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Clara Mu He & Henry Chun Tak Chung

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Clara Mu He
Harvard University

Henry Chun Tak Chung
Harvard University

Project (Un)Build: A Reversible Timber Construction Method

To mitigate the wood waste problem in landfills, this paper introduces Project (Un)Build, a timber construction system that enables reversible assembly using non-invasive strapping and friction pads instead of conventional fasteners. Conventional joining methods, such as nails and screws, make timber disassembly labor-intensive and damaging, thereby limiting the reuse of wood. In contrast to high-tech visions of circularity centered on data-driven tracking systems, this project offers a low-tech, bottom-up approach emphasizing technical simplicity, material exchangeability, and workforce adaptability. After contextualizing the proposed construction method within a lineage of design-for-disassembly strategies, the paper presents results from empirical load testing and the construction of a full-scale prototype. Findings demonstrate that strapped joints can achieve structural viability, allowing for easy disassembly and full material recovery.

◁ Opening Figure. Conceptual model of a house framed with straps. (Credit: Authors for all figures.)

Keywords: Sustainability, Material Reuse, Design-for-Disassembly, Circular Economy, Circular Construction

1. Introduction

With the construction sector accounting for approximately 40% of global carbon dioxide (CO_2) emissions, material reuse and circular construction have emerged as critical strategies to mitigate the environmental impact of the architecture, engineering, and construction (AEC) industry (UNEP 2020). Policy initiatives—such as the European Union's Circular Economy Action Plan (European Commission 2020), deconstruction ordinances in US cities like Portland, Seattle, and Denver (City of Portland 2019; City of Seattle n.d.; Miller 2023), and the Los Angeles 2028 Olympics' commitment to "radical reuse" (International Olympic Committee 2018)—reflect a growing global agenda to reduce emissions by promoting a circular economy.

Wood is uniquely prominent in construction materials due to its global prevalence and relative affordability (Ramage et al. 2017). In the United States, over 94% of new residential homes were constructed using wood in 2022, favored for its workability and cost-effectiveness (Fu 2023). Yet the demolition practices associated with timber construction pose significant environmental challenges. In 2018, US construction and demolition activities generated approximately 41 million tons of wood waste, with only 9% of it being recycled. The majority—73%—was sent to landfills, while the remaining 18% was incinerated for energy recovery (USEPA 2020, 23).

Disposal of wood waste in landfills presents both global and localized environmental risks. As wood decomposes, it initially releases carbon dioxide (CO_2) under aerobic conditions and later methane (CH_4) under anaerobic conditions—a greenhouse gas over 28 times more potent than CO_2 (ATSDR n.d.). These emissions can persist for decades, especially in unlined US construction and demolition (C&D) landfills, which are generally not required to install methane capture systems (Micales and Skog 1997; ATSDR n.d.). Additionally, the decomposition of wood waste can produce leachate containing contaminants such as arsenic, boron, and manganese, which may infiltrate soil and groundwater supplies. A Minnesota Pollution Control Agency study found that 33 out of 43 unlined C&D landfills exhibited elevated concentrations of at least one of these contaminants in downgradient groundwater samples (Chiles et al. 2019). Even untreated wood can contribute to contamination by mobilizing naturally occurring metals during decomposition (Chiles et al. 2019). These findings underscore the urgent need for scalable strategies that divert wood waste from landfills and support its reuse or recycling.

A central contributor to the problem of wood waste in landfills is contemporary timber construction practices, which typically employ single-use fixation methods, such as nails, compounded by adhesives. While efficient for assembly, these techniques make it difficult to separate components cleanly at the end of a building's life (Finch et al. 2021). The result is a system biased toward demolition rather than deconstruction, where disassembly becomes labor-intensive, costly, and often damaging to the materials themselves (Heisel and Hebel 2021). Even structurally sound timber is frequently discarded due to the high costs of separation, sorting, cleaning, and redistributing, reinforcing a linear model of consumption and disposal rather than a circular one.

To mitigate the issue of wood waste in landfills, this paper introduces Project (Un)Build, a timber construction system that enables reversible assembly using non-invasive strapping instead of conventional fasteners. This approach facilitates easy deconstruction while preserving material integrity, enabling future reuse. Designed with technical simplicity, material exchangeability, and workforce adaptability in mind, Project (Un)Build offers a low-tech, bottom-up approach to circular construction. In doing so, it asks how architectural innovation might emerge not through radical revolution, but through careful rethinking of how we connect—and disconnect—materials in the construction process.

The following sections first situate Project (Un)Build within the broader landscape of design-for-disassembly (DfD) strategies, identifying existing approaches and their limitations. They will then present the results of empirical investigations—including joint load testing and full-scale prototype construction—to evaluate the proposed system's structural viability and practical implications.

2. Context

2.1 History of DfD

While the term "Design for Disassembly" (DfD) emerged relatively recently, the underlying principle—that buildings can and should be easily disassembled—is not a contemporary concept. Across cultures and periods, impermanence in architecture was exercised with diverse motivations: the portability of Mongolian yurts suited nomadic life; the periodic reconstruction of Japan's Ise Shrine every 20 years embodied ritual renewal; and temporary wooden structures built for the Possesso in Renaissance Rome reflected political and ceremonial needs (Altangerel 2020; Sand 2015; Fosi 2002, 39).

