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Application micro home principles to affordable housing: A sustainable proposal in Brussels

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ABSTRACT

This thesis presents an innovative approach to sustainable urban housing by utilizing Cross-Laminated Timber (CLT) in the design of a micro-housing complex in the Lion City II neighborhood of Brussels. Driven by the need for sustainable and affordable urban housing solutions, the project explores the architectural and environmental benefits of CLT within a modular construction framework.

Influenced by the Kingspan Micro House competition and the C40 Cities challenge, the design prioritizes modularity and sustainability. The complex features several four-story building blocks, each containing eight units per floor, designed to foster community interaction through well-integrated communal spaces both within and between buildings.

The technical analysis of the project emphasizes the energy-efficient properties of CLT, such as enhanced thermal insulation and reduced construction waste. The architectural design includes a ventilated facade system to optimize energy performance further, promoting a comfortable living environment.

Significantly, the project integrates communal spaces strategically to enhance social interactions among residents, thereby enriching the community fabric. This thesis underscores the potential of modular CLT buildings to revolutionize urban housing by combining sustainability with vibrant community living.

INTRODUCTION

This thesis explores the application of Cross-Laminated Timber (CLT) in constructing micro-housing units within the Lion City II neighborhood in Brussels. This project was inspired by two architectural competitions: the Kingspan Micro House competition[1] and the C40 Cities challenge[2], which both emphasize sustainable urban development in response to the global housing crisis and climate change.

The project considers:

Global Housing Crisis and Urban Sustainability Challenges: Rapid urbanization has led to a significant housing shortage worldwide, prompting the need for innovative construction methods that not only address the demand for housing but do so sustainably. This project responds to such challenges by proposing a scalable, modular housing solution using CLT.

Cross-Laminated Timber (CLT) as a Sustainable Material: CLT has gained recognition for its environmental benefits, including carbon sequestration and reduced construction waste. Its prefabrication capabilities enable quicker construction times and less environmental disruption on site.

Modular Design and its Relevance to Urban Housing: Modular construction has been identified as a potential solution for mass housing due to its efficiency and scalability. The design concept of this thesis proposes a modular approach using CLT to create a series of micro-housing units, optimizing the use of space while adhering to sustainable building practices.

Influence of the architectural competitions :

Kingspan Micro House Competition

The Kingspan Micro House competition was conceived in response to the growing need for innovative housing solutions that address urbanization challenges. As cities continue to expand, land scarcity, housing shortages, and increasing costs have become pressing concerns for both residents and planners. The competition called for the design of micro houses—compact, efficient, and sustainable housing units that reimagine living spaces for modern urban lifestyles.

Micro housing plays a critical role in addressing these challenges by maximizing the use of limited space while minimizing resource consumption. By focusing on small-scale, modular designs, micro houses promote a more sustainable way of living, enabling urban dwellers to reduce their environmental footprint without sacrificing functionality or comfort. This competition highlighted the potential for micro housing to serve as a scalable solution in dense urban contexts, providing flexibility and adaptability to meet diverse needs.

For this thesis, the principles of micro housing—efficiency, modularity, and sustainability—served as a foundation for the design approach. Instead of focusing on standalone micro units, the project expands on this concept by clustering multiple micro houses into a cohesive, modular building block, enhancing both community living and urban density optimization.

C40 Cities Competition

The C40 Cities competition is an influential global initiative aimed at tackling the climate crisis through innovative and sustainable urban projects. Organized by the C40 Cities Climate Leadership Group, the competition brings together leading cities, architects, and planners to develop solutions that address climate change while enhancing urban resilience and equity. The focus lies on creating projects that are not only environmentally sustainable but also socially inclusive and economically viable.

The C40 Cities competition offered a platform to address urban sustainability issues through innovative architectural solutions, focusing on the use of sustainable materials and energy-efficient designs.

This project is situated within the Lion City II neighborhood, chosen for its potential to demonstrate how micro-housing can integrate into existing urban fabrics without compromising the community's character or the environment.

The Lion City II neighborhood in Brussels, selected as the project site, presents an opportunity to respond to the competition's challenges and principles. As an urban area characterized by high population density and diverse architectural contexts, the site encapsulates many of the issues modern cities face: the need for low-carbon construction methods, energy-efficient buildings, and spaces that foster social cohesion.

The C40 Cities competition emphasizes the integration of sustainability into all aspects of urban design, from material selection to energy performance and community impact. This aligns with the objectives of this thesis, which adopts cross-laminated timber (CLT) as the primary building material to reduce carbon emissions, and explores modular design principles to create a scalable, sustainable housing model. Furthermore, the competition's focus on innovative solutions provided the impetus for incorporating advanced technologies, such as ventilated facade systems and renewable energy strategies, to enhance the project's environmental and social impact.

2. SITE ANALYSIS

2.1 Description of the Lion City II neighborhood in Brussels

The Lion City II site is located in Molenbeek-Saint-Jean, Brussels, strategically positioned 1. Overview of the Lion City II Neighborhood in Brussels

The Lion City II neighborhood in Brussels, located in a vibrant urban setting, provides a rich context for exploring sustainable and modular housing solutions. This neighborhood is characterized by a mix of residential, commercial, and green spaces, making it a dynamic environment for architectural innovation. Its central location within Brussels offers excellent accessibility, surrounded by key infrastructure such as public transport, educational institutions, and cultural hubs. These factors make the site an ideal testing ground for implementing sustainable urban housing models.

Figure 1 – Location of the project

Figure 2 – Location of green spaces in vicinity

2.2 Urban context.

The neighborhood exhibits the typical challenges of urban density, with limited land availability and a high demand for housing. The surrounding area comprises mid-rise and high-rise buildings, creating a dense architectural fabric that emphasizes the need for efficient space utilization. Despite the density, the area includes pockets of green spaces and pedestrian-friendly zones, which can be leveraged to enhance the integration of nature and community-focused design elements within the project.

2.3 Climate and Environmental Factors.

Brussels experiences a temperate maritime climate, characterized by mild winters, moderate summers, and consistent rainfall throughout the year. These climatic conditions necessitate thoughtful architectural design to address issues such as thermal insulation, energy efficiency, and water management. The project's use of cross-laminated timber (CLT) and energy-efficient systems aims to respond to these climatic challenges while reducing the overall environmental impact of the building.

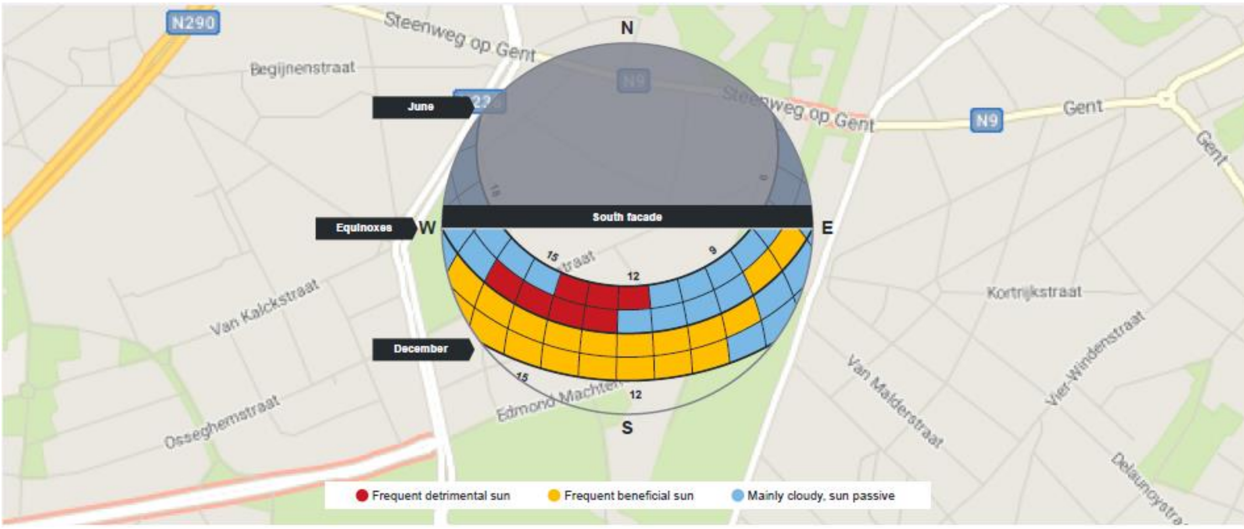

Figure 3 – Solar path on site

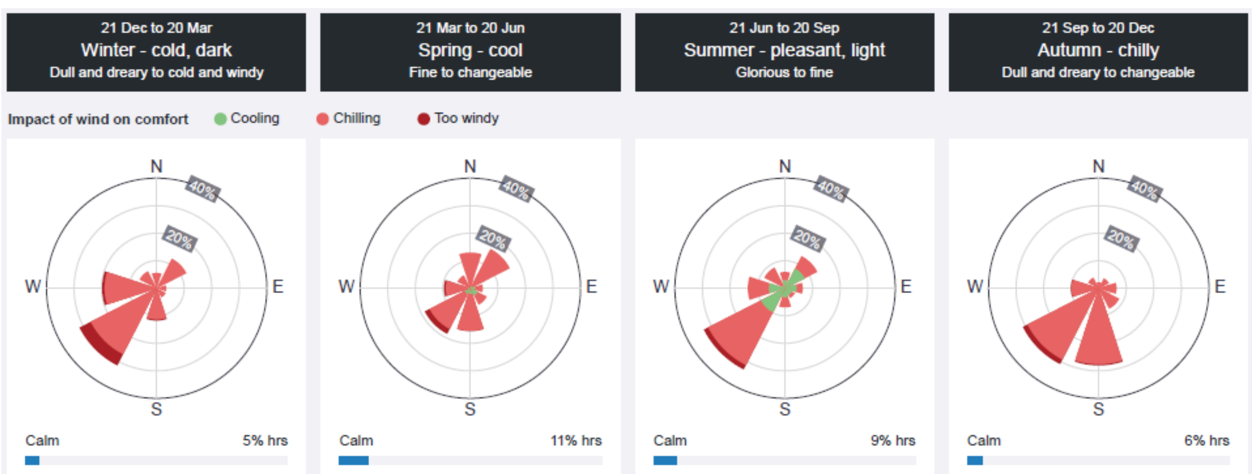

Figure 4- Wind diagram affecting the site

2.4 Transportation and Connectivity.

Lion City II is well-connected to Brussels' extensive public transport network, including metro, tram, and bus services. This connectivity supports the sustainability goals of the project by encouraging public transport use over private vehicles, thereby reducing carbon emissions. Additionally, the site's proximity to major roads and bike paths enhances accessibility for residents and promotes multimodal transportation options.

