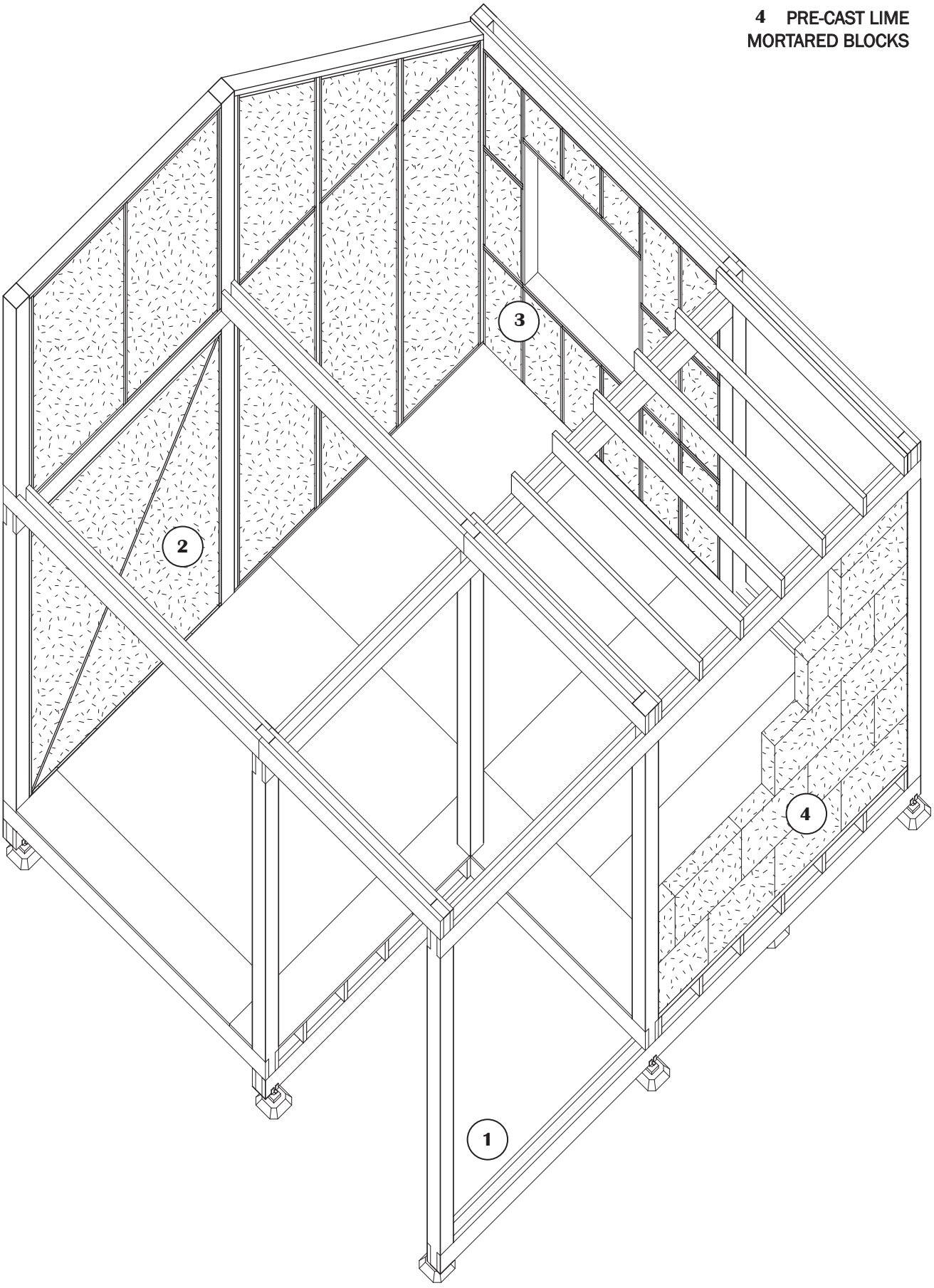


1 150X150 POST AND BEAM PORTALS

2 STRUCTURALLY INSULATED PANELS

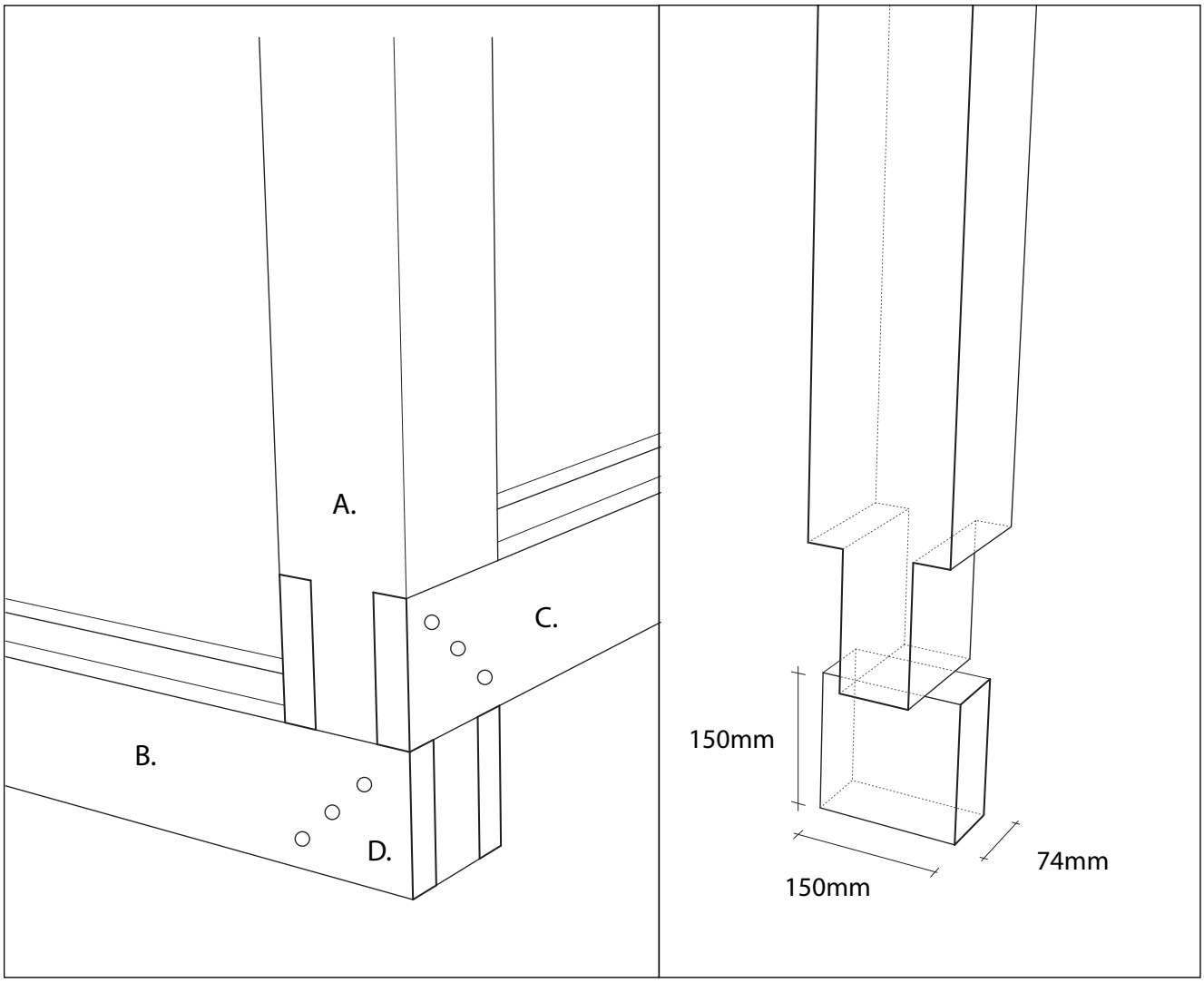
3 INTERLOCKING PRE-FILLED CASSETTES

4 PRE-CAST LIME MORTARED BLOCKS



TRANSFERRING LOADS FROM POST TO BEAM

TWIN JOIST LAPPING DETAIL



A. 150x150 post B. 38x150 twin beams C. 38x150 twin joist