In the modern era, many of the principles now associated with DfD began to surface in the 1960s, when architects increasingly turned toward ideas of flexibility, temporality, and user agency in response to the perceived rigidity and standardization of postwar modernist planning and housing (Crowther 2022). Notably, Walter Segal's self-built timber system was a critique of the homogeneity of mass housing. By employing dry connections and standardized components, his systems advocated for user customization and incremental change (Grahame and McKean 2021). Around the same time, John Harken's Support and Infill theory proposed separating permanent structure from adaptable interior elements (Habraken 1972). This layered logic also shaped Archigram's Plug-In City, where modular capsules are imagined to be plugged into a fixed infrastructure, and was echoed in the Japanese Metabolists' vision of flexible, modular urbanism (Cook et al. 1972; Kikutake 1995).

2.2 Literature Review

It wasn't until the early 2000s that DfD evolved from a theoretical proposition for spatial flexibility into an environmental imperative for reclaiming materials and amending our extractive practices. Among the many initiatives underway today, two distinct trajectories have emerged in pursuing DfD. On one hand, substantial intellectual and financial capital has been funneled into imagining a digital "circular future," in which detailed information about each building component is digitized and stored in cloud databases (Leindecker et al. 2025). On the other hand, many initiatives have sought to reinvent construction systems to be inherently reversible, carrying forward the ethos of Walter Segal's adaptable, user-driven architecture. Project (Un)Build situates itself within this second trajectory, drawing from and contributing to a broader set of experiments concerned with reversibility, modularity, and material circularity.

One line of experimentation within this trajectory centers on layered modular assemblies, which separate structure, systems, and enclosure to facilitate the independent removal or replacement of these components. The Loblolly House by Kieran Timberlake is a canonical example. Influenced by Stewart Brand's theory of architectural shearing layers, the house employs dry connections throughout and organizes its elements by function: foundation, structure, enclosure, systems, and finishes (Brand 1994; Kieran and Timberlake 2008; Stewart 1994). However, the building's logic of reversibility is tied to the panel as the basic unit. These panels—wall, floor, and roof—are custom-designed for the project, limiting their potential for broader material reuse. A similar logic applies to The Wooden Nursery by Djuric Tardio Architectes, which was designed for disassembly and relocation, but not necessarily for reusing each material element (Djuric Tardio Architectes 2013). These projects achieve reversibility at the level of preassembled elements but fall short of encouraging disassembly at the material or component level.

A second set of efforts attempted to reengineer timber framing systems using CNC-fabricated interlocking sheet materials. Projects such as X-Frame, WikiHouse, Click-Raft, and Facit Homes have all developed prefabricated systems where CNC-fabricated sheet materials interlock using tongue-and-groove joints without fasteners (Finch et al. 2017; Maliehe and Grobbelaar 2025). While these systems are highly rationalized and promote ease of assembly and disassembly, their reliance on digital fabrication limits accessibility. Moreover, the components are system-specific and not readily interchangeable with standard timber products, making reuse contingent upon the continued operation of the original system—a form of closed-loop modularity.

A third direction, in which Project (Un)Build situates itself, explores bottom-up methods for adapting existing industrial timber products through reversible fastening. Compared to the other two directions, this approach remains in an early phase, focused on joint innovation rather than developing a comprehensive construction system. In this emerging category, straps and clamps have gained traction due to their non-penetrative and reversible properties, drawing on long-standing bamboo construction techniques. In Peter Zumthor's Swiss Sound Box and AULETS' installation at the XL Craft Fair of Pollença, timber is horizontally stacked and restrained with clamps or straps, enabling full recovery of materials (Zumthor 2000; AULETS Architecture 2023). However, these techniques are insufficient to form load-bearing columns; the resulting assemblies are wall-like stacks rather than a three-dimensional structural frame. The People's Pavilion, designed by Overtreders W and Bureau SLA, attempted to create a post-and-lintel system using strapped timber members and bundling horizontal and vertical elements. However, because the straps are nonbinding and friction alone is insufficient to resist thrust forces, particularly uplift, the structure requires excessive strapping to compensate for the lack of penetrative fixation at the joints.

2.3 Research Gap

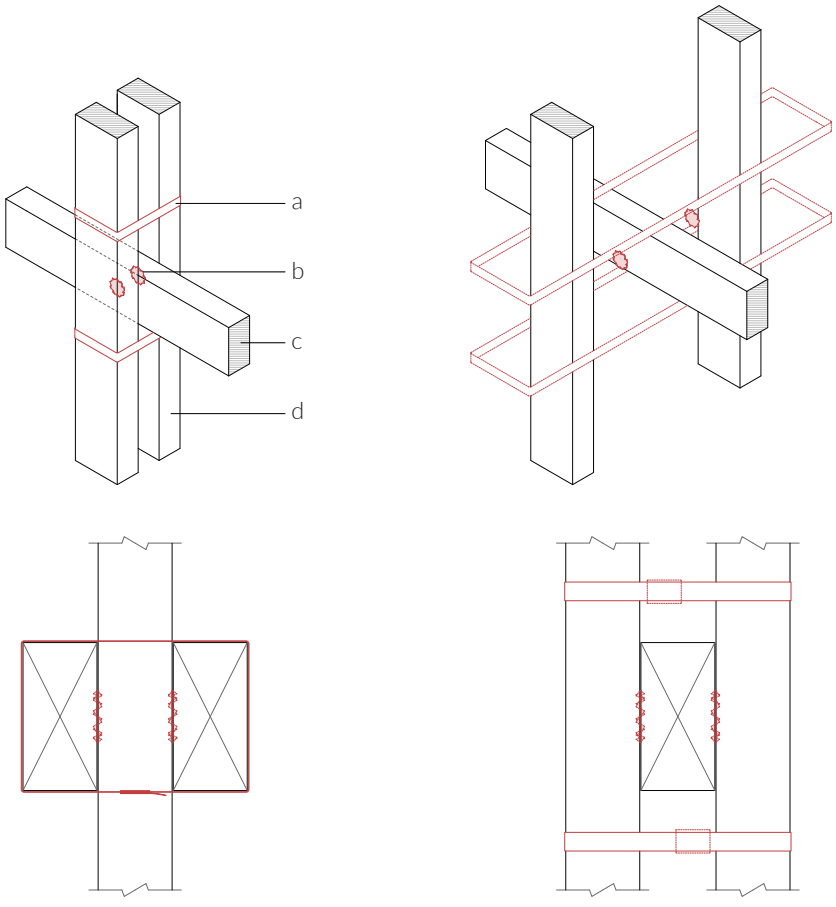
While growing interest in reversible construction has produced a range of experiments, the field remains emergent and fragmented. The infrastructure for material reuse is far from developed, particularly in terms of certification of reclaimed materials, regulatory and policy frameworks, and the costs of disassembly (Tsikaloudaki 2024). Recognizing that no single project can address all these challenges, our research focuses on advancing the structural potential of strapping-based joinery by building upon this early third trajectory. Specifically, we aim to contribute a method that promotes circularity from the bottom up by prioritizing:

