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DESIGN FOR DISASSEMBLY IN PANELIZED LIGHT TIMBER FRAMING TOWARDS CARBON NEUTRALITY: THE 4PROTRU SHOWHOUSE

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ABSTRACT: Construction and Demolition Waste (CDW) accounts for more than one-third of total waste generated a consequence of the linear production and consumption model based on take, make, and dispose. As an alternative, the Circular Economy, through Design for Disassembly (DfD), facilitates the recovery and reuse of components. In this context, 4PROTRU showhouse, a rural panelized house, was built in the Biobío region of Chile. Designed to achieve carbon neutrality by 2050, the house features high hygrothermal performance, low carbon footprint, and disassembly capability. After two years of monitoring, it will be dismantled into two-dimensional (2D) elements and relocated to its final site to be used as a single-family house. This study assessed DfD principles established in the international standard ISO 20887:2020 to identify limitations and challenges in the strategies applied. These included reversible connections with metal plates and screws, along with the "shearing layers" concept to ensure component independence. Both were used to facilitate disassembly. Although enabling disassembly requires additional economic, technical, and knowledge-based resources, this approach contributes to national carbon neutrality targets by reducing construction waste and extending the service life of buildings through design.

KEYWORDS: timber construction, reuse, timber building, Design for X, circularity

1 – INTRODUCTION

1.1 BACKGROUND

Globally, the construction sector accounts for approximately 37% of CO_2 emissions related to operational energy and production processes [1]. This is partly due to the use of high-carbon footprint materials such as concrete and steel, as well as excessive energy consumption during the operational phase caused by inefficient buildings [1]. Additionally, the sector is responsible for approximately 30% to 40% of solid waste generated by construction and demolition activities [2], a direct outcome of a linear economic model based on the unsustainable "take, make, dispose" principle [3].

If this approach persists, global raw material consumption is projected to rise to 90 billion tonnes by 2050, further exacerbating CO_2 emissions and the depletion of natural resources [4]. Unlike the linear model, the Circular Economy (CE) adopts a restorative and regenerative approach by design and through maintenance, repair, reuse, remanufacturing, refurbishment, and recycling [5]. Promoting circularity in the construction sector requires rethinking building design from the conceptual stage, incorporating design criteria that extend the lifespan of materials and facilitate their reintegration into new construction processes.

1.2 CIRCULARITY METODOLOGIES: DFX

Several methodologies have been developed to support circular construction, such as Design for Manufacture and Assembly (DfMA), Design for Disassembly (DfD), Design for Flexibility (DfF), Design for Adaptability (DfA) and Design for Repair (DfR), among others. Aimed at reducing waste, extending building lifespan, and improving resource efficiency, these methodologies are grouped under the broader concept of Design for X (DfX), which encompasses strategies aligned with circular principles [6].

In this context, DfD stands out as one of the most relevant methodologies within DfX, as it not only facilitates material recovery but also ensures that buildings can adapt and be repurposed in response to demographic, social, and technological changes, thus promoting more resilient construction practices [3]. Additionally, Crowther suggests that strategic deconstruction practices can significantly reduce the carbon footprint associated with the end-of-life stage of timber buildings [7].

The terms "Disassembly" and "Deconstruction" are used interchangeably within the "Design for" framework, as both align with the same approach [8]. DfD is based on design principles that facilitate component accessibility, promote design simplicity, ensure proper material documentation, and encourage the use of mechanical

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connections to simplify disassembly and enable the reuse of building elements [9].

Prefabrication and standardization are also fundamental criteria in DfD, as they facilitate component separation, reduce on-site waste generation, improve quality through factory controls, and shorten on-site assembly times [8, 10]. Additionally, modular design reduces the need for unplanned or improvised fasteners, which in turn simplifies deconstruction and enhances the potential for component reuse [11]. From a structural design perspective, reversible connections are crucial to preserve the functional independence of building layers and allow joints to be recovered without significant damage during maintenance [12]. In addition, reducing the number and variety of connections is recommended [13], particularly at intersections of elements with differing service lives [7]. To systematize and structure the criteria addressed by various authors, ISO 20887:2020: "Sustainability in buildings and civil engineering works – Design for disassembly and adaptability – Principles, requirements and guidance" establishes specific principles and guidelines that promote the extension of building service life and the efficient reuse of its components, thus minimizing landfill disposal [14]. This standard implicitly aligns with the concept of "shearing layers," which emphasizes the relative independence of building components such as structure, cladding and services, each understood as an interrelated system with its own lifespan [7].

