

Undergrad Thesis  
Wenxin Hu

# Grain

## RePallet Living

# Shelter

Spring  
2025

May  
01

Design Strategies for Sustainable Temporary Shelter from Reclaimed Wooden Pallets

A thesis submitted in partial fulfillment of the requirement of the Bachelor of Interior Architecture Degree in the Department of Interior Architecture of the Rhode Island School of Design, Providence, Rhode Island.

By

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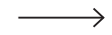


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“I was disappointed with my own profession, with being an architect. We mainly work for privileged people who have power and money. But I started to look into social issues and began adapting my recycled paper constructions for use as disaster shelters.

Before people started talking about ecology and sustainability, I was interested in using everyday materials, materials surrounding us, in an efficient way.”<sup>1</sup>

—SHIGERU BAN

## ABSTRACT

This thesis explores the potential of wooden shipping pallets as a sustainable, base element for temporary shelter design. Often discarded after a single use, pallets are abundant, standardized, and structurally capable, making them a compelling resource for rapid, low-cost construction in times of displacement.

Through material studies, design research, and model prototyping, this project investigates how pallets can form modules of shelter that are easily assembled, disassembled, and adapted to different spatial needs. The design emphasizes flexible scalability—from a single-person shelter to larger communal configurations—offering a system that grows with its context. Assembly methods prioritize simplicity, accessibility, and simple tools, encouraging repeatable use. Structure is designed to adapt different weather and environmental conditions. Lastly, sustainability is central to this approach: not only in reusing a waste material, but in promoting circularity, minimizing environmental impact, and designing for resilience.

By reimagining the overlooked pallet, this work invites a new kind of shelter-making: one that is grounded in necessity, yet open to possibility.



MOISES SAMAN, 2012  
A Syrian boy stands behind a plastic tent cover at a refugee camp near the Turkish border village of Boynuyogun. The camp houses over 1,800 Syrians that

fled since the start of the conflict in March of 2011. Boynuyogun, Hatay Province. Turkey.

# Research Question and Objectives

KEYWORDS: CIRCULATION, SHELTER, SUSTAINABILITY

This thesis begins with a simple question: **How can design transform wooden shipping pallets into adaptable, sustainable temporary shelters?**

In many regions in the world, people are facing continuous displacements due to climate change, conflicts, and economic instability. Displacement shelters are generally designed to be temporary. However, it is not rare to wit-

ness temporary arrangements become permanent settlements for complex reasons.<sup>2</sup> These current solutions are either prefabricated tent packages or solid housing which requires professional construction. The materials and shipping costs for these shelters are expensive. Moreover, components such as aluminum are valuable as a raw material. In some cases, they started selling the aluminium framings to make money and continued to

cut trees to build shelters.<sup>3</sup>

Amid all the shelter responses, there is a “material” that already arrives with the goods—wood shipping pallets. They are used globally to transport food, medical supplies, and construction materials. Once unloaded, however, pallets are often discarded, treated as waste rather than resource. These strong and uniform units end up piling up in warehouses, ports, and dumpsters. This thesis asks: If these pallets are coming on the shipment of goods and materials, can they be utilized in the shelter solution? By bringing design into this conversation, this project reimagines the pallet not just as material, but as a base element to create shelter that is responsive, adaptable, and sustainable—capable of responding to urgent needs while planting the seeds of longer-term thinking.

The core research question is supported by several key objectives:

1. To study the current landscape of temporary shelter design, with a focus on displacement camps and refugee settlements. This includes analyzing spatial, social, and logistical challenges that define emergency shelter contexts, and identifying opportunities for design improvement.
2. To investigate the physical and structural properties of wooden pallets - understanding their dimensions, strengths, challenges, and limitations as a building material. This includes safety concerns such as chemical treatment, structural stability, and longevity in temporary use.
3. To explore design strategies for flexible assembly and disassembly, allowing shelters to be adapted to different spatial needs, site conditions, or user groups. Modularity and scalability are central concerns.
4. To develop a system of construction that requires minimal tools and technical expertise,

making it accessible for community-based construction or emergency deployment in resource-limited settings.

5. To integrate sustainability principles throughout the design process, focusing not only on material reuse but on circular thinking—where components can be re-configured, relocated, or reused for other assemblies.
6. To test and evaluate design outcomes through mock-ups, models, and iterative prototyping, drawing conclusions about the practicality, and potential impact of the proposed shelter system.

Ultimately, the goal of this thesis is not only to create a viable design solution, but to reflect on the potential of design to transform people’s perceptions—revealing value in the discarded, and creating temporary spaces based on functionality, care, and resourcefulness.<sup>4</sup>

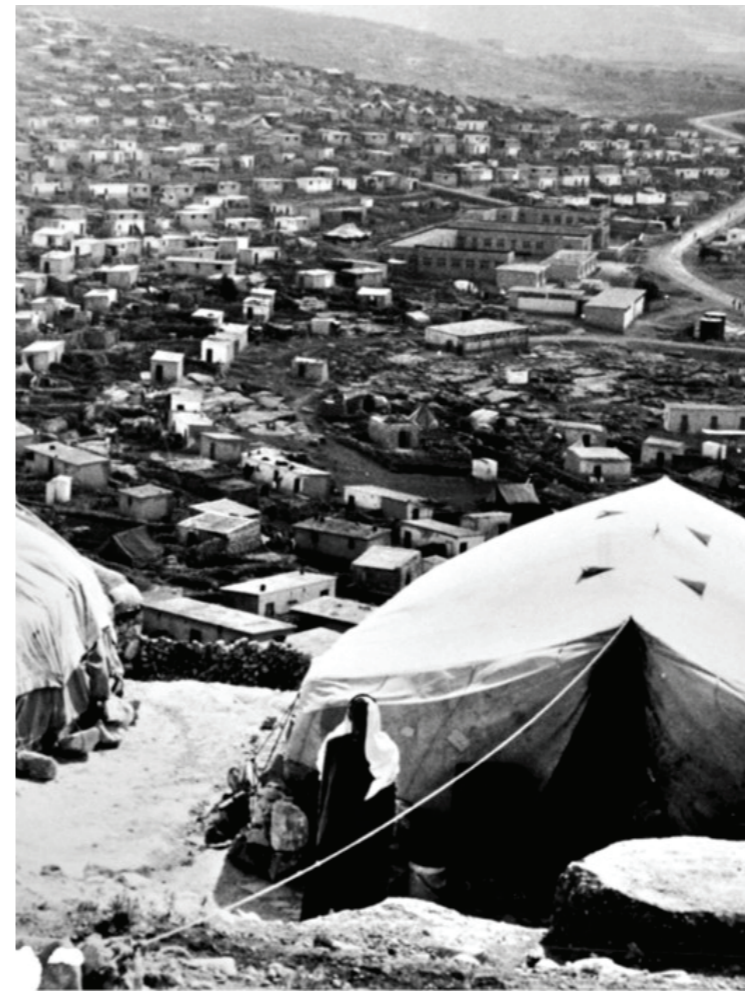


# Temporary Shelter

GLOBAL REALITIES

The word temporary reflects both urgency and possibility. It implies a moment of pause between breakdown and rebuilding—a transitional state that responds to crisis. It is also the beginning of a longer process of recovery, where the focus is on providing immediate help and humanitarian care, and then slowly rebuilding people's homes and communities. While shelter systems can evolve through several stages—from emergency tents to transitional dwellings and finally to permanent housing—this thesis focuses specifically on the temporary: structures that provide immediate relief, yet can adapt, grow, and change toward more stable living conditions.

