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Research By

Maximilian Friedmann

Tutors

Gilbert Koskamp
Thomas Offermans
Paddy Tomesen

Reimagining Timber

Tectonics, Innovation and Locality

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Timber is a material of vast architectural potential, deeply rooted in tradition yet continuously reimagined to meet the challenges of contemporary design. While traditionally associated with craftsmanship and locality, timber is increasingly shaped by advancements in digital fabrication and parametric design. This thesis examines how these innovations have transformed timber's tectonic language, moving beyond its conventional use to uncover its unique material logic and architectural expression.

Focusing on the interplay between timber's natural properties, modern technology, and sustainability, the research investigates the evolution of timber tectonics, the shifting role of craftsmanship, and the integration of traditional knowledge with digital workflows. The discussion also examines the risks associated with the misuse of timber, which can diminish woods inherent potential.

This thesis situates timber's evolving role within the Dutch context, exploring its integration at different scales. By embracing timber's strengths and leveraging digital tools, architecture can redefine timber as a material that bridges tradition and innovation.



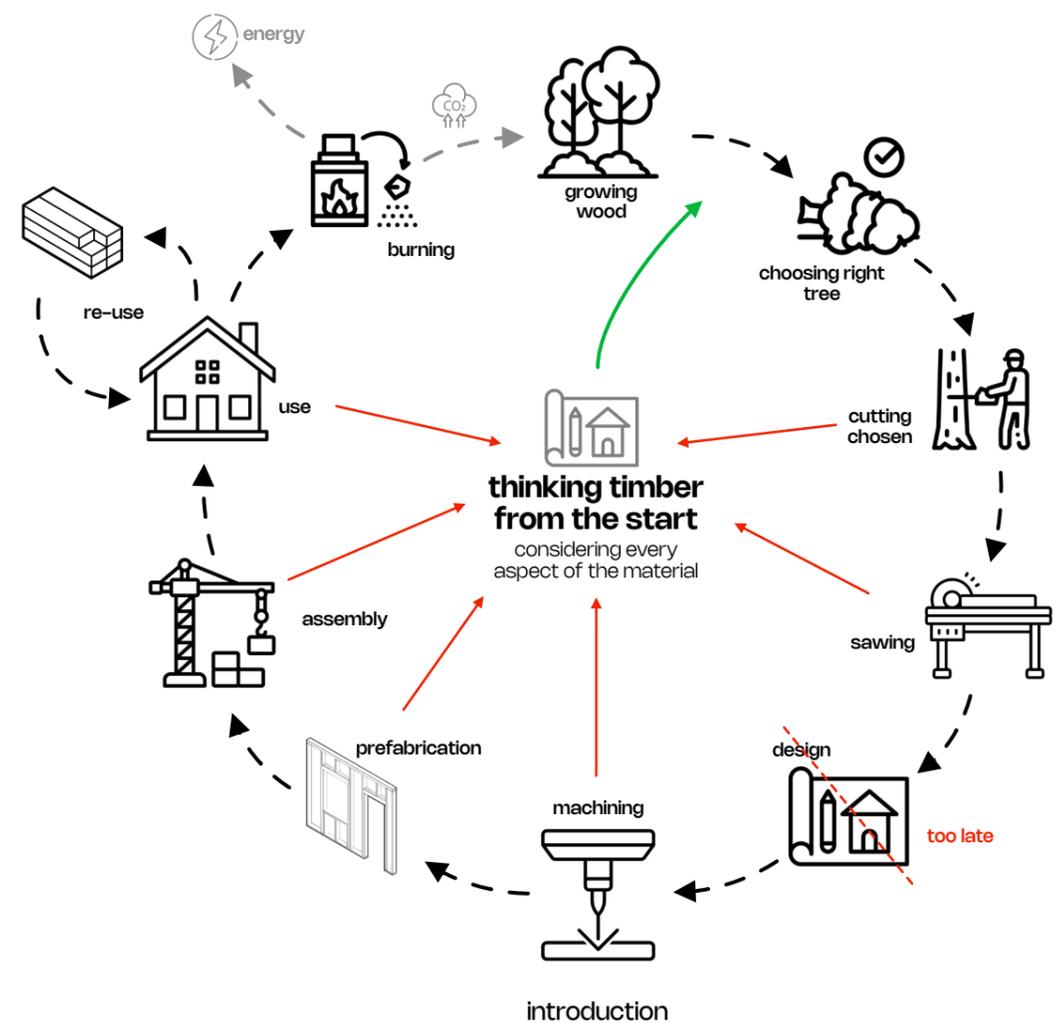
Fig. 01

2.0 introduction

Timber has been a cornerstone of architectural history, valued for its strength, versatility, and renewability. However, as demands for sustainable building practices rise, timber's role in modern construction is being redefined.

More than a material, timber represents a bridge between tradition and innovation. Advances in digital fabrication and parametric design have unlocked new possibilities, allowing timber to express its natural qualities through intricate geometries, precise joinery, and efficient construction.

This thesis explores the evolution of timber tectonics, the integration of traditional craftsmanship with modern technologies, and its implementation in the Dutch context. By leveraging timber's material logic, architecture can create sustainable, expressive, and context-sensitive solutions for the future.



3.0 framework

Problem Statement

Timber is often misused or misunderstood in contemporary construction, reducing it to a substitute for concrete or steel rather than embracing its unique qualities. Over-reliance on systems like cross-laminated timber, for example, prioritizes flat, surface-based applications that neglect timber's natural properties, such as its tensile strength, lightness, and adaptability. This approach not only diminishes timber's architectural expression but also undermines its competitiveness in a market dominated by standardized, industrial materials. Missed opportunities lie in timber's potential to redefine construction practices through its renewability, compatibility with prefabrication, and ability to integrate with digital fabrication and parametric design.

In the Netherlands, these challenges are compounded by urban density, regulatory constraints, and the country's reliance on imported timber. Despite its long history with timber construction, the current industry lacks the infrastructure and expertise needed to fully leverage timber's potential. Addressing these systemic gaps is critical for making timber a viable, sustainable, and innovative material in the Dutch context.