1.3 CHILE BUILDINGS TRANSITION

In 2021, as part of the Paris Agreement, Chile submitted its Long-Term Climate Strategy (Estrategia Climática de Largo Plazo, ECLP) to the United Nations Framework Convention on Climate Change, aiming for carbon neutrality by 2050 [15]. It promotes the transition toward a CE through sustainable city planning, energy-efficient buildings, and reduced waste generation [16]. The strategy sets a target for the construction sector to recover 50% of construction and demolition waste (CDW) through reuse and recycling, establishing a link material recovery to emissions reduction and identifying the end-of-life phase of buildings as a key intervention point. By extending the lifespan of materials and reintegrating them into new cycles, this approach supports CE objectives while advancing national climate goals. The ECLP also encourages the use of bio-based materials, such as timber, for their capacity to store carbon and reduce embodied emissions compared to traditional options like steel and concrete [17].

Concerning energy efficiency, upgraded standards have been introduced, such as the Energy Efficiency Law (Law 21.305, 2021), which mandates an energy performance certificate (Calificación Energética de Viviendas, CEV) for new buildings as a prerequisite for obtaining final approval. In addition, the law sets the long-term goal of achieving near-zero energy consumption in buildings by 2050 [18]. Moreover, thermal regulation have been updated through the modification of Article 4.1.10 of the General Ordinance on Construction and Urbanism (Ordenanza General de Urbanismo y Construcción, OGUC). This update expands thermal zoning to account for Chile's climatic diversity, increases thermal insulation requirements, incorporates both surface and interstitial condensation analysis, introduces airtightness standards, and makes mechanical ventilation systems mandatory [19]. These measures aim to improve hygrothermal comfort, enhance indoor air quality, and ultimately reduce energy consumption for climate control. They are scheduled to come into effect in November 2025.

Under the medium- and long-term climate agenda that acts as a regulatory framework, Chile faces a housing deficit of 552,046 units, according to the CASEN survey presented in 2023 [20]. To address this gap, the Emergency Housing Plan was implemented with the goal of constructing 260,000 social housing units between 2022 and 2025 [21]. By January 2025, the plan had reached only 69.63% progress, with 181,042 housing units completed [22]. In order to reduce construction lead times, industrialized building methods have been promoted, particularly through prefabricated light timber systems, a strategy that accelerates on-site assembly and ensures higher-quality housing solutions.

This paper examines the application of Design for Disassembly (DfD) principles, as defined in ISO 20887, within a panelized light timber framing system implemented in a showhouse constructed in Concepción, Chile. Using a research by design approach, it analyzes the opportunities and limitations of integrating DfD into social housing, through a demonstration unit developed as part of the country's transition toward carbon neutrality as shown in Figure 1.

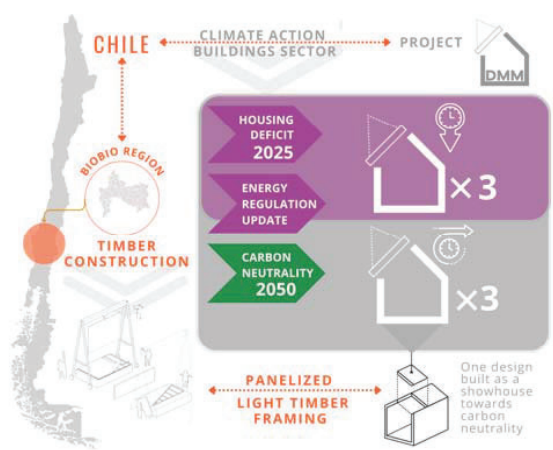

Figure 1. Towards carbon neutrality in Chile: the DMM project

2 – 4PROTRU SHOWHOUSE

2.1 DMM PROJECT

The housing deficit is driving the construction of new houses, while climate commitments demand higher quality standards. Most small and medium-sized

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enterprises in the region, though, lack the technical knowledge and resources required to deliver housing that meets these standards. Addressing this challenge demands solutions that comply with energy efficiency and climate mitigation goals, while leveraging existing installed capacity.

