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BLOQUE M-EXPERIMENTAL: Timber as an alternative to build housing projects in Colombia.

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ABSTRACT: Bloque M-Experimental project represents a pioneering initiative in the development of mid-rise collective housing built entirely with timber in Colombia. Conceived as a prototyping and innovation laboratory, this four-story building required a five-year management, design, and construction process (2013–2018) due to its complexity. Throughout its development, multiple technical, construction, and administrative challenges were *identified*, which must be comprehensively addressed to promote similar projects in the Colombian context. These challenges include structural evaluation, licensing processes, availability and supply of structural timber, skilled labor, construction logistics, coordination with utility service providers, availability of suitable finishes, and user acceptance of timber as a building material. Bloque M-Experimental stands as the first mid-rise collective housing project fully designed and built in timber in Colombia and one of the few of its kind in Latin America. Its construction sets a precedent and opens new possibilities for the development of sustainable buildings in the country, providing valuable insights for future initiatives.

KEYWORDS: Collective housing, urban timber housing, glued laminated timber, timber structures, urban timber buildings.

1 – INTRODUCTION

The development of wooden buildings for urban collective housing has gained increasing interest in recent years due to their technical and construction advantages, environmental sustainability, and ability to enhance building comfort and energy efficiency[1]. However, in Colombia and other Latin American countries, the consolidation of a timber construction industry faces significant challenges, such as regulatory updates, material industrialization, professional and specialized workforce training, coordination with public utility companies, and overcoming traditional perceptions of wood as a structural material.

An effective mechanism for evaluating and documenting these challenges is the development of pilot projects that allow for systematizing experiences and serving as a reference for future constructions. In this context, Bloque M-Experimental emerges as an urban multifamily housing project in wood, conceived as a laboratory for experimentation and innovation. Located in Bogotá, Colombia, the building is situated on an infill lot measuring 6 meters in width by 15 meters in depth, with a built area of approximately 250 m² distributed over four levels.

The main challenge of the initiative lay in the comprehensive management of the project, encompassing everything from regulatory planning and structural design to construction execution and operational implementation. During the development period (2013–2018), process monitoring enabled the consolidation of key information for future experiences, addressing crucial aspects such as structural engineering selection, licensing processes, material supply logistics, workforce availability and training, coordination with public utilities, and the range of finishing options.

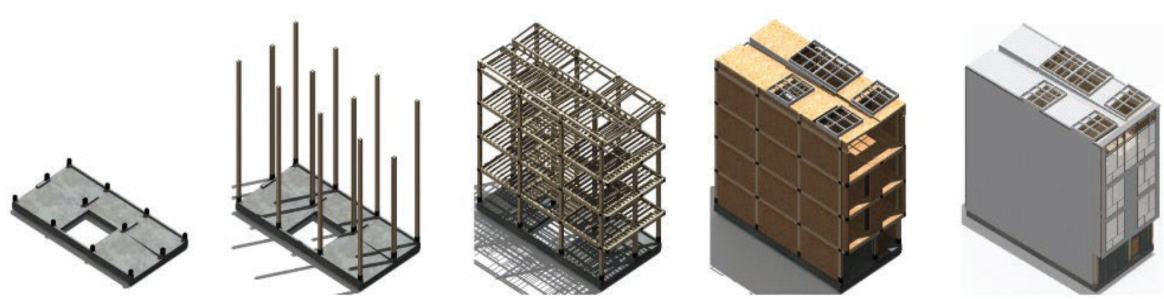

Figure 1. Constructive Sequence of the Block M-Structural Project

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Bloque M-Experimental is the first urban multifamily housing building in Colombia designed and built entirely in wood and possibly one of the few experiences of its kind in Latin America. Its development provides essential knowledge for future initiatives and contributes to innovation in sustainable construction in the region.

2 – PROJECT LIFE CYCLE ANALYSIS

To structure and communicate the experience gained during the execution of Bloque M-Experimental, an analysis based on the stages of the project life cycle is proposed: planning, design, construction, and occupation. This methodology highlights the most significant findings, key challenges, and achievements, providing valuable insights for future high-rise timber housing initiatives in Colombia and other similar contexts.