This thesis explores how timber can be reimagined to align with its inherent logic and material potential. By addressing its misuse and identifying strategies for better integration in the Netherlands, the research aims to position timber as a leading material in modern architectural practice.

Objectives

This thesis aims to redefine timber's role in contemporary architecture by addressing its misuse and underutilization. It explores how digital fabrication and parametric design can unlock timber's inherent strengths while emphasizing its unique tectonic logic. The research seeks to bridge tradition and innovation, integrating craftsmanship with advanced tools to optimize timber's potential. Additionally, the thesis examines the Dutch context, identifying systemic challenges and proposing strategies to implement timber effectively at urban, building, and detail scales. Ultimately, the goal is to position timber as a sustainable, competitive, and context-sensitive material in modern architectural practice.

Research Question

How can timber's tectonic logic evolve through digital fabrication and parametric design to create a material- and fabrication-driven, context-sensitive architecture in the Dutch context?

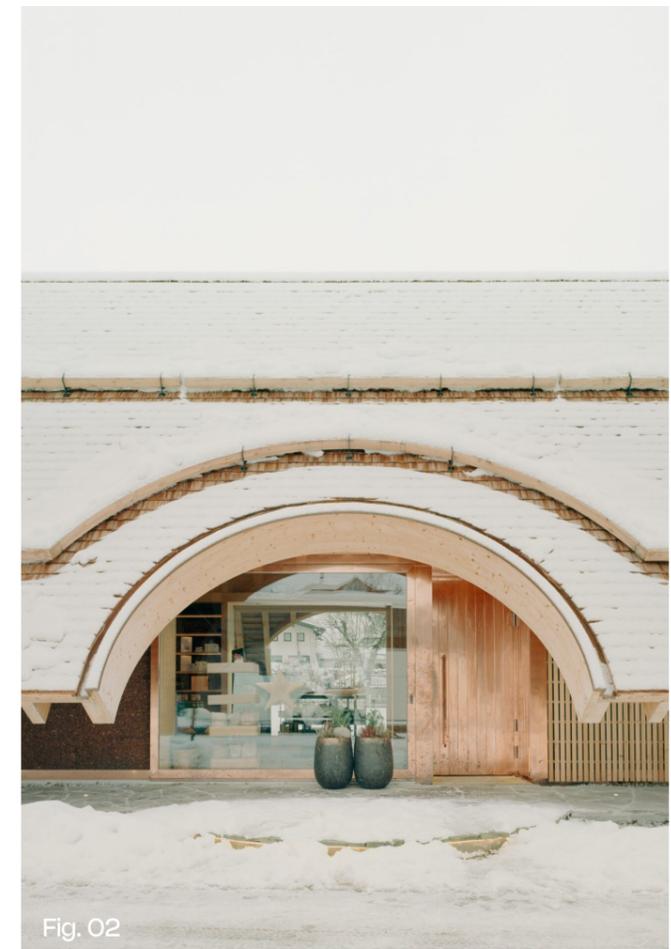


Fig. 02

4.0 methodology

Literature Review

A systematic review of academic texts, industry reports, and relevant architectural frameworks provides the foundation for this study. Key sources include *Bauen mit Holz – Wege in die Zukunft* by Hermann Kaufmann and *Advancing Wood Architecture* by Achim Menges, which offer insights into timber's historical and modern tectonics, digital fabrication, and sustainability. The review focuses on understanding timber's material properties, evolving design methodologies, and its implementation in the Dutch context.

Case Study Analysis

Several architectural projects were analyzed to assess timber's potential and its application in modern tectonics. Studio Precht's *Bauernbogen*, Herzog & de Meuron's *Hauptsitz Christoph Merian Stiftung*, Shigeru Ban's *Tamedia Building*, and the *Aussichtsturm der Landesgartenschau* by the University of Stuttgart have been the main case studies, that helped forming a greater picture of the current developments. On-site visits to selected case studies and under-construction timber projects in Germany and Austria offered additional insight into the

materials, fabrication processes, and design decisions involved.

Expert Consultations and Observations

Conversations with timber experts, architects, and craftsmen provided practical perspectives on the challenges and opportunities of using timber in modern construction. A key component of this research was attending the *Anatomy of Timber* workshop, hosted at TU Delft, which brought together industry professionals, researchers, and students to explore the material's properties and innovative applications in architecture. The workshop offered valuable insights into the integration of digital tools and traditional techniques, highlighting advancements in timber joinery, material optimization, and design workflows.

Additionally, a visit to a timber workshop run by a local craftsman allowed for hands-on observations of the fabrication process, further bridging the gap between traditional craftsmanship and modern fabrication technologies. Observations of both completed and in-progress timber projects (Fig.03/04) helped the understanding of material behaviour, tectonic language, and the impact of fabrication techniques on design outcomes.