1. Technical Simplicity—Advocating for low-tech solutions reduces costs and lowers barriers to adoption, making circular practices more accessible to smaller-scale actors and informal labor sectors.
2. Material Exchangeability—Open-ended systems should allow salvaged components to be reused across different construction systems, avoiding a closed loop.
3. Workforce Adaptability—Construction methods must consider the skills and tools already available to the labor force, enabling more seamless adoption without specialized training or equipment.

3. Thesis

These principles guided the development of Project (Un)Build, a timber construction system that utilizes straps and friction pads for reversible assembly. This approach facilitates easy disassembly while preserving material integrity, enabling future reuse. The core mechanism of the strapped wood joint is deliberately simple, consisting of two primary components: the strap and the friction pad. Wood members are wrapped with tensioned straps, and double-sided friction pads are placed between each contacting surface. Tightening the straps compresses the wood members against the friction pads, creating sufficient friction to resist movement within the joint (Figures 1 and 2).

Various strapping products, such as polypropylene (PP), polyethylene terephthalate (PET), and steel straps, are available, each offering different materials, thicknesses, widths, and break strengths (Uline n.d.). Multiple strap types are often combined within strapped structures to address varying load requirements. For instance, thin stainless steel cable ties might secure plywood sheathing, while thicker hose clamps are used



a. Strap
b. Friction pad
c. Horizontal wood member
d. Vertical wood member

◁ Figure 1. A diagram showing the assembly of a strapped timber joint.

◁ Figure 2. Prototype of a strapped timber joint (left) and different types of friction pads used in strapped timber joints (right).

to bundle studs into load-bearing elements. The choice of friction pads also plays a crucial role in the system's effectiveness. Metal plates with small teeth (1/32–1/16″, 1–2 mm) on both sides are recommended for load-bearing joints to maximize friction. This design is inspired by double-sided toothed connectors commonly used with bolts to enhance shear strength (Konzal 1937; Herzog et al. 2012, 119). Alternatively, double-sided heavy-grain sandpaper is an adequate substitute for joints that primarily resist lateral loads (Figure 2).

Beyond technical simplicity, Project Un(build) advocates for open-ended construction systems that do not depend on specialized parts or joints, allowing materials to be exchangeable with other systems. The method can join dimensional lumber as well as engineered wood products, such as laminated veneer lumber (LVL) and glulam. A key advantage of this approach over conventional wood-joining methods, such as nails and bolts, is that it avoids penetrating the wood members. Preserving the material's integrity and preventing damage, such as nail holes or marks, ensures that the timber remains in good condition for future applications.

Lastly, the technique is easily adaptable to the skill sets of the current workforce, requiring no retraining or reliance on a new workforce knowledgeable in advanced technologies. Because of its low skill requirement and affordability, it makes material reuse more accessible for local builders and small stakeholders.

4. Methodology

This research employs two complementary methods—load testing of individual joints and full-scale prototype construction—to evaluate the structural performance and practical viability of the proposed strapped timber construction system.

4.1 Load Testing

Controlled laboratory tests were conducted to evaluate the strength and stiffness of the strapped joints in comparison to three conventional timber connections: nails, screws, and bolts. The objective was to determine whether strapping could be a structurally viable alternative to penetrative fasteners. The tests were performed per *ASTM D5652–15 Standard Test Methods for Single-Bolt Connections in Wood and Wood-Based Products* (ASTM International, 2015). Two sets of four tests were conducted using standardized timber specimens fabricated under consistent material conditions and design parameters. A hydraulic press applied axial loads to the wood members, each fastened with a different connector type, incrementally until failure. In addition to measuring ultimate load capacity and identifying failure modes, qualitative observations—including slippage and deformation—were documented to contextualize the quantitative results.

4.2 Prototype Construction

Two full-scale timber prototypes were assembled exclusively with the proposed Project (Un)Build Method to explore constructability and design implications. The first prototype implemented a basic post-and-beam configuration, while the second attempted to assimilate wood-framing with straps. These construction trials enabled the evaluation of assembly time, construction tolerances, skill demands, and overall structural behavior. Field observations also informed refinements to strap placement and sequencing procedures, thereby providing feedback that contributed to system optimization.

