Incremental House

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CONTEXT

According to the United Nations Environment and International Energy Agency study on accompanying energy consumption, 39% of total global carbon emissions are linked to building construction. While approximately 72% of this segment occurs over the course of a building's operable lifespan, the 28% associated with embodied processes of construction offers a significant opportunity to address carbon emissions on the front end of construction. Carbon sequestration will play an increasingly important role in addressing atmospheric carbon in the timespans required to avoid the most devastating impacts of climate change. While much attention has been directed recently to bio-based methods of construction such as mass-timber, there are an expanding array of harvested materials that have great potential to sequester carbon, reduce reliance upon petrochemicals, while offering distinct material/structural/spatial configurations.[1]

Our research is interested in the affordances of hempcrete as a lower tech, biogenic method of construction that has the potential to simplify traditionally multi-layered exterior wall assemblies, while serving as a substantial carbon sink. Incremental House reveals the unique capacities of this material matrix to combine traditionally disparate elements of a residential wall assembly.

Incremental house re-imagines the farmhouse as the site of bio-based material construction. It explores a simple question - how might a home's material constitution, spatial organization, and construction sequence reveal the affordances of harvested materials.

Incremental House references the typology of agrarian longhouses to produce a long narrow structure that incrementally expands from west to east through three stages of construction. While longhouses traditionally collected spaces for harvest storage, animals, and humans, within a single structure, the Incremental house collects spaces for hemp drying, decortication, and storage with spaces for living.

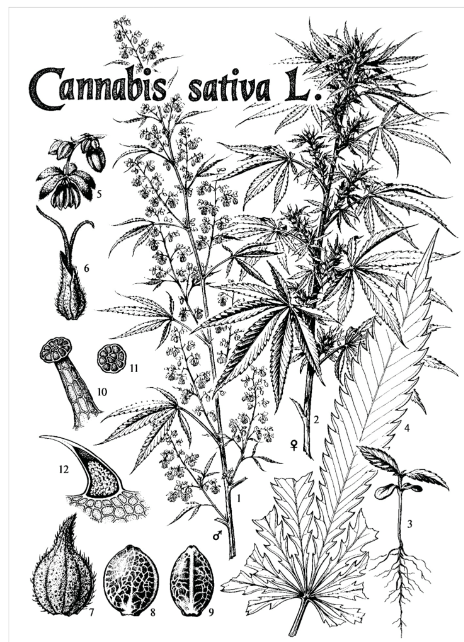

Figure 1. Morphology of Cannabis sativa L. drawing by E.W. Smith.

INDUSTRIAL HEMP

Hemp, Cannabis sativa L., is one of the world's earliest cultivated fiber plants, with confirmed use in Japan and China dating to 8000BCE and 4000BCE, respectively. Hemp farming in North America pre-dated the founding of the United States, through Spanish colonization in 1545. By the mid 1600's industrial hemp was established across the New England colonies and by the mid-1800s, throughout most Midwestern states. Long prized for its wide range of potential applications, hemp was a highly effective circular crop that contributed to the natural regeneration of topsoil and a reduced reliance upon chemical fertilizers. As one of the strongest natural fibers, hemp was widely used in the production of ship line. By the early 1900s industrial hemp cultivation in the United States began to wane, and by 1937 industrial farming effectively ended through the passing of the US Marijuana Tax Act. While prohibitions on growing industrial