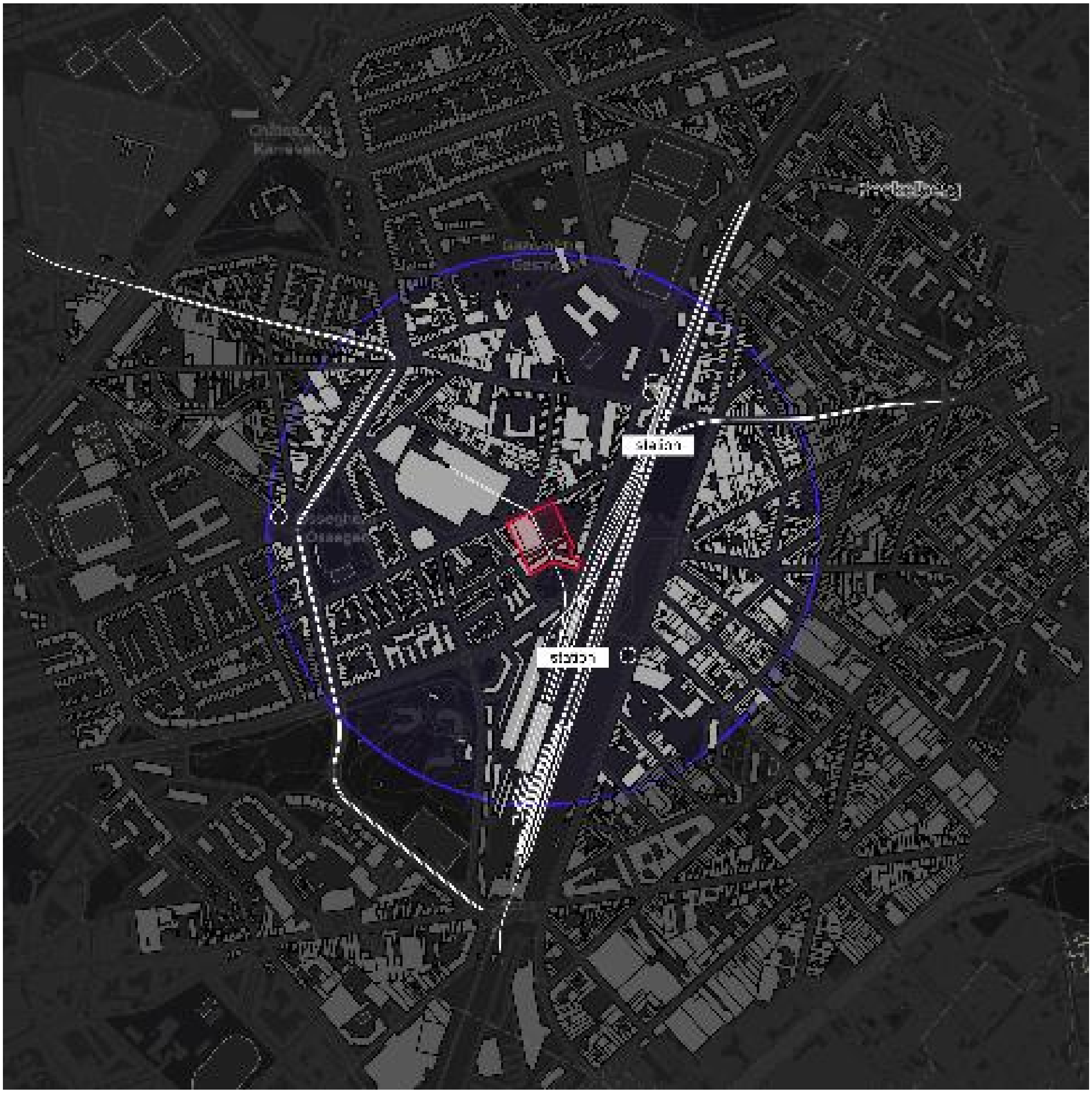

Figure 5 – Train rails and metro stations

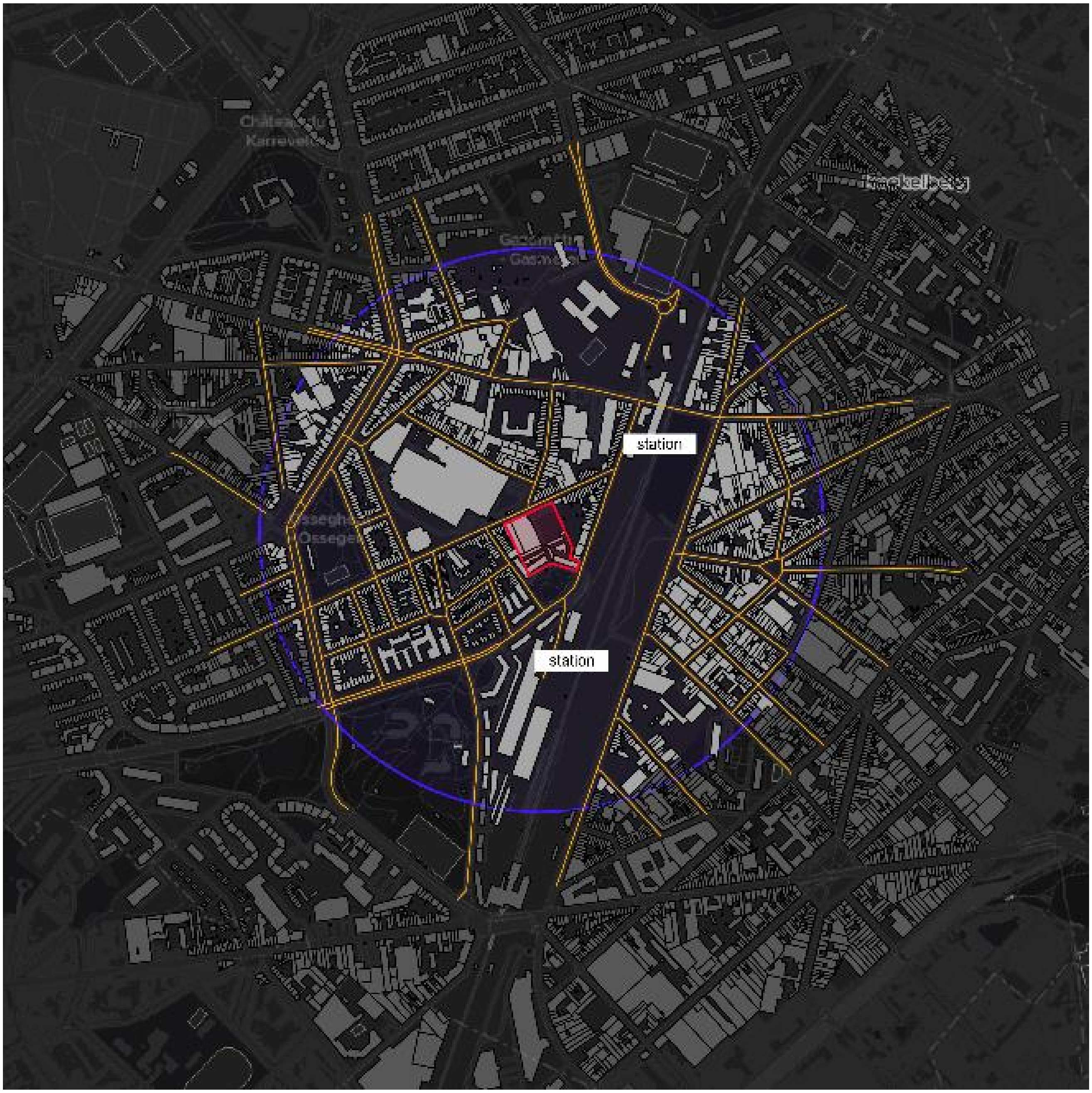

Figure 6 – Roads in site's vicinity

2.5 Influence of the Site on Design Decisions

The urban density and architectural diversity of Lion City II directly influenced the decision to adopt a modular design approach, clustering micro housing units into compact, efficient building blocks. The availability of green spaces and pedestrian zones provided inspiration for incorporating outdoor communal areas and greenery into the project. Furthermore, the site's connectivity and climate encouraged the integration of sustainable building materials, such as CLT, alongside advanced energy-efficient systems to ensure the project aligns with both environmental and social objectives.

2.6 Challenges and Opportunities

Challenges: The high population density and limited land availability pose constraints on design flexibility. Additionally, integrating the modular housing design into the existing urban fabric without disrupting the neighborhood's character requires careful planning.

Opportunities: The site’s central location, connectivity, and emphasis on sustainability present unique opportunities for creating a model urban housing project that sets a benchmark for sustainable design in dense urban environments.

3. DESIGN CONCEPT

3.1 Sustainability principles: CLT as a material and environmental considerations.

Cross-Laminated Timber (CLT) was selected as the primary material for this project because of its excellent structural properties and visual appeal. The engineered layers of CLT enable it to support large spans and create thin wall profiles, making it highly adaptable for diverse design needs. The natural wood finish of CLT adds warmth and enhances the visual dynamics of interior spaces, often being left exposed to contribute to the aesthetic quality of the design.

Recognized for its environmental benefits, CLT stands out as a sustainable choice in modern construction. It produces significantly lower carbon emissions during its production than traditional materials like concrete and steel. As a renewable resource, wood plays a crucial role in carbon sequestration, absorbing carbon dioxide during its growth phase. This not only helps in reducing the overall carbon footprint of the project but also aligns with the goals of sustainable building practices.

The lifecycle of CLT, which includes careful forest management, efficient production processes, and the potential for end-of-life recycling, supports sustainable development goals. These processes ensure that the material's impact on the environment is minimized and contributes positively to the ecological balance.

Additionally, the use of CLT is supported by its local availability in Belgium, which bolsters the local economy and reduces environmental impacts related to transport logistics. Opting for locally sourced CLT not only cuts down on the carbon emissions associated with transporting materials over long distances but also supports local industries. This approach to material sourcing is crucial for promoting sustainability in construction, as it leverages local resources and reduces the overall environmental impact of building projects.

3.2 Modular design: why multiple blocks of micro houses were chosen.

The implementation of modular design principles is crucial for addressing key challenges in social housing, notably reducing construction time and costs. Modular construction involves the prefabrication of units in a controlled factory environment, which greatly accelerates the construction process. This approach significantly reduces the need for on-site labor, lowers associated costs, and minimizes delays caused by adverse weather conditions, resulting in more predictable project timelines.

Additionally, the standardized production of modular units leads to economies of scale, which decrease the cost per unit as production volumes increase. This cost reduction is particularly beneficial in social housing projects, where budget limitations are a common constraint. The prefabrication process also enhances material efficiency and reduces waste, contributing positively to both economic and environmental sustainability.

Incorporating modular units into construction projects facilitates a quicker return on investment, an essential benefit for investors and stakeholders in the social housing sector. The rapid on-site assembly of prefabricated elements not only shortens the overall construction timeline but also enables quicker occupancy of the buildings. This reduces the time between construction and habitation, providing a significant advantage in areas experiencing housing shortages. Early occupancy is crucial for meeting urgent housing demands and improving the socio-economic stability of the community.

3.3 Volume Design.

The accompanying volume design diagrams illustrate how individual cubic modules are assembled to create the structure of a four-story building. Each floor includes communal spaces, strategically designed to foster community interaction and enhance livability. These diagrams visually break down the modular construction process and highlight the efficient use of space made possible by modular design.

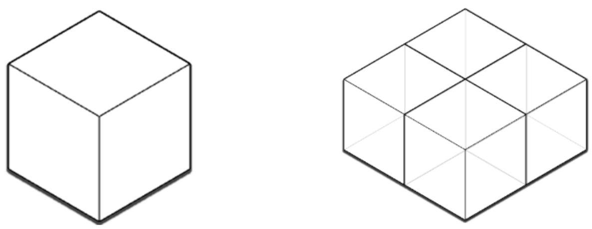

Figure 7 – Combination of a 2.5 by 2.5 meters cube into a 25 square meter unit

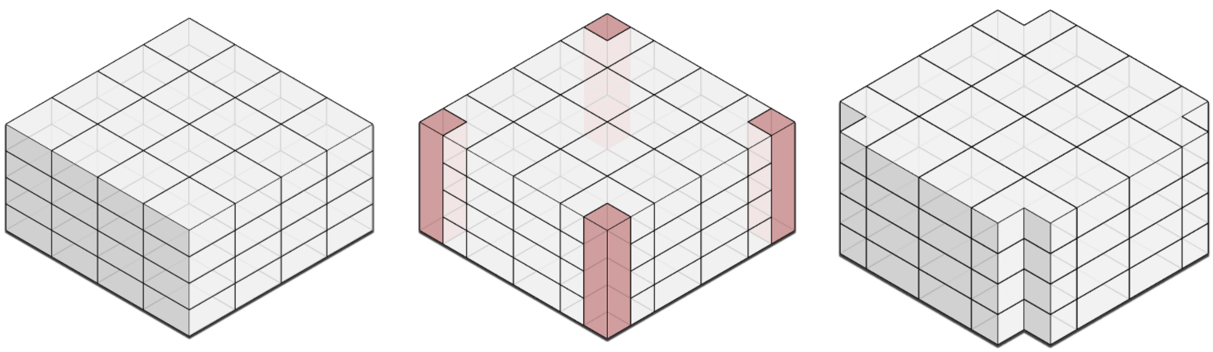

Figure 8 – Creation of the mass using units and removal of the corners

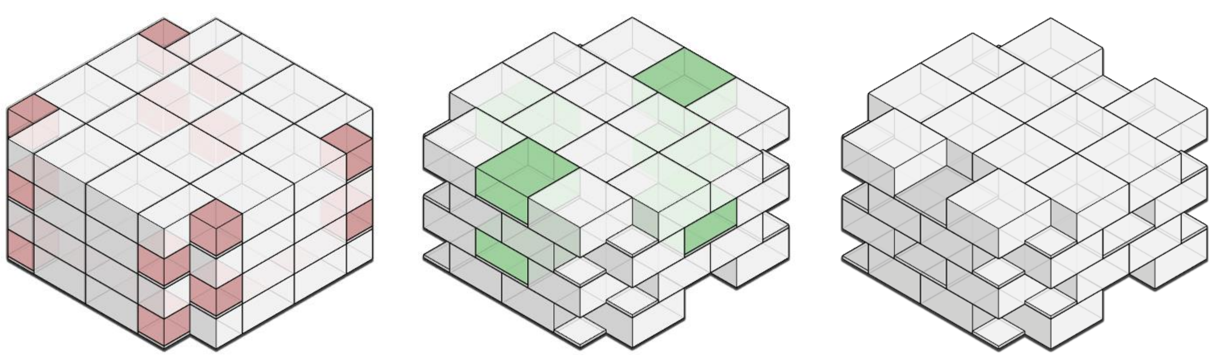

figure 9 – Integration of balconies and communal spaces resulting in final volume

4. TECHNICAL CHOICES

4.1 Construction System

This project employs Cross-Laminated Timber (CLT) and Rothoblaas[3] connection systems, which are chosen for their exceptional structural efficiency and sustainability. These technologies are fundamental in addressing the demands of modern architecture, providing solutions that are ecologically responsible and structurally robust.

Manufacturing and Properties of CLT

Manufacturing Process: CLT is produced by layering and bonding solid-sawn lumber perpendicular to each other, using advanced adhesives. This process involves selecting high-quality softwoods, kiln-drying them to reduce moisture content, precisely machining the wood, and then bonding the layers under high pressure. This method enhances the dimensional stability and structural integrity of CLT, making it suitable for diverse architectural applications.

Benefits of CLT: CLT is renowned for its environmental and structural advantages. It serves as a natural carbon sink, significantly reducing the building's overall carbon footprint. Structurally, it provides substantial load-bearing capacity, seismic resilience, and thermal insulation, making it ideal for energy-efficient building designs.

Enhancing Fire Resistance and Acoustic Performance of CLT:

- Fire Retardant Treatments: These chemicals are applied to CLT to reduce flammability and slow down the rate of burning.
- Protective Coatings: Special coatings can protect the CLT from high temperatures, maintaining structural integrity during a fire.
- Design Strategies: Incorporating fire stops and selecting thicker CLT panels can increase resistance to fire, providing crucial time during emergencies.

- Layering Techniques: Installing mass-loaded vinyl or other sound-dampening materials between CLT panels can effectively reduce noise transmission.
- Sealing Joints: Properly sealing joints and intersections in CLT constructions helps eliminate sound bridges, crucial for urban living environments.
- Flexible Joist Connections: Employing joist hangers with sound-absorbing materials reduces impact noise through floors and walls.

4.2 Connections System

Detailed Analysis of Rothoblaas Technologies: Rothoblaas connection systems are integral to the structural integrity of CLT buildings:

- Pillar Technology: Supports substantial vertical loads and allows for larger spans in multi-storey structures.
- X10 System: Provides adjustable, concealed joints for dynamic structural conditions, enhancing flexibility in design.
- WHT and WHT Plate T: These brackets are essential for efficient timber-to-timber and timber-to-concrete connections, facilitating the transfer of tensile and shear forces.
- Titan V and Titan Plate C: Designed for high seismic performance, these systems ensure stability and safety in earthquake-prone areas.

Sustainable Connection Choices: Using durable, galvanized steel in Rothoblaas connectors minimizes maintenance, enhances longevity, and supports sustainable construction practices by reducing the environmental impact throughout the building's lifecycle.