The research project titled "Design for Manufacture and Assembly: Social Housing Proposals for the Biobío Region" was carried out by *Polomadera*, a program led by the Department of Architecture at the *Universidad de Concepción*. The project aimed to design six panelized light timber framing social housing. The project was funded through the *Bienes Públicos* program of Chile's Production Development Corporation (CORFO) and developed in collaboration with the Ministry of Housing and Urban Development (MINVU), through its regional office (SEREMI Biobío). Three of the designs comply with DS49 regulations [23], which establish standards for social housing in urban areas, while the other three follow DS10 [24], which apply to rural contexts. Both decrees are issued by the Housing and Urbanization Service (SERVIU), the public agency responsible for implementing Chile's housing policies and managing the development of social housing projects.

Furthermore, three of these are designed to meet the updated thermal regulations, while the remaining three represent advanced designs oriented toward long-term carbon neutrality objectives, as shown in Figure 2. These future-oriented solutions incorporate enhanced energy performance through increased thermal insulation thickness, lifecycle optimization, and the integration of CE principles.

All technical information generated through this project will be available as open access to companies and stakeholders, facilitating knowledge transfer and enabling the replication of these solutions within a regional context, thus supporting their implementation at a larger scale.

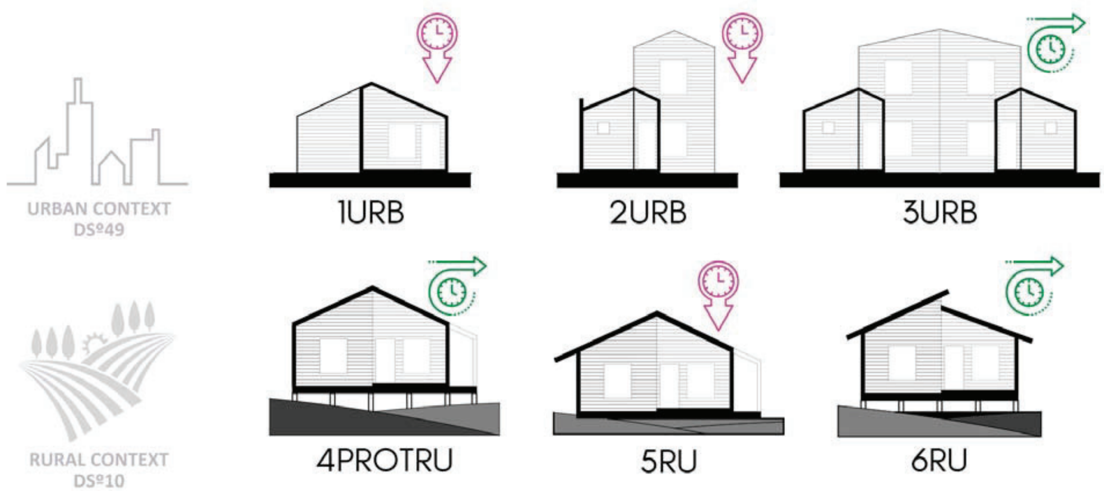

Figure 2. Housing typologies of panelized light timber framing proposed by the DMM project

2.2 FUNCTION AND CONTEXT

One of the six typologies, the 4PROTRU showhouse, which is one of the models designed to achieve carbon neutrality, was built in 2024. This house design is part of the rural habitability program (DS10) and was designed to be finally located in the Santa Juana community. Its architectural approach engages with the rural environment through design decisions that acknowledge the specific characteristics of the context and reinforce territorial identity.

The design features a total built area of 73 m², including an exterior corridor along the house that serves as an intermediate space between interior and surroundings. As shown in Figure 3, this element enhances integration with the rural context, strengthens the relationship with the landscape, and provides a versatile area for daily activities.

The design also integrates the living room, dining room, and kitchen into a single space to enhance flexibility in its use.

To enhance spatial performance, the roof was designed without trusses, using inclined structural elements directly supported by the walls. This configuration increased the interior volume, with heights ranging from 2.4 to 3.8 meters, and contributed to improve indoor air quality by promoting air renewal and reducing saturation. Additionally, four heat recovery ventilators were installed to reduce ventilation heat loss and lower heating demand by recovering outgoing thermal energy. To increase the thermal performance of the building envelope, the dimensions of the structural components were increased compared to those typically used in social housing, allowing for thicker insulation layers.