2.1 PLANNING

Main challenge: Formation of a specialized technical team.

Regulatory Review and Project Parameters

The project is located on a mid-block urban plot measuring 6 m in width by 15 m in depth. The initial phase involved reviewing the current urban and construction regulations, particularly the Colombian seismic-resistant standard NSR-10[2], which allows timber buildings up to five stories high using structural frame systems for various uses, including housing. The applicable urban regulations set a limit of four stories or a maximum height of 12 meters, with a mandatory three-meter rear setback.

Based on these parameters, a buildable area of 6 m in width by 12 m in depth was defined, with a maximum height of four levels or 12 meters.

Team Formation and Initial Challenges

After overcoming the regulatory phase, the selection of a technical team was undertaken, with a special focus on structural engineering. However, identifying a structural engineer with experience in timber construction proved to be a significant challenge. The search extended for 18 months, involving approximately 30 meetings with various engineering firms in Colombia, revealing the scarcity of professionals specialized in timber structures in the country.

Based on these parameters, a buildable area of 6 meters in width by 12 meters in depth was defined, with a maximum height of four levels or 12 meters.

Structural and Construction System

After forming the engineering team, GLULAM was chosen as the primary structural technology due to its advantages in prefabrication, material optimization, and reduced assembly times. A dual structural system composed of frames and shear walls was defined.

Availability of Structural Timber

Procuring timber for the prefabrication of structural and non-structural components presented a significant challenge. Initially, a commercial agreement with a local company was considered, given Colombia's high timber production potential. However, after an exhaustive search and detailed analysis of potential suppliers, it was confirmed that none had the required production capacity in cubic meters or the necessary dimensional stability and drying properties. These limitations would have hindered and delayed both the prefabrication and assembly processes.

After more than six months of consultations and meetings, the decision was made to source the timber from the Chilean company Arauco. While this ensured compliance with technical requirements, it introduced additional challenges, including the carbon footprint associated with transportation and the frustration of not being able to use locally sourced wood.

Basic Scheme

Based on the decisions made, a basic scheme was developed that integrated the characteristics of glued laminated timber and defined preliminary dimensions for structural elements, spans between supports (in coordination with the structural engineer), minimum placement conditions, functional heights for circulation and habitable spaces, as well as areas and material quantities. In terms of materiality, the following materials were established:

- Radiata Pine for the primary and secondary structure.
- OSB panels, selected for their cost-effectiveness for walls and floors.

Figure 2. Structural elements in GLULAM at the prefabrication plant and on-site.

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- Steel connection systems, supplied by a local provider.
- Reinforced concrete, used for foundations and substructures.

The basic scheme, with its detailed technical data, facilitated the management of the necessary financial resources, which were obtained through a mortgage loan under the self-construction modality.

2.2 DESIGN

Main challenge: Obtaining the Construction Permit.

Once the necessary resources for the project's construction were secured, the development of the preliminary architectural design commenced, aiming for the processing and acquisition of the construction permit.

Parameters and Characteristics of the Preliminary Architectural Design

For the detailed development of the preliminary project, the following aspects were considered:

Parametric Model as an Integrated Management Strategy: A parametric model was implemented using Rhinoceros and Grasshopper software to minimize errors and waste in the prefabrication of elements, optimize the construction process, and improve control over the quantities and dimensions of architectural components[3]. Additionally, construction tolerances were optimized, and a detailed calculation of waste generated by cutting was performed.

Spatial and Functional Configuration: The architectural design incorporated wood as the primary material and prioritized spatial flexibility. Levels 2 to 4 feature a central core for services (vertical circulation, sanitary facilities, and kitchen), with flexible areas towards the front and rear façades, adaptable to occupants' needs. On the ground floor, the main entrance leads to a versatile area designated for productive activities, workshops, social gatherings, or parking. Storage spaces, a laundry area, and a rear patio are also included. All technical installations were left exposed to facilitate maintenance and future updates.