Across history and geography, the tent has been one of the most common and instinctive forms of temporary shelter. It is lightweight, collapsible, and easy to assemble, making it ideal for mobility and speed. But tents are more than just a basic necessity; they also represent the start of architecture. Over time, the basic tent has evolved, gaining layers of structural strength, thermal protection, and spatial quality. Projects such as the Refugee Housing Unit (RHU), developed by the IKEA Foundation and UNHCR, offer a prefabricated alternative to the traditional fabric tent. It was designed for rapid deployment, providing improved insulation, ventilation, and durability.<sup>5</sup> However, their



production and distribution are costly.

Architect Shigeru Ban has a different approach. He uses simple, often recycled materials like cardboard tubes, sandbags, and local timber to create low-cost shelters. His work focused on the modular paper cone as building materials and community involvement for construction. Ban's designs prioritize dignity and human scale, proving that even temporary structures can offer spatial richness and emotional comfort.

These examples highlight the wide spectrum of approaches to temporary housing—from industrial prefabrication to hands-on, community-built systems. Yet, across all contexts, the challenges remain similar: cost, speed, material availability, climate conditions, and the durability.



# Resource Scarcity, Material Reuse

In emergency situations, the immediate need for shelter often collides with the scarcity of building materials. Infrastructure may be damaged, supply chains disrupted, and costs inflated by urgency. In these conditions, conventional construction becomes difficult, forcing humanitarian responses to rely on whatever is most immediate, adaptable, and available. This scarcity pushes design toward creative and efficient solutions, and evokes rethinking of what counts as a building material.

The idea of recycling building materials is not new. Historical practices, such as the Roman use of “spolia,” have had repurposing materials from older buildings into newer constructions.<sup>6</sup> In this thesis, a similar mindset can be applied more broadly—

not only to traditional building elements, but also to discarded objects that were never intended for architecture.

Shipping pallets fall into this category. Though not made for construction, they travel the world with goods and become abundant at sites of delivery. Their availability is a byproduct of global logistics, making them a recurring material even in remote or resource-limited settings.<sup>7</sup> As wood, they can be dismantled, reassembled, or adapted. They also participate in the global wood recycling stream, which plays a role in storing carbon and extending the carbon cycle through reuse.

# PALLET

# LETT

## THE LIFE OF THE PALLET FROM INDUSTRY TO WASTE

During my research on the Rhode Island School of Design campus, I noticed that all of the campus workshops have weekly deliveries on wooden pallets. However, these pallets are often left outside until someone collects them and removes them for disposal. There is no formal practice of recycling pallets. This is not something unique to RISD; it is a common practice of pallets being improperly disposed after used with no standard procedure for reuse and recycling.

Wooden pallets are a fundamental part of logistics processes globally and provide ease of transportation and handling for goods over long distances.

Made primarily of softwoods like pine, they are designed to be heavy-duty yet easy to handle. It is often hard to track the journey of pallets because of the lack in standard recycling. The typical lifecycle of a pallet involves multiple uses, repairs, and ultimately, disposal. While some pallets are repaired and re-enter the circulation, many of them end up in landfills and become a problem environmentally.<sup>8</sup>

Currently, there are estimated to be more than 1.8 billion wooden pallets in circulation in the United States and almost 500 million produced annually. Many of these are used only once before being discarded or burned.<sup>9</sup> Although lumber recycling

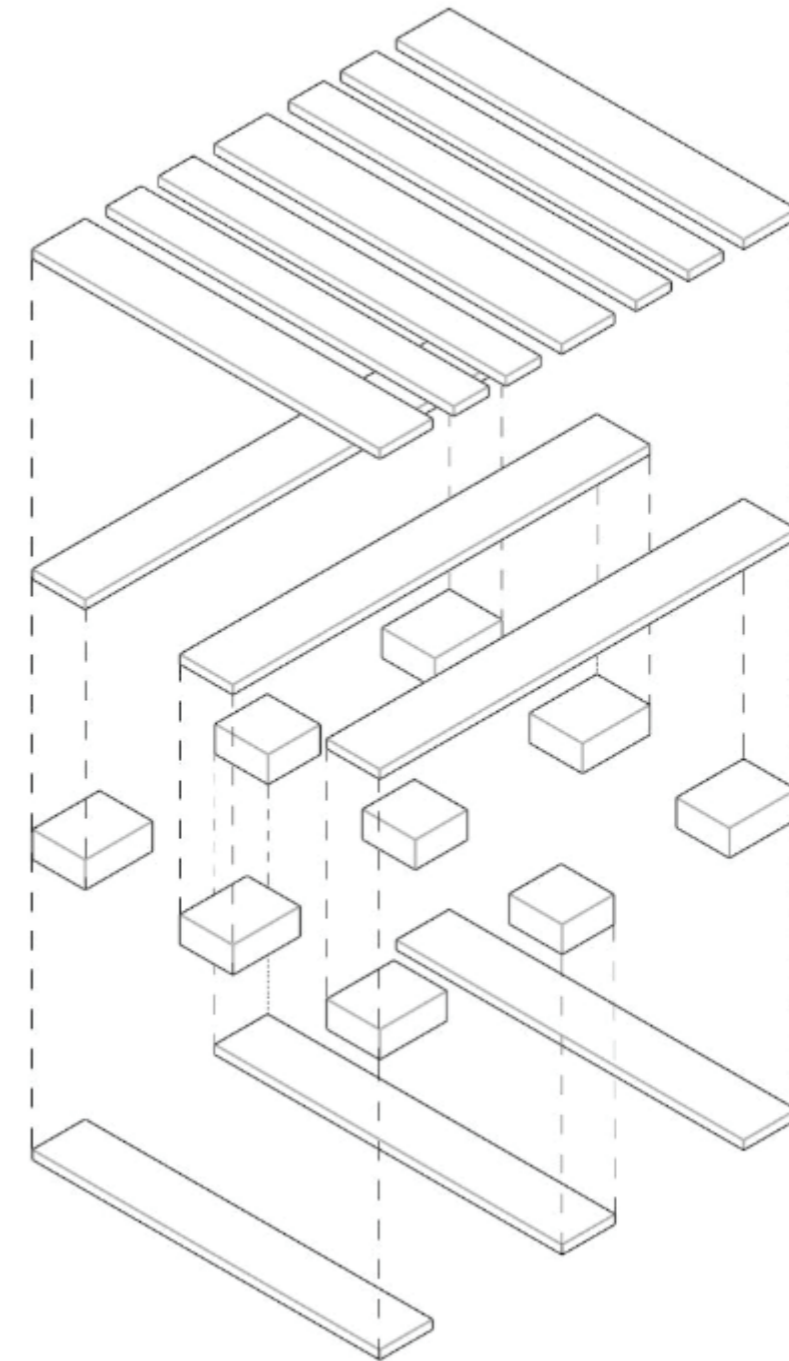
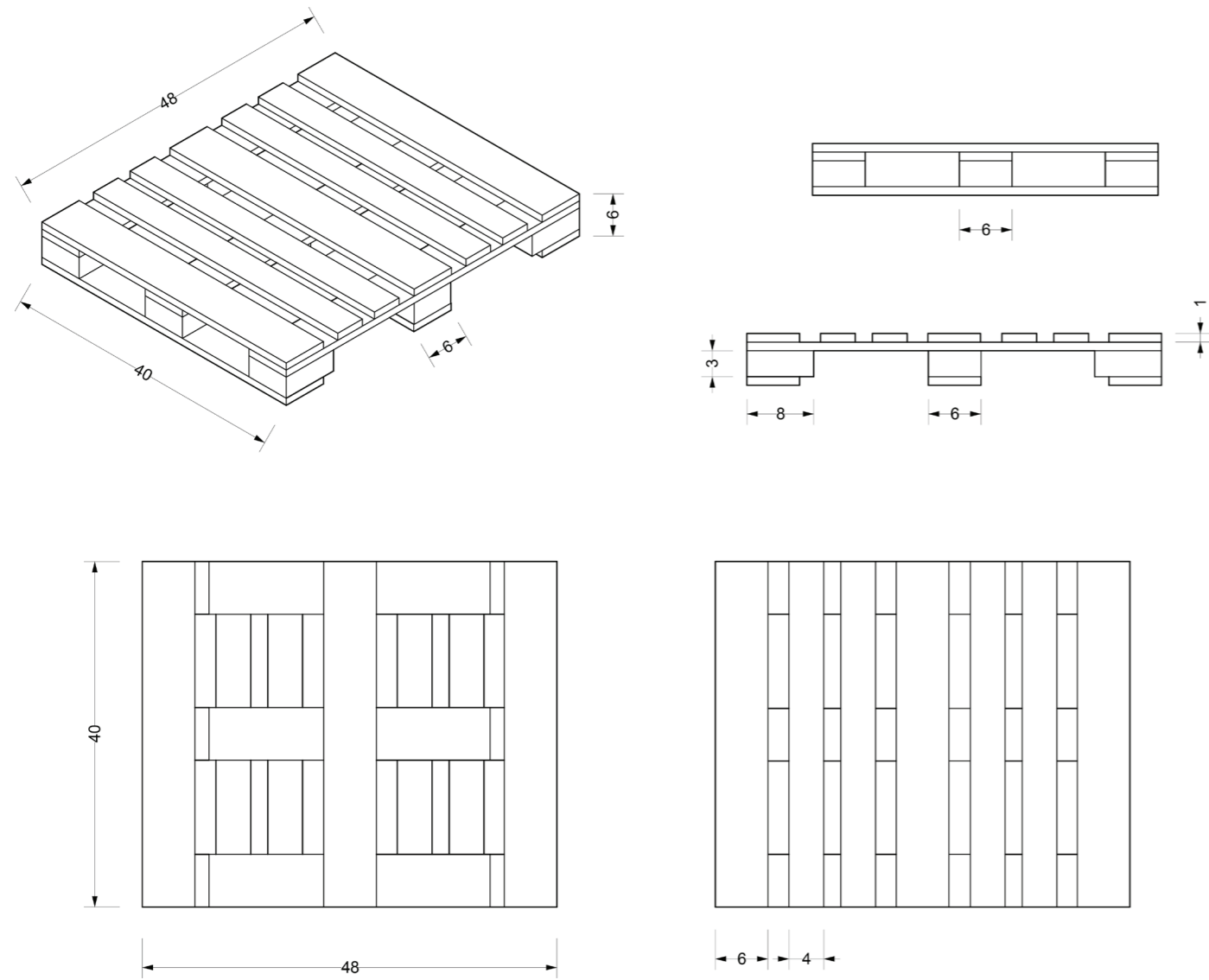
rates seem to have improved, the infrastructure for consistent re-use of pallets is largely inconsistent.

