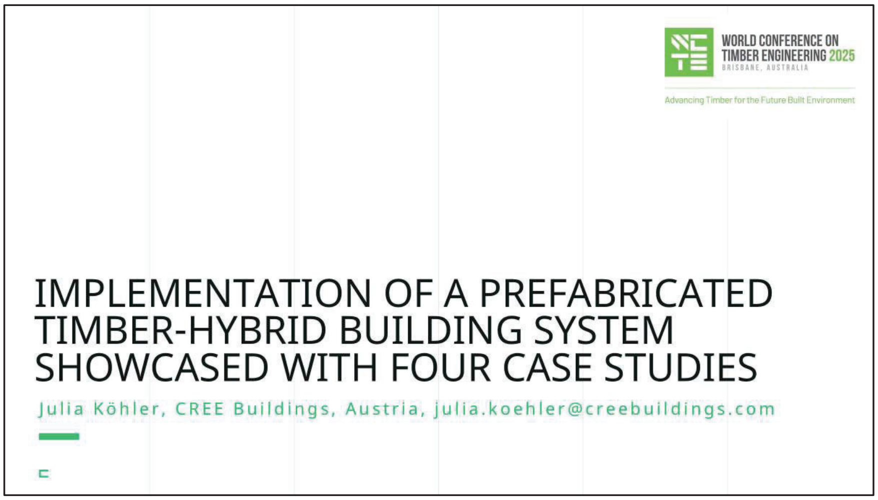

In the face of climate crises and urbanization, the construction industry has to provide regenerative multistorey building solutions at a rapid pace. Timber as a building material, clever designs, and prefabrication address these challenges effectively and seem like the obvious solution. However, given the slow pace of the construction industry, several factors create obstacles on this path. These include limited production capacities, international availability, price disparities, existing standards, and the openness and willingness of designers and constructors to adopt new solutions. Consequently, designs for prefabricated timber solutions rarely win out against traditional concrete and steel designs. In this context, CREE has developed a prefabricated timber-hybrid building system that leverages the benefits of prefabrication and the sustainability of timber while integrating traditional concrete and steel to meet existing performance standards to bridge the gap towards sustainable building solutions.

This paper presents four case studies that were designed using this timber-hybrid system. The entire process, from design to the use of the buildings, is critically analyzed and compared to traditional building methods and mass-engineered timber solutions.

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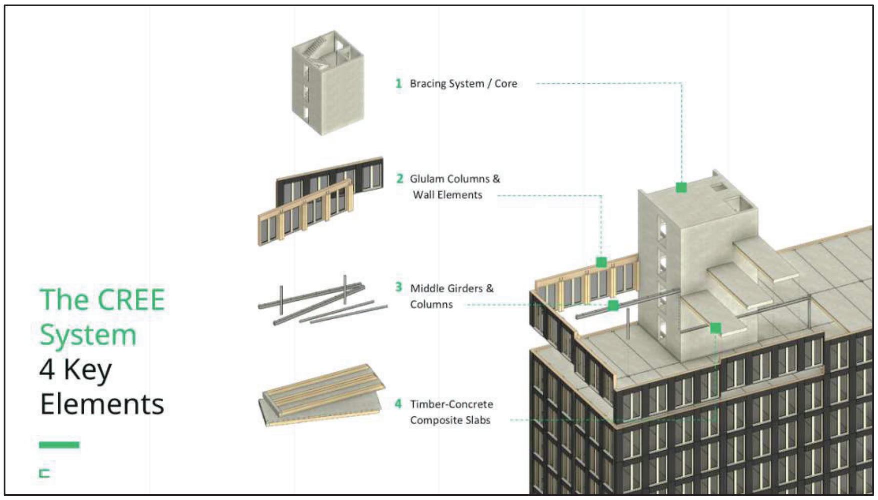
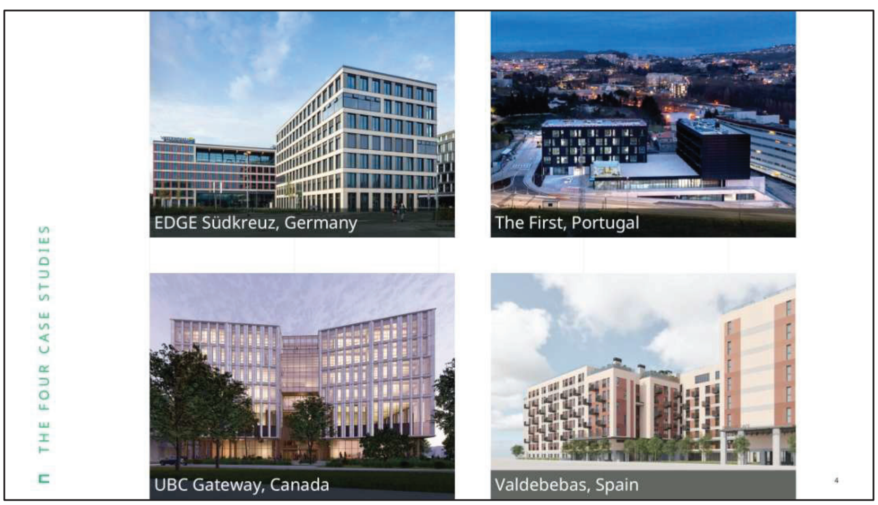