Together, these two modes of inquiry provide an empirical foundation for assessing the feasibility of the proposed technique and its potential contributions to reversible, low-tech construction practices.

5. Results and Discussion

5.1 Load Testing

Two sets of four tests were performed to evaluate the strength of the proposed strapping technique compared to conventional wood fastening methods. Within each test set, specimens were constructed using standard 1×4 red oak members fastened with four different connectors. The first set used a single ¼″ (6 mm) bolt, one nut, and two 1-1/4″ (32 mm) washers (Figure 3a); the second used one #8 2-3/4″ (70 mm) Phillips flat wood screw (Figure 3b); the third used two 2-3/4″ (70 mm) stainless steel nails (Figure 3c); and the fourth used two 1/2″ (13 mm) wide hose clamps in combination with two friction pads to represent the proposed strapping method (Figure 3d).

The two sets of tests differed in grain orientation. One set of connected members had fasteners aligned parallel to the grain, while the other applied compression forces perpendicular to the grain. This configuration enabled a comparative assessment of the performance of each fastening method under different loading conditions (Figure 4). Tables 1 and 2 summarize the results from both sets of tests. Load capacities are reported in short tons (1 short ton = 2,000 lb.; 0.91 metric tons). All subsequent references to "ton" in this paper refer to short tons unless otherwise noted.

The bolted and strapped specimens exhibited the highest ultimate load resistance among the tested fastening methods. The bolted connections reached an ultimate load of 0.9 tons (0.82 metric tons) in perpendicular- and parallel-to-grain compression tests. In both cases, failure occurred due to cracking of the red oak members, indicating that the material strength of the wood governed the failure mode under increasing axial load (Figures 5a, 6a).

The strapped connections reached 1.0 ton (0.91 metric tons) in the perpendicular-to-grain configuration and 0.8 ton (0.73 metric tons) in the parallel-to-grain configuration. This variation suggests that the orientation of the friction plates relative to the wood grain affects the effectiveness of the strap joint. The primary failure mode was wood slippage once the axial load exceeded the maximum friction resistance provided by the plates (Figures 5d, 6d).

The screw specimens withstood only 0.2 ton (0.18 metric tons) in both orientations. Their failure mode resembled that of the bolted specimens, with the wood cracking under load. However, the cracks formed at lower loads, likely due to the internal stresses induced when the screw was driven into the wood, making the material more prone to failure (Figures 5b, 6b).

The nailed specimens showed the lowest performance,

Table 1. Load testing with connections perpendicular to grain in compression.

	Bolts	Screws	Nails	Straps
Specifications	One 1/4" bolt, one nut and two 1-1/4" washers	One #8 2-3/4" Philips flat wood screw	Two 2-3/4" stainless steel nails	Two 1/2" wide hose clamps and two metal friction pads
Ultimate load (short ton)	0.9	0.2	0.1	1
Mode of failure	Wood cracking (Figure 5a)	Wood cracking (Figure 5b)	Nails deforming and slipping out from wood member (Figure 5c)	Load applied exceeding friction plate maximum friction (Figure 5d)
Legend: Load values were read from an analog hydraulic pressure gauge (RAM DIA 45 mm, range: 0-16 metric tons / 0-18 US tons). Due to the visual resolution limits and potential parallax error inherent to analog dials, the estimated uncertainty for each reading is ±0.25 tons. These values should be interpreted as approximate indicators of load capacity for preliminary comparison rather than precise measurements.				

Table 2. Load testing with connections parallel to grain in compression.

	Bolts	Screws	Nails	Straps
Specifications	One 1/4" bolt, one nut and two 1-1/4" washers	One #8 2-3/4" Philips flat wood screw	Two 2-3/4" stainless steel nails	Two 1/2" wide hose clamps and two metal friction pads
Ultimate load (short ton)	0.9	0.2	0.1	0.8
Mode of failure	Wood cracking (Figure 6a)	Wood cracking (Figure 6b)	Nails deforming and slipping out from wood members (Figure 6c)	Wood slipping (Figure 6d)
Legend: Load values were read from an analog hydraulic pressure gauge (RAM DIA 45 mm, range: 0-16 metric tons / 0-18 US tons). Due to the visual resolution limits and potential parallax error inherent to analog dials, the estimated uncertainty for each reading is ±0.25 tons. These values should be interpreted as approximate indicators of load capacity for preliminary comparison rather than precise measurements.				

resisting only 0.1 ton (0.09 metric tons) in both configurations. The thin stainless-steel nails deformed easily under load. As axial force increased, wood displacement caused the nails to bend and eventually slip out. The 0.1-ton threshold corresponds to the load at which deformation and slippage began (Figures 5c, 6c).