Technical-Construction Conditions and Structural Pre-Dimensioning: The structural design was developed in collaboration with the structural engineer, establishing an orthogonal grid with four transverse and three longitudinal axes. The vertical structure consists of lateral columns measuring 11 m in height with a cross-section of 25 cm x 24 cm and central columns measuring 10.5 m in height with a cross-section of 30 cm x 24 cm. The horizontal structure includes perimeter longitudinal beams up to 12.5 m long with a cross-section of 8 cm x 30 cm, transverse beams of 5.8 m with a cross-section of 8 cm x 30 cm, and central beams of 3.8 m with a cross-section of 8 cm x 40 cm. Floor slab joists range from 50 cm to 3 m in length, with a cross-section of 3 cm x 19 cm. A standardized "T"-shaped metal joint was designed to connect beams and columns, using ½" bolts and four shear rings supported on the column. The transition between the concrete foundation and the wooden structure was executed using a 40 cm high metal base anchored with nine ½" bolts.

Wood Protection Strategy by Design: Since the plot is a mid-block lot, moisture protection strategies were implemented, including 22 cm high plinths to isolate the wood from ground contact. For the party walls, an enclosure system was designed using corrugated metal sheets, an anchoring structure with metal profiles, a condensation barrier, and an air chamber. The roof employs a similar system but with UPCV tiles for durability and easy maintenance. For the main façades, a lightweight metal frame system with an air chamber and light laminate finish was used, allowing for future modifications. Initially, transparent cellular polycarbonate was selected due to cost and ease of assembly.

Sustainability and Habitability: The design prioritized energy efficiency and water management strategies. Façade and roof surfaces were maximized for natural light capture. A rainwater collection and reuse system was planned, with storage on the first-floor patio and wastewater treatment integrated into the technical duct. For thermal and acoustic comfort, sandwich panels with OSB sheets, asphaltic noise barriers, and mineral wool insulation were incorporated.

Flexibility and Modularity in Technical Installations: From a strategic design perspective, flexibility and modularity of installations were prioritized. Consequently, all installations were designed to remain visible. Their layout begins at the main entrance, where an

Figure 3. GLULAM Main structure.

external technical cabinet houses public service meters: water, electricity, natural gas, and communications. A roof duct connects this cabinet to the project's main technical duct, extending from the ground floor to the roof. This vertical duct not only facilitates pipe routing but also contributes to natural lighting and ventilation.

To optimize the efficiency of the hydro-sanitary system, appliances were placed adjacent to the main technical duct, minimizing distances for potable water supply and wastewater evacuation.

The electrical system on each level was designed with an elevated channel running through all spaces, allowing for component derivation for power supply and wireless communications. This configuration provides flexibility in the distribution and quantity of power outlets, adapting to the changing needs of each space. Additionally, the channel houses communication, data transmission, and closed-circuit television (CCTV) systems. All installations can be easily inspected and updated, ensuring maintenance and evolution according to project requirements.

Construction Permit Management

Any architectural project developed in a Colombian city must undergo an approval process before an urban curatorship or local planning office. This standardized national process evaluates multiple regulatory aspects, including urban planning regulations, building placement, setbacks, structural and construction conditions, and habitability requirements, among others. On average, project approval takes between six and eight months.

In 2015, the Bloque M Experimental project began the process of obtaining a construction permit from one of Bogotá's five urban curatorships. After submitting all required technical documentation, the design and structural teams were summoned to address concerns regarding various aspects related to wood as a structural material. Topics discussed included the feasibility of wooden structures exceeding two levels in urban environments, seismic performance of such buildings, construction details of wooden structural systems, minimum regulatory requirements, calculation reports, and structural pre-dimensioning. Despite providing all requested technical information and adequately substantiating each aspect, the technical team of the curatorship did not deem the project viable from a technical-construction perspective. This lack of consensus caused delays in the permitting process and ultimately led to the denial of the construction permit due to expiration of the established deadlines. These discussions highlighted both a lack of awareness of local regulations applicable to timber construction (NSR-10) and limited familiarity with construction technologies for this material, a determining factor in either promoting or inhibiting the development of timber buildings. This initial permitting attempt took a total of eight months.