Integration of CLT and Rothoblaas in Construction

Structural Design Considerations: The combination of CLT's natural properties and Rothoblaas's advanced connection technologies enables innovative architectural designs that are both structurally sound and aesthetically pleasing. This integration is essential for achieving high seismic resilience and supporting complex load-bearing architectures.

Construction Efficiency and Waste Reduction: Prefabricated CLT panels, combined with Rothoblaas connections, streamline the construction process. This method reduces build times, decreases labor costs, and minimizes on-site waste, aligning with sustainable construction practices.

Technological Enhancements in CLT

Technological advancements in CLT include the development of fire retardants and acoustic enhancements that make it suitable for a broader range of applications. Precision-cutting technologies like CNC ensure accurate panel dimensions, facilitating quick assembly and allowing for complex, customized designs.

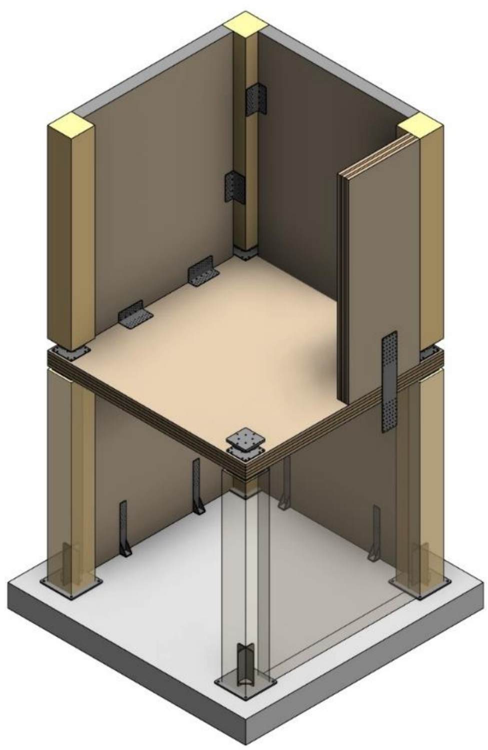

figure 9 – Clt Connections

4.3 Ventilated Facade

The envelope is characterized by a ventilated façade system: Ventilated facades are an advanced cladding system that incorporates a cavity between the cladding layer and the building's exterior wall. This design promotes natural ventilation and provides several benefits, including improved thermal regulation, moisture control, and enhanced energy efficiency. The air gap allows for continuous air flow, which helps to keep the building cooler in summer and warmer in winter by minimizing thermal bridges and providing an additional layer of insulation.

Benefits of Ventilated Facades:

- Energy Efficiency: By reducing the demand for artificial heating and cooling, ventilated facades contribute to significant energy savings over the building's lifecycle.

- Moisture Management: The air gap helps to prevent moisture accumulation by allowing for constant air movement, which reduces the risk of mold growth and water damage to the building envelope.

- Aesthetic Flexibility: Ventilated facades offer a variety of design options in terms of materials, colors, and textures, allowing architects to enhance the building's exterior according to aesthetic and functional requirements.

Sustainable Aspects: Ventilated facades support sustainable building practices by using durable materials that require minimal maintenance. Additionally, they can be designed to incorporate eco-friendly materials and systems that further reduce the building's environmental impact.

Integrating Ventilated Facades with CLT

Synergistic Benefits of Combining CLT with Ventilated Facades:

Thermal Performance Optimization: Ventilated facades enhance a building's thermal efficiency by creating a buffer zone that regulates heat exchange. When paired with CLT, known for its excellent insulation properties, this combination maximizes the building's thermal performance. The result is a stable internal climate with reduced energy consumption for heating and cooling, aligning perfectly with sustainable building objectives.

Improved Moisture Management: CLT's susceptibility to moisture can be mitigated by pairing it with a ventilated facade. The continuous air flow within the facade's cavity efficiently removes any moisture that penetrates the exterior layer, protecting the CLT panels from potential water damage. This proactive approach ensures the durability and longevity of the structure, maintaining the integrity of the wood over time.

Acoustic Benefits: The integration also boosts the building's sound insulation. The air gap provided by the ventilated facade acts as an extra layer of sound barrier, complementing CLT's natural sound absorption qualities. This is particularly valuable in noisy urban settings, where reducing exterior noise intrusion is crucial for creating a peaceful indoor environment.

Aesthetic and Design Versatility: Ventilated facades offer a wide range of design options, allowing architects to achieve both functional and aesthetic goals. Whether aiming to contrast or harmonize with the natural look of CLT, designers have the flexibility to choose from various materials and finishes to enhance the building's exterior appeal.

Environmental Impact and Sustainability: This combination supports eco-friendly construction by optimizing material use and energy consumption. Both ventilated facades and CLT can be sourced sustainably and are designed to minimize environmental impact. Their use together not only improves the building's energy efficiency but also promotes the sustainability of construction practices through recyclable materials and efficient resource use.

Installation and Technical Integration: CLT provides a sturdy framework for the installation of ventilated facades, with Rothoblaas connection technologies ensuring a secure and precise attachment. These specialized connectors are capable of handling the dynamic loads and environmental stresses associated with facade systems, facilitating a reliable and effective integration that enhances both safety and performance.

4.4 Rockpanel Woods

Sustainability and Material Origin: Rockpanel[4] Woods cladding panels are manufactured from compressed natural basalt, a volcanic rock that is both abundant and sustainable. This material choice reflects our commitment to environmental responsibility, as basalt is sourced close to our production facilities, reducing transportation impacts and supporting local resources.

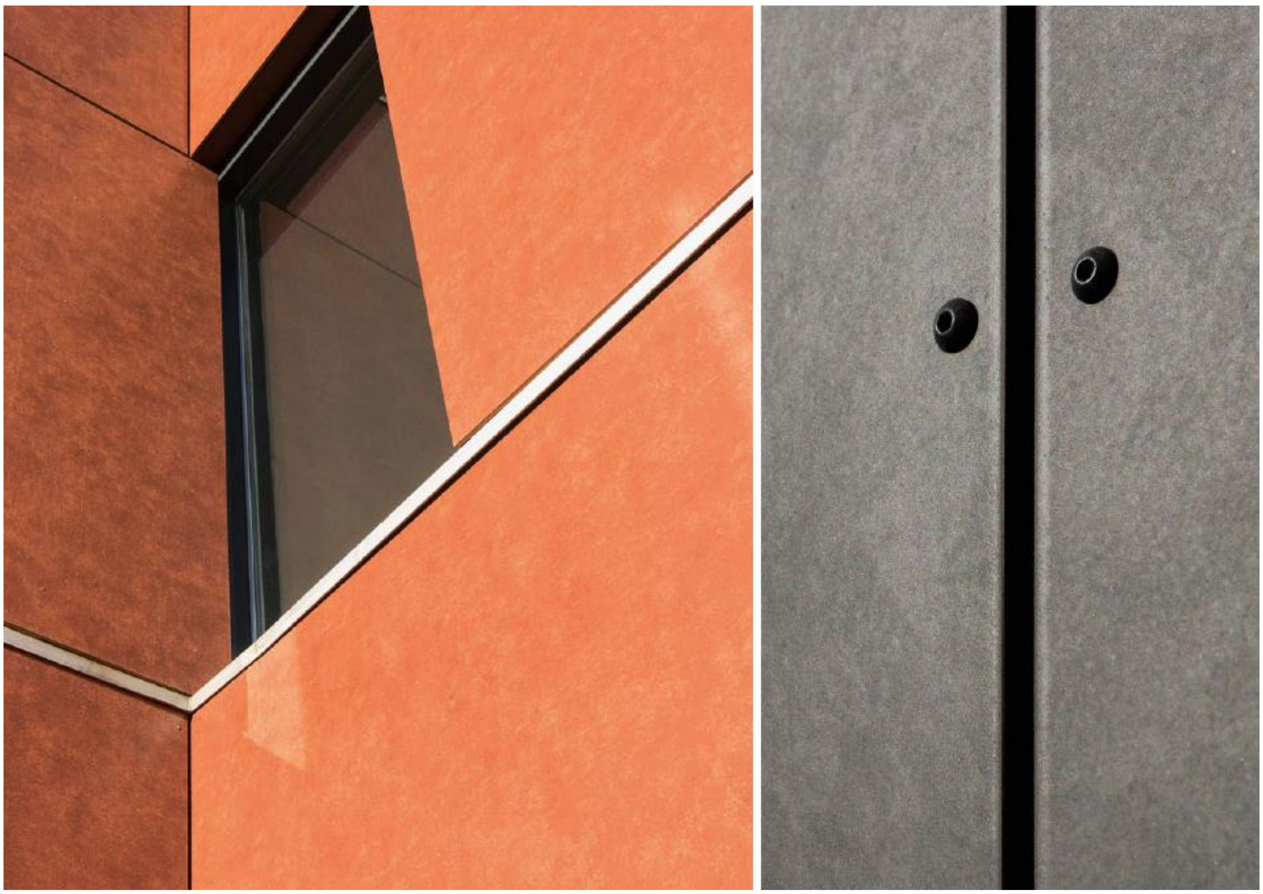

Figure 10-Rock Panel Sample

Fire Safety: Rockpanel Woods panels are inherently fire-resistant, meeting the stringent Euroclass A2-s1, d0 standards. This classification ensures that the panels are non-combustible, making them an ideal choice for use in high-rise and high-risk buildings. The natural fire resilience of basalt allows these panels to provide superior safety without the need for chemical fire retardants, aligning with modern safety regulations and sustainable building practices.

Durability and Maintenance: Unlike traditional wood, which can degrade over time, Rockpanel Woods offers exceptional durability. These panels are immune to moisture, do not expand or shrink due to temperature changes, and maintain dimensional stability throughout their lifespan. This results in a facade solution that remains aesthetically pleasing and functionally robust for decades with minimal maintenance, reducing the overall lifecycle costs and environmental impact.

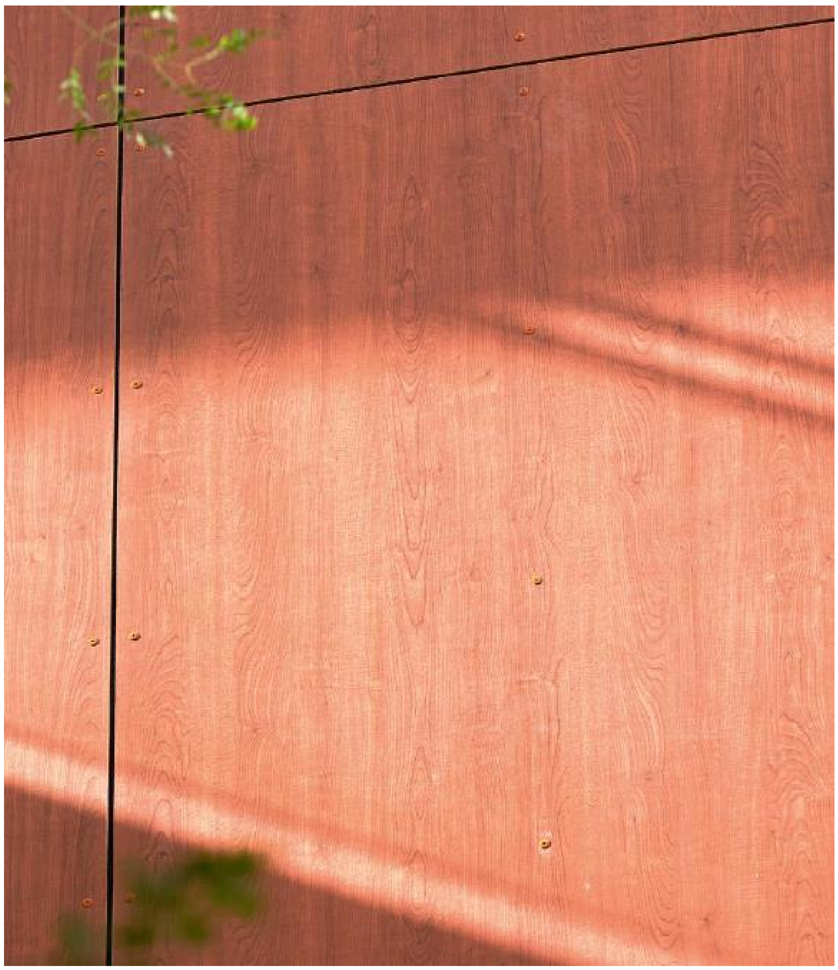

Figure 11-Rock Panel Sample

Aesthetic Flexibility: Rockpanel Woods provides the natural appearance of wood with enhanced aesthetic flexibility. Available in a variety of finishes, these panels allow for creative freedom in design while offering the practical benefits of a non-wood material. This makes Rockpanel Woods suitable for a wide range of architectural styles, from traditional to contemporary, without the limitations typically associated with wood.