The traditional life cycle of a pallet involves production, primary use, collection, possible repair, and eventual disposal. However, due to labour logistics and small incentives, the ability to reuse is not performed effectively.

Wood recycling through pallet reuse offers modest but meaningful sustainability benefits. It acts as a carbon-storing material, contributing to short-

term carbon sequestration when reused rather than discarded.<sup>10</sup> The reuse of pallets thus has potential not only to reduce waste but also to participate in a circular carbon economy—particularly relevant in emergency contexts where new material may be scarce.





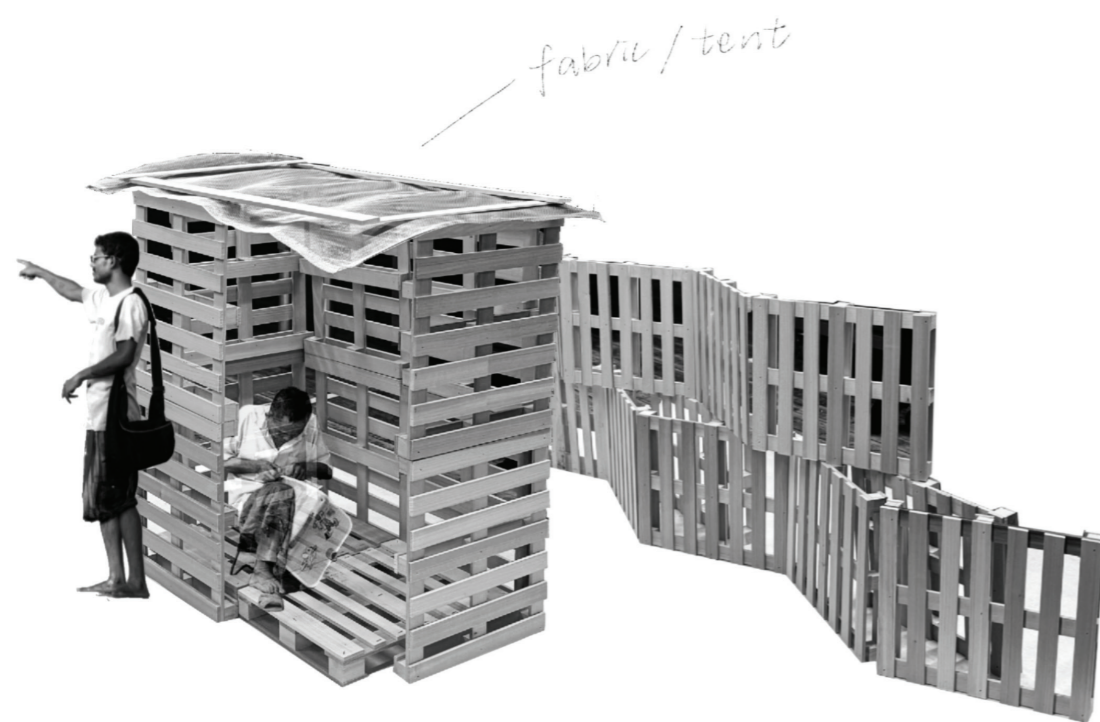
### PALLET ANATOMY

The pallet type selected for this project is the most common type in international shipping, the standard wooden 48x40 inch wide pallet. It is the most widely utilized type in international shipping and industry, for it is the most compatible size in global freight systems. The 48x40 in pallet was originally designed to have a reasonable balance between portability, amount of load, and also structural performance. It is typically constructed from soft-

wood or mixed hardwoods. The modular geometry and structural redundancy of the pallet makes them stackable, spanned, and repetitively used, making it not only a perfect transport device, but also a constructible building module in temporary structures. The inherent strength of this form, originally designed to bear industrial loads, provides a strong starting point for reimagining the pallet as a structural wall component in shelter design.