Following the denial from the first curatorship, the project was resubmitted to a second curatorship, with the expectation that the engineering team would have greater knowledge of timber technology. As part of this new strategy, technical documentation was reinforced to minimize potential objections from the evaluating team. This time, the process was significantly more agile, requiring only clarification on specific aspects of the project's seismic performance. Subsequently, the construction permit was granted. This second process also took eight months, resulting in a total of sixteen months to obtain the construction permit.

2.3 CONSTRUCTION PROCESS

Preliminaries

The existing structures were demolished, including a three-story house that was 35 years old, primarily constructed from clay block and concrete. The demolition was carried out by a specialized contractor.

Foundation

A soil study was conducted to assess the site conditions and establish the foundation parameters. As a result, it was necessary to excavate 1.5 meters of soil and replace it with compacted selected material. On top of this base, a reinforced concrete foundation slab with a thickness of 25 cm was constructed. Additionally, over-founding elements were incorporated to protect the wooden structure. A perforation was also made in the foundation slab for the future installation of the wastewater treatment system.

Main Structure and Roofing

To assemble the wooden structure, six scaffolding towers were temporarily assembled and connected by wooden beams to ensure greater stability. Pulleys and winches were installed to handle and lift both vertical and horizontal structural elements.

The assembly strategy was based on the sequential construction of structural axes, progressing from the first to the last level. Initially, the external longitudinal axes

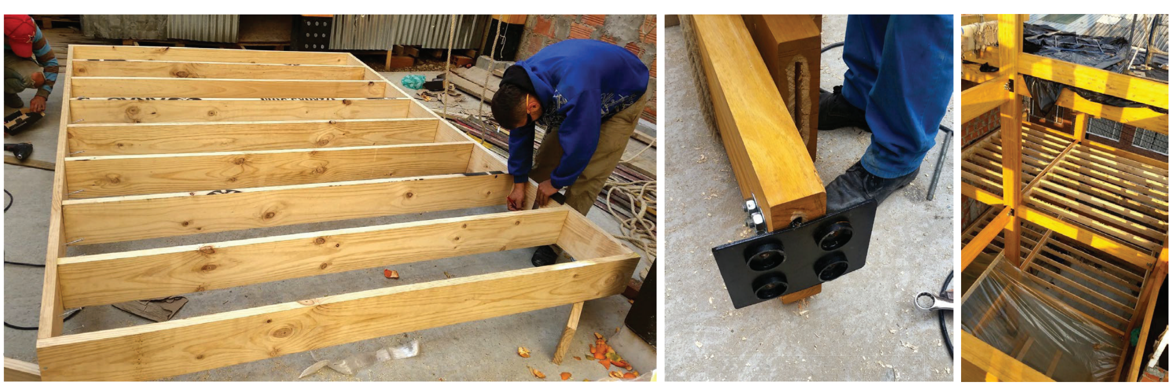

Figure 4. Slab components

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adjacent to the plot boundaries were assembled. Then, the transverse structural axes, consisting of beams and columns, were installed, progressing from the courtyard towards the street.

The intermediate floor was prefabricated in complete modules of beams at the first floor level, which were later lifted and fixed in their final position. This methodology not only optimized construction time but also minimized the risk of falls from height.

Adverse weather conditions during construction required adjustments to the assembly sequence. Priority was given to installing the roofing elements, including their finish, to create a protected working environment. The assembly sequence was carried out in descending order, starting from the fourth level and finishing on the second. Additionally, a provisional staircase was set up to facilitate vertical movement during construction.

Finally, the intermediate floor was completed with the installation of the surface finish, consisting of 15 mm thick OSB sheets. The structural elements of the intermediate floor were fixed with structural screws.

Enclosure and Protection

The construction of the perimeter enclosure towards neighboring plots was prioritized to protect the wooden structure from weather exposure and ensure the safety of the construction team. For this enclosure, corrugated metal sheets were used, mounted on a framework of metal profiles anchored to the wooden columns.