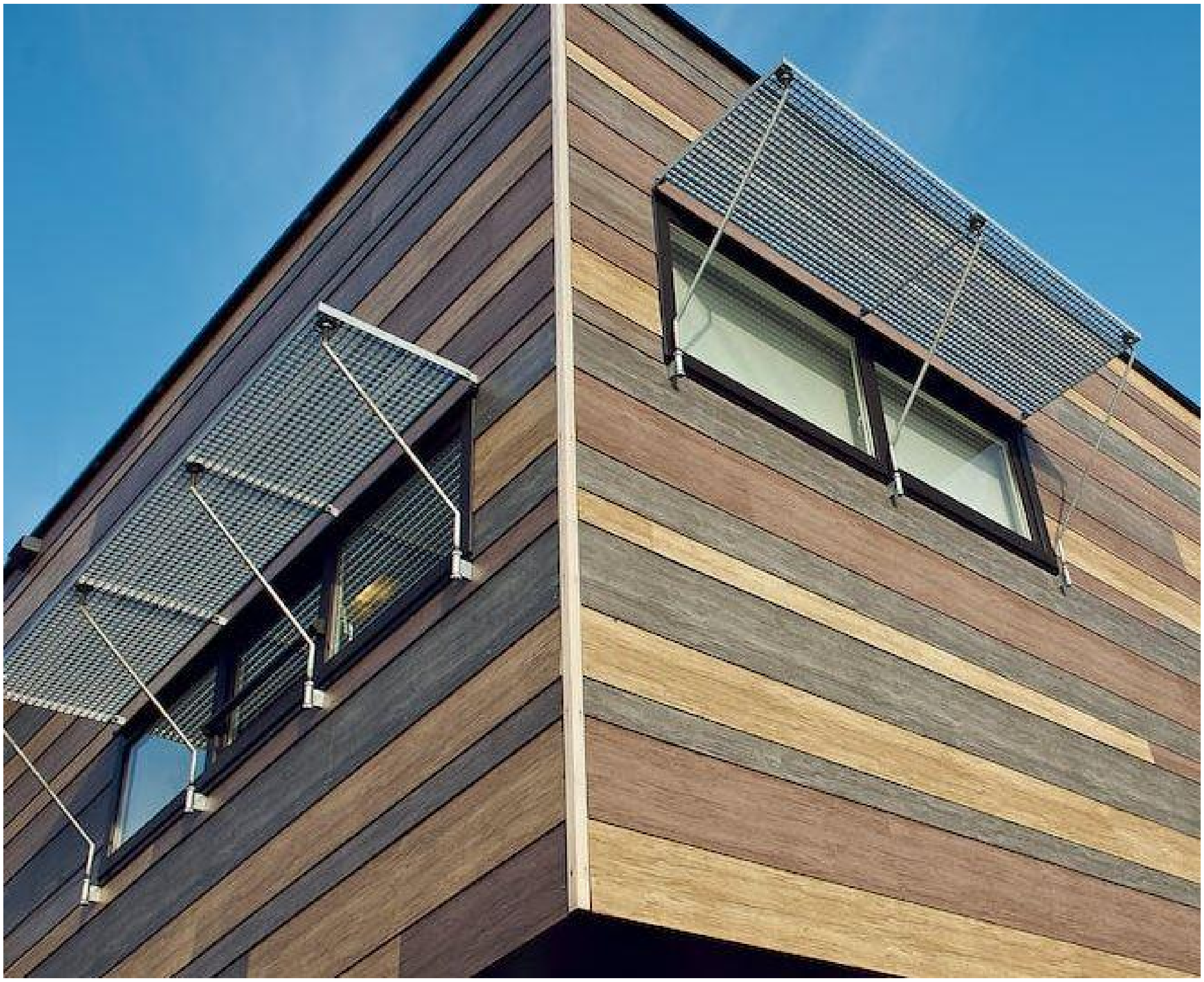

Figure 12-Rock Panel Sample

Installation and Workability: Despite their robust nature, Rockpanel Woods panels are lightweight and easy to handle, facilitating straightforward installation. They can be easily cut and adjusted on-site using standard tools, which simplifies the construction process and reduces installation time. This feature is particularly beneficial for projects with tight deadlines or complex architectural requirements.

Eco-Friendly and Recyclable: In line with sustainable building practices, Rockpanel Woods panels are fully recyclable at the end of their life cycle. This contributes to the reduction of construction waste and supports the principles of a circular economy, making Rockpanel Woods an eco-friendly choice for facade cladding.

5. ARCHITECTURAL DESIGN

5.1 Master Plan

The site plan for the Lion City II micro-housing project was meticulously crafted to align with principles of sustainability and community integration. The layout was strategically designed to optimize land use and foster a sense of community among residents, considering the urban context, environmental considerations, and the project's overarching sustainability goals.

Urban Context and Integration: Located in the bustling neighborhood of Lion City II in Brussels, the site plan was influenced by the need to integrate seamlessly with the surrounding urban fabric. The design utilizes existing roads as axes for pedestrian pathways, creating a dynamic flow through the site. These paths are aligned to form primary and secondary axes among the buildings, with their intersection serving as a communal gathering point. This design strategy enhances the efficiency of space utilization and promotes vibrant community interactions in shared outdoor spaces.

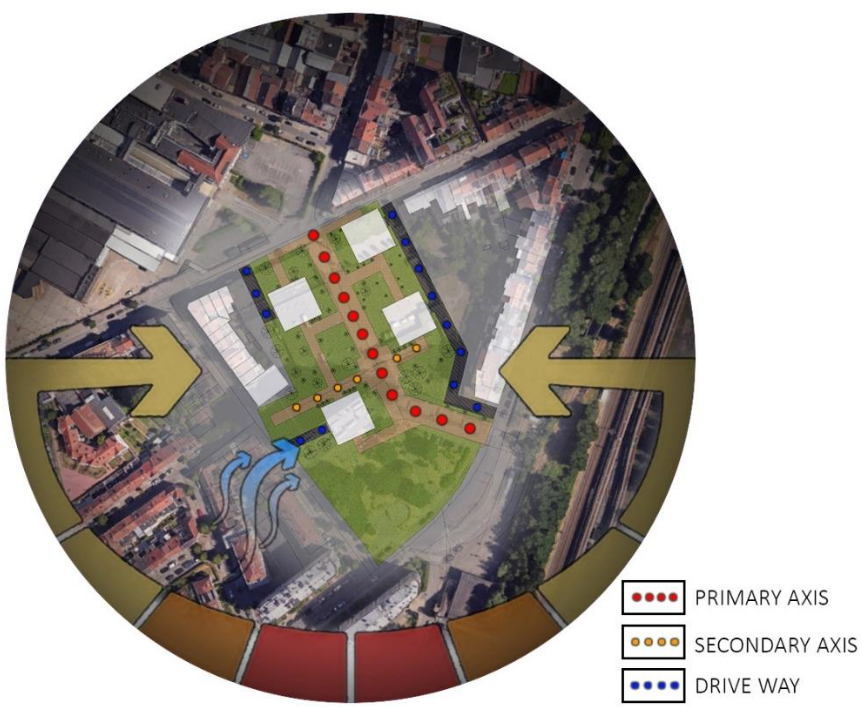

Figure 11-Master Plan

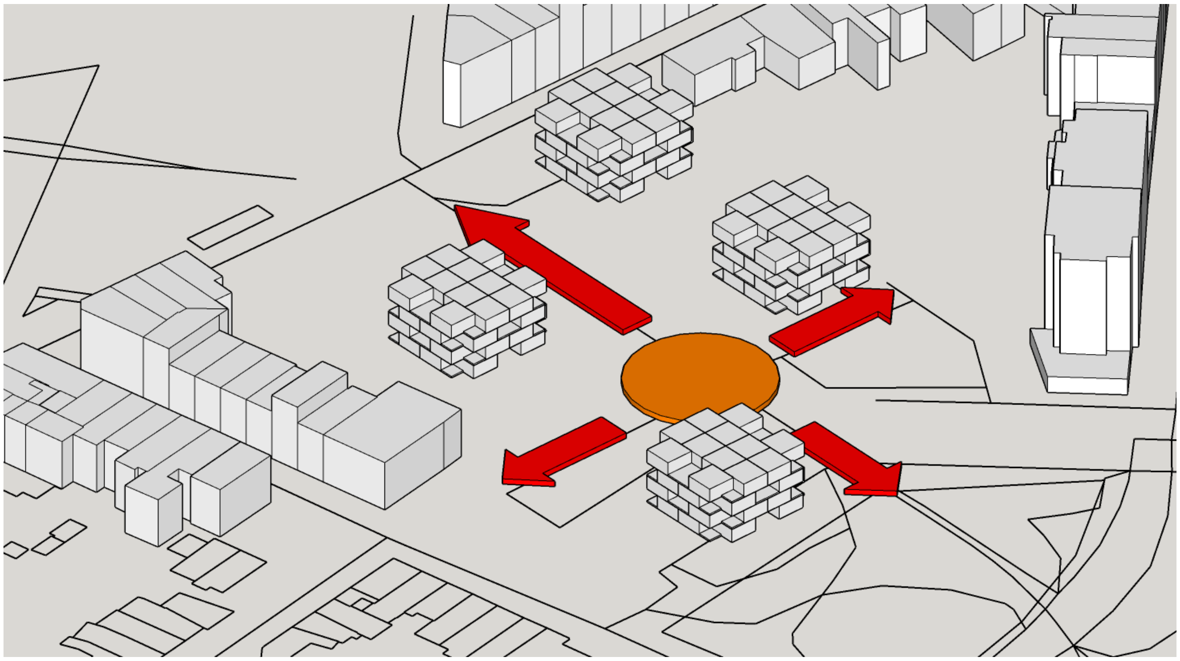

Figure 12- Site Access Diagram

Figure 15-Hand Sketch of the master plan

Environmental Considerations: The orientation and positioning of the buildings were strategically chosen based on solar and wind analyses to maximize natural lighting and ventilation. This reduces the reliance on artificial lighting and air conditioning, aligning with the project's energy efficiency goals.

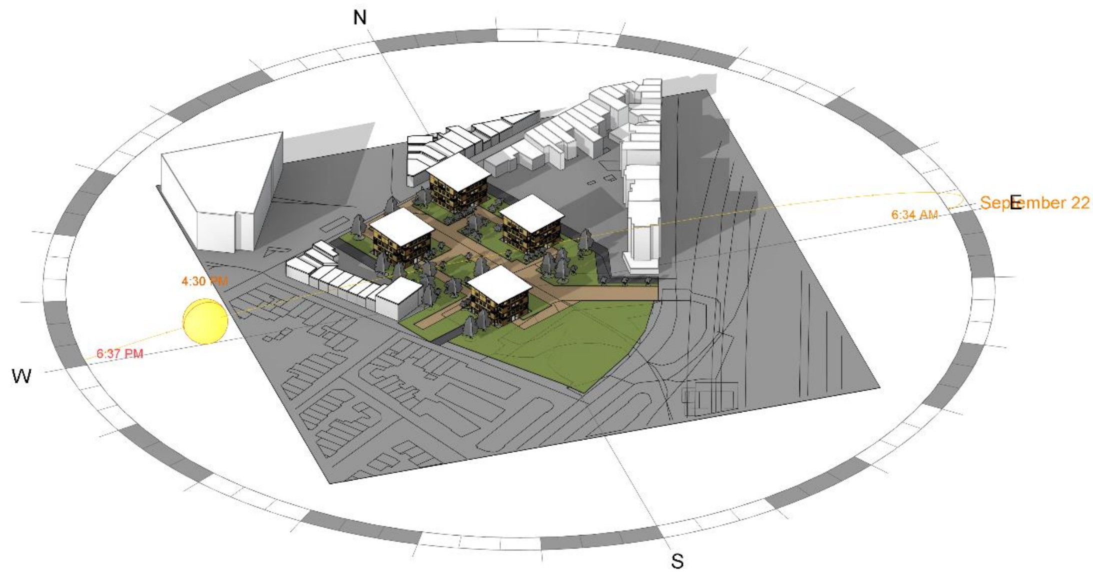

Figure 16-Solar Path Diagram on Site

Accessibility and Connectivity: The pedestrian pathways are integrated with the city's broader transit network, connecting directly to nearby mobility hubs. This integration encourages a car-free lifestyle among residents, supporting sustainability by reducing fossil fuel dependence and enhancing residents' quality of life through improved air quality and reduced traffic noise.

Community Spaces: The intersection of the pedestrian axes is designed as the main communal area, visible from the communal balconies of surrounding buildings. This setup not only fosters social interactions but also offers expansive views towards Lion City I, enhancing the sense of connection to the wider urban landscape. The communal areas are flexible, accommodating various activities that strengthen community bonds.

Figure 17-Site Plan

Figure 18-Viewer Perspective of the area

5.2 Micro-Unit Composition and Natural Lighting

The architectural design of the Lion City II project showcases innovative modular unit integration, forming efficient and compact micro-housing. Each micro-unit consists of three meticulously designed modules, which come together to optimize both space and functionality, reflecting enhanced layouts visible in the plans.

Module Configurations

Entrance and Service Module: This module strategically houses the entrance and bathroom facilities, maximizing space efficiency. The updated layout improves accessibility to these essential services directly from the entrance, enhancing convenience and eliminating the need for corridors within the unit.

Kitchen and Dining Module: Located immediately adjacent to the entrance module, this area facilitates a seamless transition to cooking and dining spaces. Its positioning adjacent to the entrance enhances the functional flow and accessibility, making it easier for residents to engage in cooking and dining activities upon entering the unit.

Living and Night Zone Module: This module serves as a combined living and sleeping area, crafted for flexibility and privacy. The thoughtful open plan supports various lifestyle needs and living arrangements, optimizing the use of space for relaxation and rest.

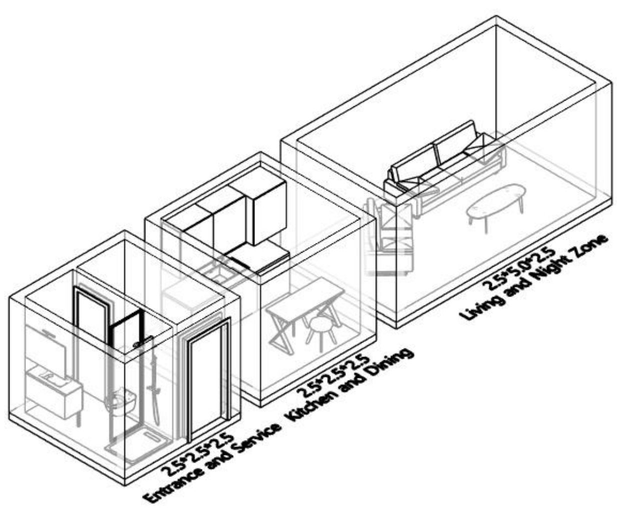

Figure 19-Primilinary Module Diagram

Natural Light and Ventilation: The design incorporates large openings on the northern and southern facades to ensure ample natural light and promote effective cross-ventilation, reducing reliance on artificial lighting and mechanical ventilation. In contrast, the eastern and western facades feature fewer openings to minimize solar heat gain during the mornings and evenings, thereby maintaining a comfortable internal temperature and enhancing the building's overall energy efficiency.