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Figure 3. Architectural floor plan of 4PROTRU showhouse

Walls, floors and roofs, two-dimensional (2D) elements, are made of local sawn timber and braced with OSB (Oriented Strand Board) interior panels. The walls included 41 × 90 mm studs, spaced 400 mm, with 90 mm of glass wool insulation between them and OSB 11.1 mm thick. The roof was built with 41 × 185 mm joists, spaced 400 mm, with 180 mm of insulation and 11.1 mm OSB. The floor was formed with 41 × 138 mm joists, spaced 400 mm, with 130 mm of insulation and 15 mm OSB.

To further optimize hygrothermal performance, all 2D elements include a ventilation façade, as well as airtight membranes and sealing tapes to minimize air infiltration and improve the home's airtightness. As a result, the house achieves a highly efficient energy performance, with a total demand of 40.9 KWh/m²-year, based on a simulation conducted using the Chilean Home Energy Rating System (CEV), This total includes heating requirements of 33.1 kWh/m²-year and cooling requirements of 7.8 kWh/m²-year. These values represent a 78% reduction compared to the average energy demand of the housing stock in Climate Zone E, corresponding to the Greater Concepción area, which reaches 198.1 KWh/m²-year [25]. 4PROTRU's energy performance aligns with the highest energy efficiency standards defined for long-term climate goals.

A streamlined Life Cycle Assessment (LCA) was performed, covering only the product stage and operational energy use. The analysis, carried out using One Click LCA software and based on ISO 14040 and EN 15804 standards, enabled the collection of data on energy consumption and carbon emissions, which were compared to benchmarks from timber-based housing.

The results show a low embodied carbon level of 219.1 kgCO_2e/m² in the product stage, with walls and roof accounting for 58% of the total. Foundation impacts were significantly lower than expected due to an efficient pile design. When biogenic carbon sequestration is considered, the 4PROTRU showhouse achieves carbon neutrality in the product stage and could reach operational neutrality by employing efficient active systems.

To empirically assess the performance of the showhouse over a two-year period, the unit is currently installed on the *Universidad de Concepción* campus see Figure 4, in the city of Concepción, and will later be relocated to its final site in Santa Juana, 53 km away. During monitoring, embedded and point moisture sensors will be used to measure the moisture content of selected studs and verify the absence of interstitial condensation. In parallel, relative humidity, temperature, and CO_2 levels will be recorded through onboard sensors to evaluate indoor air quality and compare the results with previous energy simulations.

The construction process followed an off-site approach aimed at optimizing on-site time and resource use. A total of 46 elements distributed as 14 walls (bottom), 11 walls (up), 7 floors, 7 roofs and 7 corridor roofs, Figure 5. Each element, with maximum dimensions of 2.4 × 4 meters and an approximate maximum weight of 500 kilograms, was manufactured in a controlled environment using low-tech methods. These included a prefabrication table, a pneumatic nail gun, and a swing-type overhead crane, along with standard cutting hand tools.

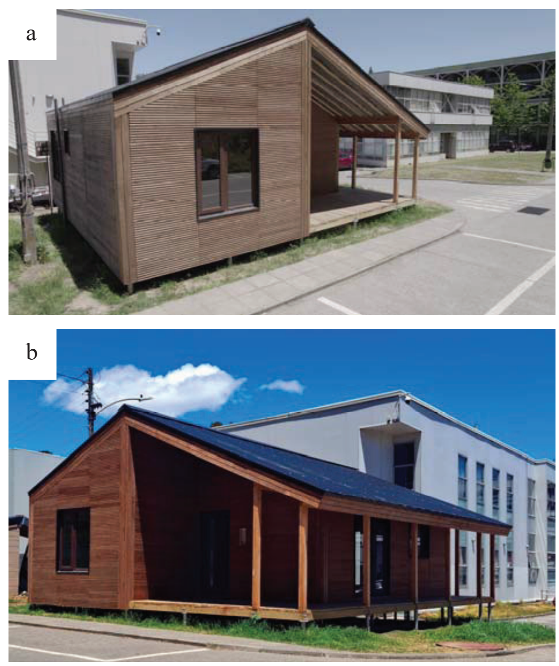

Figure 4. Showhouse located at the Universidad de Concepción, Concepción, Chile. a) East Orientation; b) North Orientation

Each 2D element corresponds to a High-Level Component (HLC), defined as a constructive unit in which multiple technical functions are integrated into a single physical entity, conceived to optimize assembly processes by minimizing sequential on-site operations [26]. These HLCs integrated the structural framework along with factory-preassembled layers of thermal insulation, moisture barriers, and vapor control, as well as battens installed over the membrane layers on both sides.