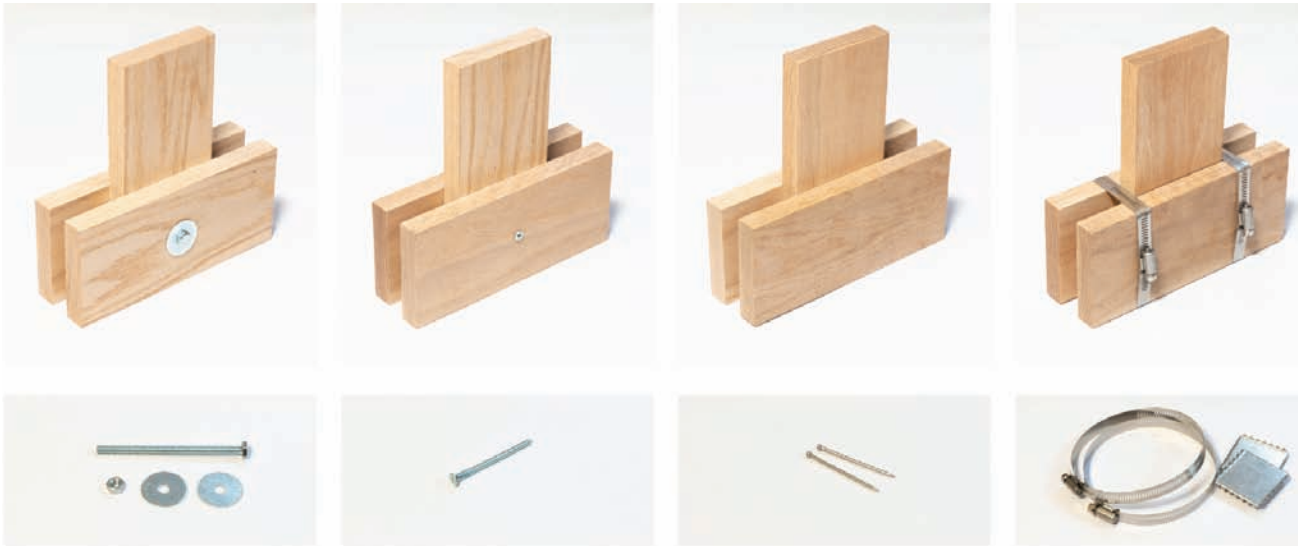
These benchmark tests were not intended to determine a superior fastening method, but rather to validate the structural viability of the proposed strapping technique compared to conventional wood joinery. While both bolt and strap connections demonstrated relatively high axial load resistance, they exhibited distinct failure modes. Bolt connections concentrated stress at the penetration point, often causing the wood to crack. Strap connections, conversely, produced slippage without damaging the wood member, avoiding the concentrated stress associated with fastener penetration points. Using friction plates further enhanced rotational stability compared to a single bolt, suggesting that the proposed strapping technique is a structurally feasible alternative for reversible timber assembly.

5.2 Prototype Construction

To demonstrate the versatility of Project (Un)Build, we built two prototypes, each of which experimented with a different structural type. At its core, the method uses a simple yet effective technique of creating sandwiched joints, where two wood members are positioned on either side of a third and secured with straps. This assembly method is suitable for various structural types, including post and lintel systems, parallel frames, and stick frames.

The first prototype was developed as a proof of concept (Figure 7). The structure consisted of six parallel frames measuring 8 ft. (2.4 m) in length, 4 ft. (1.2 m) in width, and 8 ft. (2.4 m) in height. These frames were assembled flat on the ground, lifted upright, spaced 18″ (0.5 m) apart, and connected with horizontal beams. Plywood panels were added to provide lateral stiffness, each predrilled with holes and strapped directly onto the structure using stainless steel cable ties (Figure 8). Timber members measured 1-1/4″ × 1-1/4″ (32 mm × 32 mm) and 1-1/4″ × 3-1/2″ (32 mm × 89 mm), secured with cable ties rated for a 200 lb. (91 kg) breaking strength (Figure 9). Friction between touching wood surfaces was enhanced using 40-grit double-sided sandpaper. The structure was divided into three modular sections during construction to accommodate transport and exhibition constraints, enabling partial disassembly and reassembly on-site. After the exhibition, the entire prototype was disassembled by simply removing the straps, and all materials were reclaimed for reuse.

The second prototype is an exhibition wall measuring 8 ft.



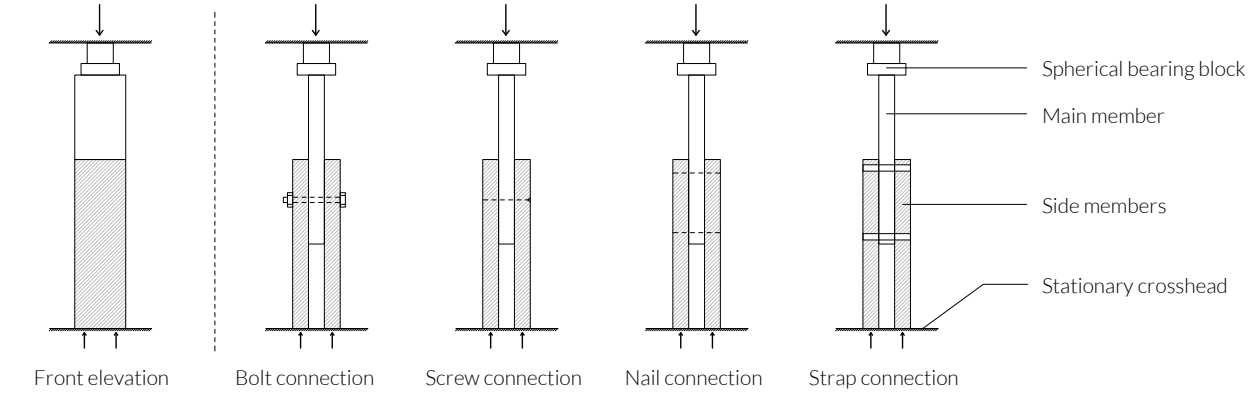
a. One 1/4" bolt, one nut and two 1-1/4" washers

