SUSTAINABLE AND EFFICIENT RECONSTRUCTION: THE USE OF WOOD IN THE ACCELERATION OF POST-DISASTER PROCESSES

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ABSTRACT

Natural tragedies are devastating events that require rapid and effective responses to minimize social and economic impacts on affected communities. This article explores the use of timber construction technologies, specifically Cross Laminated Timber (CLT) and Light Wood Frame (LWF), as viable solutions to speed up reconstruction processes. Based on case studies and the analysis of technical, cultural and regulatory challenges, the article proposes strategies to overcome the barriers to the expansion of these technologies in Brazil, with emphasis on the need for a national study that establishes specific cost compositions, financing of industrial plants, public-private partnerships for CLT and LWF in the context of public works.

Keywords: CLT. LWF. Post-disaster reconstruction. Sustainability. Engineered wood.

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INTRODUCTION

In recent years, Brazil and the world have faced a significant increase in the occurrence of natural disasters, resulting from heavy rains. These tragedies have caused large-scale destruction, leaving thousands of fatalities, people homeless, damaging infrastructure, and causing damage to both the public and private sectors. The need for rapid and efficient reconstruction therefore becomes a priority for governments, businesses and affected communities.

Emerging solutions for post-disaster reconstruction include timber construction technologies such as Cross Laminated Timber (CLT) and Light Wood Frame (LWF). These technologies offer not only speed of construction, but also significant benefits in terms of sustainability and reduced environmental impact. However, its large-scale implementation faces technical, cultural, and regulatory challenges that need to be overcome so that they can be adopted in reconstruction projects, especially in public works.

This is not just a discussion about improvements, but a matter of urgency. Exploring wood construction technologies, their benefits and challenges, is essential to propose solutions that promote their expansion in Brazil. This is a blessed country, where any seed that falls on the ground bears fruit, and the exploration of this vocation begins with a detailed national study. Such a study should establish specific cost compositions for CLT and LWF, enabling its inclusion in the National System of Research on Costs and Indices of Civil Construction (SINAPI) and, consequently, its application in public works projects.

THE URGENCY OF QUICK AND SUSTAINABLE SOLUTIONS IN THE POST-TRAGEDY

Natural tragedies are recurrent and devastating events that require quick and efficient responses to minimize social and economic impacts. In post-disaster scenarios, rapid reconstruction is crucial to restore normalcy and ensure the safety of affected communities. Construction technologies such as Cross Laminated Timber (CLT) and Light Wood Frame (LWF) have proven effective, combining speed of assembly, sustainability, and the ability to adapt to the specific needs of the affected areas.

In 2012, in New Zealand, a Christchurch Central Recovery Plan (CCRP) was created after a major earthquake destroyed most of Christchurch city centre. The CCRP aimed to rebuild the city of Christchurch to optimised standards. However, the rebuilding process was not as quick as expected, resulting in significant delays in most projects. Researchers Shitong Tian and Don Amila Sajeevan Samarasinghe realized that CLT technology was entirely aligned with the purposes of CCRP, due to the speed of assembly combined with fire resistance, good environmental performance and high mechanical resistance, that is, everything that is expected in a good enterprise. *"CLT has positive features such as good environmental performance, high fire resistance, high shear force resistance and rapid assembly, all of which are in line with the objectives of CCRP".* (Tian and Samarasinghe, 2022).

Modularity and adaptability approaches are central to the effectiveness of disaster responses. The CLT panel is a construction material of quick completion, as it is prefabricated with openings and pre-cut electrical and plumbing installations. This means that the completion of a structure is not difficult and does not require highly skilled workers to erect and connect it on site (Divekar apud Tian and Samarasinghe, 2022), consequently, there can be considerable savings in on-site operating costs due to the rapid assembly of components.

The adoption of emerging technologies, such as Building Information Modeling (BIM) and modular construction methods, are necessary to enhance the use of CLT and LWF in post-disaster scenarios. As discussed at the 44th AUBEA Conference (Australasian Universities Building Education Association), integration of these innovations with construction methods such as CLT and LWF not only accelerates the reconstruction process, but also increases the resilience and sustainability of the rebuilt structures, however, and this is perceived across the globe, the high costs associated with the implementation and management of BIM, as well as the lack of expertise in the system, have hindered its adoption (Karia et al, 2021).

Other, very significant challenges still need to be overcome to ensure the effective implementation of these technologies. The logistics of transporting and storing materials, the need for specialized training for the workforce, and cultural and regulatory barriers are some of the obstacles identified, overcoming these barriers requires a coordinated approach that includes education, training, and strategic partnerships between governments, the private sector, universities, and international organizations.