Fig. 03

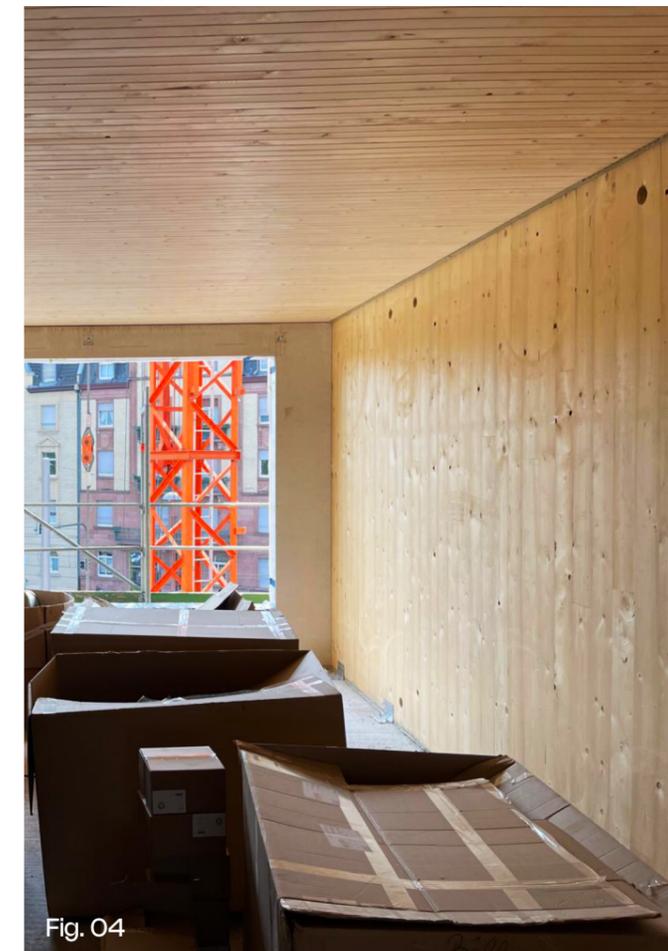


Fig. 04

5.0 **digital fabrication and parametric design**

Digital fabrication and parametric design have profoundly altered the possibilities of contemporary architecture, particularly in timber construction. These advancements enable architects and engineers to go beyond traditional limitations, creating complex geometries, optimizing material use, and enhancing precision in fabrication. By harnessing computational tools and automated processes, designers can now address the demands of modern construction while simultaneously embracing sustainable practices.

For timber, these innovations mark a critical turning point. Historically appreciated for its adaptability and natural qualities, timber has gained renewed relevance as digital technologies unlock its potential for high-performance applications. This confluence of material tradition and technological progress has expanded the role of timber, from traditional to experimental pavilions and multi-story urban developments.

definition and overview

The integration of digital fabrication and parametric design into architecture has redefined construction processes and enabled new possibilities for timber. Digital fabrication refers to the use of computer-controlled tools and machinery to produce physical components with high precision. These technologies, which include CNC milling, robotic arms, and 3D printing, allow designers to bridge the gap between digital models and physical reality, enabling the production of complex, customized forms with minimal material waste. Parametric design, on the other hand, is a computational approach to creating flexible, data-driven models. By embedding parameters such as material constraints, structural performance, and environmental data into design models, architects can generate geometries that adapt dynamically to changes in input conditions.

The origins of digital fabrication in architecture can be traced back to the late 20th century, with significant advancements in computational tools in the 1990s and early 2000s. Software such as Rhino, launched in 1998, and Grasshopper, its parametric design plugin introduced in 2007, became revolutionary tools for architects. Bianconi and

Filippucci (2019) highlight that Rhino and Grasshopper represented a pivotal moment in architectural practice by bridging the gap between design intent and fabrication possibilities. These programs allowed users to develop complex geometries, automate repetitive tasks, and integrate real-world data into design models.

Digital fabrication technologies have advanced in parallel, with CNC (computer numerical control) milling becoming a staple for cutting timber components with extreme accuracy. In CNC milling robotic arms now enable the production of freeform geometries that were previously infeasible. This combination of tools has allowed timber to be used in ways that maximize its strength and aesthetic potential while minimizing waste. Bianconi and Filippucci (2019) emphasize that robotic arms provide exceptional design freedom by fabricating intricate, curved, or irregular timber components that were previously considered impractical or impossible.

Parametric design extends its impact beyond the generation of complex 3D geometries. By embedding data into design models, it can simplify processes across the project lifecycle. For example, architects can integrate performance data such as structural loads,

material efficiency, and environmental conditions into parametric models. This ensures that the design is optimized for fabrication and assembly while reducing potential errors.

The synergy between digital fabrication and parametric design has significantly influenced timber architecture. These advancements address contemporary challenges, such as the demand for sustainable, efficient, and high-performance buildings, particularly in dense urban environments.

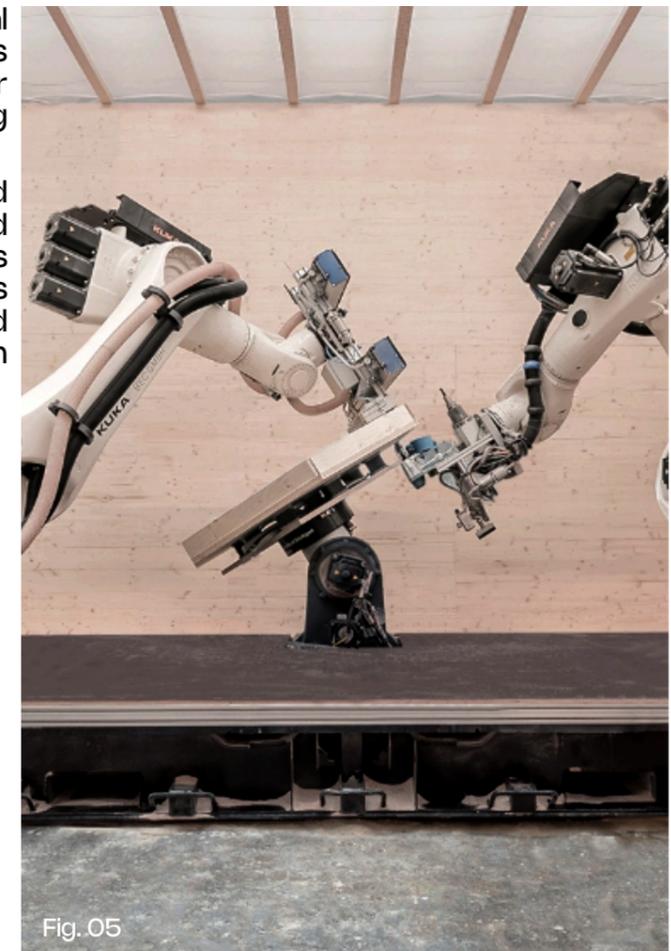


Fig. 05

impact on timber architecture

The integration of digital fabrication and parametric design has revolutionized timber architecture, redefining how the material is used in construction. These technologies enable greater precision, efficiency, and flexibility in design and fabrication, offering timber a new central role in innovative and sustainable construction practices. However, alongside these advancements come significant challenges, particularly regarding the environmental impact of engineered wood products and the complexities of digital workflows.