Figure 20- South Elevation

The strategic modular configuration and the thoughtful placement of openings are designed to create a harmonious living environment that maximizes environmental sustainability and supports modern urban living. This modular approach not only streamlines the construction process with prefabricated elements but also significantly reduces on-site construction time and environmental impact, illustrating a profound commitment to sustainable building practices.

5.3 Plans

The floor plans for the Lion City II project have been thoughtfully designed to enhance resident interaction and accessibility within each building block. Central to the layout is the strategic placement of communal balconies on both sides of each building, accessible to all residents. These balconies serve as vital communal spaces where residents can gather, enjoy the outdoors, and interact with their neighbors, thus fostering a strong sense of community.

Communal Balconies: Positioned on opposite sides of the building, these spacious balconies offer panoramic views of the surrounding area and Lion City I, creating an inviting atmosphere that encourages residents to come together. The design ensures that these areas are easily accessible from all units, promoting regular use and social interactions among the community members.

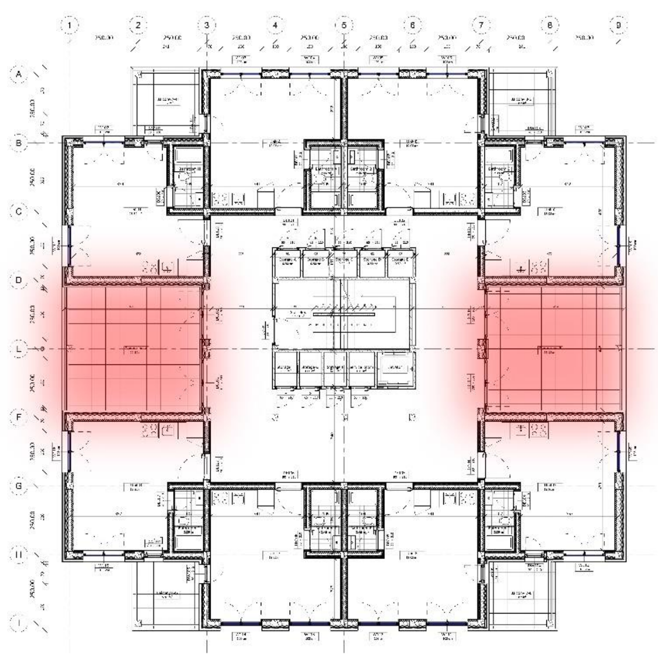

Figure 21-Floor Plan Showing Communal Balconies

Central Stair Box and Corridors: The stair box, located centrally within each building block, is surrounded by corridors that provide efficient and easy access to all units. This central positioning not only facilitates quick access to the communal balconies but also ensures that movement within the building is straightforward and safe.

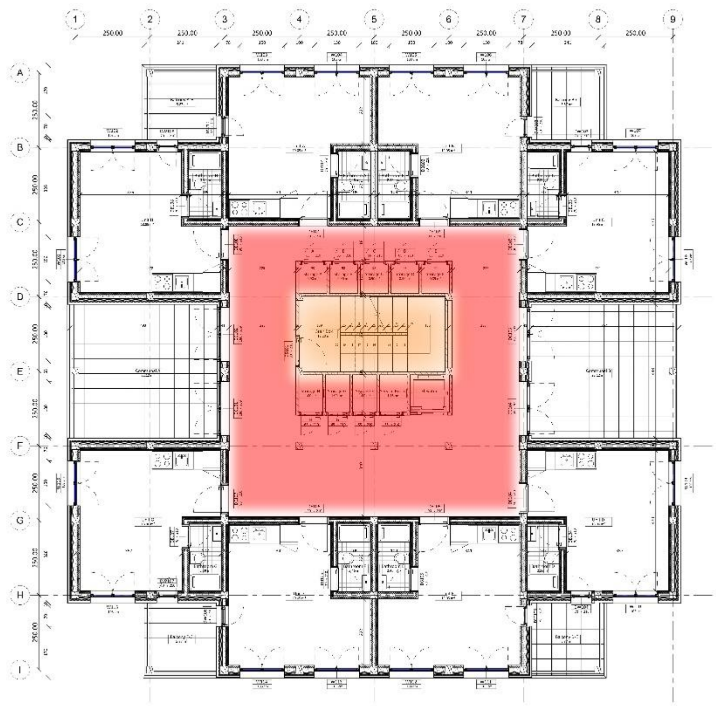

Figure 22-Floor Plan Showing Stair box and Corridors

These design choices reflect a commitment to creating a living space that balances private living quarters with communal areas, enhancing the quality of life for all residents by promoting a community-oriented environment.

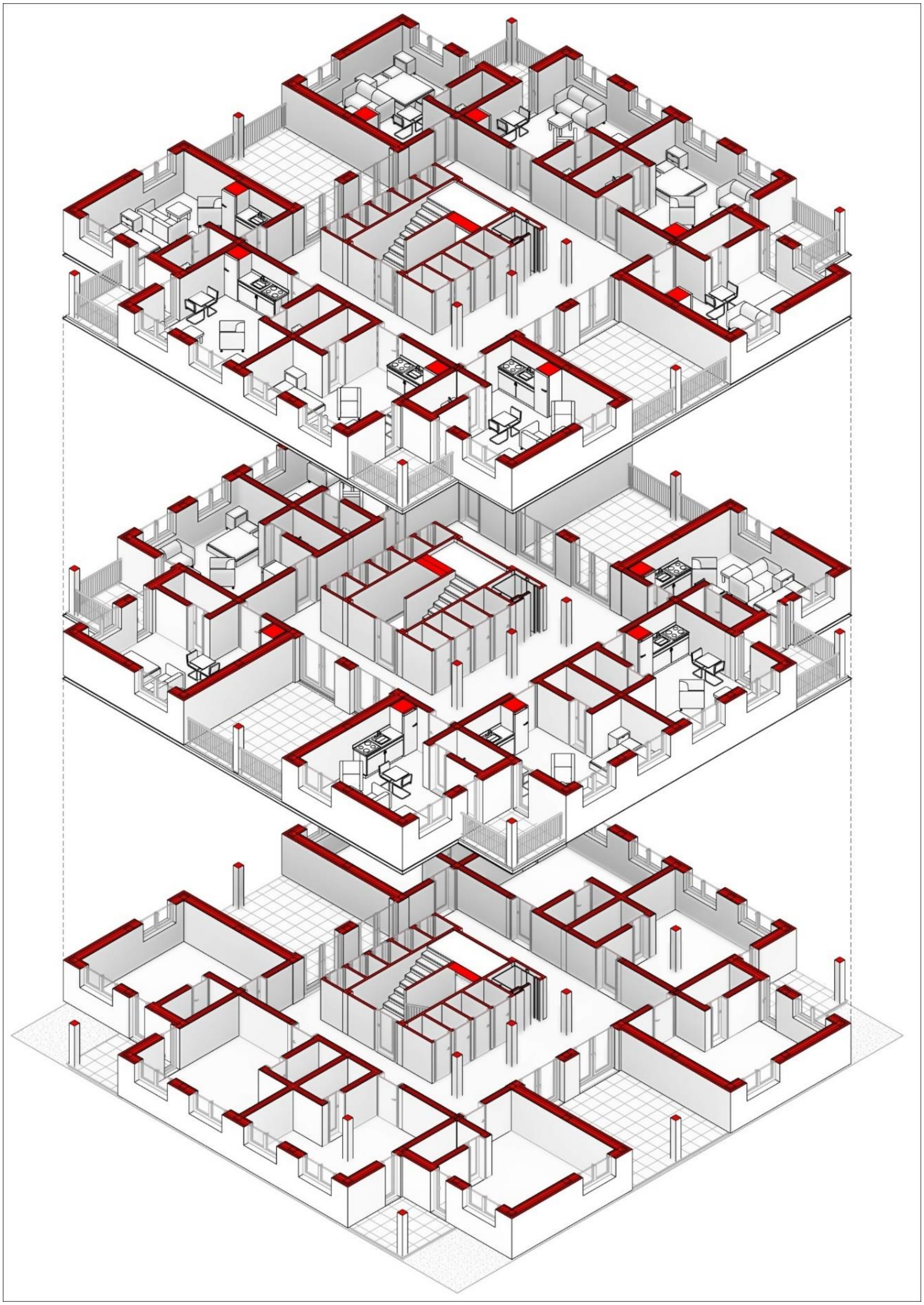

Figure 23 –Diagram of the Floors

5.4 Exterior Wall

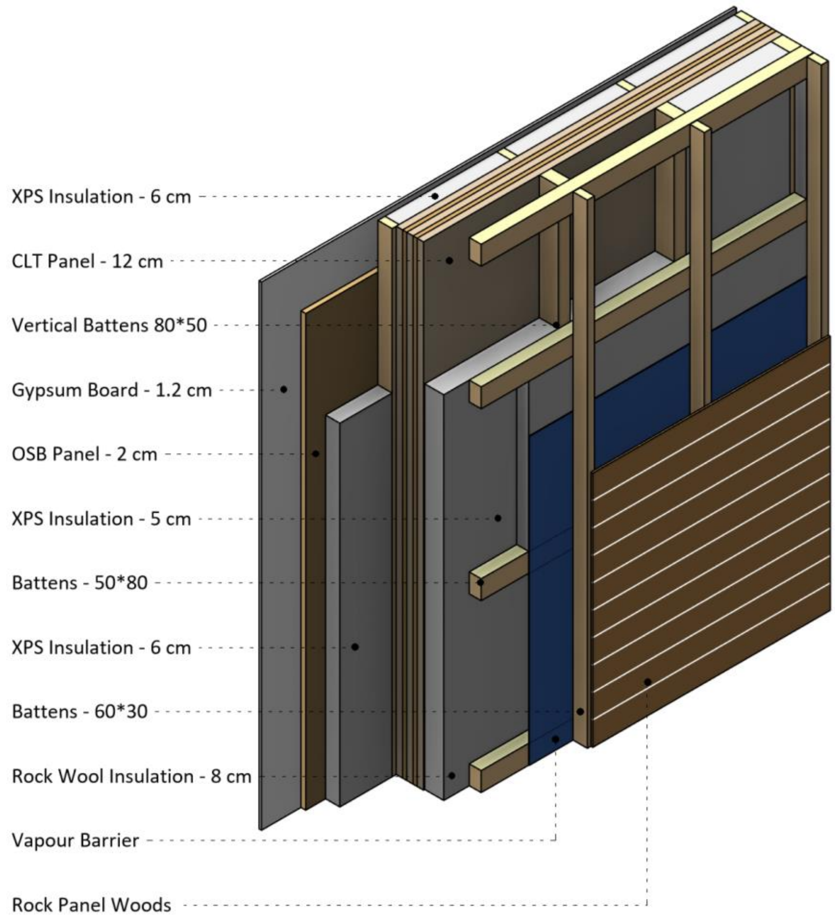

figure 24 – Diagram of the exterior wall

Material	Thickness[cm]	λ [$^{W}/_{m.k}$]	ρ [$^{kg}/_{m^3}$]	U - Value
Gypsum Board	1	0.25	800	0.146
OSB Panel	2	0.13	600	
XPS Insulation	6	0.035	30	
Rock Wool Insulation	8	0.035	150	
Rock Panel	1	2	2500	
CLT Panel	12	0.13	500	

Table 1 – Physical characteristics of the exterior wall

5.5 Interior Wall

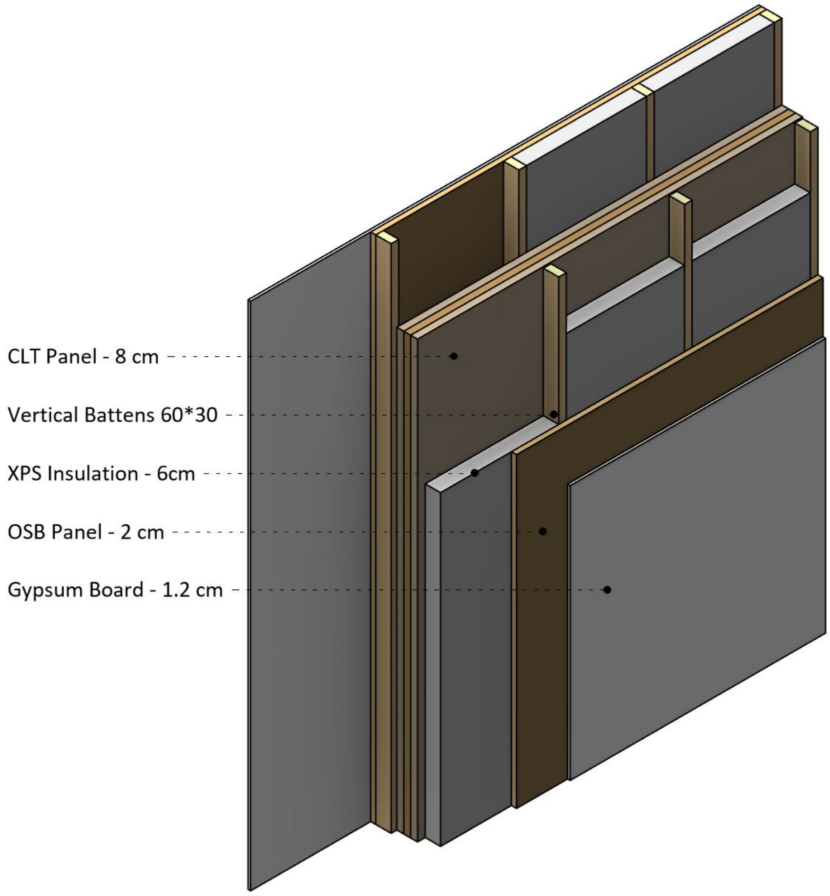

figure 25– Diagram of the interior wall

Material	Thickness[cm]	λ [$^{W}/_{m.k}$]	ρ [$^{kg}/_{m^3}$]	U - Value
Gypsum Board	1	025	800	0.226
OSB Panel	2	0.13	600	
XPS Insulation	6	0.035	30	
CLT Panel	8	0.13	500	