Finally, the sustainability of post-disaster reconstruction solutions must be considered a priority, after all, as has been ventilated in all the news, disasters will increase in magnitude, reconstruction must associate speed with respect for the environment. The use of CLT and LWF not only facilitates rapid construction, but also contributes to reducing the carbon footprint of new constructions, since wood is a renewable and low-carbon material, in fact, "wood sequesters carbon" (DIAS, 2018). This sustainable approach is essential to ensure that rebuilt communities are resilient not only to future disasters, but also to increasing environmental pressures.

CASE STUDIES

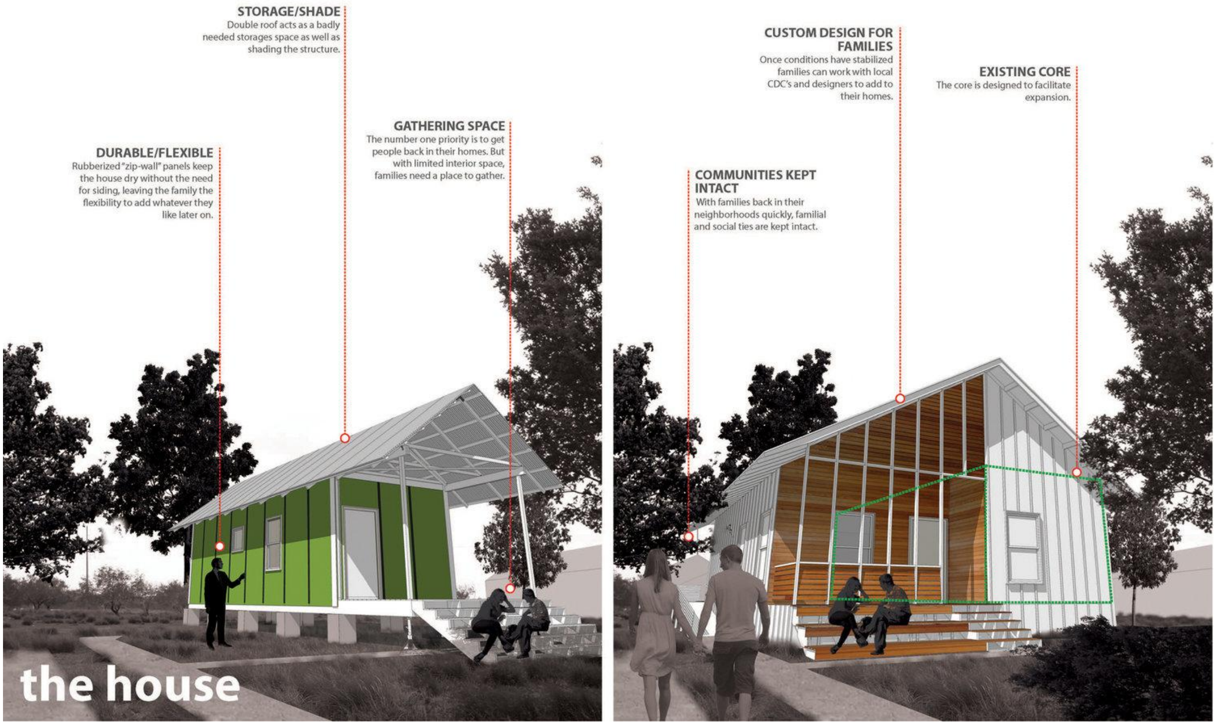
In this chapter, two representative examples of post-disaster housing solutions will be analyzed, which demonstrate the application of sustainable technologies that combine efficiency, speed and low cost. The RAPIDO program, developed in the United States, stands out for the rapid implementation of expandable modular units, offering an efficient solution to serve communities in emergency situations. The Villa Verde project, led by ELEMENTAL in Chile, presents an incremental approach with wooden structures, allowing families to expand their homes according to their needs and resources. Finally, the integration of technologies such as Building Information Modeling (BIM) with wooden construction systems, such as CLT and LWF, will be discussed, highlighting how the use of digital tools can optimize the planning and execution of works in post-disaster reconstruction contexts.

RAPIDO: RAPID TRANSITION TO PERMANENT HOUSING

The RAPIDO (Recovery Accelerated Program for Inhabitable Dwellings Operations) program was developed in the United States after Hurricane Dolly in 2008, to offer fast, scalable and adaptable housing solutions in emergency scenarios. It combines prefabricated central units based on the Light Wood Frame (LWF) system, which can be installed quickly to meet emergency housing needs, and subsequently adapted or extended for permanent use (DUSTIN et al., 2024).