Originating from a 2008 research project, the CREE system is now utilized globally. It uses fully prefabricated components for efficient manufacturing, featuring a concrete core for lateral stability, glulam columns for vertical load transfer, middle girders for greater building depths, and timber-concrete composite slabs. Non-load-bearing timber-frame walls are directly attached to the glulam columns, facilitating rapid assembly of 400-500 square meters of enclosed floor space per day. The timber-concrete composite combines the advantages of both materials: timber provides a lighter structure, CO2 storage, and high tension resistance, while concrete improves performance in terms of vibration and acoustics due to its weight. This composite approach uses materials resource-efficiently, significantly reducing CO2 emissions.



The four chosen projects showcase the use of the prefabricated timber-hybrid system across various asset classes, highlighting its adaptability and innovative applications. Each project demonstrates unique structural and architectural solutions tailored to different geographic and environmental contexts.

EDGE Südkreuz in Berlin features advanced structural solutions like Steel Vierendeel trusses and steel transfer beams in a high-performance office building. The First in Guimaraes demonstrates the system's versatility with comparative structural core designs and extensive prefabrication. UBC Gateway in Vancouver addresses seismic design challenges and local material supply issues through international collaboration. Valdebebas in Madrid sets a precedent for high-rise timber-hybrid constructions in Spain.

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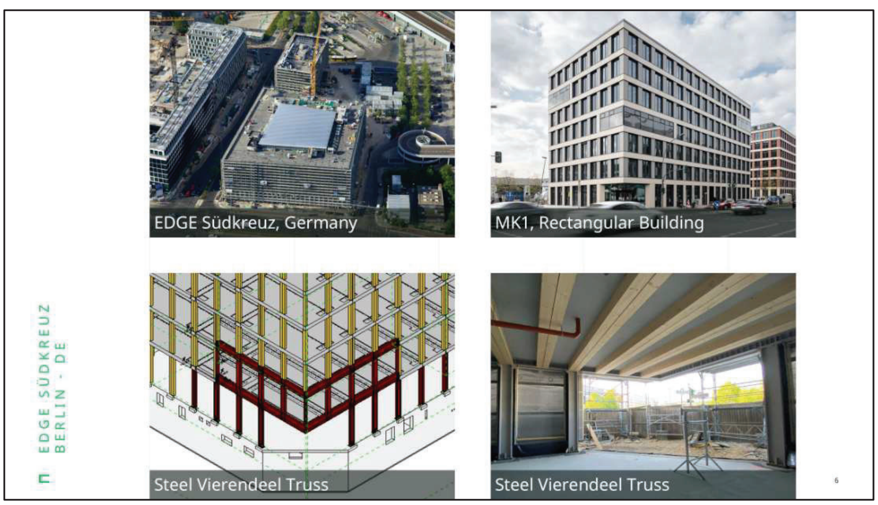

Completed in 2022 in Berlin, the EDGE Südkreuz project consists of two office buildings: MK1 (seven stories) and MK2 (eight stories). With a total area of 32,000 square meters, it holds Germany's highest DGNB score. Both buildings feature unique architectural elements. MK1, a rectangular structure, includes a cantilevered corner on the ground floor supported by a Steel Vierendeel truss. To enhance resilience against progressive collapse, some glulam columns were replaced with steel ones.