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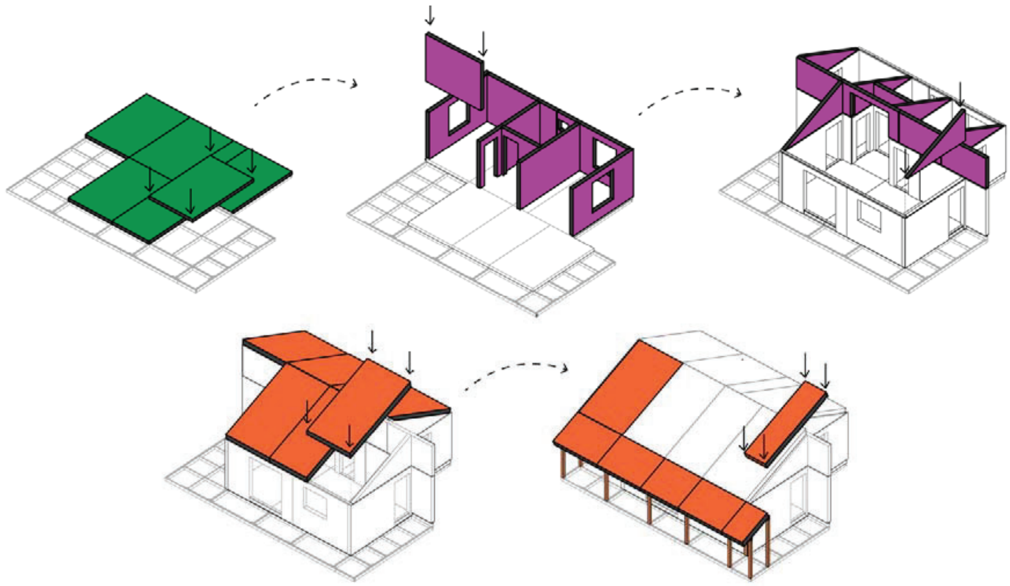

Figure 5. Assembly sequence of the 2D elements: floor (in green), walls (in purple), and roof (in orange)

By integrating multiple components at the factory, HLCs reduce on-site activities and overall construction time. As a result, the assembly process was completed in five days, and the house was immediately protected by membranes on both the interior and exterior. This high level of prefabrication also improved quality by allowing greater control over fabrication conditions.

In terms of circularity, two complementary design strategies were applied: DfMA and DfD. Although both are integrated during design stage, they address different phases of the building's life cycle: DfMA, primarily, focuses on optimizing off-site manufacturing and on-site assembly, and DfD aims to enable disassembly and component recovery. In 4PROTRU, DfMA facilitated the efficient planning of HLC manufacturing and assembling, reducing on-site waste, whereas DfD introduced criteria for future: dismantle, handling, and reuse. 4PROTRU showhouse during assembly process, in Figure 6.

Figure 6. 4PROTRU showhouse during assembly process

While DfMA and DfD lies in different stages, are closely related, for instance, manufacturing decisions directly impact on the feasibility of disassembly. For this reason, both strategies should be considered in a coordinated manner from the design stage. However this research covers only DfD, being the objective the disassembly analysis of HLCs.

2.3 DESIGN FOR DISASSEMBLY

The adopted strategy involves the disassembly of HLCs for reinstallation at the final location, preserving its initial architectural identity and functional organization. This aims to extend the building's service life and represents just one of several possible alternatives under DfD principles. According to ISO 20887:2020, effective application requires defining the intended destination of the building from the initial design stage. While multiple outcomes are possible, the most common is the recovery of individual components for reuse or recycling.

The applied design criteria aim to maximize the complete recovery of HLCs, reducing the need for reconditioning and minimizing material loss. This approach helps avoid additional costs and lowers the environmental impact associated with the use of new materials required to ensure hygrothermal performance during their final stage as a single-family house.

The following outlines the strategies applied to the showhouse according to the seven disassembly principles established in ISO 20887:2020.