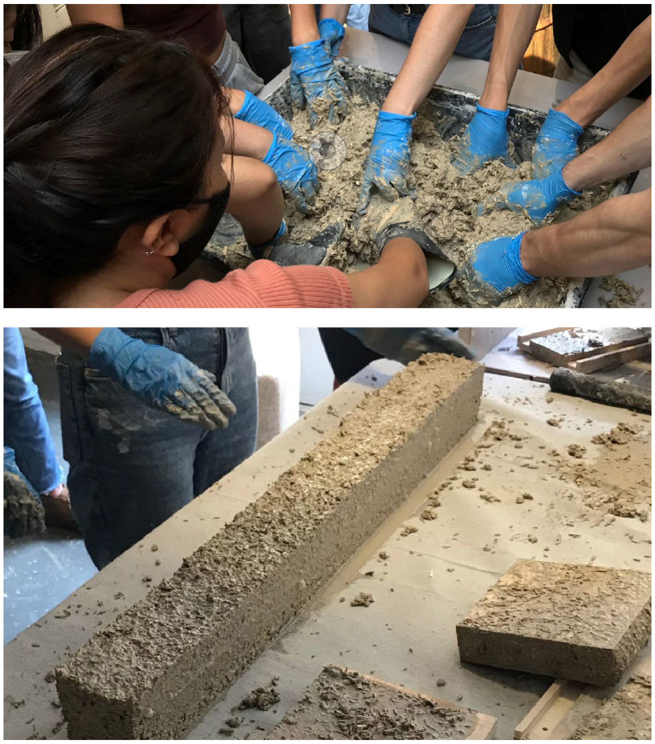

Figure 2. Hempcrete mixing and casting. photo by author.

hemp were briefly lifted during the second World War, cultivation of C. sativa remained illegal in the United States until the passing of the 2018 Farm Bill, that defined hemp as an industrial commodity. As one of the fastest CO2 to biomass conversion tools, industrial hemp is receiving renewed attention as a high yield, comparatively low water, carbon sequestering crop.[2]

Contemporary applications of hempcrete emerged in France in the 1980s through experiments into alternative methods of waddle and daub construction. Hempcrete is created through the combination of dried ground hemp stalk, typically referred to as hurd, along with lime, and water. While moist, the resulting mixture can be formed into blocks, sprayed onto surfaces, compacted into prefabricated components or rammed on site into monolithic architectural elements. Once cured, hempcrete can act as insulation, vapor barrier, and depending upon the application, interior and exterior finish surface. Recent projects such as Flat House on Margent Farm in the UK have illustrate an application of prefabricated hempcrete/timber wall cartridges in which the dried fibrous hempcrete is left exposed on the interior wall surfaces.[3]

THE SIMPLIFIED WALL

Conventional exterior wall construction assigns performance to distinct elements - structure, sheathing, insulation, vapor barrier, cladding, and finishes. While these perform quite well collectively, they typically result in assemblies with high levels of embodied energy and a reliance upon petroleum based adhesives. As a result, the construction of typical American houses impede implementation of design for disassembly.[4]

Our research explores monolithic methods of carbon sequestering wall construction as an alternative to layered enclosure systems. It seeks to leverage the unique moisture and temperature regulating characteristics of hempcrete construction to achieve robustness through simplified methods of construction while spatially revealing material affordance.[5]

Hempcrete wall construction shares similarities with straw bale construction, a method with longer vernacular traditions and significant contemporary applications. Sverre Fehn's Mauritzberg vacation home reveals the conditions and primary constraints of these fiber based methods. Straw bale and hempcrete walls require increased thickness to achieve desired r-values. While these thickened walls yield qualities associated with stereotomics such as mass, solidity, and poche, the material's limited structural capacity necessitates the presence of a tectonic structure. In the case of Fehn's prototype project, constructed with the assistance of his students in 1991, this is achieved through a heavy timber portal frame to support a wooden vault roof. The result yields conditions associated with both tectonic and stereotomic construction.[6]