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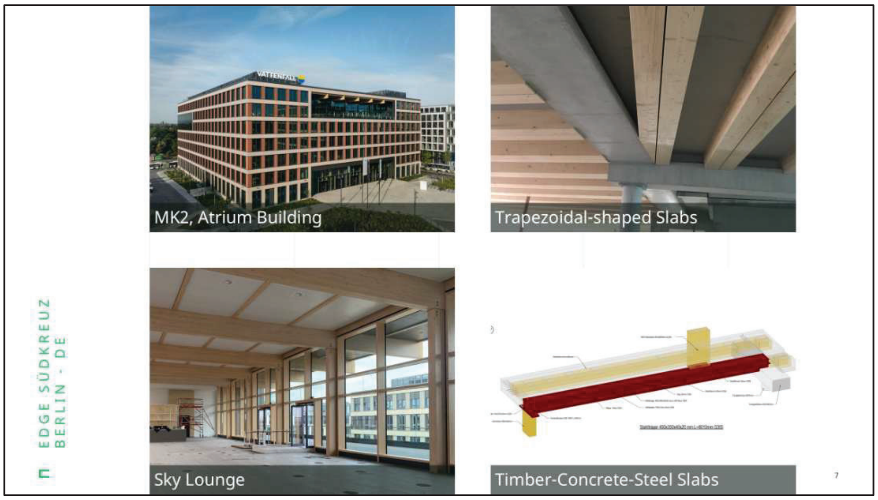
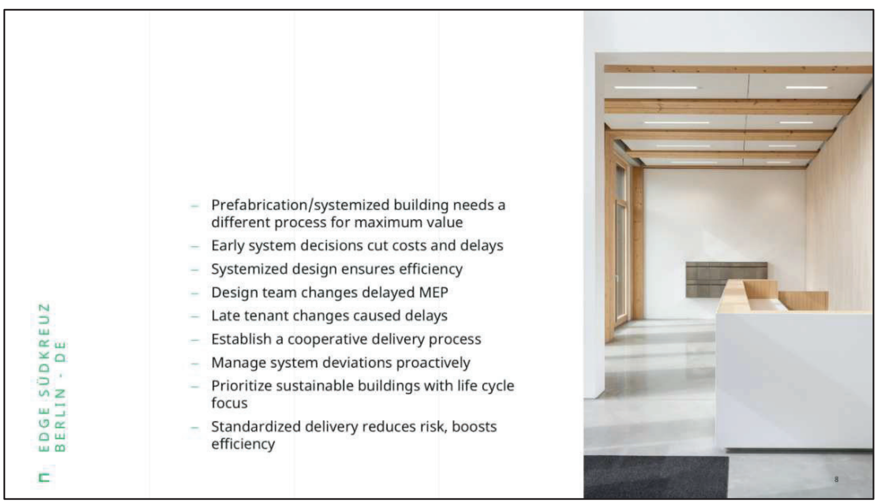


MK2 boasts an atrium and a timber sky lounge, requiring innovative solutions such as steel transfer beams in timber-concrete composite slabs to manage additional point loads without increasing slab depth. The atrium's design necessitated trapezoidal-shaped timber-concrete composite slabs due to angular building blocks.