# Design

STARTING FROM... P(ALLETS)OSSIBILITIES

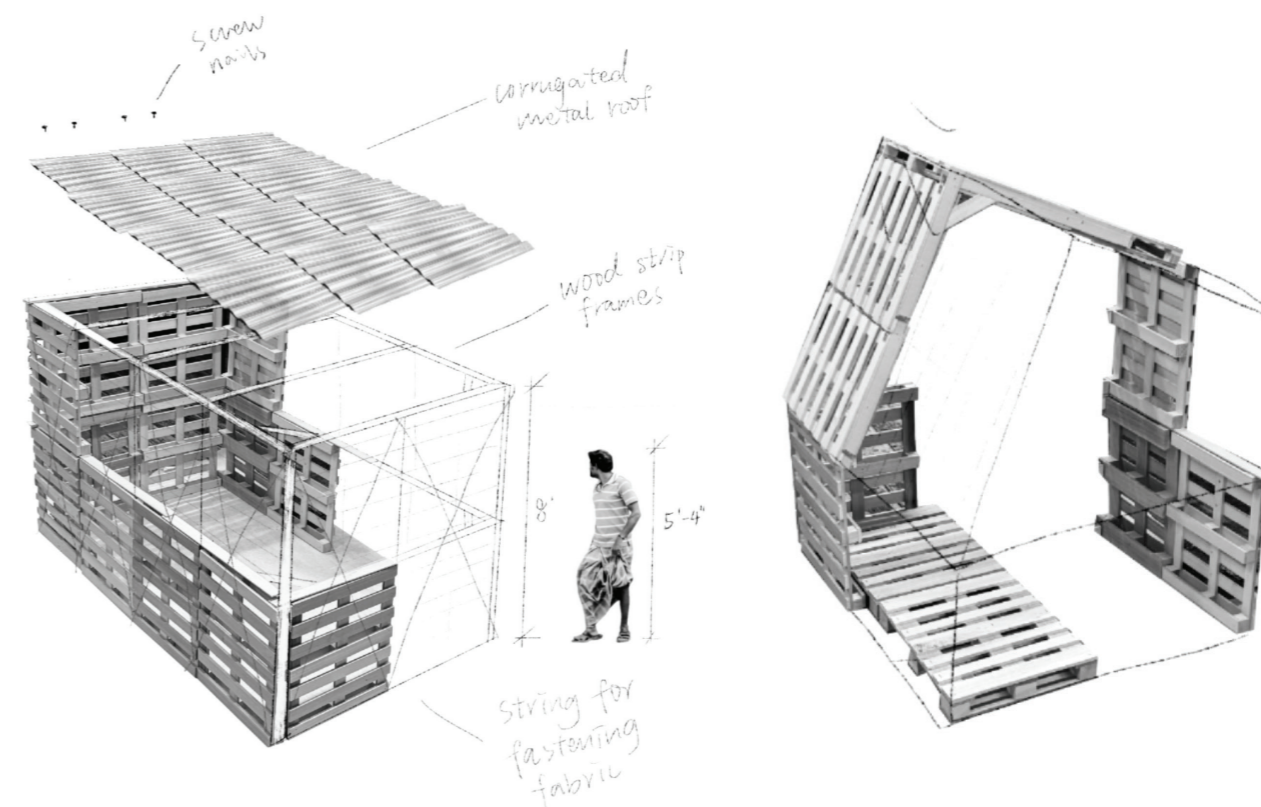


After producing quarter scale physical pallet models, I tried assembly in an intuitive fashion, inspiring me to imagine the construction of temporary shelters. This process sparked many inspirations for me on thinking through the process of construction of temporary structures. Testing various

arrangements with scaled down pallets also gave me a better understanding of the structural capacity dependent on the orientation of the pallets and consequential connectivity.

Throughout the testing and building process, an observation on the level of complexity was also noticed. I went through the process of thinking about the simplest assembly in smaller scale to the more sophisticated structure on a larger scale. This path actually aligns with the integration and transition

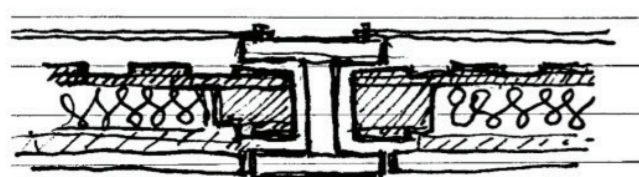
from temporary shelter to permanent architecture, with tools and structures being upgraded on each step using the same pallets. The diagrams from left to right follows the pattern of temporary/simple to permanent/complex. More pallets and supplement materials are needed for the transition.



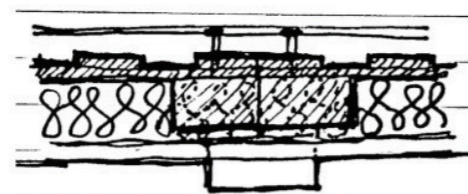
In the assembly of a complete shelter, the roof presents the most significant design challenge when working with pallet structures. Due to their weight and limited span, pallets are not ideal as roofing elements without substantial additional support. restriction prompted some

consideration of alternative materials that can be sourced in the local area. Corrugated metal sheets and fabric tarps, often used in temporary shelters, offer practical solutions due to their ease of use, durability, and local availability.

# Joinery



Vertical "I" channel



Cross shaped steel plates

Joinery is the critical element in transforming pallets from shipping platforms into structural building blocks. This thesis aims to develop a simple and modular joinery system that ensures structural stability while allowing for ease of assembly and disassembly. Two early systems were prototyped during the design process, each offering different approaches to connecting pallet units both vertically and laterally.

## System 1: Vertical Channel Connection

The first approach explored vertical stacking. A continuous channel system was proposed to align