b. One #8 2-3/4" Philips flat wood screw

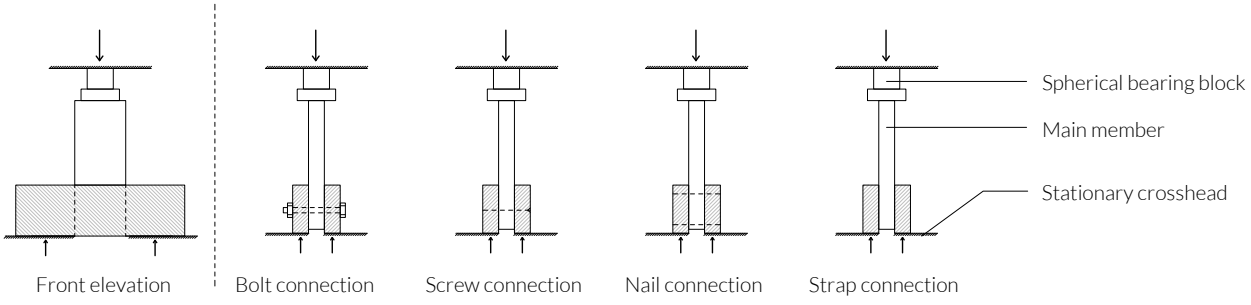
c. Two 2-3/4" stainless steel nails

d. Two 1/2" wide hose clamps and two metal friction pads

△ Figure 3. Load test specimens assembled using different fastening methods.

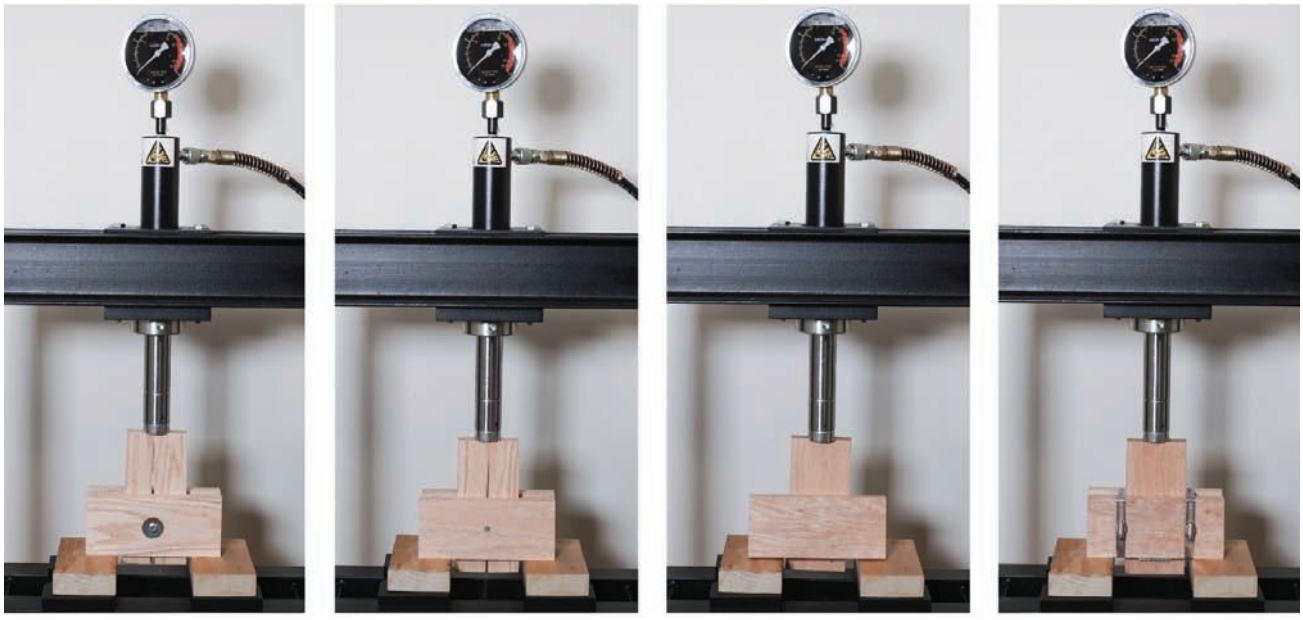


Assembly for testing various connections parallel to grain in compression



Assembly for testing various connections perpendicular to grain in compression

△ Figure 4. Diagram of test assemblies with perpendicular to grain connections under axial compression (bottom); and with parallel to grain connections under axial compression (top).



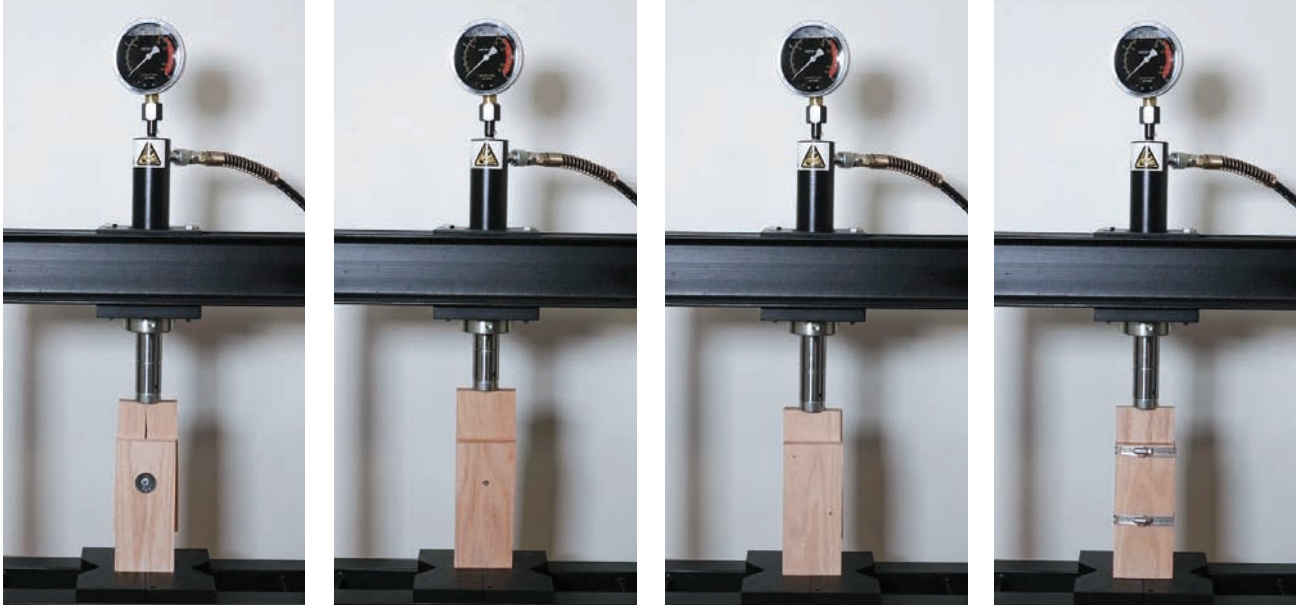
a. Bolt connection
Ultimate load: 0.9 tons
Failure: Wood cracking