2.3.1 Ease of access to components and services

As a primary strategy to facilitate access to building services, the incorporation of an interior technical wall is proposed an uncommon design criterion in light timber frame housing in Chile. The solution includes 41 × 41 mm vertical battens aligned with the wall studs, allowing the routing of electrical and low voltage wiring without perforating the airtight membrane or compromising thermal insulation. In wet areas, 6 mm

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thick high-density pressed fiber cement boards are proposed as the interior finishing. In other spaces, 12 mm grooved plywood board are proposed, fixed to the battens with screws featuring exposed heads. This solution facilitates disassembly for inspection and reinstallation, ensuring both accessibility and material integrity.

Other materials, such as gypsum board, commonly used in conventional housing, complicate disassembly, as frequent handling tends to cause damage, particularly at the edges, limiting its potential for reuse [6].

This challenge is further amplified in interior finishing with ceramic tiles, where removal typically destroys the material, avoiding both inspection and reuse in future construction cycles.

2.3.2 Independence

Independence refers to the ability to dismantle 2D elements or individual components without significantly affecting the surrounding system, allowing for reuse. In 4PROTRU, this was addressed through two complementary approaches operating at different levels of the building system. These levels, by type of connection, are defined by authors for panelized systems: *Inter*, located between 2D elements (HLCs), and *Intra*, located within components in a single HLC.

Inter connections, were used to connect elements either at 180° or 90°, using reversible fasteners, specifically shear plates, tension plates, and angle brackets, as shown in Figure 7.

Intra connections are linked to the principle of easy access to components and services, and in 4PROTRU, were applied to roof, wall, and floor 2D elements. The main strategy in *Intra* consists of incorporating a technical interior façade in walls and roof. Using reusable finishing boards that can be removed and reinstalled to access to the interior of the HLC. Additionally, screws are used between layers to enable disassembly and allow for potential reinstallation.

Based on the disassembly level, the recovery strategy focused on extracting 2D elements, understood as building independent units composed of multiple preassembled layers. For that reason, timber pieces and OSB boards were nailed in the factory, without prioritizing the individual future reuse of structural components. This decision supports the retrofitting of HLCs for reinstallation in the final location. It is recommended for HLCs reinstallation, a quality evaluation, assessing materials original properties replacing them if primarily performance is not guarantee.

2.3.3 Avoid unnecessary treatments and finishes

Minimizing the use of chemical treatments in timber can facilitate its reuse and reduce its environmental impact. However, in Chile, standard NCh 819: “Requirements for Preserved Radiata Pine Timber” forces the impregnation of this species, the most widely used for construction in the country, limiting reuse.

As 4PROTRU showhouse is an experimental building and maximize reuse is aimed, it was decided to reduce timber chemically treated and prioritize in durable products, as thermally treated wood in façade finishing.

In addition, protection by design was considered, prioritizing solutions that enables natural moisture evaporation and prevent its accumulation within the envelope layers.

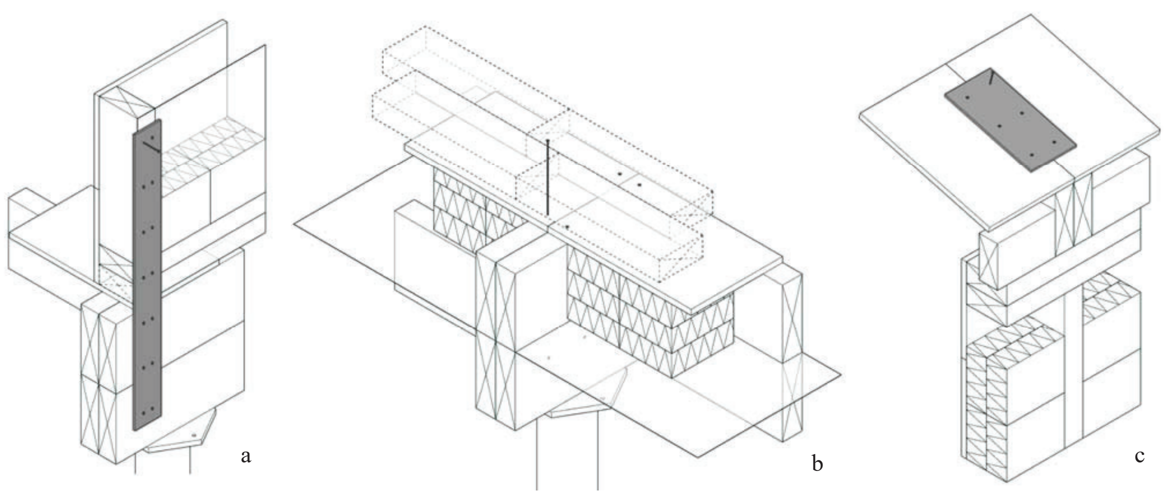

Figure 7. Inter reversible connections detail: a) Wall (LBV perforated plate (60 × 600 × 1.5 mm)); b) Floor (HBS screws 8×100 mm) and c) Roof (LBV perforated plate (100 × 200 × 2.0 mm))