Prefabricated and systemized building methodologies necessitate a distinct governance framework and delivery process to optimize value compared to conventional construction approaches. Early determination of the building system is critical to minimizing unnecessary design costs and mitigating schedule disruptions. A systemized approach from project inception enhances design efficiency and integration. For the Südkreuz project, modifications in the design team resulted in delays in MEP engineering, while late-stage tenant-driven interior design changes further impacted the project timeline. To address these challenges, a cooperative project delivery framework should be implemented to streamline coordination and decision-making. Deviations from standardized system solutions are feasible but require proactive, centralized management to ensure consistency and performance adherence. Sustainable buildings should be prioritized with a strategic emphasis on life cycle cost optimization. Furthermore, the implementation of standardized and repeatable project delivery methodologies reduces risk exposure while enhancing overall efficiency and profitability.

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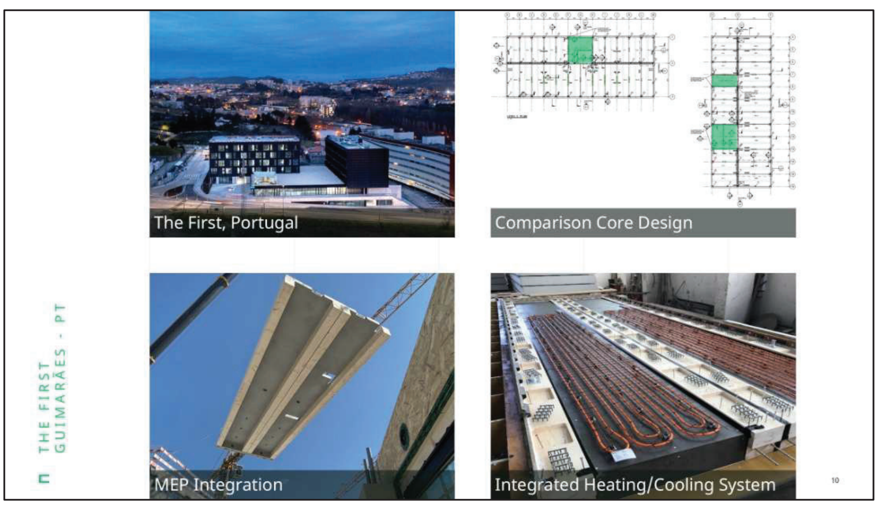

"The First" is a hotel development in Guimaraes, encompassing 8,300 square meters across five stories. It is the first timber-hybrid building on the Iberian Peninsula and the first CREE building in an earthquake zone. The project comprises two identical buildings, differentiated by their structural cores: one with a single concrete core and the other with two concrete cores, allowing for comparative analysis of the diaphragms. Element fabrication processes were established from scratch, and the buildings include fully prefabricated MEP components and distribution racks. Prefabricated bathroom modules were lifted into place during the structural assembly.

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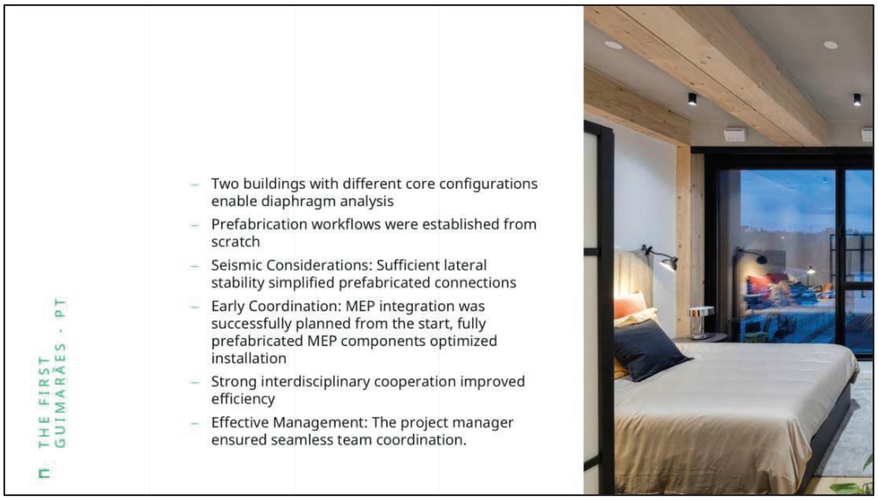

The project consists of two identical buildings with different core configurations—one with a single concrete core and the other with two—allowing for a comparison of the diaphragms. Sufficient elements for bracing lower the amount of connectors between the prefabricated elements drastically. Fabrication processes were developed from scratch, and the buildings include fully prefabricated MEP components, distribution racks, and bathroom modules, all integrated during structural assembly.