b. Screw connection
Ultimate load: 0.2 tons
Failure: Wood cracking

c. Nail connection
Ultimate load: 0.1 tons
Failure: Nails deforming

d. Strap connection
Ultimate load: 1.0 ton
Failure: Wood slipping

△ Figure 5. Failure modes of wood assemblies with connections perpendicular to the grain under axial compression.



a. Bolt connection
Ultimate load: 0.9 tons
Failure: Wood cracking

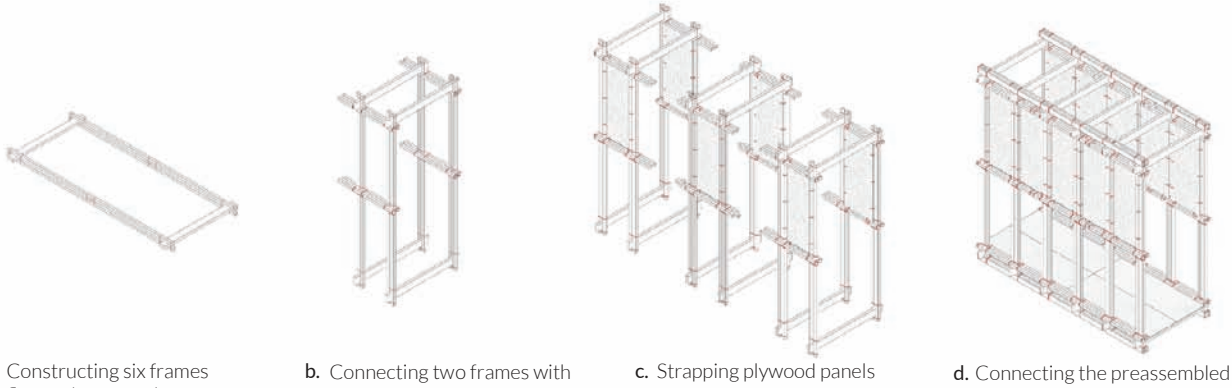
b. Screw connection
Ultimate load: 0.2 tons
Failure: Wood cracking

c. Nail connection
Ultimate load: 0.1 tons
Failure: Nails deforming

d. Strap connection
Ultimate load: 0.8 tons
Failure: Wood slipping

△ Figure 6. Failure modes of wood assemblies with connections parallel to the grain under axial compression.

◁ Figure 7. A mock-up structure built at Harvard University using the method proposed by Project (Un)Build (left), and its disassembly process (right).



a. Constructing six frames flat on the ground

b. Connecting two frames with four pairs of horizontal beams

c. Strapping plywood panels onto the frames as stiffening planes

d. Connecting the preassembled frames with horizontal beams

▽ Figure 8. Diagrams illustrating the construction sequence of the mock-up structure using strapped joints.

◁ Figure 9. Detail of a strapped joint used in the mockup structure.

△ Figure 10. A strapped timber wall built for exhibition at Harvard University.

△ Figure 11. A strapped timber bench constructed for exhibition at Harvard University.

in height and 20 ft. in length, constructed to demonstrate the structural application of wood framing (Figure 10). The wall comprises two panels secured with straps. Like conventional wood framing, each panel was framed flat on the ground, with vertical studs attached to top and bottom plates. However, hose clamps replaced nails as the fastening mechanism in this case. Metal plates with 1/8″ (2 mm) teeth were used as friction pads at the four corners of the wall, while 36-grit double-sided sandpaper served as friction pads in other joints. After the frames were completed, they were stiffened by strapping plywood sheathing to the frames using stainless steel cable ties. To enhance audience engagement, a strapped wood bench was installed in front of the wall, inviting visitors to sit and experience the structural rigidity and stability of strapped timber construction firsthand (Figure 11).

Both prototypes demonstrated notable structural rigidity and ease of disassembly, yet several challenges emerged during the construction. First, the visual quality of reclaimed timber was compromised (Figure 12, left). In the first prototype, poplar—a relatively soft wood—was used, resulting in corner damage during strap tensioning. Although these damages did not compromise the structural integrity of the wood, they affected the material's aesthetic appeal. Corner protectors may be required when using softer wood to address this. This issue was resolved in the second prototype using hardwood, which proved more resistant to the forces applied during tensioning. While the friction plates did leave minor impressions on the wood surface, these marks were minimal and can be easily removed through light sanding (Figure 12 right).