As part of the protection system, a condensation barrier was incorporated along with an air chamber to mitigate moisture accumulation and preserve the integrity of the wood. The metal sheets were dimensioned in manually transportable sizes and installed progressively by levels, starting from the fourth floor and finishing on the first.

Structural and Non-Structural Walls

The installation of structural and non-structural walls was carried out once the intermediate floor and vertical enclosure towards the neighboring plots were completed. Initially, the structural walls corresponding to the longitudinal axes were mounted, followed by the walls on the transverse axes, including the main facades.

Main Staircase

In line with the project's sustainability criteria, the staircase design incorporated reused wood elements from the manufacturing and assembly process of the intermediate floor. This strategy significantly reduced material waste. The staircase consists of eight identical segments, each formed by a double-beam structure with floating steps. The open frame configuration of the steps promotes natural lighting on all levels. The final finish used was 6 mm thick laminated glass.

Facades

For the installation of the facade finish, a system of metal frames anchored to the main structure was developed. These frames were intentionally separated from the wooden elements to create an air chamber as a strategy for protection and thermal control. The system allows for flexibility, enabling the replacement and updating of the facade finish over time. In its initial form, alveolar polycarbonate sheets were used as the facade cladding.

Technical installations

The project's technical installations were executed according to the established design strategy. However, the activation of the electrical and natural gas systems was subject to review and approval by the respective service companies.

Initially, the energy and natural gas companies rejected the activation of both systems, citing supposed incompatibilities with wooden construction. However, after a series of technical meetings, it was demonstrated that the current regulations do not impose restrictions on the structural material, and that wood does not pose an inherent risk to the proper functioning of the installations.

After a month of deliberations, approval was granted for the implementation of energy and natural gas services throughout the project. This case highlights the need to update existing regulations regarding public services to recognize wood as a viable material for both structural elements and partitioning.

2.4 OCCUPANCY

Finally, after five years, the project was ready for occupancy. Due to budgetary restrictions, the occupation began before some finishes were completed. The finishes on levels 3 and 4 were installed progressively, while level 2 was finished one year after the initial occupancy. This dynamic approach to defining and implementing finishes allowed for experimentation with various materials and construction solutions.

Currently, the experimentation process continues, covering finishes, furniture, lighting systems, and other components, with the goal of optimizing the overall efficiency and reaffirming the experimental nature of the M-Experimental Block as a prototype for applied

Figure 5. Construction process interior images.

research. The installation of rainwater harvesting systems and wastewater treatment is still pending, as they form part of the project's integrated sustainability strategy.

3 – RESULTS

Technical Challenges and Solutions Implemented:

Structural Engineering: The planning phase revealed a critical shortage of engineers specialized in the design of wooden structures in Colombia. This represents a significant challenge for the promotion and development of timber-based buildings within the country.

Local Structural Timber Industry: Issues were identified in the production, standardization, and distribution of locally sourced timber. Consequently, the decision was made to source timber from Chile, which increased the project's carbon footprint. This situation underscores the urgent need to strengthen the local timber industry.

Construction Permit: During the design phase, it became apparent that urban curatorships had limited knowledge of seismic-resistant regulations and the specific construction conditions applicable to timber buildings. This lack of expertise poses a substantial barrier to the timely approval of construction permits for projects of this nature.

Availability of Skilled Labor: The construction phase highlighted the scarcity of specialized labor in timber construction. To address this gap, it is essential for technical training institutions to incorporate academic programs focused on the construction of multi-story timber buildings.

Public Utility Providers: Difficulties were encountered with public utility providers concerning the review and approval of technical installations in timber buildings. This issue highlights the pressing need to update technical regulations, incorporating specific provisions for timber-based constructions.

BIM Technology: The development of a parametric model optimized the accuracy in manufacturing structural components, joints, and the overall construction process. This contributed significantly to improved efficiency and the reduction of material consumption.