Table 2 – Physical characteristics of the interior wall

5.6 Bathroom Wall

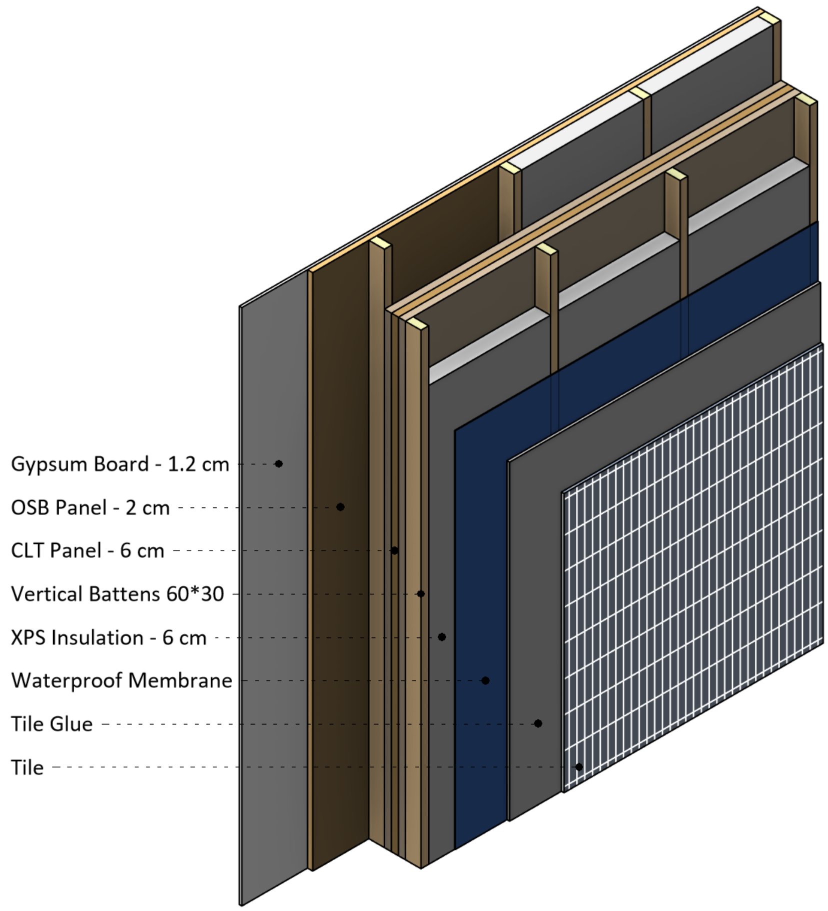

figure 26 – Diagram of the bathroom wall

Material	Thickness[cm]	$\lambda\ [^{W}/_{m.k}]$	$\rho\ [^{kg}/_{m^3}]$	U - Value
Gypsum Board	1	025	800	0.243
OSB Panel	2	0.13	600	
XPS Insulation	6	0.035	30	
CLT Panel	8	0.13	500	
Ceramic Tile	1.2	1.3	2000	

Table 3 – Physical characteristics of the Bathroom wall

5.7 Roof

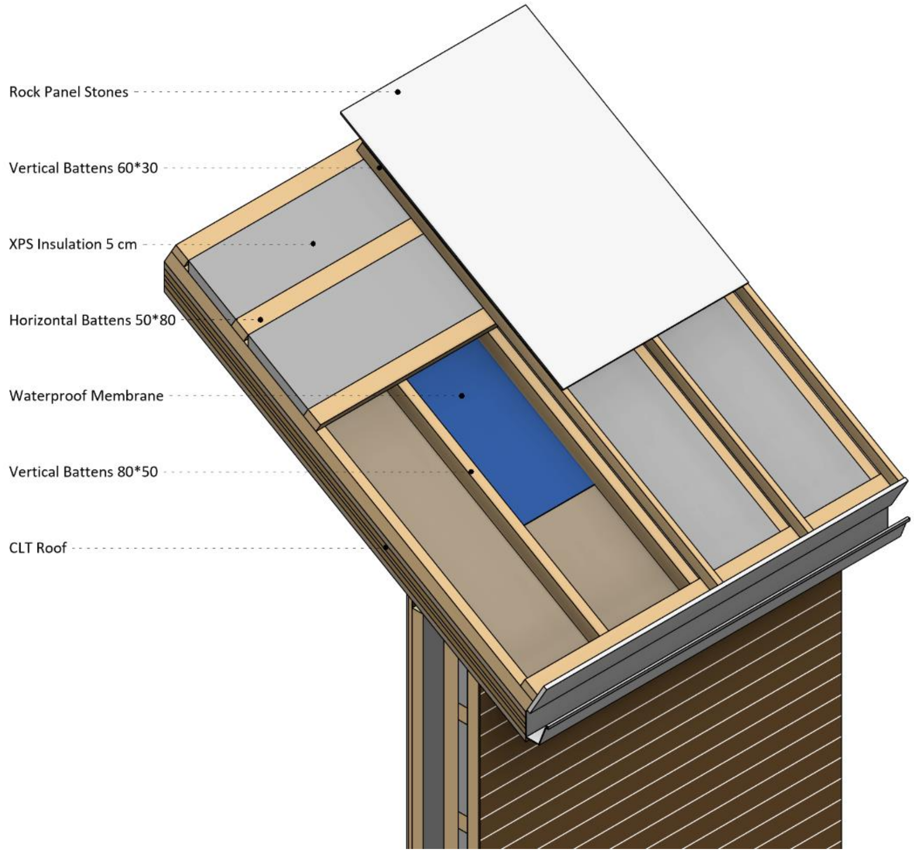

figure 27 – Diagram of Roof

Material	Thickness[cm]	λ [$^{W}/_{m.k}$]	ρ [$^{kg}/_{m^3}$]	U - Value
Rock Panel	1	2	2500	0.243
Air Cavity	6	-	-	
XPS Insulation	5	0.035	30	
Rock Wool Insulation	5	0.035	150	
CLT Roof	14	0.13	500	

Table 4 - Physical characteristics of the roof

5.8 Separating Floor

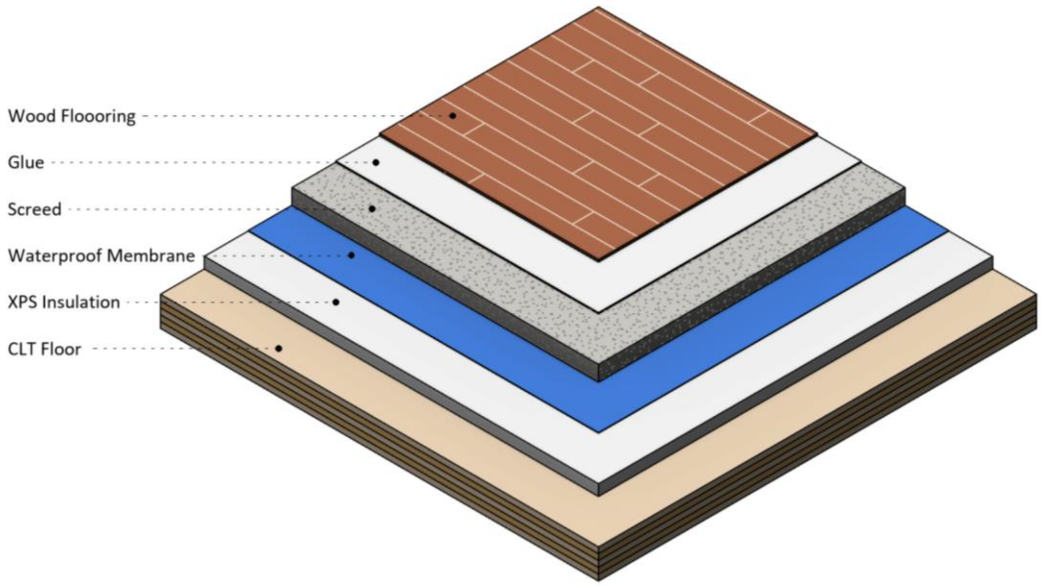

figure 28 – Diagram of the Separating Floor

Material	Thickness[cm]	λ [$W/m.k$]	ρ [kg/m^3]	U - Value
Wood Floor	1.2	0.13	400-600	0.375
Wood glue	1	0.5	1500-1800	
Screed	7	1.4	2200	
Insulation	5	0.035	30	
Clt Floor	14	0.13	500	

Table 5 - Physical characteristics of the Separating floors

5.9 Bathroom Floor

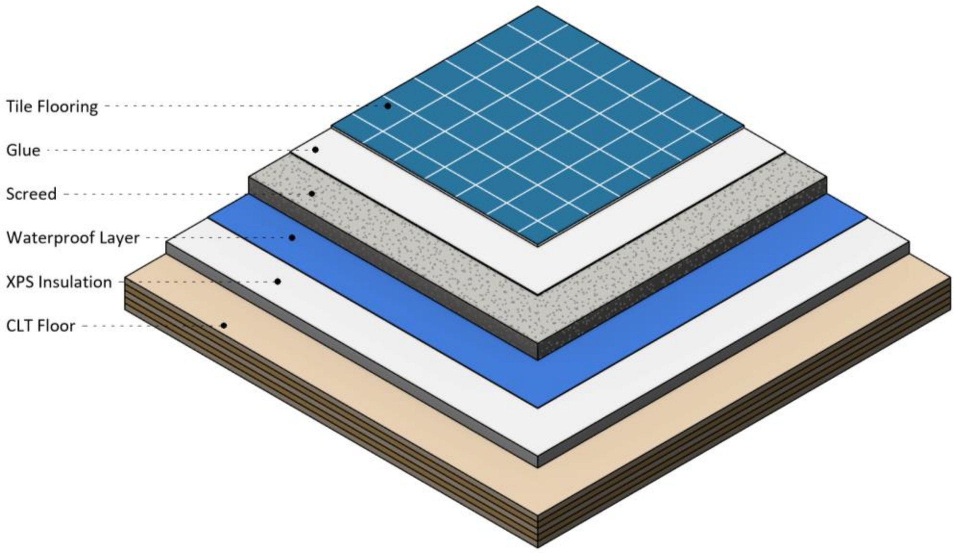

figure 29 – Diagram of the bathroom floor

Material	Thickness[cm]	λ [$^{W}/_{m.k}$]	ρ [$^{kg}/_{m^3}$]	U - Value
Flooring Tile	1.2	1.3	2300	0.378
Ceramic glue	1	0.5	1500-1800	
Screed	7	1.4	2200	
Insulation	5	0.035	30	
Clt Floor	14	0.13	500	

Table 6 - Physical characteristics of the Bathroom floor

CONCLUSION

This thesis represents a substantial advancement in sustainable urban housing, showcasing how Cross-Laminated Timber (CLT) can revolutionize construction methods to meet contemporary demands for affordability, sustainability, and community-centric living. The project, inspired by the Kingspan Micro House competition and the C40 Cities challenge, not only adheres to but advances the principles of modular design and environmental consciousness, setting a precedent for future developments in the field of architecture.

The architectural and technical choices made throughout this project emphasize the viability and efficiency of CLT, particularly in urban settings where space and resources are limited. The use of CLT and the incorporation of Rothoblaas connection systems have demonstrated significant benefits in structural integrity, environmental impact, and aesthetic flexibility. The building's design, featuring a ventilated facade system, highlights a forward-thinking approach to energy efficiency, enhancing thermal performance and moisture management.

Furthermore, the project has successfully integrated communal spaces that foster social interactions, thereby enriching the community fabric. This aspect of the design underscores the role of architecture in enhancing quality of life and promoting social cohesion.

Challenges encountered during the design and implementation phases, such as integrating the modular housing units with the existing urban fabric, were addressed with innovative solutions that did not compromise the project's environmental or aesthetic goals. These solutions not only resolved practical and logistical issues but also provided valuable insights into the scalability and adaptability of modular housing in different urban contexts.

The implications of this research are far-reaching, offering a blueprint for future projects that aim to balance density, sustainability, and livability. It encourages urban planners and architects to embrace CLT and modular construction not just as alternatives, but as preferred methods that align with global sustainability targets and urban development strategies.

REFERENCE

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[2] C40 Cities. (n.d.). C40 Cities Climate Leadership Group. Retrieved [15.09.2024], from https://www.c40.org/

[3] Rothoblaas. (n.d.). Rothoblaas - Solutions for Timber Construction. Retrieved [20.10.2024], from https://www.rothoblaas.com/

[4] Rockpanel. (n.d.). Rockpanel - Pannelli per facciate ventilate. Retrieved [11.11.2024], from https://www.rockpanel.com/it/

ANNEX 1

- **Drawings**

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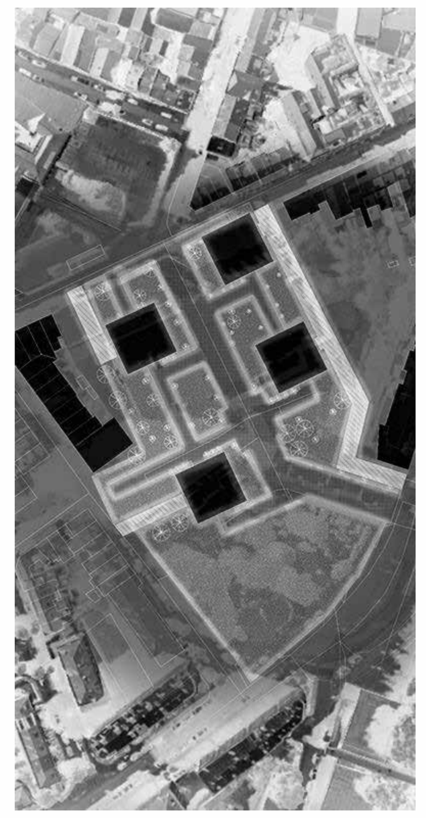
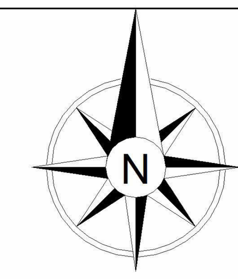
Tutor : Marika Mangosio