RAPIDO stands out for its efficiency in reducing the time between the disaster and the delivery of an initial housing solution. Housing units are assembled quickly and designed to allow expansion without occupants being displaced. The modularity of the structures facilitates the integration of improvements and extensions in a cost-effective and sustainable way. The program also prioritizes the use of sustainable building materials, contributing to the reduction of the carbon footprint and environmental impact associated with post-disaster reconstruction. Figure 1 illustrates an application of the RAPIDO program, highlighting its main attributes:

Figure 1: Schematic drawing of RAPIDO deployment



Source: RAPIDO

Image Description: The illustration presents two stages of the implementation of the RAPIDO program. On the left, the initial installation of the prefabricated central unit is demonstrated, which uses lightweight and durable panels, providing safe and flexible shelter. The double roof serves as storage space and additional shade. On the right, the expansion of the unit is presented, with the incorporation of additional modules designed according to the needs of the family, keeping the communities intact and promoting sustainable reconstruction.

In addition, the application of RAPIDO has demonstrated its effectiveness in mitigating the impact of disasters on vulnerable communities, offering a replicable model for other contexts. Programs like this could be adapted to meet the housing demand in post-disaster scenarios in Brazil, especially in areas that are difficult to access or lack specialized labor.

ELEMENTAL: INNOVATIVE RECONSTRUCTION IN CHILE

After the 2010 earthquake and tsunami that devastated the city of Constitución, Chile, the architectural firm ELEMENTAL, led by Alejandro Aravena, was invited by the forestry company Arauco to develop a housing plan for the affected workers. The result was the "Villa Verde" project, an initiative that exemplifies the application of incremental housing solutions in post-disaster contexts (ELEMENTAL, 2012).

Like the RAPIDO project, the project's central concept is based on the construction of two-story "half-houses", delivering to families an initial structure that meets basic housing needs, but can be expanded and customized over time according to the resources and preferences of the residents. This approach allows families to complete their residences according to their means, fostering a sense of ownership and active participation in the reconstruction process.

The modularity and flexibility of the project facilitate the adaptation of the housing units to the specific needs of each family, allowing horizontal and vertical expansions without compromising the structural integrity or aesthetics of the complex. In addition, the use of local materials, such as wood supplied by Arauco, has contributed to sustainability and the regional economy, reducing construction costs and times.

Figure 2: Vila Verde Housing - ELEMENTAL

Source: ELEMENTAL, 2012

The LWF system, as exemplified in the image, stands out for its speed of execution, lightness and efficiency in the use of materials. Its prefabricated structures allow for agile assembly on the construction site, with high precision, resulting in constructions that can be completed in a few weeks. In addition, LWF facilitates expansions and adaptations over time, providing flexibility for future needs.

On the other hand, integration with the CLT could further enhance these advantages. With its robust cross-laminated wood boards, it provides greater structural strength, excellent seismic and thermal performance, in addition to contributing to more sustainable and durable buildings. The combination of LWF for lightweight structure with CLT for slabs would create an optimized hybrid system, further accelerating delivery times and increasing responsiveness in post-disaster scenarios.

The Villa Verde project stands out for its ability to balance constructive efficiency, community participation and sustainability, serving as a model for interventions in emergency situations. The incremental approach taken by ELEMENTAL not only provided immediate shelter to affected families, but also laid the foundation for the development of resilient and cohesive communities capable of growing and adapting to future needs (ELEMENTAL, 2012).

SYSTEM INTEGRATION

Technological advances, such as Building Information Modeling (BIM), enable greater accuracy in the planning and execution of reconstruction projects. Despite challenges such as high upfront costs and lack of training, BIM combined with CLT and LWF presents opportunities to reduce waste, optimize resources, and accelerate the delivery of resilient and sustainable housing solutions.

Studies show that the implementation of BIM can result in a reduction of up to 41% in project delivery time, in addition to increasing the profitability of the professionals involved by up to 35% (SANTIAGO et al, 2021). These gains occur due to BIM's ability to integrate multidisciplinary information into a three-dimensional digital model, facilitating the early identification of incompatibilities and improving communication between work teams. Consequently, there is a reduction in rework and an optimization of the resources employed, accelerating the construction schedule (MEIRELES et al, 2024).

In addition, the use of technologies such as BIM combined with CLT and LWF allows for faster and more sustainable execution in post-disaster contexts, offering solutions that combine speed and construction precision. By automating processes and optimizing assembly logistics, BIM reduces waste and promotes greater efficiency in all stages of construction (FERREIRA et al, 2020).