A second challenge was the lack of compatible tools. No tools exist specifically for inserting friction pads or tensioning straps in this context. Installing metal pads was particularly labor-intensive with hardwoods and required clamping to seat the pads fully. In terms of tensioning, the first prototype, due to its small scale and the use of stainless-steel cable ties as straps, proved sufficient with a metal strapping tensioner—commonly used for bundling steel tubes or fixing traffic signs to poles. For the second prototype, hose clamps were used but were incompatible with standard strapping tensioners. To address this, the hose clamps had to be pre-bent to appropriate sizes to simplify the tensioning process.

Despite these challenges, the lack of suitable tensioning tools does not diminish the potential of this system. As construction methods evolve, new tools will be developed to meet emerging needs, much like the invention of nail guns revolutionized the use of nails, enabling their widespread adoption. Similarly, the development of purpose-built strapping tools could significantly enhance the practicality and scalability of this construction system. While we acknowledge that strapped timber construction is not a comprehensive circular solution capable of entirely replacing nails at this stage, such as for constructing fully insulated multistory buildings, it still offers significant potential for various applications. These include office partitions, temporary shelters, outdoor pavilions, exhibition walls, decks, patios, and other small-scale constructions that do not require insulation.

5.3 Future Research Directions

This research represents an early step in exploring strapping as a viable method for timber construction within circular design paradigms. While the initial findings are promising, several

△ Figure 12. Damaged corners on softwood members (left) and minor surface impressions left by friction pads (right).

directions remain open for future development:

Durability Testing: Additional testing is required to evaluate the long-term performance of strapped joints, particularly under environmental exposure. The effect of wood's natural expansion and contraction is of particular interest due to moisture and temperature changes. These dimensional fluctuations could gradually loosen the tension in straps or compromise the friction-based joints, raising questions about the system's durability over time.

Envelope Integration: A fully reversible building envelope will require expanding the current construction logic beyond frames, including walls, floors, and sheathing systems. Future research could focus on developing demountable sheathing clips compatible with strapped timber frames and designing the attachment wall panels and floor joists that enable a complete envelope to be constructed using only non-invasive, reversible techniques. These developments are essential to demonstrate strapped timber construction's architectural viability and system-level scalability.

Tool Development: Future work should also focus on tool development to facilitate broader adoption. The lack of purpose-built tools makes strapping labor-intensive and less efficient. Designing small, handheld machines tailored for strapping and friction pad placement could significantly increase the speed, precision, and accessibility of the system for local builders.

Together, these research directions can help refine strapped timber construction from a proof of concept into a practical and adaptable building methodology with far-reaching applications in circular construction.

6. Conclusion

In recent years, the sustainability movement has increasingly invested intellectual and financial resources in building a "circular future," where comprehensive data on each building component is digitized and stored in cloud-based systems. This information would allow materials to be reassessed and reused at the end of a building's service life (European Innovation Council 2021). Yet achieving this vision relies on a cross-sectoral transformation—from extraction to supply chain to design and construction—which remains distant from the reality of most construction practices. While Building Information Modeling (BIM) has gained traction in managing mid-to-large-sized developments, the data infrastructure necessary for a fully functioning circular economy remains underdeveloped. Many data-intensive circular systems depend on significant financial and technological resources, making them inaccessible to many industries, particularly smaller contractors and local builders (Thirumal et al. 2024). While the sector gradually transitions toward a digitalized future of circular construction, there is also a need for an alternative approach—one that is localized and incremental, rather than global and revolutionary.

Project (Un)Build presents one such intervention: a reversible timber construction system designed to support material reuse without relying on advanced technology or specialized labor. By leveraging existing tools and aligning with the current workforce's skill sets, it seeks to foster a bottom-up circularity based on simplicity, adaptability, and practical implementation. This bottom-up momentum is created by reducing labor costs and technical barriers associated with disassembly and salvaging, making material reuse more viable and profitable. An increase in reclaimed materials flowing into the reuse market can, in turn, drive the development of sorting, reassessment,

and distribution processes for salvaged materials, fostering the growth of reuse infrastructure on a larger scale.

While innovations like Project (Un)Build may not revolutionize the industry overnight, they serve as critical interventions—acupuncture points—in the broader transition toward a circular economy. They highlight the potential for similarly reversible approaches, such as adaptable steel or concrete construction systems and removable flooring, siding, or roofing. Together, these acupunctural innovations can eventually form an interconnected ecosystem of reversible construction methods that advances the infrastructure of sustainable construction, offering a bottom-up pathway to mitigating the environmental impacts of the built environment.

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Datasets

The data generated and analyzed in this study consist of basic structural load test results, which are presented in tabular form within the manuscript. No large-scale datasets or proprietary algorithms were used. Additional raw data supporting these findings are available from the corresponding author upon reasonable request.

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Clara Mu He is the Cofounder of Project (Un)Build, a research initiative promoting wood reuse and design for disassembly. She holds a BA in Art History from Columbia University and an MArch from Harvard, where her thesis received the James Templeton Kelley Prize and Peter Rice Prize. Her work is featured in the Venice Architecture Biennale College 2024–2025. She works at LEVER Architecture.

Henry Chun Tak Chung is the Cofounder of Project (Un)Build, a research initiative promoting wood reuse and design for disassembly. He holds a BArch with Distinction from the University of Hong Kong and a MArch from Harvard. His thesis received the Digital Design Prize. His work is featured in the Venice Architecture Biennale College 2024–2025. He practices at William Rawn Associates.