Master Plan

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Checked by	M.Mangosio

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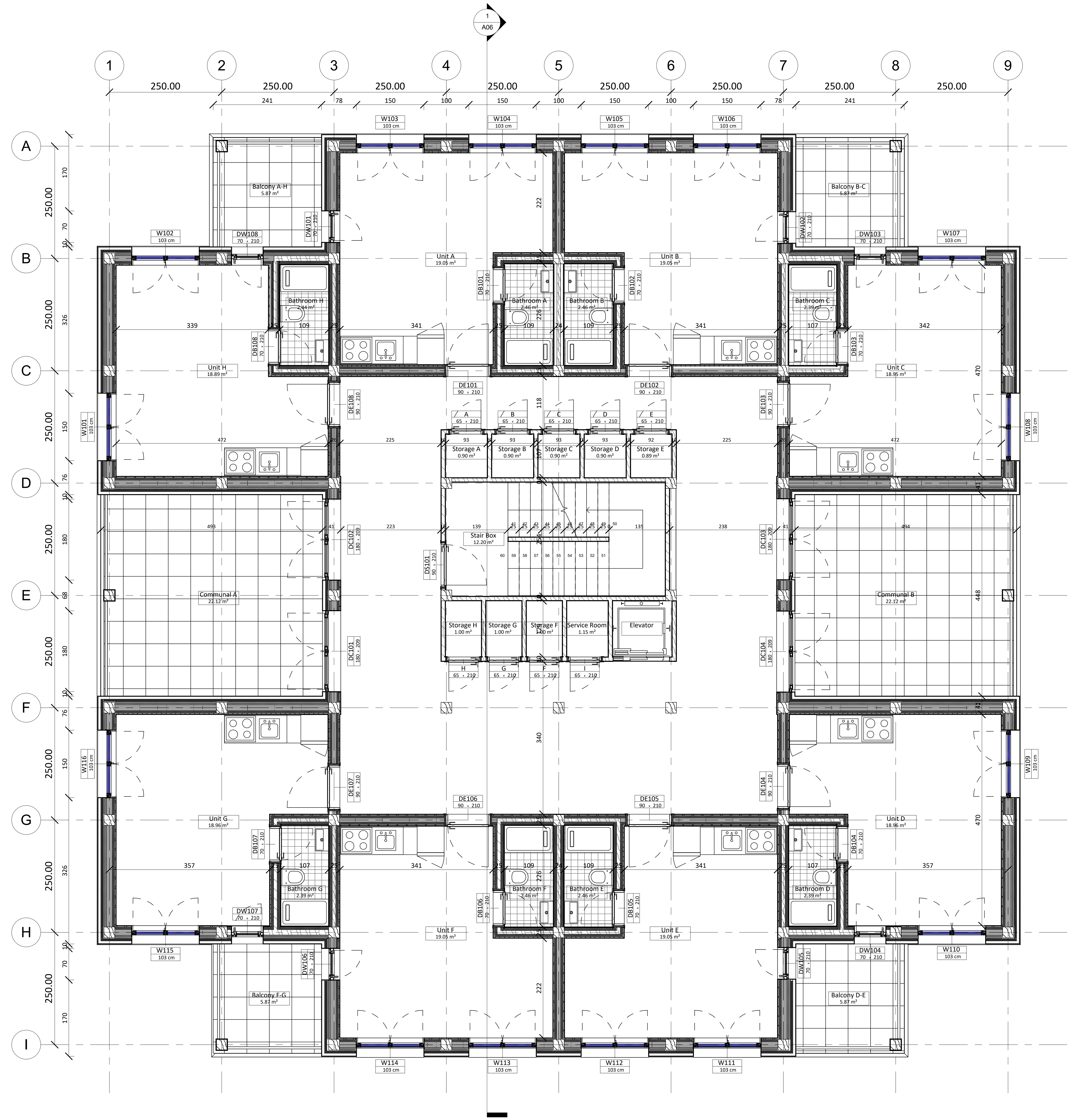

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First & Third Floor DIM

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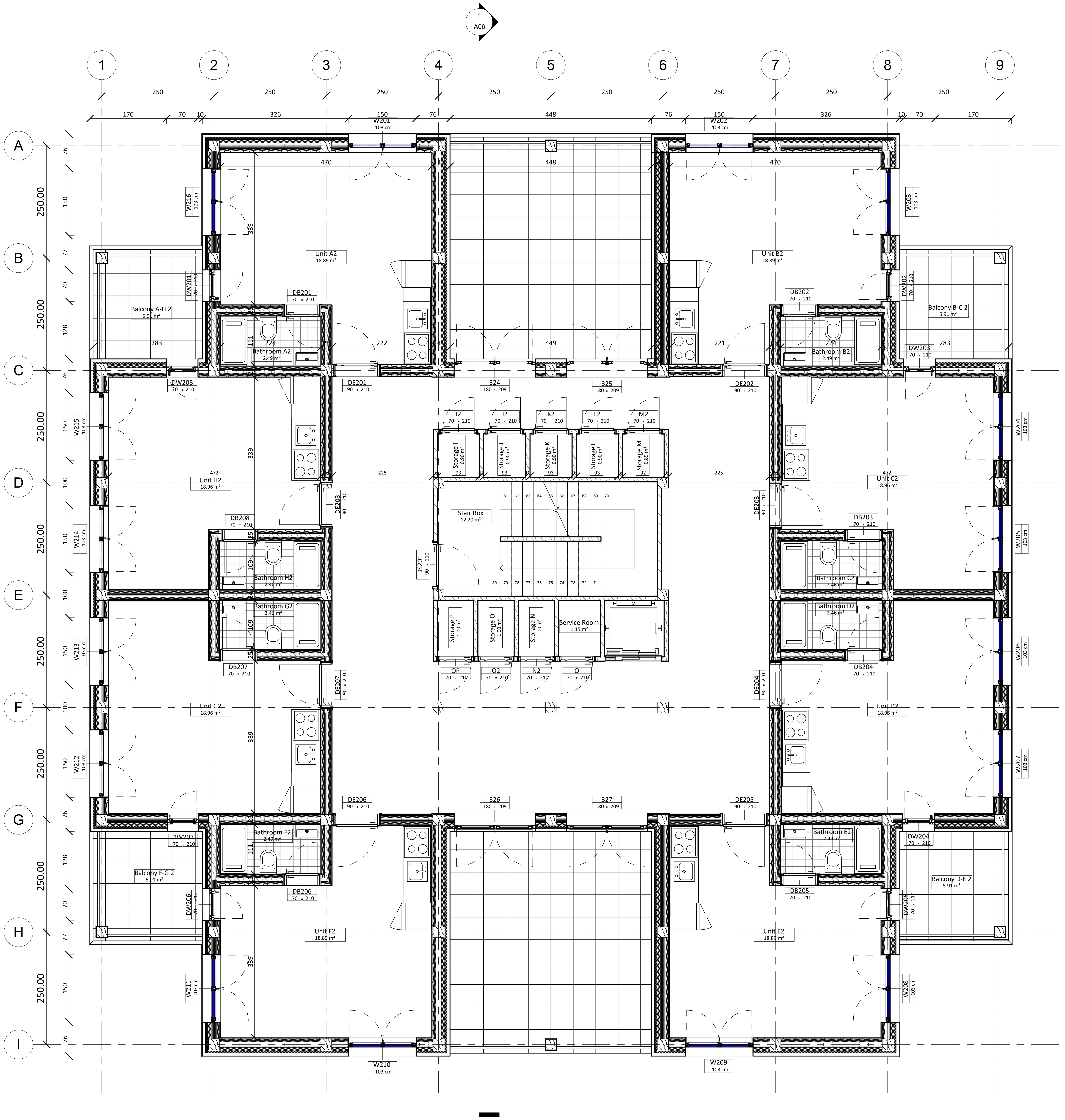

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Ground & Second Floor DIM

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North & South Elevation

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A-04

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West & East Elevations

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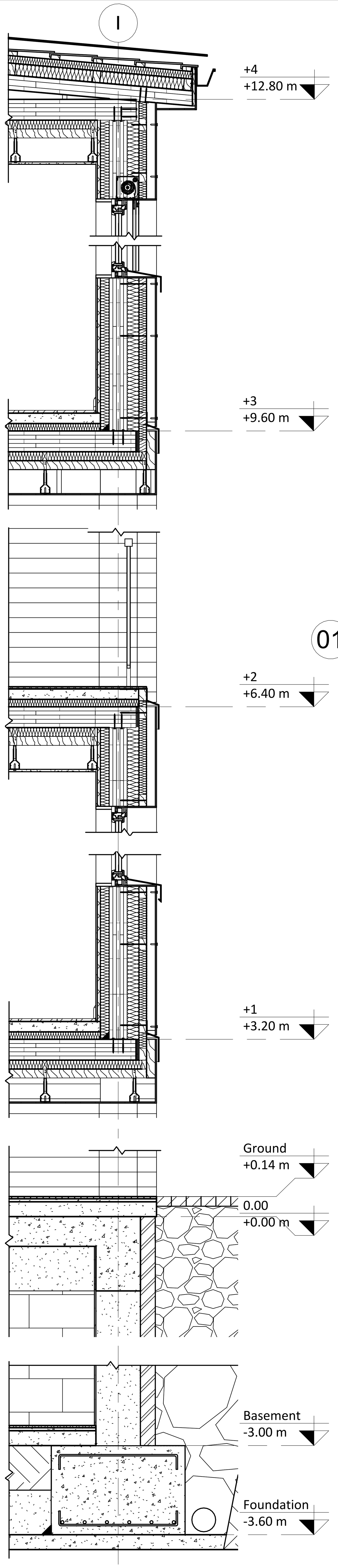

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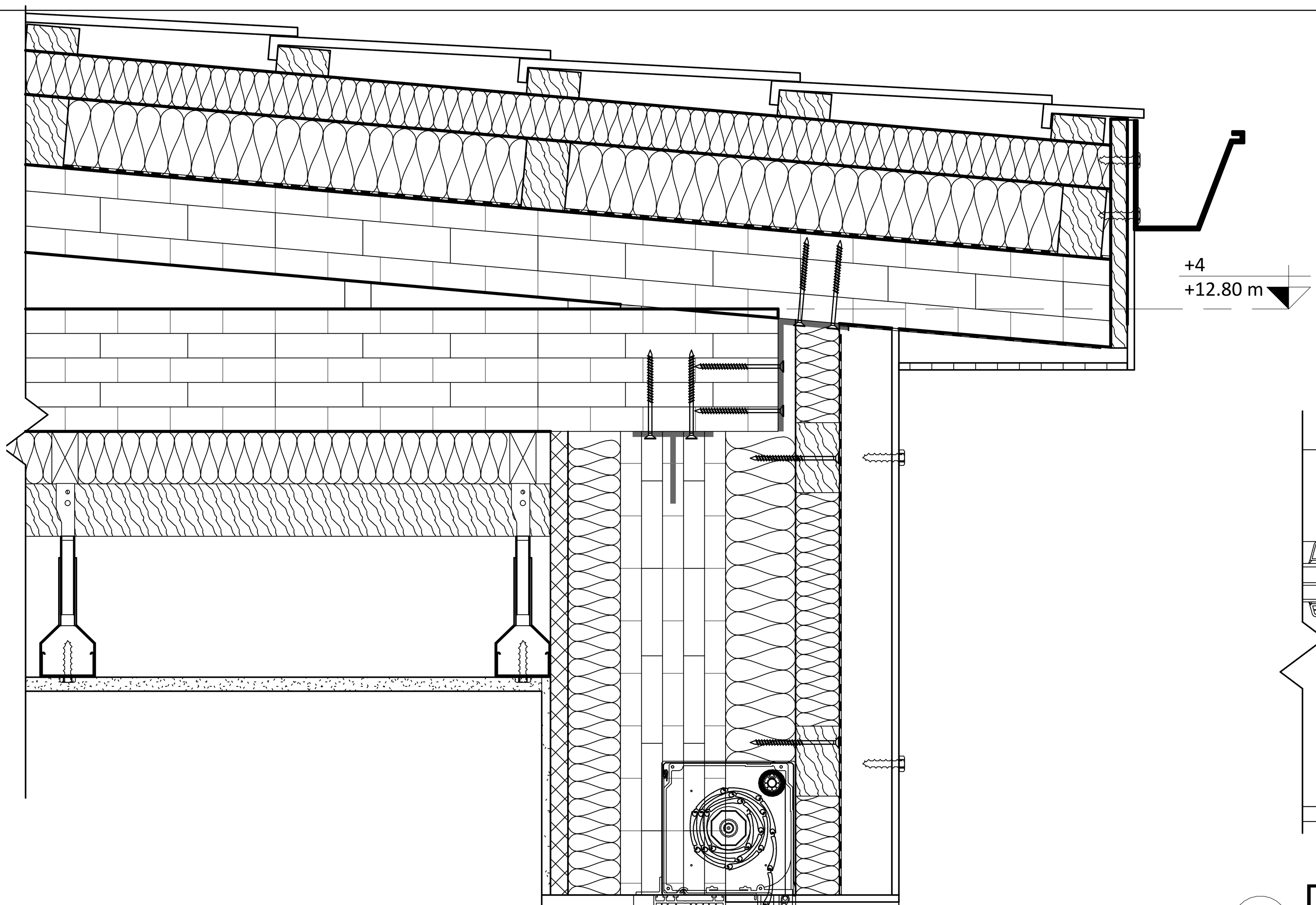