PROPOSAL FOR APPLICATION TO THE BRAZILIAN CONTEXT

Brazil faces severe landslides and floods annually, especially during the rainy season in mountainous and urban regions. These natural disasters, aggravated by the disorderly occupation of the land and the lack of adequate infrastructure, generate significant social and economic damage. Given this reality, the expansion of wood construction technologies, such as Light Wood Frame (LWF) and Cross Laminated Timber (CLT), combined with digital tools such as BIM, presents itself as an efficient and sustainable solution for the reconstruction of housing in affected areas.

Light Wood Frame constructions can be implemented quickly, offering safe, low-cost housing in locations that need emergency responses. Its lightness and ease of assembly reduce the impact on the ground and construction time, making it ideal for hard-to-reach regions. In addition, its modularity allows adaptations according to the needs of families, creating flexible and scalable solutions. The use of CLT, in turn, ensures greater structural strength, thermal and acoustic performance, in addition to contributing to resilient buildings in areas vulnerable to disasters.

For areas affected by landslides, prior mapping of risk zones is required, using geotechnical and climate monitoring technologies. The application of CLT and LWF in these regions should prioritize stable terrain, with optimized foundation systems that ensure safety and durability. The rapid assembly of prefabricated structures minimizes the exposure of work teams to additional risks, in addition to speeding up the delivery of housing to homeless families.

In flood-affected regions, housing design should consider raising the level of structures with the use of pilotis or high foundations, ensuring that habitable areas are above the water level. This solution, combined with materials that are resistant to moisture and rot, such as the treatments applied to engineered wood, can extend the useful life of buildings. Additionally, the use of prefabricated CLT panels makes transportation and installation easier, allowing complete housing units to be delivered in a matter of days.

The use of Building Information Modeling (BIM) plays a crucial role in this context, optimizing the planning and execution of projects. Through BIM, it is possible to integrate multidisciplinary information, predict possible failures in the project and ensure the efficient management of resources. The application of this technology combined with CLT and LWF allows a significant reduction in execution time and operating costs, facilitating the reconstruction of entire communities in an organized and sustainable way.

To make these proposals feasible in Brazil, it is essential to promote public policies that encourage the adoption of these technologies. The inclusion of the CLT and LWF in popular housing programs and the updating of national technical standards are fundamental steps. In addition, investments in workforce training, public-private sector partnerships, and tax incentives for engineered wood industries can accelerate the implementation of these solutions in the country.

Finally, the combination of the proposed technologies not only offers quick and sustainable solutions, but also creates a resilient reconstruction model to address the recurring climate challenges in Brazil. The adoption of these practices is essential to mitigate the impacts of natural tragedies, ensuring safe, durable, and environmentally responsible housing for the affected populations.

CONCLUSION

In view of the current scenario, marked by the increase in the occurrence of natural disasters, such as floods and landslides, the search for quick, efficient, and sustainable solutions for post-disaster reconstruction becomes an urgent priority. Innovative technologies such as Light Wood Frame (LWF) and Cross Laminated Timber (CLT), widely studied and applied in international cases, have proven to be viable alternatives to respond to emergency needs, offering structural safety, construction speed and a reduced environmental impact.

The analysis of examples such as the RAPIDO program, in the United States, and the Villa Verde project, developed by ELEMENTAL in Chile, shows how modular and adaptable solutions can transform the reconstruction of affected communities. Such initiatives highlight the potential of wooden buildings not only to house families in record time, but also to promote resilience and community participation, ensuring safe and long-lasting housing.

In addition, the integration of digital technologies such as Building Information Modeling (BIM) represents a qualitative leap in the management and execution of works, enabling a reduction of up to 41% in delivery time and minimizing rework and waste. This combination of efficient construction methods and technological tools places wood construction as a competitive option, even when compared to conventional methods, especially in contexts where speed and precision are fundamental.

For Brazil, where natural disasters such as floods and landslides affect thousands of families annually, the implementation of these solutions requires joint efforts between the public, private and academic sectors. It is essential to promote public policies that encourage the use of the CLT and LWF, including their regulation in national cost systems and indexes, such as SINAPI. The training of labor, the financing of industrial plants and the encouragement of public-private partnerships are fundamental steps to enable affordable construction on a large scale.

Finally, the use of engineered wood in post-disaster reconstruction goes beyond the delivery of emergency housing. It represents an opportunity to align efficiency, sustainability and innovation, contributing to the reduction of the carbon footprint and offering a resilient reconstruction model for the future. The international experience and technological advances available provide a clear path for Brazil to lead initiatives that combine speed, quality, and respect for the environment in responding to natural tragedies. It is time to turn challenges into opportunities by adopting solutions that can rebuild not only infrastructure, but also the dignity and well-being of affected communities.

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