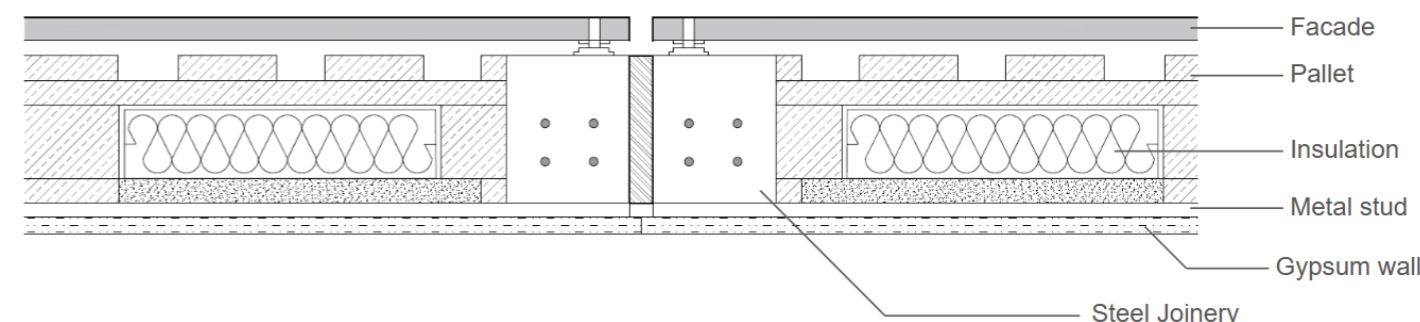
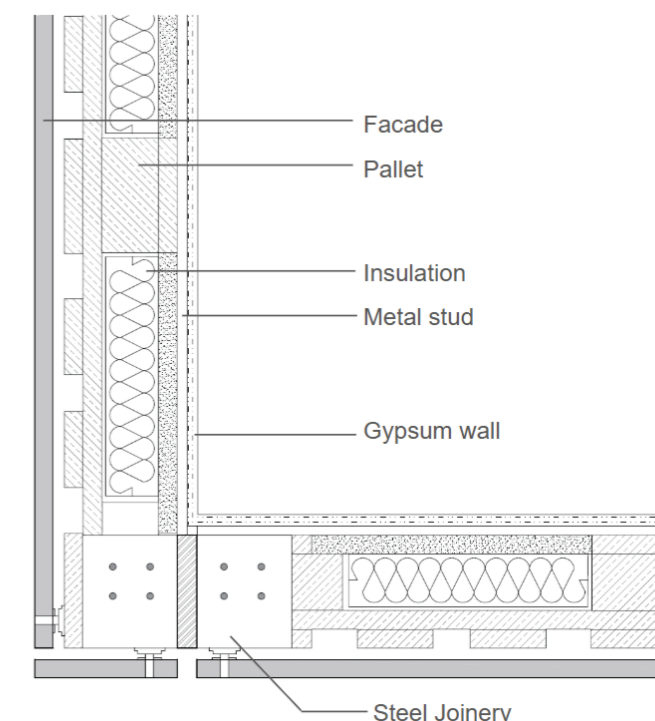
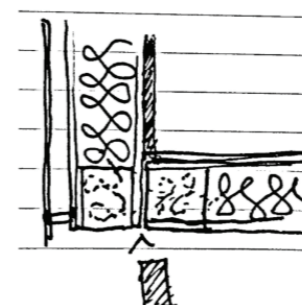
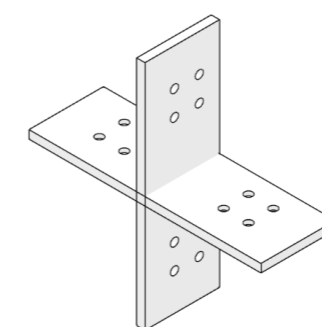
and anchor pallets vertically. In theory, this method provided a clean and rigid structure. However, this system demands a high quantity and quality of additional materials for each vertical connection. For a temporary shelter meant to be rapidly assembled with minimal resources, this approach was ultimately not viable.

## System 2: Cross-Shaped Steel Plate Joinery

The second experiment drew inspiration from timber frame construction. A cross-shaped steel plate was designed to connect pallets laterally by anchoring into the 6 x 6 inch corner blocks where

structural strength is concentrated. Screwed into the internal faces of each pallet, the steel piece created a hidden joint with minimal interference to the existing pallet geometry. This method also allowed for integration with infill wall modules, which could provide insulation or environmental protection for a long-term construction. The diagrams below show the sections of complete wall assemblies.

While this system offered a more compact and structurally solid solution, it came with its own set of challenges. The fabrication of custom steel plates posed a cost barrier, especially for applications in low-resource contexts. The method also limited disassembly and reuse of components. Additionally, the narrow gaps introduced between pallets by the steel connectors proved difficult to seal, affecting further installation of insulation.<sup>11</sup>





## JOINERY

Therefore, these constraints led to a third iteration—a threaded rod system. Inspired from interior constructions in furnitures and roofings, a combination of threaded rod and nuts is developed be-

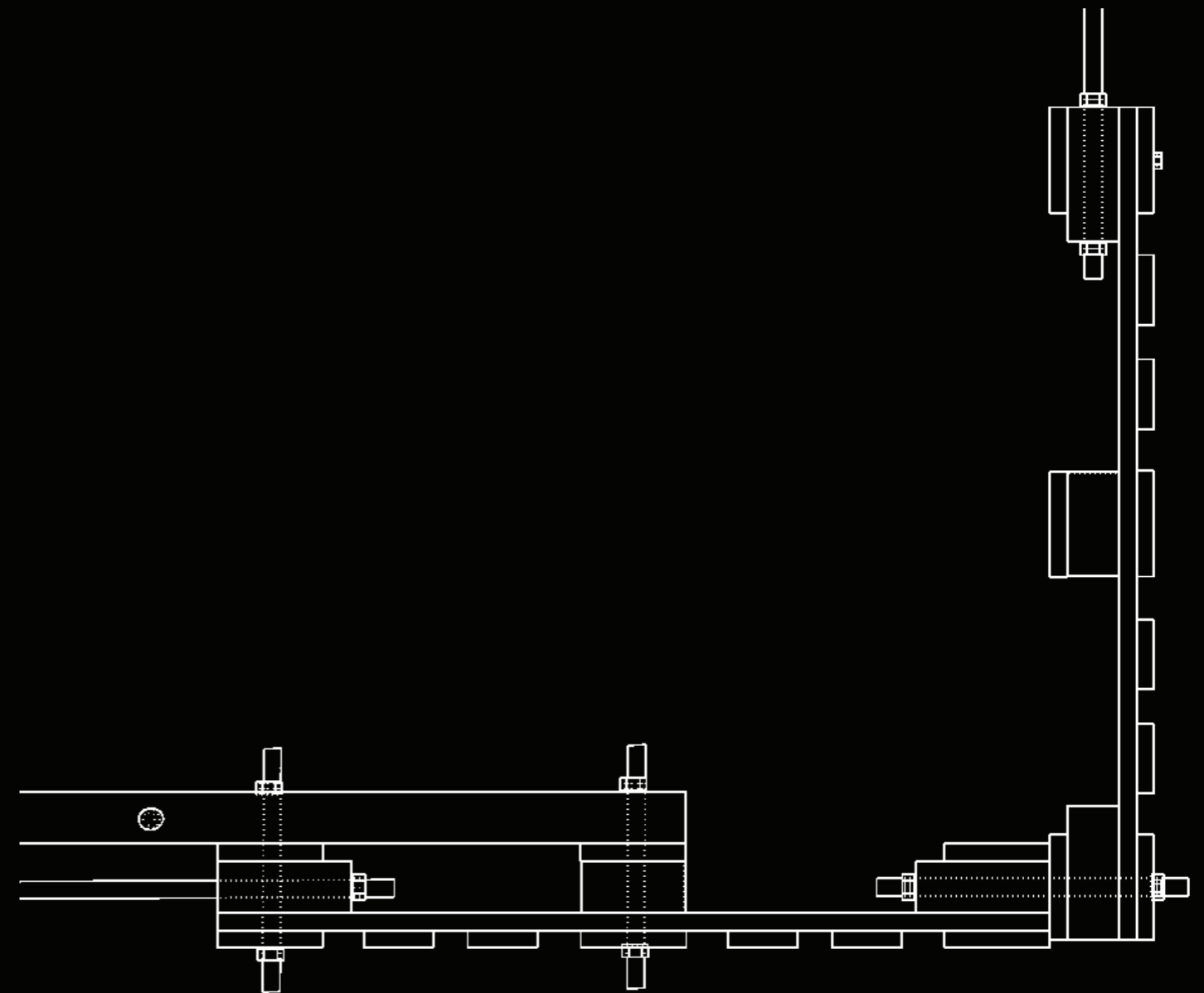
tween each pallet unit. The inward force provided by the pressure between the two nuts brings better structural stability than the Cross-Shaped Steel Plate Joinery.

This requires only a drill for installation. Threaded rods are precut and delivered on-site as part of a modular hardware set, including galvanized rods, washers, and nuts. Unlike previous systems, this connection is fully reversible, allowing for the shelter to be easily disassembled and reconfigured as needed using the same tool set and materials.