D. (3) 6.7x100mm timberlock screws/side

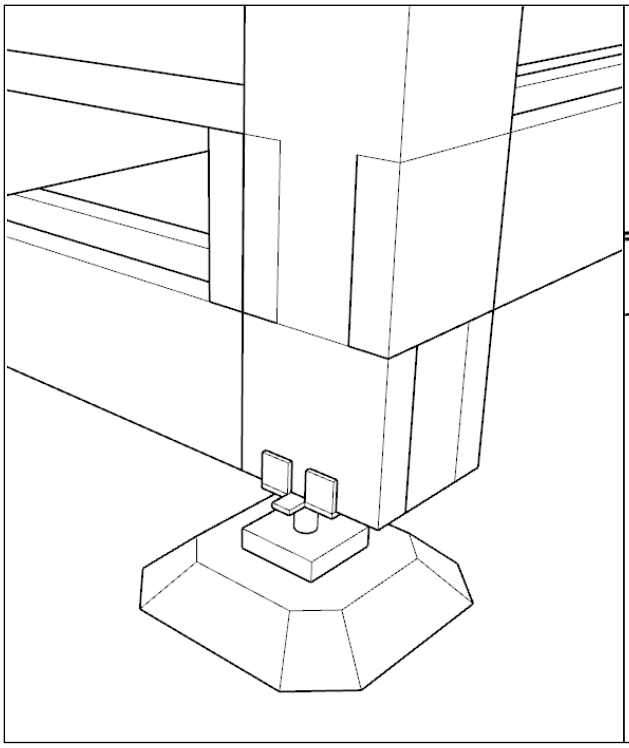
NOTES:

150x150 posts are given stacked, alternating lap joints on either side to accomodate 38x150 twin beams and joists. The joists are secured with (2) 100mm timber screws on either side, 4 in total.