Early integration of MEP systems was effectively managed. The project followed a collaborative design process, with the project manager ensuring all relevant teams, including the prefabricator, were involved in key meetings to ensure smooth coordination.

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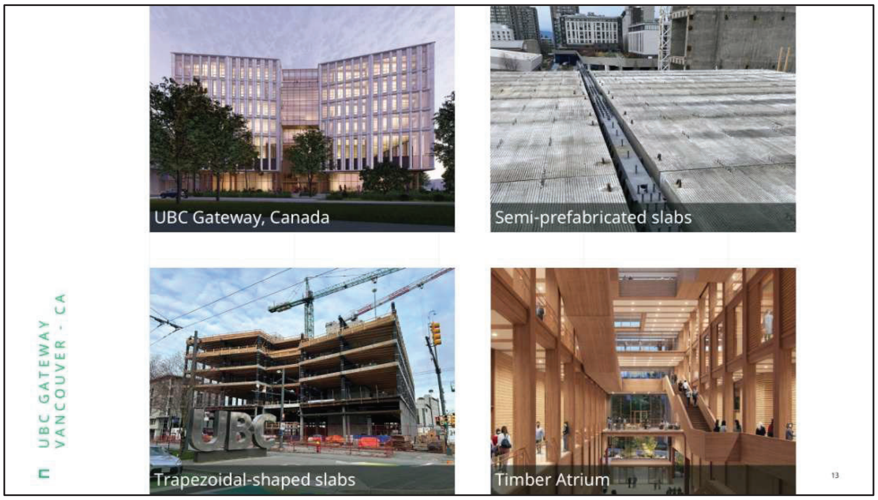
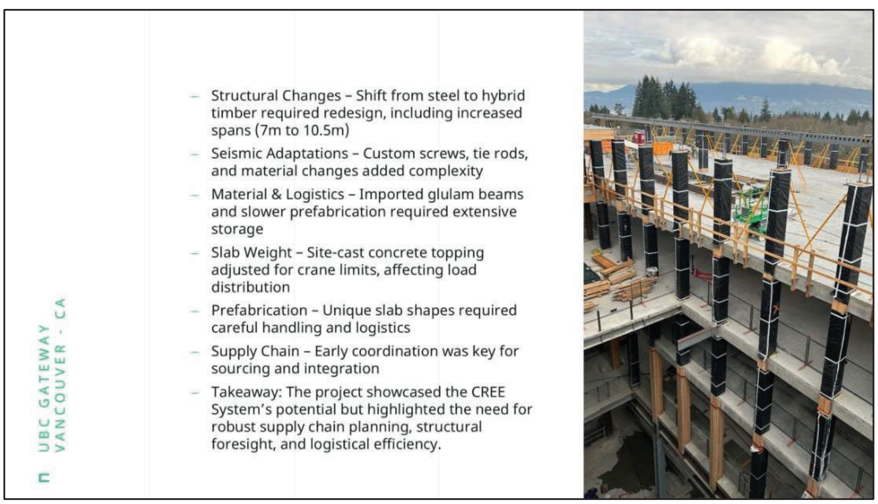


The UBC Gateway, a health science academic and research building, is located at the historic entrance to the University of British Columbia's Point Grey campus in Vancouver. Designed by Perkins&Will in collaboration with Schmidt Hammer Lassen, the 25,000 square meter building includes wet and dry labs, clinical spaces, lecture theatres, classrooms, gym and fitness facilities, as well as office and administrative areas. Unique design challenges included pushing slab dimensions to 3.00 meters by 10.50 meters. Due to crane capacity limitations, the concrete slab was split into off-site and on-site parts, reducing construction speed but improving diaphragm creation due to Vancouver's high seismicity. The local supply of glulam and coordination among numerous design parties were significant challenges. The building has 6 floors above ground.