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Despite of previously mentioned, as some structural timber components presents greater exposure to moisture and consequently higher risk, impregnation was necessary to prevent premature degradation. Specifically, first timber pieces above foundation, Figure 7b, were treated with Micronized Copper Azole (MCA), an alternative treatment in Chile, which is progressively replacing CCA (Copper-Chromium-Arsenic) salts due to its lower environmental impact and reduced toxicity.

2.3.4 Support for reuse business models

This principle promotes component reuse and recycling throughout their service life and after it, facilitating reintegration into new production cycles. In the showhouse, the timber structure was prescribed for its compatibility with prefabrication and its potential for reuse and recycling. To enhance circularity, the use of chemical treatments was minimized, as explained in section 2.3.3.

The election of insulation materials, hygrothermal membranes, and finishing materials followed a circularity approach, prioritizing durable solutions suitable for complete reuse in a second life cycle. Nevertheless, materials with an Environmental Product Declaration (EPD) available in Chile were sometimes selected due to their incorporation into the LCA, despite of alternatives with higher circularity potential. For thermal insulation, wood fiber could not be used due to its unavailability in the national market at the time of project development.

To avoid site intervention, galvanized steel screw-pile foundations were used, as shown in Figure 8. This solution eliminates the need for reinforced concrete foundations, allowing for minimally invasive installation, particularly in temporary locations and facilitating future relocation. These foundations can be efficiently recovered, reused at end of life, or recycled, unlike reinforced concrete, which presents significant recycling challenges due to its composite nature and demolition complexity.

2.3.5 Simplicity

Simplicity refers to designing systems, elements, and components in a straightforward manner to facilitate their disassembly for reuse. In the case of 4PROTRU, reducing the number of HLCs was considered; however, compliance with SERVIU's regulatory requirements regarding minimum surface areas and spatial distributions limited the possibility of such a reduction. Moving forward, adjustments are being made in the development of other housing typologies to reduce the number of distinct HLCs, which will improve efficiency in manufacturing, assembly, and reuse, based on lessons learned from the showhouse assembly. Regarding reversibility of connections, but not simplicity, different structural fasteners were employed in 4PROTRU showhouse to evaluate their disassemblability.

Figure 8. Installing foundation screws with an auger drill at a construction site

Looking for simplicity, in the other housing designs, an optimizing analysis would facilitate the reduction and standardization of fasteners without compromising structural stability or dismantle for future reuse.

2.3.6 Standardization

In Chile, the dimensional standardization of construction materials is not fully defined nor optimized for timber construction. This limited the potential for further optimization in the design.

The dimensions of the HLCs were initially defined in line with the dimensions of OSB, whose commercial sheets measuring 1.22 × 2.44 m established a modulation criterion aimed at reducing cuts and minimizing material waste. While this decision improved resource efficiency, it led to incompatibilities with other components, such as fiberglass insulation, whose widths did not align with this modulation, complicating its installation and generating additional waste.

2.3.7 Disassembly Safety

Ensuring disassembly safety from the early design stages requires considering variables that may not be fully defined at that initial phase. A disassembly plan was developed with technical procedures to protect workers and reduce adverse environmental impacts. This plan includes the use of a crane truck to facilitate the safe and efficient handling of HLCs, following the reverse procedure of assembly to recover them in a controlled manner and minimize damage.

The disassembly of the showhouse, scheduled for the medium term, will be carried out by the same company that performed the assembly. Although the process will be supervised and follow a detailed plan with safety measures, its success will largely depend on human factors, particularly precision and time management.

3 – LESSONS FROM DfD STRATEGIES

The implementation of DfD principles in 4PROTRU showhouse provided an opportunity to assess how material selection, connection types, and construction processes influence its disassemblability and the reuse of high-value components. Although the disassembly process has not yet been carried out, the design and applied solutions allow for projecting its performance in future stages, with a focus on disassembly efficiency and component recovery. The following section outlines the key insights gained from the development process, emphasizing the factors that may impact its future feasibility in panelized light-frame construction.