One of the most transformative impacts of digital fabrication is its ability to minimize material waste. CNC milling, robotic fabrication, and parametric design allow timber components to be precisely optimized for structural and aesthetic purposes. Studies indicate that these processes can reduce material waste (Hudert & Pfeiffer, 2019). This reduction is particularly significant when working with high-cost engineered wood products like CLT and glulam. These materials, which offer structural reliability and dimensional stability, are well-suited to CNC and robotic workflows. However, the reliance on these materials has also introduced environmental concerns. CLT, for example,

requires significant energy to produce and relies heavily on synthetic adhesives, which complicate recycling and reduce the material's overall circularity (Allner et al., 2021).

The shift from traditional sawn timber to engineered wood products has notably transformed timber construction. Materials like glulam and CLT, with their dimensional stability and structural reliability, are particularly well-suited to digital fabrication processes such as CNC milling and robotic assembly. These advancements have not only enhanced timber's structural performance but also opened up new possibilities for high-rise construction, modular systems, and freeform geometries.

Digital fabrication has also opened new formal possibilities for timber architecture, enabling intricate geometries and freeform designs that celebrate the material's natural properties. Robotic fabrication, in particular, allows architects to explore designs that were previously unattainable due to the limitations of manual craftsmanship. The ICD/ITKE Research Pavilion 2017–18 in Stuttgart demonstrates this potential, with its doubly curved timber panels achieving a 30% reduction in material usage through optimized parametric workflows (Fernández et al.,

2016). However, this focus on complex geometries often increases the energy required for production and assembly, raising questions about the balance between design ambition and sustainability.

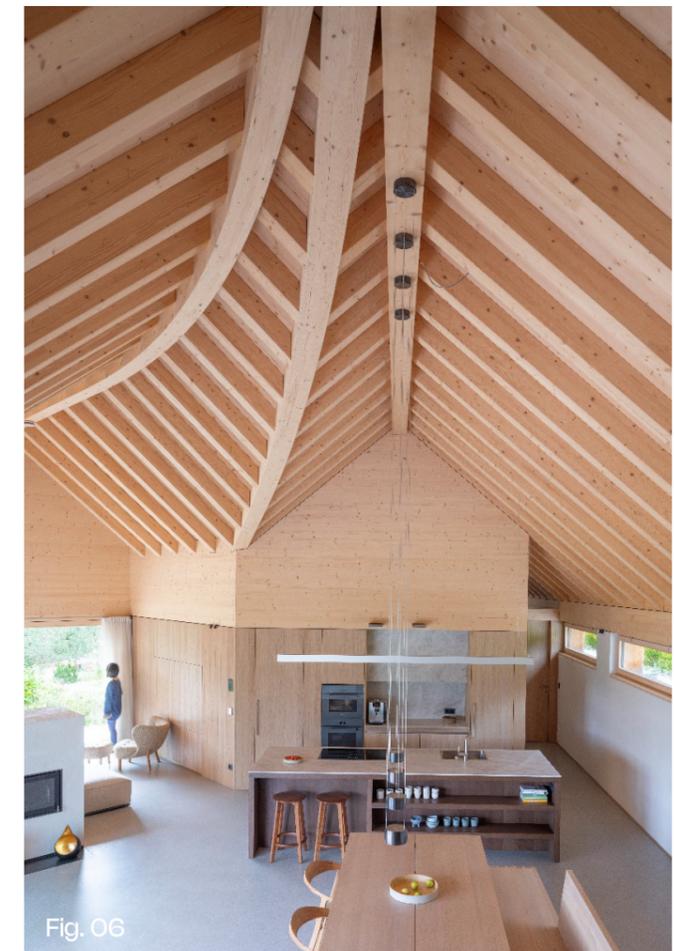
Parametric design further enhances timber's potential by integrating performance optimization into the design process. By embedding data such as structural loads, wind resistance, and environmental conditions into computational models, architects can refine geometries that are both functional and sustainable. These tools not only improve the design process but also streamline fabrication and assembly, reducing potential errors and ensuring seamless integration of components. An example of this is how Heatherwick Studio's Maggie's Centre in Leeds utilized parametric modeling to design an organic timber structure that maximizes natural light while maintaining structural efficiency. The project demonstrates how these tools can integrate aesthetic, functional, and environmental considerations into a cohesive design.

Prefabrication, facilitated by digital fabrication tools, has further expanded timber's role in construction by streamlining workflows and improving quality control. Prefabricated timber panels and modular systems allow for off-site production in controlled environments, reducing construction times (Hudert & Pfeiffer, 2019) and minimizing disruptions on-site. However, the logistics of transporting large prefabricated elements can introduce additional carbon emissions and require careful planning, particularly in dense urban areas with limited access or storage.

Despite these advancements, the increasing reliance on digital tools and engineered wood products presents notable challenges for the timber industry. According to Matthias Elsässer, a wood expert and owner of a medium-sized timber company in Mannheim, Germany, employing around 50 people, these developments often demand substantial investments in software, machinery, and workforce training. Elsässer noted that such requirements can create significant barriers for smaller firms, making it difficult for them to compete effectively with larger, more resource-rich companies. Furthermore, the complexity of managing parametric models and robotic fabrication processes can lead to inefficiencies if not carefully coordinated. Addressing these challenges will require greater collaboration between architects, engineers, and fabricators, as well as policy

support to incentivize the adoption of sustainable practices.

In summary, digital fabrication and parametric design have transformed timber architecture by enhancing precision, enabling complex forms, and reducing environmental impacts. However, these advancements come with trade-offs, particularly regarding the sustainability of engineered wood products and the energy demands of digital workflows. As timber continues to evolve in response to contemporary challenges, balancing innovation with ecological responsibility will remain a critical focus for architects and engineers alike.



5.3 pioneering examples

The convergence of parametric design, digital fabrication, and timber construction has created new possibilities for architectural innovation. By enabling precision, flexibility, and sustainability, these technologies allow architects to push boundaries and explore forms and techniques previously unattainable. To illustrate the range of opportunities available today, this section highlights five pioneering projects. Each project demonstrates a unique aspect of what can be achieved when advanced tools and engineered timber come together, from freeform geometries to large-scale prefabrication.