When two pallets are aligned side by side, the connection is made by drilling through the corner blocks of each unit. A threaded rod passes through both pallets at these solid wood blocks, where the material is densest and structurally strongest. Galvanized washers and nuts are placed on either end of the rod, and tightened to compress the

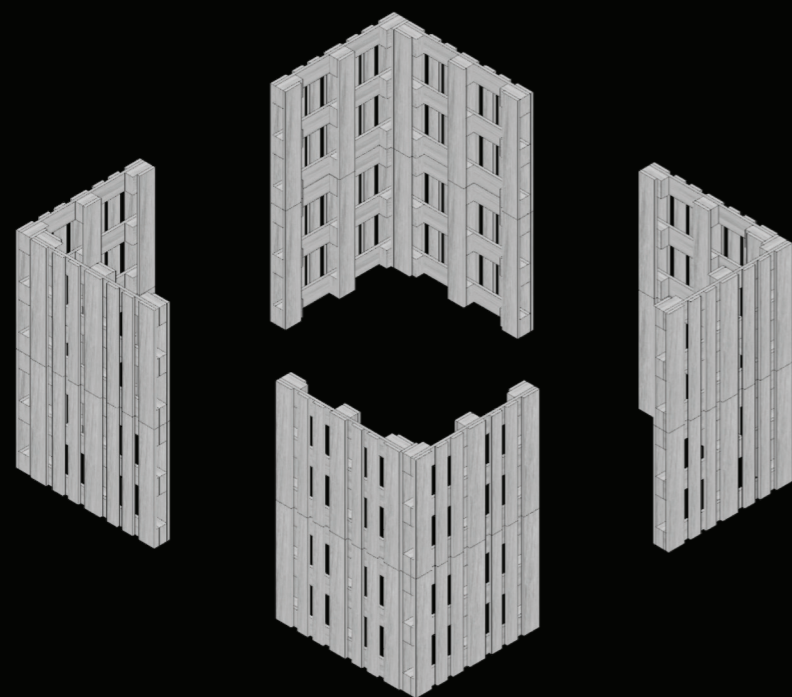
pallets together. This tension-based joinery creates a strong mechanical bond that holds the structure in place without adhesives or intrusive hardware.

Another advantage of this joinery method is its ability to generate new anchor points from the extended threaded ends. These protruding points allow for additional elements to be connected to the structural frame—such as wall panels, tarps, or corrugated metal roofing—without introducing new systems. This integration supports a more adaptable and expandable architecture, enabling the pallet frame to respond to different environmental needs and programmatic uses over time.



# Flexible Structure

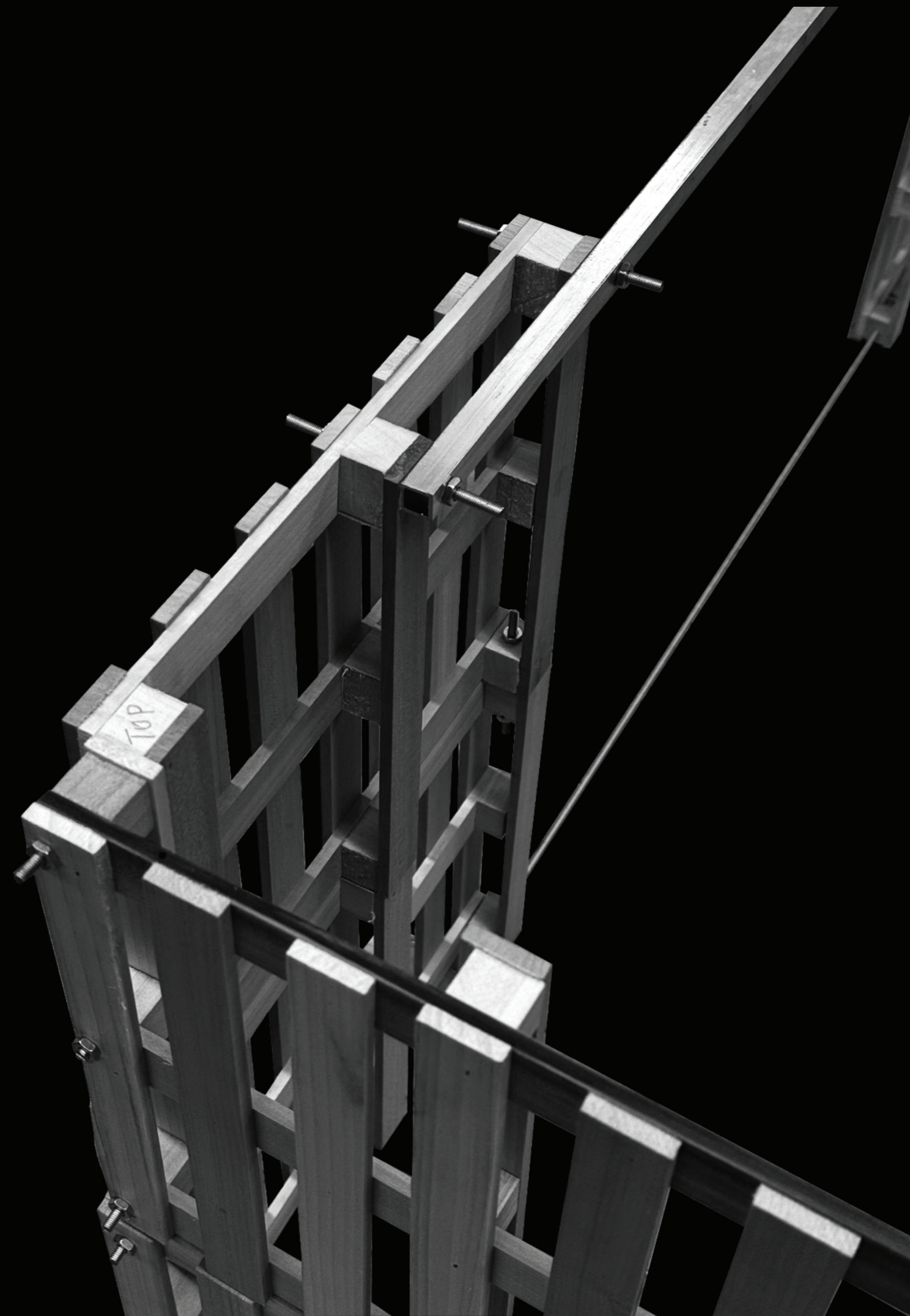
GROWTH, TRANSITION



## L-shaped Tower Structure

The design principle for this project is to use the least and simplest materials possible for a easy temporary shelter construction. Therefore, to minimize material use while maintaining structural integrity, the design began with a test of the minimum number of pallets required for a stable shelter frame. The resulting system is based