The UBC Gateway project faced challenges in transitioning to the CREE System, requiring structural modifications, seismic detailing, and careful logistics. Expanding spans from 7m to 10.5m eliminated a column line but required wider glulam beams and reinforced slab supports. Seismic resilience was addressed with specialized fasteners and tie rods to prevent displacement.

Prefabrication lagged behind on-site installation, necessitating extensive storage and custom handling for uniquely shaped slabs. Crane limitations required separating a 75mm concrete topping for site casting, which also enhanced seismic stability. Supply chain constraints, particularly in sourcing wider glulam beams, highlighted the need for early coordination. Despite these challenges, the project proved the CREE System's adaptability to long spans and seismic demands, offering key insights for hybrid construction.

Currently under construction, this project by DAZIA CAPITAL and AERMONT CAPITAL in Madrid's Valdebebas district addresses Spain's growing housing demand. It comprises 500 flats and will rank among the largest CREE system buildings globally, second largest in Europe, and one of Spain's tallest industrialized structures at eight stories. The design incorporates two system variations: standard, integrating a concrete edge beam directly into timber-concrete composite slabs, and detached, allowing for greater column spacing and linear support conversion. Instead of timber-frame walls, prefabricated concrete walls attach directly to glulam columns. This project is the first CREE building to feature balconies.

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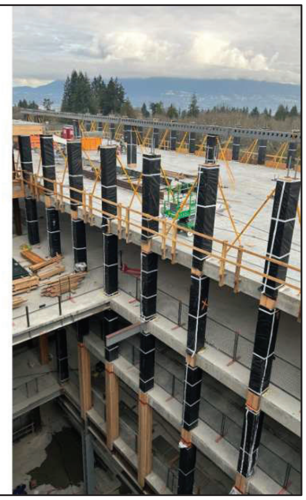
VALDEBEBAS
MADRID - ES

- Time-Sensitive Execution: Rapid design, early completion, and lean principles ensured efficiency
- Design Adaptability: 90% modular standardization, increased balconies/rooms, and optimized CREE slabs
- Structural & Logistical Innovation: Smart MEP integration, modular slab alignment, and 1,900 prefabricated components
- Cross-Project Coordination: Lessons from Tres Cantos improved efficiency and adaptability
- Collaboration & Technology: Seamless integration through teamwork and digital tools
- Conclusion: Valdebebas exemplifies modular construction's efficiency in tight schedules and mid-project changes.



The Valdebebas project faced significant challenges, primarily a highly compressed timeline, requiring the design to be completed in just three months and construction to finish six months ahead of schedule using lean principles. Design adaptability was crucial, as mid-construction changes, including increasing rooms from 460 to 500 and tripling balconies, required rapid adjustments. Structural and logistical constraints, such as strict airport height restrictions limiting floor-to-floor height to 3.15 meters and integrating 1,900 prefabricated components, demanded precise coordination. Strong collaboration among architects, engineers, and industrial partners, supported by digital planning tools, ensured seamless execution. The project demonstrated modular construction's adaptability, balancing prefabrication with conventional elements while maintaining speed and precision under evolving requirements.

ANALYSIS AND COMPARISON

Aspect	Traditional Construction Methods	Prefabricated Timber-Hybrid	Mass Timber
Speed	Slower with longer on-site construction	Faster than traditional	Faster due to off-site fabrication, but material coordination challenges exist
Sustainability	Higher embodied carbon	Significantly reduced carbon footprint	Reduced carbon footprint
Cost	Well-known costs, slower construction leads to higher overall costs	Potential savings from efficient design but higher initial costs	Lower costs due to fast construction, but material costs fluctuate
Supply Chain	Established supply chains with predictable lead times	Requires careful coordination of diverse materials	Simplified, but dependent on specialized suppliers
Labor requirements	Labor-intensive with a brad skill set	Reduced on-site labor, but skilled assembly is required	Reduced on-site labor, but skilled assembly is required
Quality Control	Quality varies based on contractor practices	Off-site fabrication ensures high quality	High quality from controlled manufacturing
Adaptability to Changes	High adaptability, changes can be made during construction	Modifications are complex due to interconnection	Limited adaptability once fabrication starts