The Swatch Headquarters in Biel, Switzerland (Fig.08), designed by Shigeru Ban, is a striking example of how parametric design and digital fabrication enable freeform timber structures. The building's sinuous, flowing roof is composed of interconnected glulam beams, precisely fabricated using CNC milling and assembled to create a seamless, organic form (Timber Design and Technology, 2019). Parametric modeling was essential to optimizing the curvature of the structure, ensuring both visual elegance and structural efficiency.



Timber's inherent properties make it an ideal material for such ambitious forms. Its light weight simplifies the logistics of handling and assembly, while its adaptability to CNC milling allows for precise shaping of the intricate components required for the design. Although the Swatch Headquarters represents an extreme application, it serves as an important lesson in what is achievable when advanced tools and engineered wood products are combined. Projects like this inspire architects to think beyond conventional forms and explore the material's full potential.

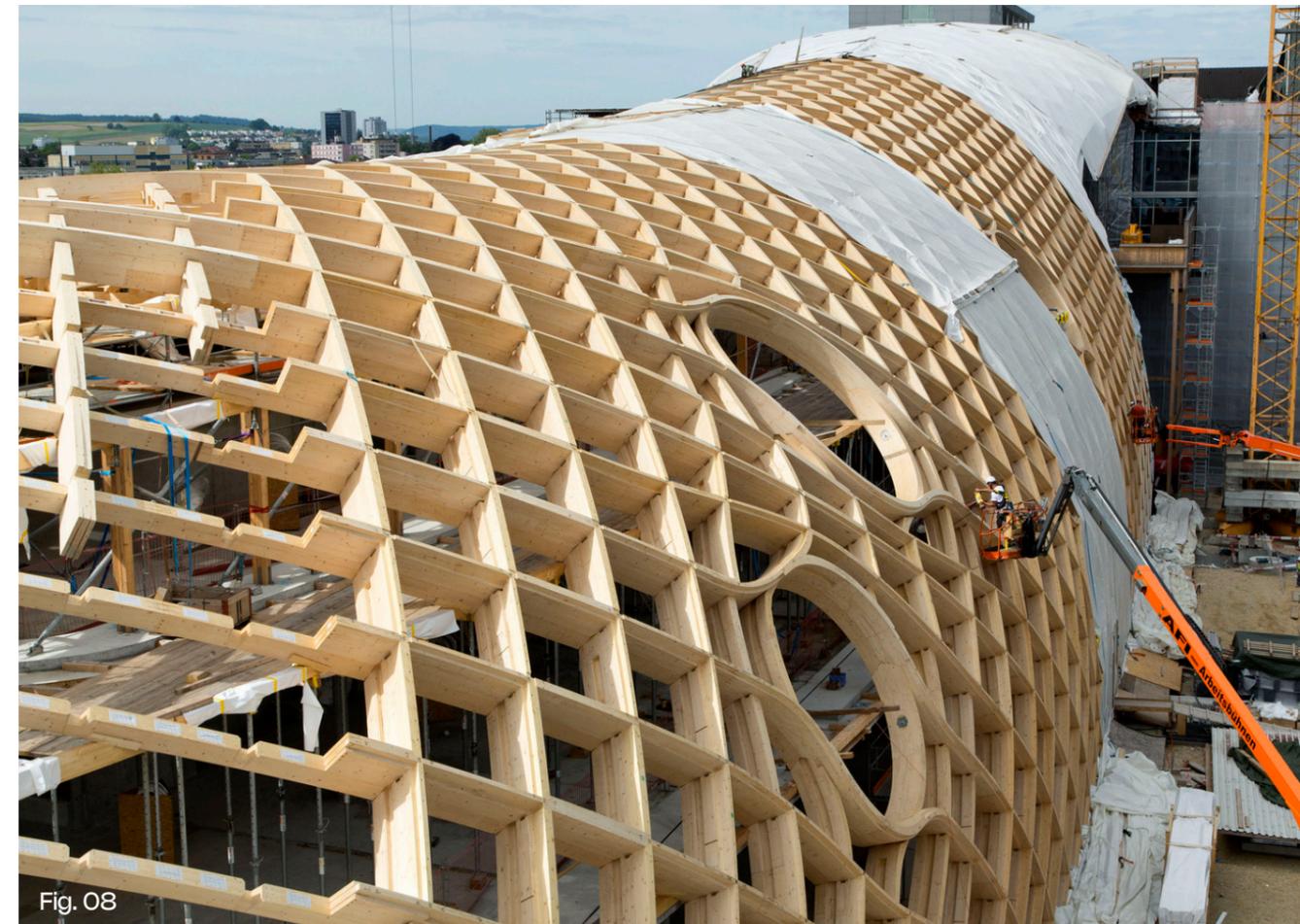
On a smaller scale, Studio Precht's Bauernbogen in Austria (Fig.07) demonstrates how the merging of local traditions with digital fabrication can create deeply contextual yet forward-looking architecture. The project, a curved, timber-framed pavilion, draws inspiration from traditional agricultural forms while using parametric tools to shape its sweeping arcs (Bauernbogen, 2023). The result is a structure that blends seamlessly with its rural surroundings while showcasing a distinctly modern tectonic language.

Timber is an ideal material for projects like the Bauernbogen because of its ability to bridge the past and the future. Its natural warmth connects to the traditional, while its

adaptability to parametric workflows enables the realization of complex geometries. The project exemplifies how digital design tools can reinterpret local heritage in innovative ways, offering architects a way to honor tradition while exploring new possibilities. The Bauernbogen highlights how the digital realm can shape projects at every scale, showing that small structures can be as impactful as larger ones when crafted thoughtfully.

The Aussichtsturm der Landesgartenschau in Wangen im Allgäu, Germany (Fig. 10), designed by Achim Menges and the ICD Universität Stuttgart in collaboration with Blumer Lehmann, is an experimental tower that integrates timber's intrinsic properties with cutting-edge computational design. This 30-meter observation tower is made of interlocking timber lamellas, robotically fabricated and assembled to form a doubly curved lattice structure. The tower exemplifies how timber's hygroscopic properties, its ability to absorb and release moisture, can be harnessed within a highly engineered framework (Blumer Lehmann, n.d.).