Figure 3. Mauritzberg Vacation House Prototype Construction. Sverre Fehn

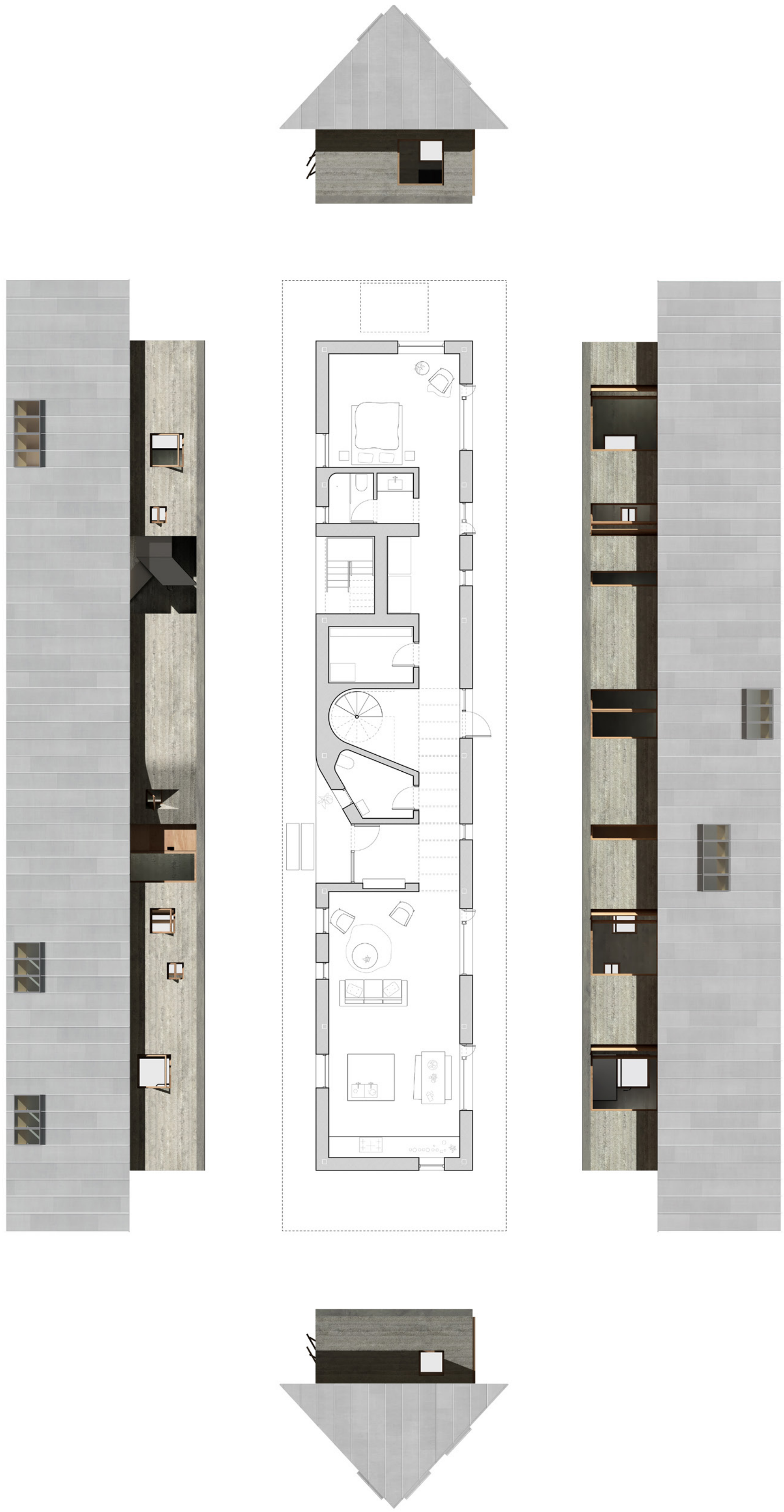

Figure 4. Incremental House, Exterior elevations

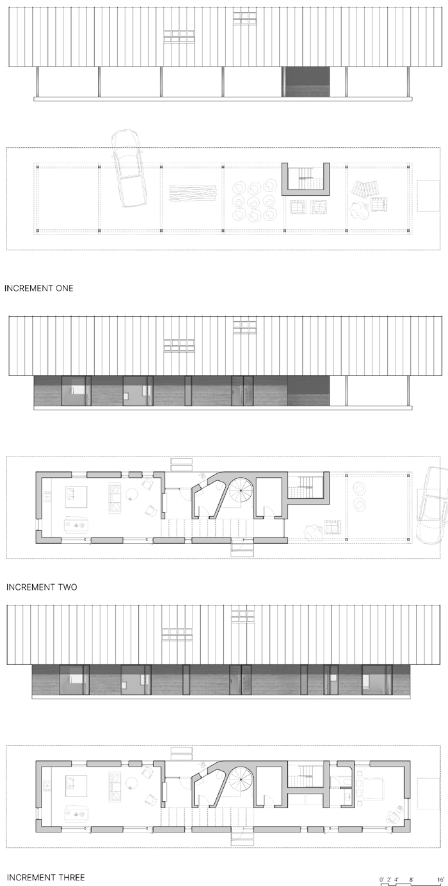

Figure 5. Incremental stages of construction and inhabitation

TECTONIC AND SPATIAL ORGANIZATION

The arrangement of the two primary elements of the house, the gable roof - a ubiquitous element across American agrarian landscapes, and the hempcrete walls reflect a desire for an architecture of low resolution in which the fundamental affordances of hempcrete, such as mass and variegated surface are foregrounded. The first phase of construction yields a gable roof structure to provide space for drying and processing of hemp hurds. Based upon a repeating bay module, the portal frame and arrayed roof rafters lay out a simple geometric logic for subsequent phases of construction. Over its three distinct increments of construction the ratio of farm shed to house inverts to provide increased living spaces amongst the hempcrete walls and within the roof volume. The encapsulated space within the roof is both utilitarian and domestic. Protected storage for hemp hurds is allocated along the eastern segment of the house and sleeping space within the central zone of the house. Rooms within the incremental house are organized along the east-west axis, where sleeping spaces utilize southern exposure and the corridor serves as a thermal buffer along the north facade. Calibrated for the climate of central Pennsylvania, the narrow structure promotes cross ventilation through the alignment of operable windows along opposing exterior walls. Achieving an r-value of 40, the 18 inch thick exterior walls encapsulate the timber portal frame to create an envelope that is perforated and interrupted in response to desired interior environmental conditions.