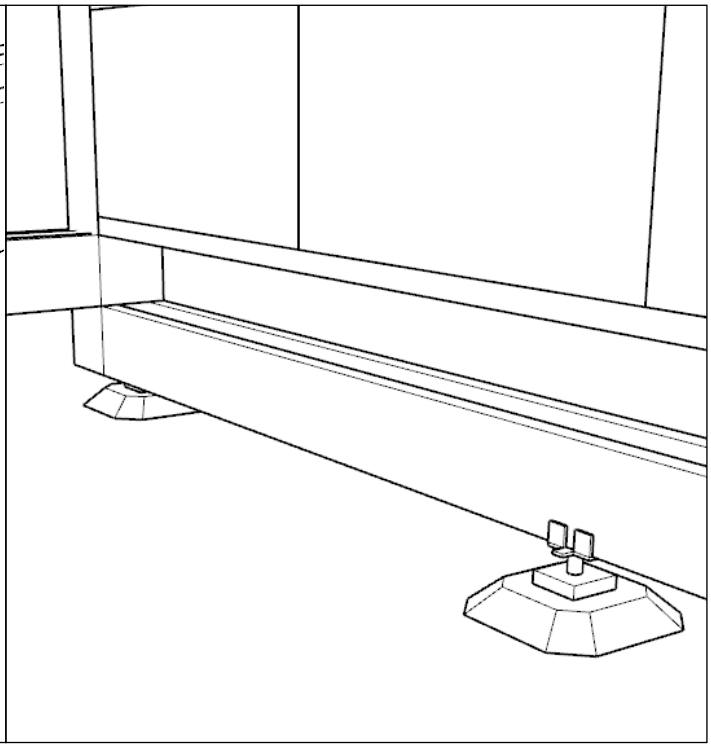
This allows the load of the posts to transfer directly onto the beams via shoulders. the beams are then supported by EasyPad 2" t-brackets which alternate on the sides of the twin beams to distribute load.

FOUNDATION DETAIL

EASY PAD TEMPORARY ADJUSTABLE FOOTINGS



easypad 2" t-bracket foundation.