Parametric tools allowed the designers to calculate and optimize the tower's geometry for material efficiency and structural stability.



The project demonstrates a harmonious blend of natural material behaviors and advanced engineering, offering a vision of how digital tools can reconnect architecture with the natural world. The collaboration with Blumer Lehmann, a leading timber fabrication company, underscores the importance of expertise and innovation in pushing the boundaries of what timber can achieve. The Aussichtsturm challenges conventional notions of material use, presenting timber as a bridge between the organic and the digital.

Heatherwick Studio's Maggie's Leeds Centre takes a more human-centered approach, showcasing how parametric design and timber construction can shape spaces that promote well-being (ArchiDiaries, n.d.). The center's organic roof, composed of prefabricated cross-laminated timber (CLT) panels, creates a warm, inviting environment for cancer patients and their families. The curving, natural forms of the structure were shaped by parametric modeling, which optimized the building's natural light and ventilation.

What makes Maggie's Leeds Centre (Fig.09) particularly noteworthy is its biophilic design philosophy, which prioritizes the connection between architecture and nature. The use of timber reinforces this connection, bringing warmth and texture to the interior spaces. The project illustrates how parametric tools can shape more than just structural efficiency, they can also influence the emotional and sensory experience of a building, creating spaces that support healing and comfort.

HAUT in Amsterdam stands as a testament to the capabilities of large-scale prefabrication in timber construction. As a 21-story residential tower, it is one of the tallest timber-hybrid buildings globally and the first residential project in the Netherlands to receive BREEAM Outstanding certification (The Institution of Structural Engineers, n.d.). The building's load-bearing structure comprises CLT panels manufactured off-site, ensuring low waste production and fast, clean on-site assembly (Team V Architecture, n.d.). Such precision and efficiency are attainable only through contemporary advancements in parametric design and digital fabrication, positioning HAUT as a prototype for sustainable urban development.

Parametric design played a critical role in optimizing HAUT's structure, from managing wind loads to reducing material usage. The project's BREEAM Outstanding certification highlights its environmental achievements,

emphasizing timber's role in sustainable urban development. HAUT exemplifies how digital tools can make timber a viable option for large, complex projects, bridging the gap between traditional craftsmanship and contemporary technological advancements.

These projects illustrate the versatility of timber when paired with parametric design and digital fabrication. From the freeform experimentation of the Swatch Headquarters to the contextual sensitivity of the Bauernbogen, the material behavior exploration in the Aussichtsturm, the biophilic design of Maggie's Leeds Centre, and the urban ambition of HAUT, they collectively demonstrate timber's capacity to address diverse architectural goals. While each project has its unique strengths and challenges, together they highlight the transformative potential of modern timber construction in shaping the future of sustainable, expressive, and high-performance architecture.

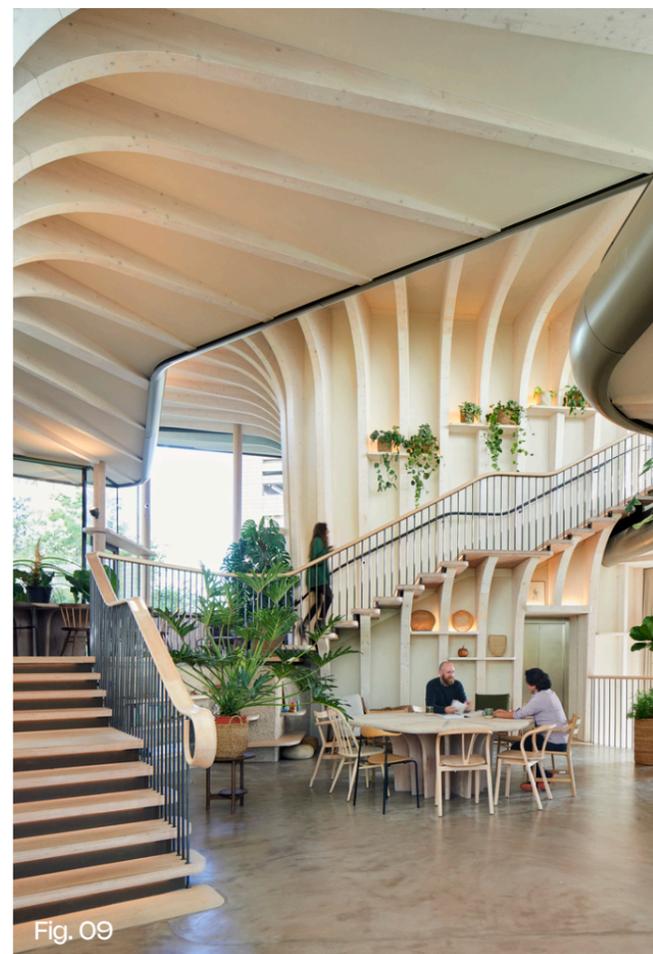


Fig. 09



Fig. 10

potential and challenges in the dutch context

The Netherlands' high population density and limited space demand efficient and adaptable construction methods. Digital fabrication, especially when paired with timber, is uniquely suited to these conditions by for example enabling prefabrication through digital workflows. Parametric design further enhances this adaptability by incorporating site-specific data into the design process. Tools like Rhino, Grasshopper; Cinema 4D, Blender and many more allow architects to embed variables such as wind loads, solar orientation, and spatial constraints directly into computational models, enabling the creation of optimized designs that respond to environmental and contextual demands. As highlighted in *The City as a System: Metabolic Design for New Urban Forms and Functions*, modern computational tools can process vast amounts of data, facilitating urban models that integrate infrastructure, energy flows, and material efficiency (Dooghe et al., 2021). This capacity for data-driven design is particularly relevant in cities like Amsterdam and Rotterdam, where parametric workflows can help architects navigate the complexities of dense urban environments while enhancing the performance and sustainability of timber structures.