Structural Design: Glued Laminated Timber (GLULAM) was chosen as the primary structural material, demonstrating its technical viability for medium-rise buildings. Prefabrication of both structural and non-structural elements was successfully executed, proving that construction systems utilizing large-format timber elements are both competitive and feasible.

Constructive Feasibility: The use of lightweight technologies and manual equipment for the installation and assembly of structural elements was confirmed as a viable solution, resulting in notable reductions in both construction costs and timelines.

Construction Efficiency: The efficiency of the construction process was particularly notable. The main structure was assembled by a team of four workers within three weeks, while the installation of both primary and secondary structural elements took a total of five weeks. Based on the actual construction times, it is estimated that a 250 m², four-story building could be completed within a period of five to six months. This timeline presents a competitive advantage over traditional building methods such as masonry and concrete.

Sustainability: A marked reduction in construction waste was observed when compared to conventional construction systems. For example, the reuse of floor joist cuttings for the prefabrication of the main staircase elements highlighted the efficiency and sustainability of wood as a building material.

4 – CONCLUSION

Architectural and Construction Innovation

The Bloque M-Experimental project stands as the first urban building in Colombia constructed with laminated timber at height, marking a significant milestone in sustainable and experimental collective housing construction in Latin America.

Identified Barriers

Scarcity of Specialized Professionals: The limited availability of professional, technical, and vocational training in the country is a key factor inhibiting the widespread adoption of similar projects.

Regulatory Challenges: A significant regulatory gap exists in the practical implementation of NSR-10 for timber structures. This gap necessitates adjustments to licensing policies to accommodate this form of construction.

Figure 6. Fourth floor interior images.

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Challenges in the Local Timber Production Industry: The limited capacity of the local timber industry to produce structural-grade timber led to the importation of the material, increasing the carbon footprint of the project. This situation underscores the need to develop a robust domestic timber industry.

Contributions to the Sector

This project demonstrates the technical and economic feasibility of using timber as a structural material in multi-story buildings. It provides valuable insights into regulatory frameworks, design methodologies, and construction strategies within the Colombian context. The lessons learned are directly applicable to future projects, offering a comprehensive approach from planning through to occupation to optimize resource utilization, minimize construction times, and enhance sustainability.

Future Opportunities

Promotion of Timber as a Structural Material: It is recommended that specialized academic programs at various educational levels be developed, alongside the implementation of flexible regulatory frameworks that involve key stakeholders from all sectors of the industry.

Pilot Projects and Evaluation: As a "living laboratory," the Bloque M project will continue to serve as a resource for ongoing research and prototyping, aimed at evaluating innovative solutions in timber construction and sustainability.

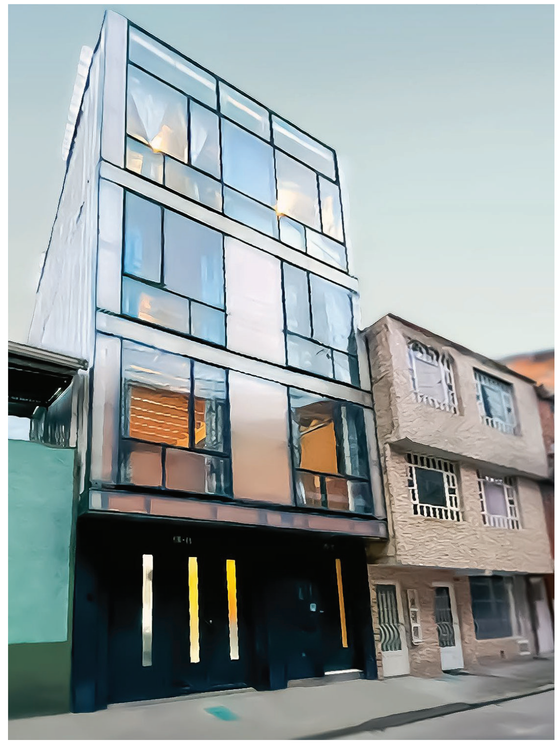

Figure 7. Main façade.

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