• **Selection of reversible connections**. Incorporating reversible connections in inter-HLC increases the potential for reusing entire 2D elements. While this approach required longer installation times and led to higher costs compared to conventional panelized systems, it represents a strategic investment in disassemblability, with an increase of at least 30% over solutions without reversible connections.

• **Structural timber treatments.** One of the principles established by the international standard encourages avoiding chemical treatments in materials to facilitate reuse. However, Chilean regulations still require protection for non-durable timber, posing a challenge to this approach. In the 4PROTRU showhouse, impregnated timber was not used in the structure of the 2D elements, although treated timber was applied to the base platform that supports the floor HLCs, making its potential for reuse uncertain.

• **Materials with varying degrees of circularity**. Some materials were chosen for their technical performance, such as durability (e.g., MCA-treated timber), or due to their market availability (e.g., fiberglass), despite having limited circularity potential. Factors such as poor recyclability, short lifespan, or degradation in subsequent cycles reduce their reusability. Nevertheless, their inclusion was necessary to meet performance and availability requirements.

• **Reusable and low impact foundations.** The showhouse used point foundations with screw piles, designed to enable disassembly and potential reuse. Unlike concrete foundations, which are typically demolished or only partially recycled, screw piles can be removed and reinstalled. Considering the estimated relocation timeframe, their reuse is technically feasible.

• **Lack of standardization in the disassembly industry.** Broad component reuse depends partly on dimensional uniformity, as standardized dimensions facilitate integration into new projects. In this context, the lack of standardization was not a limitation, since the main objective was to relocate the house. However, if the aim had been exclusively circularity, this condition would have represented a significant constraint.

• **Execution Challenges.** Installing reversible connections required specialized and experienced workers. In addition, to adopt new solutions could create reluctance, as happened for reversible fasteners installed in 4PROTRU showcase. Regarding execution tools, specific equipment is needed, such as a crane truck for assembling the HLCs. These factors added complexity to the construction process and present challenges for broader implementation.

• **Advance disassembly planning.** The showhouse was designed to be disassembled and reassembled in its original form after two years, so specific criteria were established to facilitate this process. A disassembly plan defined the sequence for component removal, storage, and transportation. However, its success will depend on proper on-site execution, including the availability of appropriate equipment and careful handling to preserve components in good condition. In the built environment, by contrast, disassembly usually takes place decades after construction, once the building reaches the end of its service life. In such cases, factors like material degradation, lack of technical documentation, regulatory changes, or untrained labor can hinder the process and limit the effectiveness of design stage strategies.

4 – CONCLUSION

The 4PROTRU design, a panelized light timber frame showhouse developed in Concepción, Chile, was designed as part of challenges to achieve carbon neutrality by 2050. This showhouse provided an opportunity to explore Design for Disassembly strategies based on ISO 20887 principles, aiming to recover and reuse high-value components in future buildings.

Although DfD promotes circularity by reintegrating elements into new projects, in this case, the house was designed to be relocated to a permanent site following a two year monitoring period, with the aim of maintaining its performance through minor or non-structural adjustments. This strategy involved higher initial costs, primarily in labor and connections, along with additional time required for installation and disassembly planning. However, its benefits, including reduced waste generation, extended system lifespan, and lower environmental impact, demonstrate the value of these decisions for timber construction.

The possibility of relocating the house with minimal waste generation, mainly limited to interior claddings or

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membranes, represents progress toward more circular construction models, reducing the extraction of raw materials and the emissions associated with their production.

To facilitate the broader adoption of DfD, it is essential to optimize both costs and disassembly times, particularly in reversible connection systems. in Chile. The lack of standardized material dimensions hinders both the industrialization of housing and the development of a market for reused low and high level components, limiting the feasibility of this approach. Standardizing construction product dimensions at the local level would facilitate prefabrication, reduce waste, and improve the efficiency of dismantle and circular construction.

The use of circular materials is another key aspect in reducing environmental impact, although their specification often depends on technical factors, costs, and market availability.

The circularity of a house depends not only on its design but also on the productive and regulatory context. Developing specific regulations for timber construction designed for disassembly could encourage its adoption, promoting the recovery and reintegration of materials into new production cycles, thus strengthening a value chain focused on efficiency and reuse

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