Despite the potential of digital fabrication and parametric design, the Netherlands faces challenges in fully integrating these technologies into timber construction. While many Dutch architects have embraced advanced design tools, practical knowledge of robotic fabrication and CNC workflows remains limited, especially among smaller firms. Furthermore, the country lacks a robust infrastructure of fabrication facilities capable of supporting complex digital workflows (Zeisser, 2024). Unlike timber hubs in countries like Austria or Switzerland, where companies such as Blumer Lehmann provide end-to-end solutions for parametric timber design and fabrication, the Dutch timber industry is still developing its capacity to meet the demands of digitally driven projects.

This gap highlights the importance of encouraging collaborations between architects, engineers, and fabricators to bridge the knowledge divide. Expanding access to training programs and incentivizing investment in fabrication infrastructure will be critical for positioning the Netherlands as a leader in digitally fabricated timber architecture. To fully harness the potential of digital fabrication and parametric design in the Dutch context, targeted investments and

policy initiatives are essential. Government support for sustainable construction methods, such as subsidies for adopting advanced fabrication tools, and training programs for computational design can accelerate the adoption of these technologies. Collaboration with international leaders in the field, could provide valuable expertise and accelerate the integration of robotic workflows into Dutch projects (Helsinki-Uusimaa Regional Council, 2021).

Additionally, research into the integration of circular economy principles with digital fabrication is vital. By optimizing material use, developing bio-based adhesives, and advancing modular designs for disassembly, timber construction in the Netherlands can align with its ambitious sustainability goals. These initiatives would not only enhance the environmental performance of timber architecture but also ensure its relevance in addressing contemporary urban challenges.

Digital fabrication and parametric design have revolutionized timber construction, enabling precision, material optimization, and innovative geometries. These advancements enhance timber's sustainability credentials while expanding its architectural possibilities, from modular systems to freeform designs. Projects like the Swatch Headquarters and HAUT in Amsterdam demonstrate timber's potential to meet contemporary demands for efficiency, aesthetics, and ecological responsibility.

Despite these innovations, challenges persist. Engineered wood products like CLT and glulam face environmental trade-offs, and integrating advanced technologies requires significant investment and expertise, often creating barriers for smaller firms. However, the synergy between digital tools and timber highlights an exciting future for architecture that blends tradition with cutting-edge innovation.

6.0

historical evolution of timber in the netherlands

Timber has been one of the most essential and versatile materials in architecture throughout history. From ancient vernacular structures to modern engineered systems, it has continuously adapted to cultural, technological, and environmental demands. Globally, timber has served as a primary construction material, shaping iconic structures such as Japanese pagodas, Nordic stave churches, and European timber-framed buildings.

In the Netherlands, its role evolved in response to the country's environmental conditions and economic needs due to limited local forests and waterlogged and reliance on imported timber, shaping the architectural identity of both urban and rural landscapes.

pre-industrial timber practices

Timber has long been a cornerstone of architecture, valued across cultures for its versatility, strength, and natural abundance. In the Netherlands, this material became deeply imbedded in the architectural identity, adapting to the unique challenges of the Dutch environment. The reliance on timber was not only a practical response to available resources but also a reflection of cultural and economic dynamics, particularly during the nation's maritime dominance. The Netherlands' waterlogged soils necessitated innovative solutions, and timber became the primary material for creating stable foundations. Amsterdam, famously referred to as a city built on poles, relied on timber piles to support its iconic canal houses. These piles, primarily crafted from imported oak, enabled the development of dense urban environments on otherwise unstable ground (Endo & Hanazato, 2023). In rural areas, timber was used to construct large farmhouses and barns, featuring simple yet robust wooden frameworks that embodied practicality and resilience. Sophisticated joinery techniques like mortise-and-tenon were hallmarks of Dutch timber construction, influenced heavily by shipwright expertise,

showcasing the adaptability and precision of Dutch builders (Cruz et al., 2014).

Timber also played a pivotal role in Dutch windmills, iconic structures essential to the nation's water management and grain milling. These buildings showcased the adaptability of timber, from the intricate mechanisms that powered the mills to their towering structural frameworks. Jorissen and Leijten (2008) noted that Dutch windmills exemplify the versatility of timber through their intricate mechanical systems and towering structures, symbolizing both technological ingenuity and the country's connection to its environment. Beyond their functionality, they embodied a deep respect for the material's inherent qualities.

Due to the limited availability of forests in the Netherlands, a robust timber trade network emerged, connecting the country to suppliers in Scandinavia and Germany. According to van Helmond (2022), timber played a key role in shaping the architectural style of gabled canal houses while also reflecting the socio-economic resilience of a nation limited by natural resources and influenced by its maritime ambitions. The lightness and ease of transport of timber made it ideal for rapid urban expansion, particularly during the Dutch

Golden Age. In Amsterdam, timber frames enabled the construction of narrow, gabled canal houses that maximized efficiency on constrained plots. This architectural response reflected the ingenuity of Dutch builders in adapting to both material limitations and urban density.

Timber's role in Dutch architecture extended beyond its practical applications. It also held cultural and symbolic significance, representing resilience and a connection to nature in a land constantly shaped by water. Windmills and timber-framed houses became enduring icons of the Dutch landscape, blending functionality with artistry. The craftsmanship and ingenuity that characterized timber use in the pre-industrial era faced significant challenges during the industrial revolution.



Fig. 11

the industrial revolution

The Industrial Revolution marked a turning point in the use of timber within Dutch architecture. As industrialization reshaped economies and cities, timber's role shifted from a primary construction material to one increasingly overshadowed by the introduction of steel and concrete. Advances in mechanization and changes in architectural needs disrupted the centuries-old reliance on timber, forcing it to adapt to new roles within the built environment. This transition reflected broader societal and technological shifts, profoundly influencing Dutch construction practices and architectural identity. Mokyr (2000) noted that the early stages of the Industrial Revolution required a close cooperation between knowledge of nature and its application to technology, a dynamic that significantly influenced transitions in construction materials.