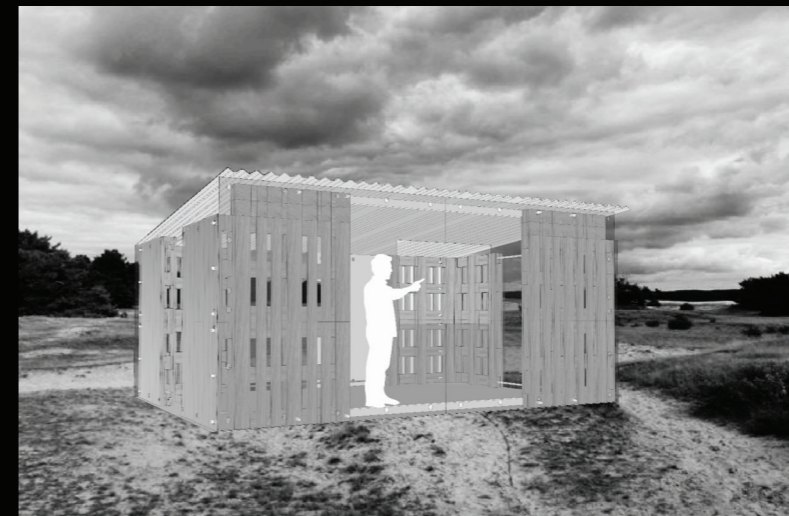
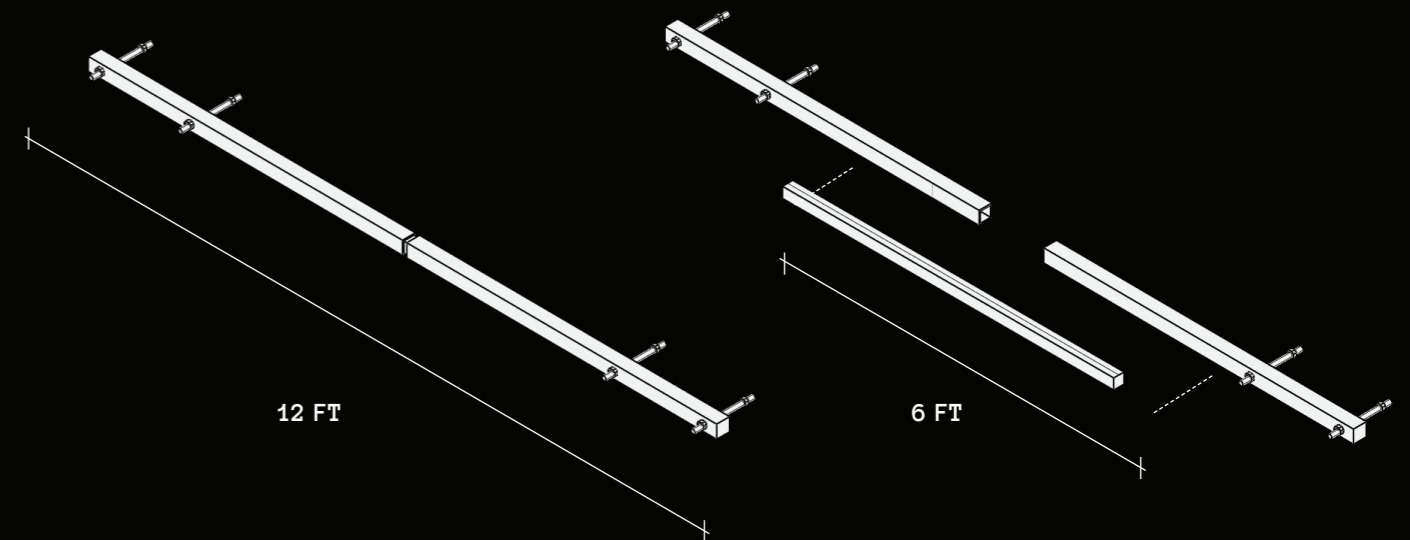
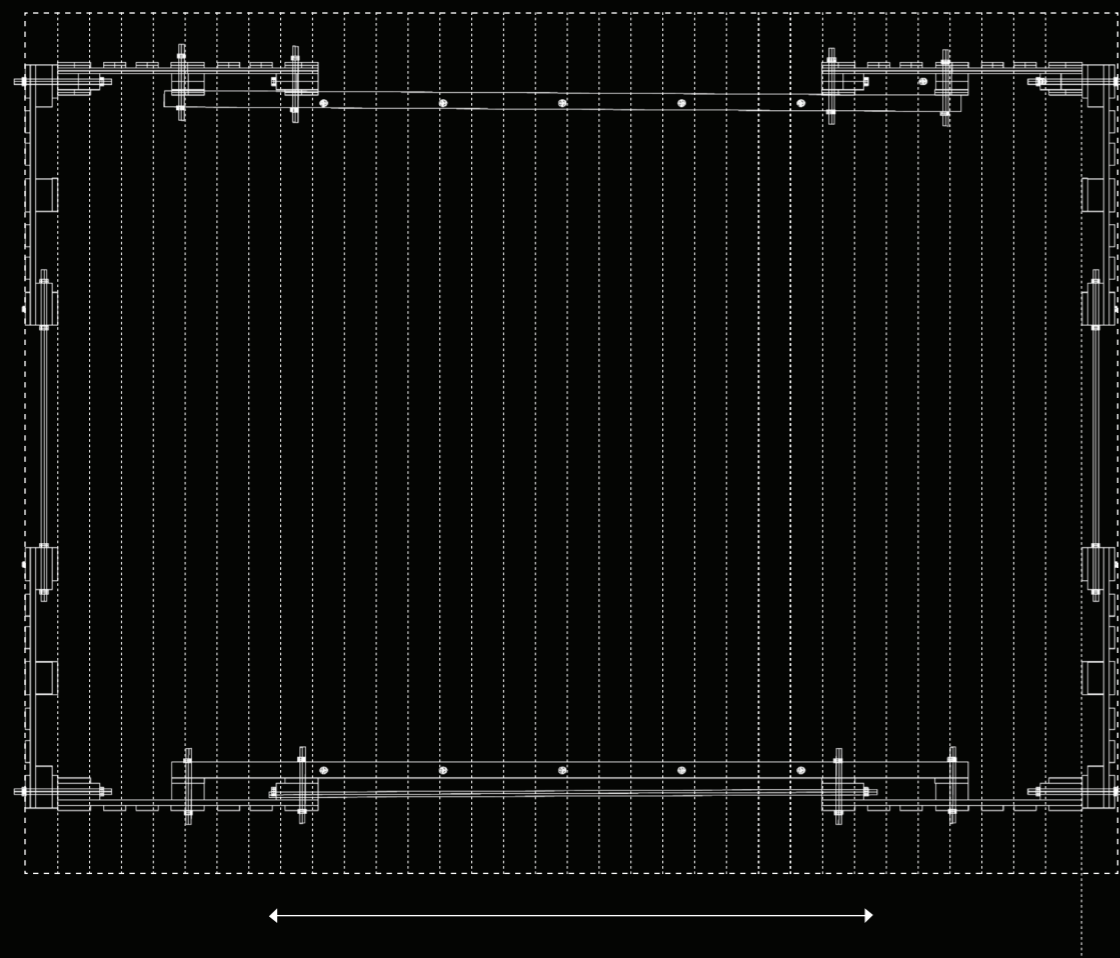
on four vertical corner units—L-shaped towers—each constructed by stacking two pallets to form a corner post. These towers define the perimeter of the shelter and serve as primary structural supports. Their L-shape is achieved by connecting two pallets at a right angle, creating a strong connection by threaded rod system.