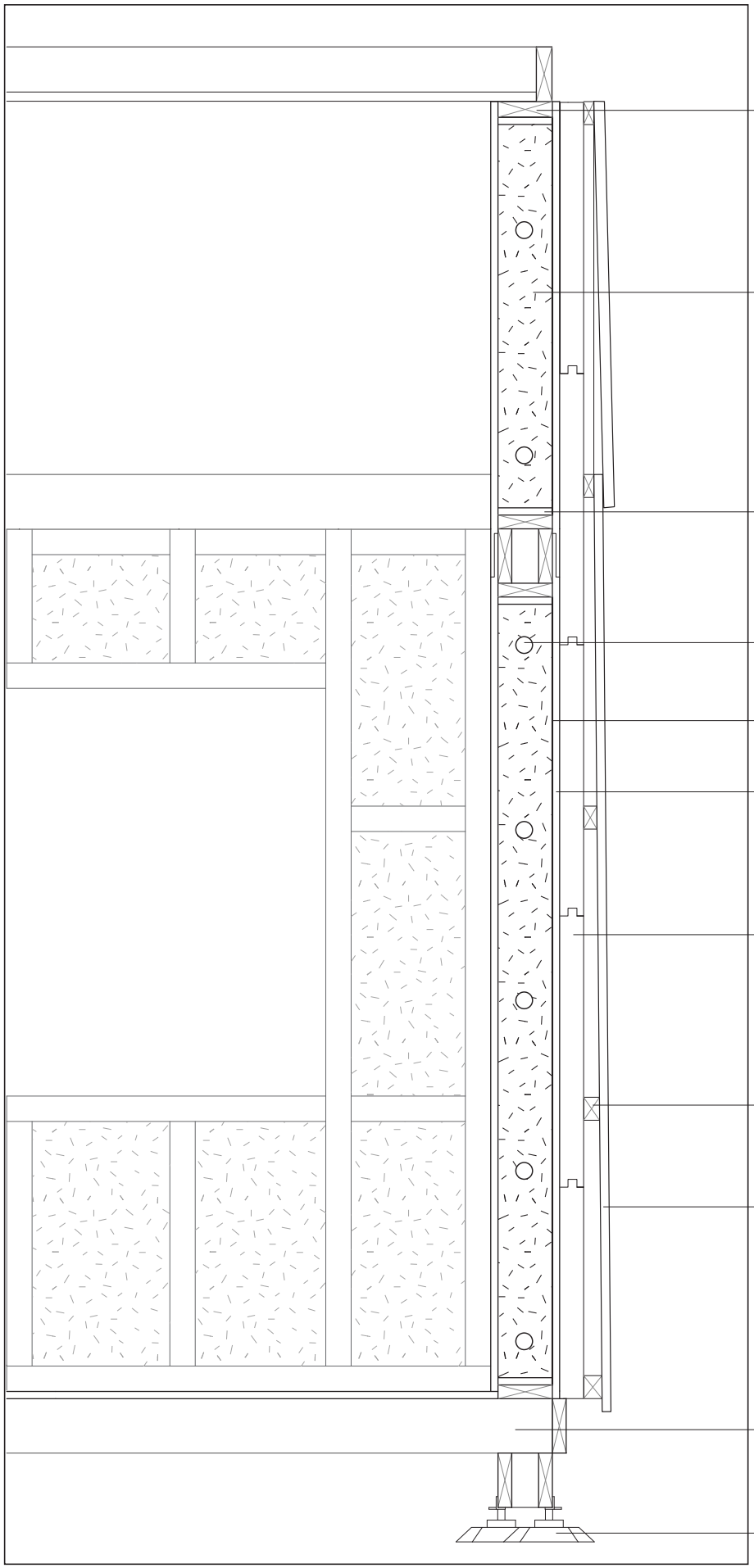


mid-span foundation support.

NOTES:

The EasyPad foudations enable a low-load building to be constructed with low impact to the ground. They are adjustable up to 4cm to take up non-level ground to begin with and can be reused for future projects.
They use the weight of the building to keep the brackets in place, so is not ideal for long-term building which must account for occasional storms.
The pads alternate to distribute the load between the twin joists..

TYPICAL WALL SECTION
HEMP AND CLAYSIP PANEL



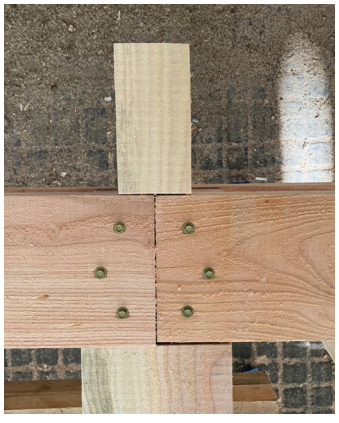
03. CONSTRUCTION

01. STACKED TWIN LAP JOINT

1cm kerf cuts made with a skill saw to outline the joint. Material is then easily removed with a chisel.