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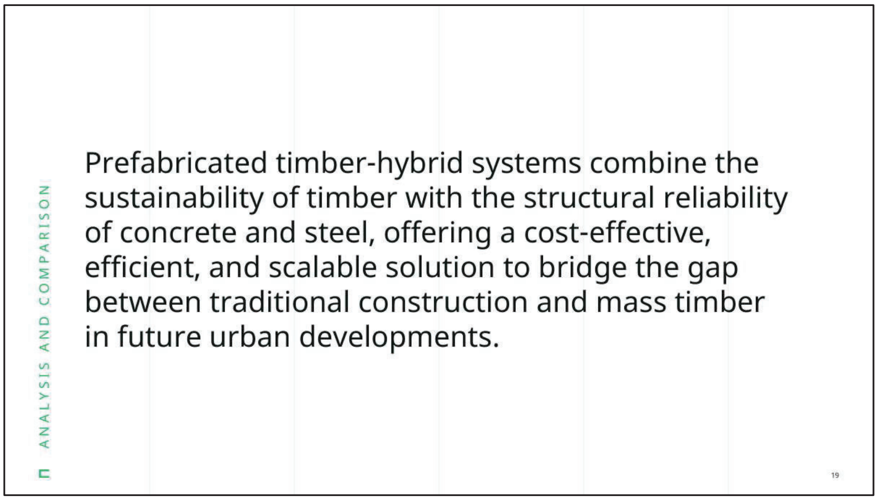
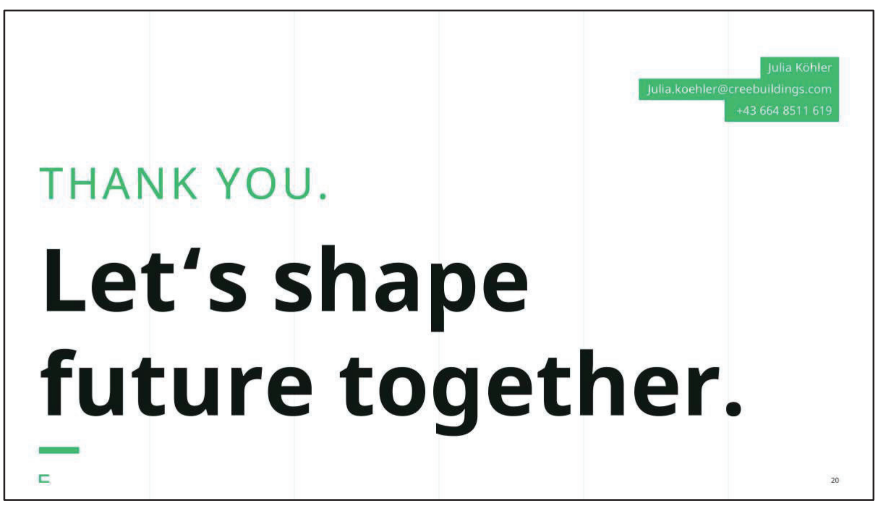


Prefabricated timber-hybrid systems bridge the gap between traditional construction methods and mass timber solutions by combining the sustainability of timber with the structural reliability of concrete and steel. This hybrid approach addresses key challenges such as rapid urbanization, climate crises, and the need for regenerative multi-storey buildings. While prefabrication enhances efficiency, reduces carbon footprint, and offers economic viability, it also navigates obstacles like limited production capacities and market resistance. By leveraging early collaboration, integrated planning, and minimizing interfaces, timber-hybrid systems optimize both design and construction processes. These systems present a sustainable and cost-effective alternative to traditional methods while laying the groundwork for broader adoption in the future, ultimately contributing to more resilient, sustainable urban development.



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