Figure 6. Hempcrete walls along interior passage

PROJECT

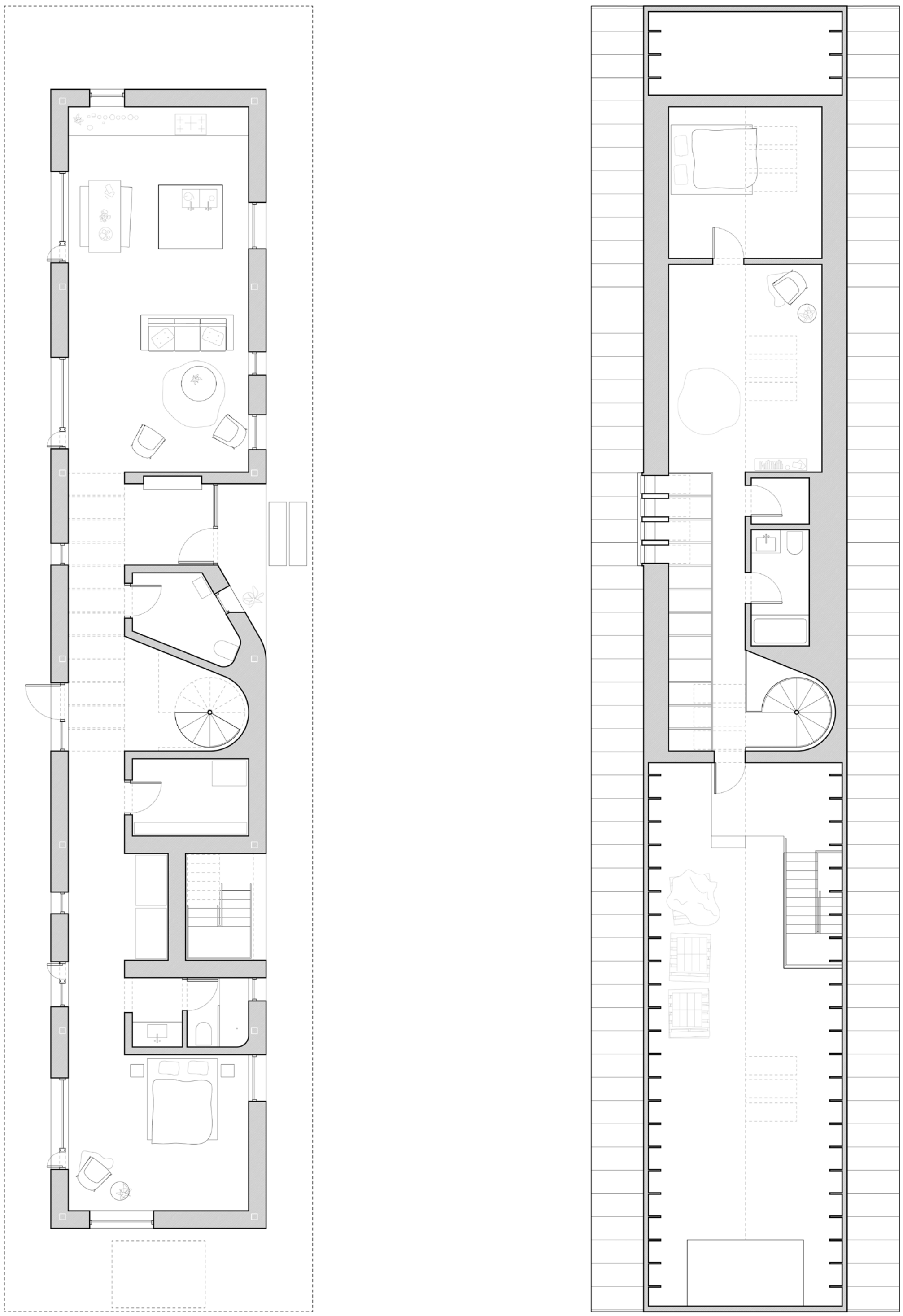

Figure 7. Completed spatial organization at first and second levels

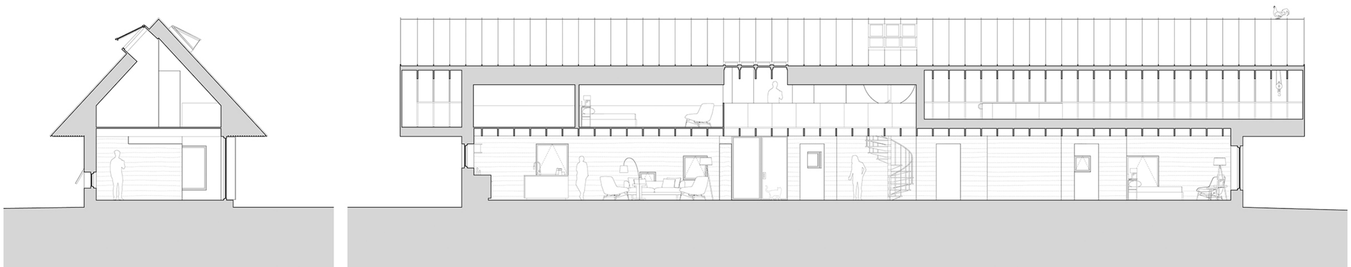

Figure 8. North-South and East-West Sections

Figure 9. View along hempcrete walls at entry

Incremental House situates an architecture of limited extraction in which material flows and entanglements are foregrounded. It collapses the distance between material generation, processing, and construction through the superimposition of spaces of domesticity and production.

ENDNOTES

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