01 DET 101-Roof
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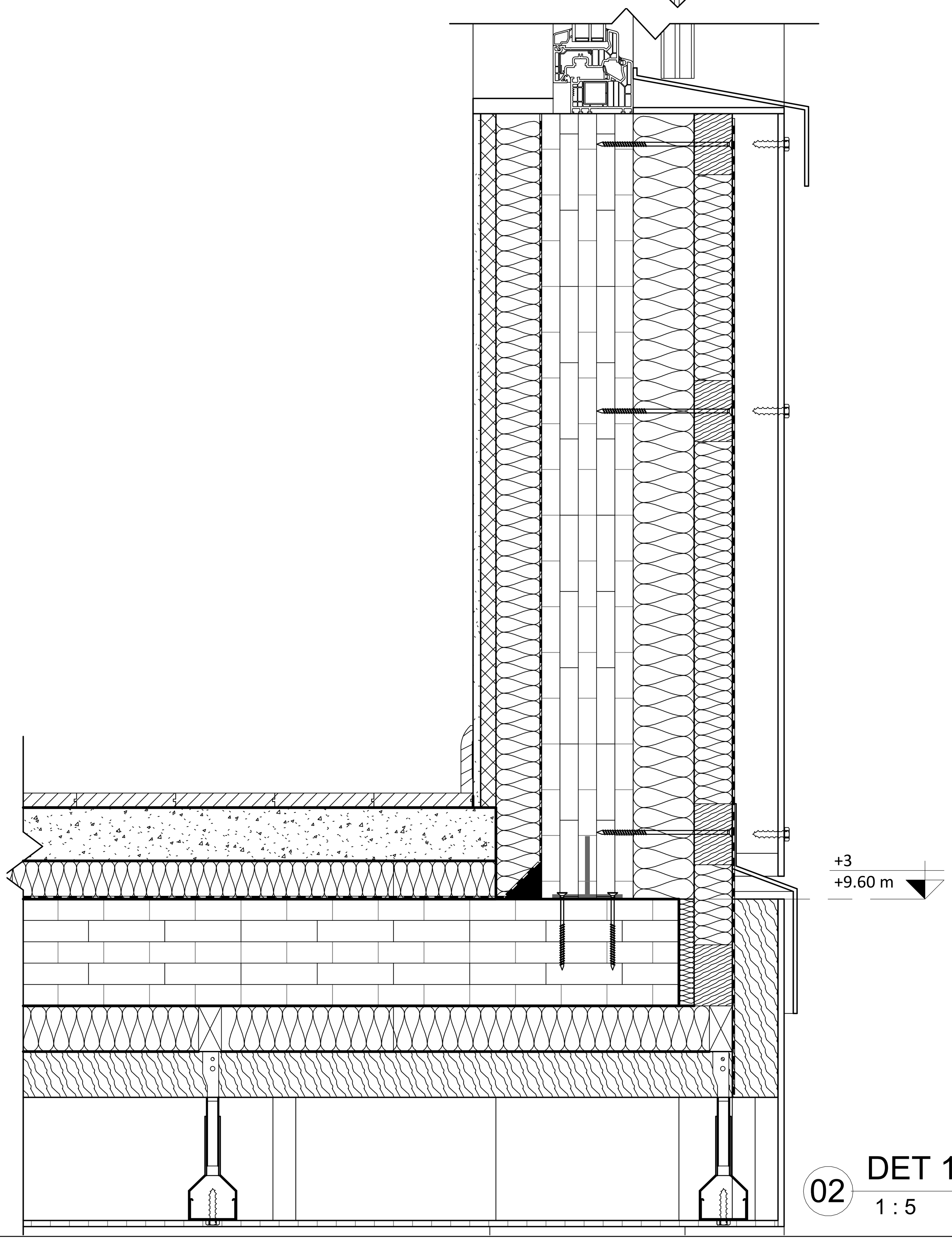

02 DET 102-Bottom of Window
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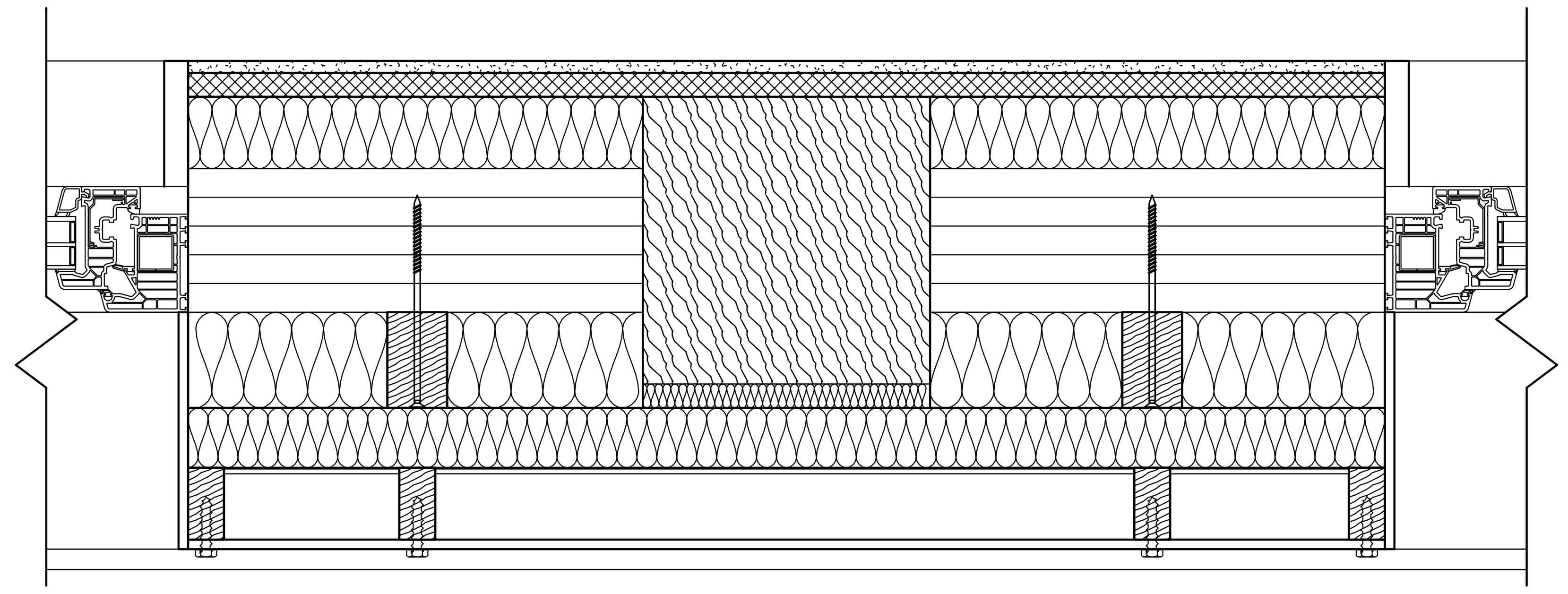

04 DET 104-Plan View
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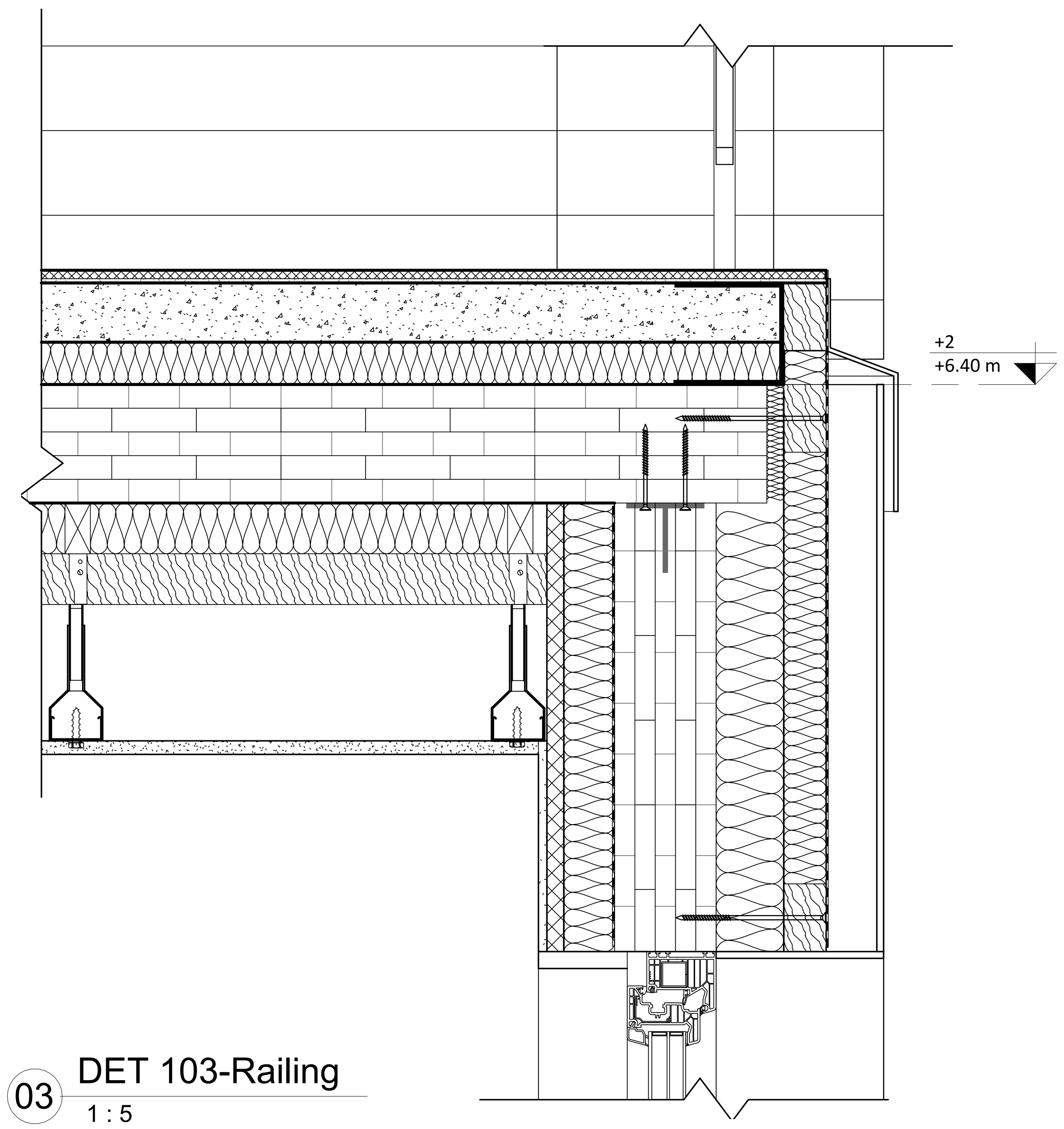

03 DET 103-Railing
1 : 5

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Wall Section

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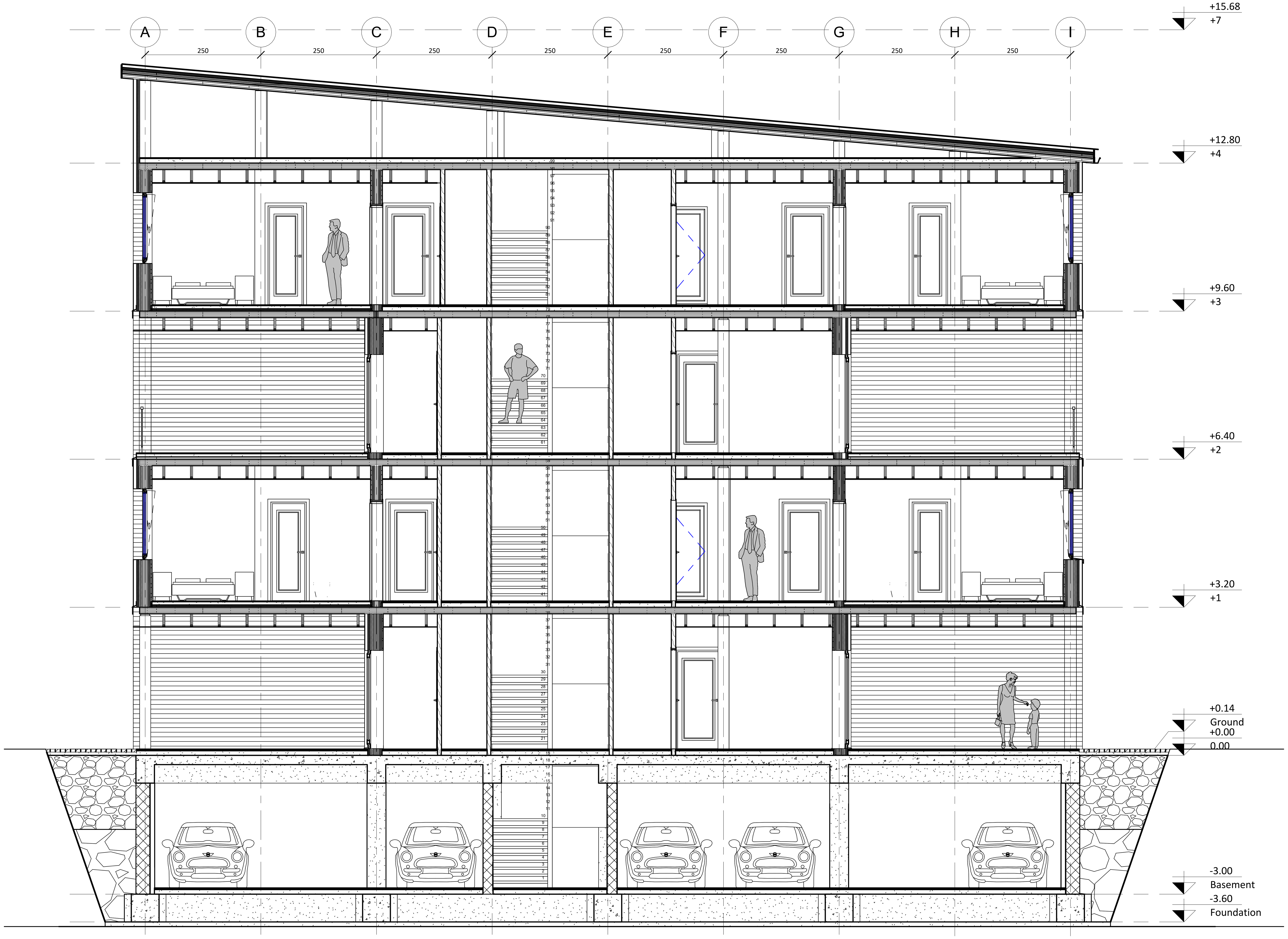

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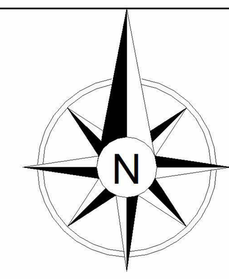

SECTION A-A

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