## Growth

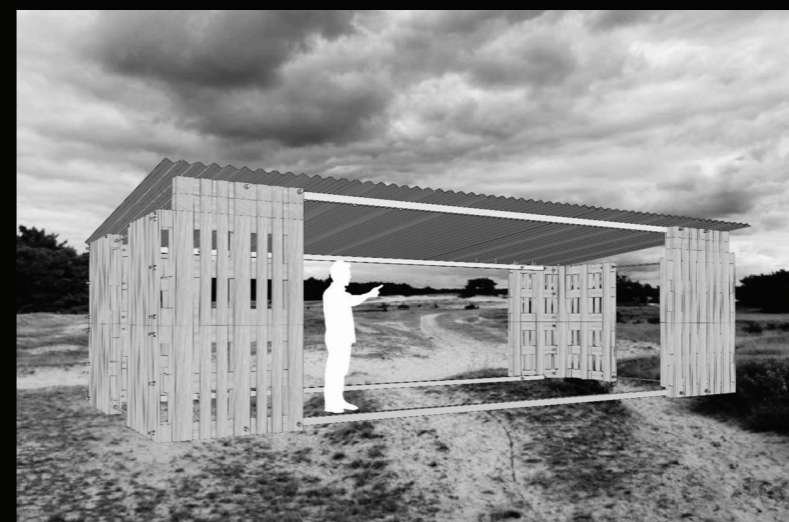
Connecting the four pallet towers is a steel sliding bar system that acts as both a stabilizing element and a structural beam. These bars are designed to span between towers along the longer side of the shelter, providing the necessary support for a lightweight roof system, such as corrugated metal sheets. Their strength ensures that the roof load is safely transferred to the corner towers without overburdening the pallet frames.

The sliding bars also introduced flexibility for the shelter by sliding between the towers. The length can be adjusted to accommodate different spatial needs, allowing the shelter to expand or contract depending on the site conditions or program requirements. It helps support a modular growth system, where the same structural logic can be reused to create larger or smaller units using the same components and connection methods.



### Scenario 1: Single family unit

When the shelter is assembled at minimum setting, the dimension is about 11 ft x 16 ft, meeting the basic need for a small family to live for months.



### Scenario 2: Community Atelier

When it is expanded to the maximum assembly, the dimension becomes 11 ft x 22 ft. Multiple sides can be opened to be pathways for circulation. The shelter could possibly become a public community center, emergency station, classroom, or just a bigger shelter that can cover more residents.

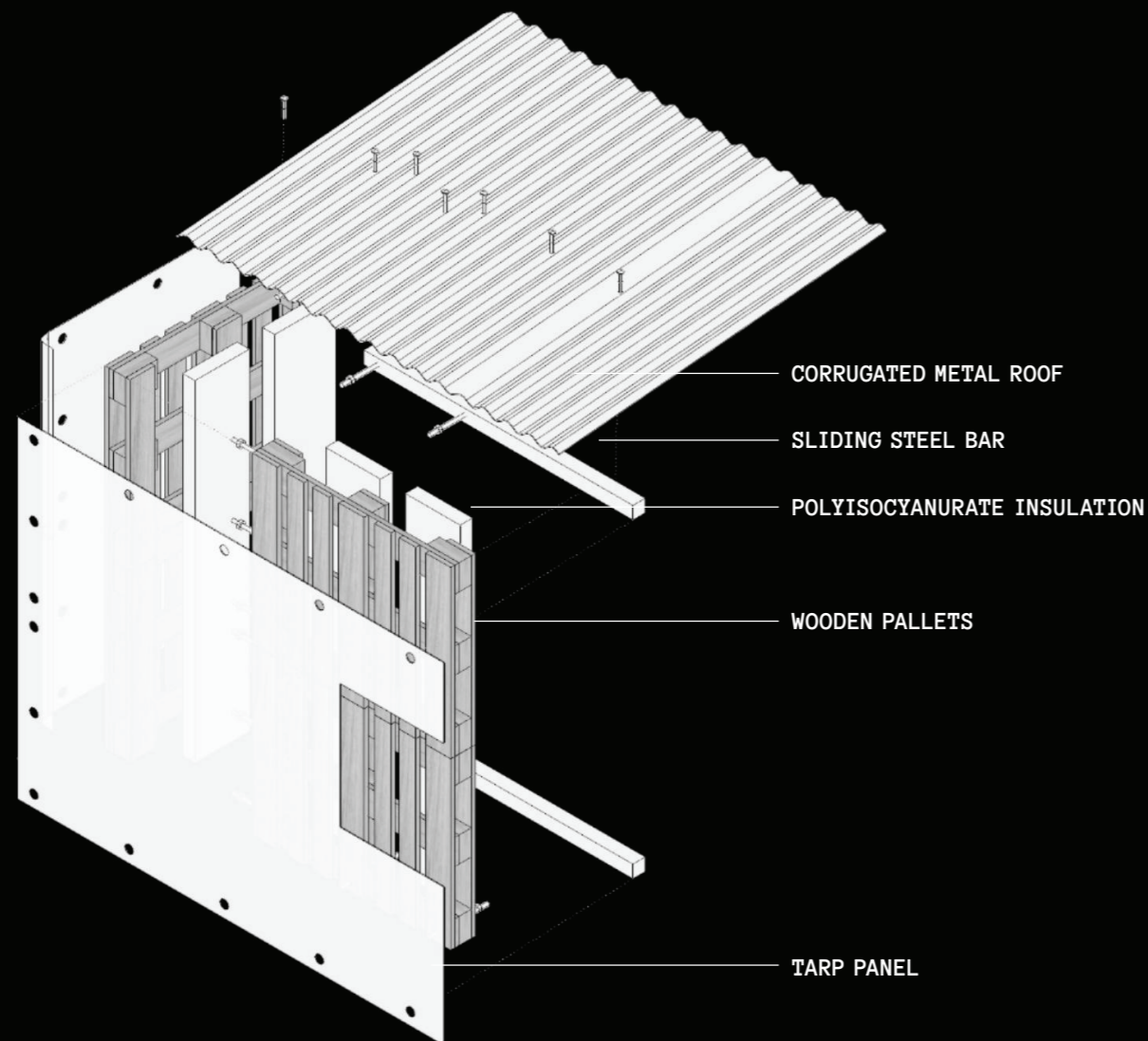
## Transition

For many reasons, temporary shelters become “permanent” as people stay for longer periods of time. Over the course of this extended use, residents often gather local materials or receive additional resources from elsewhere, both of which help strengthen and stabilize their homes.

This section presents a complete version of the shelter design, assuming some building materials are available in the region. It is a simplified form of a standard housing structure, using polyisocyanurate and aluminum insulation panels, tarp, and other wall materials for wind

and waterproofing. Offcuts from the pallets are also reused to raise one side of the roof, creating a slope that allows rain and snow to drain to one side.

This configuration addresses many environmental concerns and shifts the design from temporary shelter toward transitional housing. The pallets remain the core structure, supporting other systems. With this modular approach, they can be reassembled and reused for different configurations, turning discarded shipping waste into flexible building material.



As the shelter evolves, it begins not just to protect, but to create space for love, for community, for recovery. The modular nature of the system allows for additions and improvements over time, responding to changing needs and conditions. Whether through added insulation, extended shading, or more durable wall panels, each intervention builds upon the last.

“Grain Shelter” is not just a structural proposal, but a design philosophy: that shelter, like grain, should be elemental, sustaining, and responsive. The shelter design becomes a flexible system

for building through modular assembly, simple joinery, and a minimal kit of parts. RePallet Living, what was once waste becomes the framework for a more responsive and grounded form of shelter.



This final image shows the shelter as it is imagined in use—a simple, adaptable space built from what was once overlooked. Inside, pallets become walls,

structure, and even furnitures, creating a private and durable space of order and safety.

The design is not just about solving an urgent need, but about creating dignity and flexibility through minimal means. As part of a growing community,

these shelters can respond, expand, and change over time—proving that even the most ordinary materials can help build a more thoughtful future.

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