02. PREPARING THE FRAMES

Frames are prepared horizontally on sawhorses by two people, checking squareness by matching the distances of diagnols.



Variation in timber widths required bespoke fitting.

03. PREPARING FOR FRAME TILT-UP

Temporary cross bracing is added to make single frames rigid.

Easypads are adjusted and shimmed to create a level foundation plane.

04. FRAME TILT-UP

Frames are moved near to foundations on sawhorses and tilted up by four people using props for leverage.

Blocks are shimmed to foundation level to assist with the tilt up.

05. ATTACHING CROSS JOISTS

Temporary props are fixed to stabilize the structure while cross joists are added.

06. HEMP CASTING

First hand-mixed clay and hemp cassette. High soil in the mix, shrinkage and too little water compromised the structural integrity.

06. HEMP CASTING - Hemp and lime

Lime, water and hemp are mixed in the cement mixer to produce easily workable hemp-crete. Shrinkage data is being collected.

06. HEMP CASTING - Hemp and clay

Clay is ground and soaked in water before being added to the mixer to avoid clumping. Compaction levels and shrinkage is being tested and monitored.

Corner brackets introduced to prevent slippage.

07. NEXT STEPS

INFILL RESEARCH

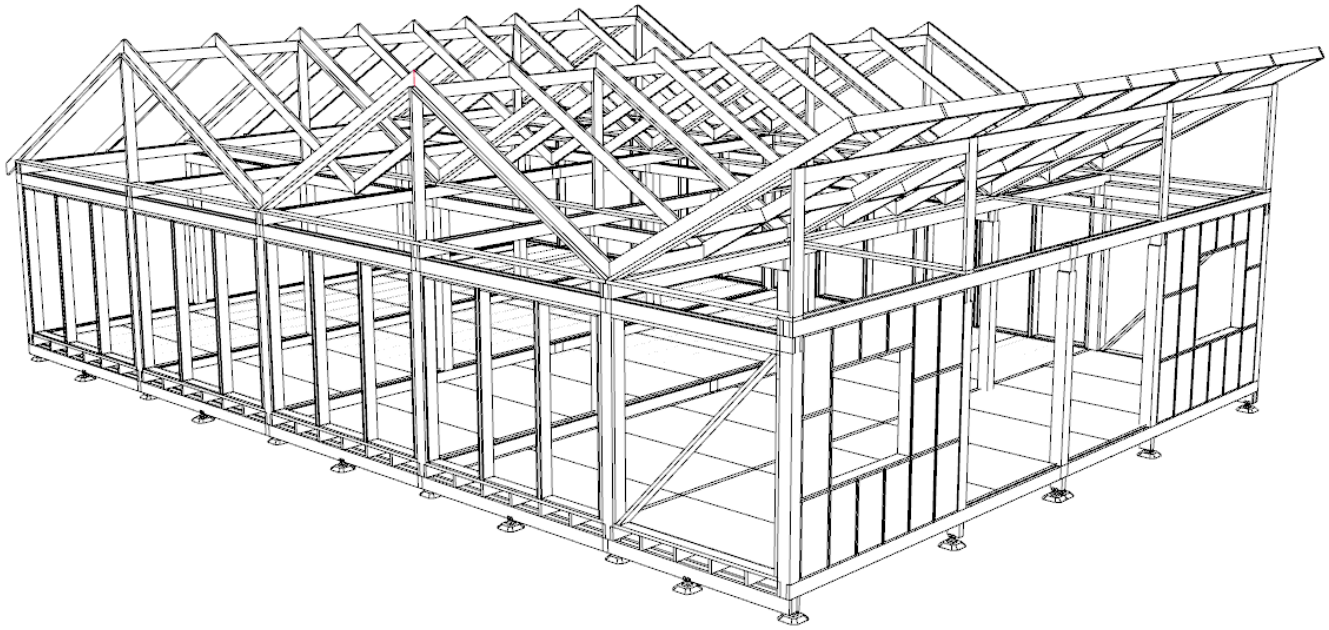
Hemp and local clay

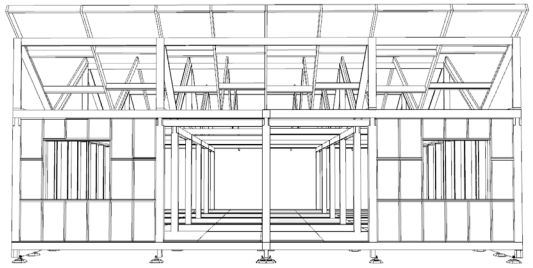
Hemp and lime

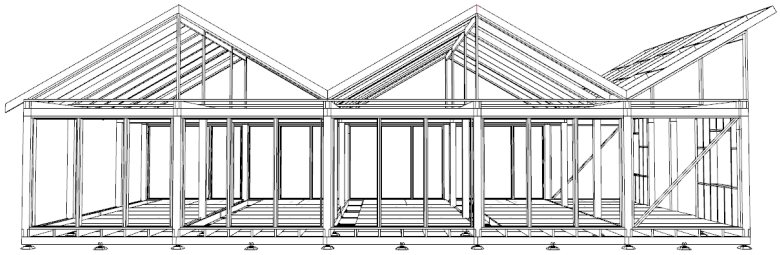
Prototyping insulation modules with hemp and clay, exploring reinforcement techniques and assemblies that optimize placement within the wall and the buildup.

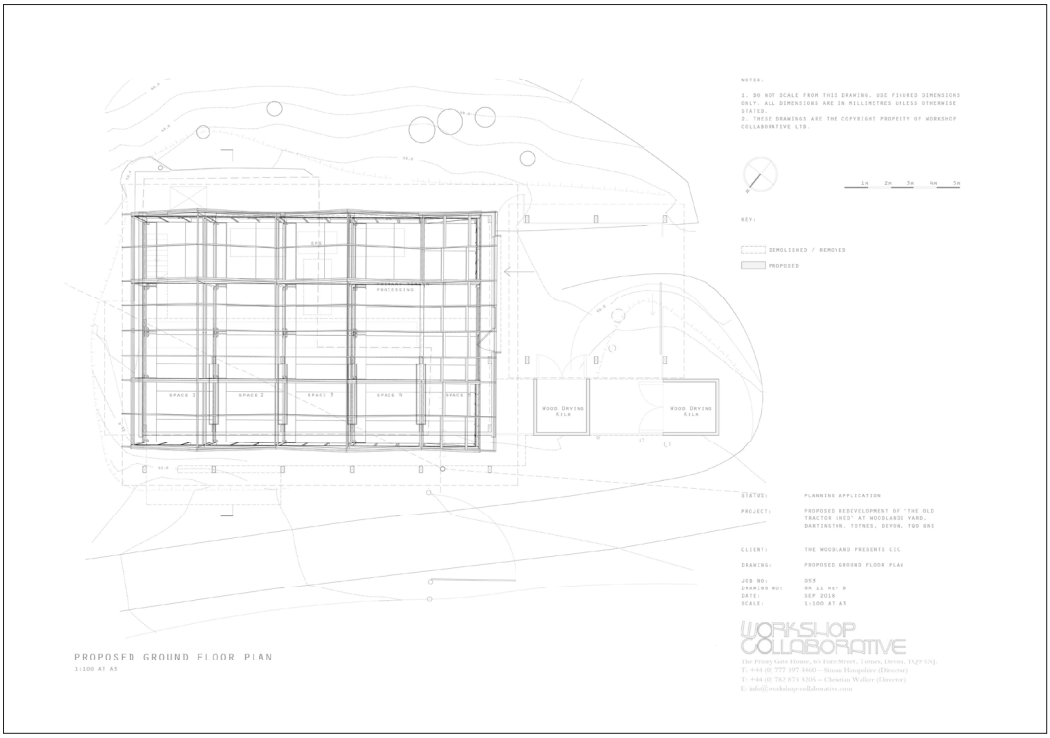
07. NEXT STEPS

FOUNDRY LEA SKILLS CENTRE









The application of the Denhay prototype is to be used as the first bays of the Foundry Lea Skills Centre. At this stage, an estimate of structural timber can be made.

Further work must be done to develop foundation, roofing, electrical fit out, both interior and exterior cladding and the deployment of hemp as an insulation material.