Mechanization brought significant changes to timber production, particularly through the introduction of mechanized sawmills. These innovations increased the efficiency of timber processing, reducing costs and enabling the mass production of standardized wood components. However, while these advancements made timber more accessible, they also contributed to its commodification,

diminishing the value placed on traditional craftsmanship. Van Tussenbroek (2022) observed in his research on Dutch buildings that the shift to mechanized production marked the decline of artisanal traditions that had long characterized Dutch timber construction. During this period, timber found itself increasingly confined to secondary and decorative roles. Steel and concrete, praised for their strength and fire resistance, became the materials of choice for load-bearing structures, particularly in urban environments where fire safety regulations imposed stricter limitations on timber use. The catastrophic fires that swept through densely populated European cities in the 18th and 19th centuries heightened concerns about timber's flammability, leading to its diminished prominence in urban architecture. In response Lintsen et al. (2018) noted that Dutch builders moved towards materials like brick and steel, reducing timber to interior and non-structural applications.

Despite its decline in urban settings, timber retained an important role in rural and industrial applications. Dutch agricultural buildings, such as barns and granaries, continued to rely on timber for their structural frameworks, where practicality and cost-

effectiveness were central. Similarly, timber remained essential in maritime construction, particularly for shipbuilding and port infrastructure. Cruz et al. (2014) highlighted that timber's adaptability allowed it to remain relevant, especially in situations where steel and concrete were less practical or cost-effective.

The Netherlands' reliance on imported timber continued during the Industrial Revolution, sustained by robust trade. However, the increasing availability of steel and concrete began to shift the balance of material imports. Van Helmond (2022) noted that while timber imports persisted for scaffolding and temporary structures, steel became a dominant material, reshaping urban construction practices.

In structures like the Central Station in Amsterdam (1889), timber played a supportive role, with intricate roof trusses and scaffolding systems demonstrating its versatility in combination with steel. These hybrid approaches foreshadowed the eventual resurgence of timber as a complementary material in modern construction. Jorissen and Leijten (2008) pointed out that although timber lost its dominance during the Industrial Revolution, its

continued use in high-profile projects preserved its techniques and traditions.

The Industrial Revolution reshaped perceptions of timber, associating it with rural and traditional contexts in contrast to the modernity symbolized by steel and concrete. This shift in perception was both a limitation and an opportunity. While timber was sidelined in many urban projects, its enduring use in rural and maritime contexts reinforced its connection to Dutch heritage and environmental adaptability. These associations would later play a role in timber's 20th-century revival as a sustainable material with cultural resonance.



Fig. 12



Fig. 13

modern developments

In the 20th and 21st centuries, timber has undergone a remarkable resurgence in architecture, driven by environmental sustainability and technological innovation. Timber, once overshadowed by the dominance of steel and concrete during the Industrial Revolution, has regained prominence as a primary construction material, addressing many of the most pressing challenges in modern construction.

The revival of timber construction in the post-World War II period was significantly influenced by material shortages and the need for rapid reconstruction across Europe. Schauerte (2010) explained that in Finland, standard wooden houses were developed after World War II, supported by construction manuals and assembly sets that enabled self-building efforts, effectively addressing the urgent post-war housing demand. Similarly, Sweden responded to the housing shortage in Great Britain by exporting prefabricated timber houses, with 5,000 homes built from kits made in Sweden and assembled on-site. Timber, widely available and easily processed, became a practical choice for rebuilding efforts.

Over time, the perception of timber shifted from being a temporary solution to a



Fig. 14

sustainable alternative to steel and concrete. This evolution was supported by the development of engineered wood products such as plywood, glulam (glued laminated timber), and CLT (cross-laminated timber). These innovations addressed many of timber's natural limitations, such as dimensional instability and limited load-bearing capacity, enabling its use in larger and more complex structures. Structville (2020) highlighted that engineered wood products such as CLT and glulam provide structural reliability, dimensional stability, and a low carbon footprint, making them well-suited to meet modern construction demands.

Technical Development

CLT, in particular, has transformed timber's potential, especially in high-rise construction. Projects like HAUT in Amsterdam exemplify this innovation. Designed to achieve BREEAM Outstanding certification, HAUT (Fig.14) demonstrates how hybrid timber structures can combine sustainability with architectural ingenuity. Arup (2024) emphasized that projects like HAUT in Amsterdam illustrate how hybrid timber structures can successfully integrate sustainability with architectural innovation, achieving outstanding environmental performance.

Advancements in digital fabrication and timber joinery have further expanded the possibilities of timber construction. While traditional joinery techniques have given way to industrialized connectors like steel dowels and adhesives, digital tools such as CNC milling and robotic fabrication have revolutionized the field. Eindhoven University of Technology (2024) highlights that digital timber design and robotic fabrication have transformed timber construction by enabling precise and waste-efficient production of complex components. By allowing for intricate and precise designs, these technologies not only reduce material waste but also open new possibilities for innovative architectural forms, as seen in computationally designed projects like the ICD/ITKE pavilions.

Political Development

Sustainability has been a driving force behind timber's resurgence. The Netherlands has embraced timber as part of its national sustainability objectives, with the goal of achieving a circular economy by 2050, emphasizing sustainable material use as a key component of this broader environmental strategy (UNECE, 2019). Sustainable procurement policies further reinforce this commitment, mandating that all timber used in

public construction projects must come from certified sustainable sources (UNECE, 2024). Such policies have positioned timber as a cornerstone of efforts to reduce carbon emissions in the construction sector.

Timber's compatibility with circular economy principles enhances its appeal. Unlike many conventional materials, timber can be reused, recycled, or biodegraded at the end of its lifecycle. This aligns with the Netherlands' vision for sustainable construction, which aims to minimize the environmental and health impacts of building materials throughout their entire life cycle, from sourcing to eventual reuse or disposal (IRBNet, 2024). Exemplary projects such as the Triodos Bank in Zeist demonstrate how timber can embody these principles. Designed for disassembly and reuse, the building highlights how timber integrates seamlessly into circular economy strategies while maintaining architectural quality (ArchDaily, 2024).

The Dutch context further illustrates timber's resurgence through ambitious and innovative projects. Patch 22 in Amsterdam, designed by FRANTZEN (Fig.15), is a hybrid timber and steel structure that prioritizes energy efficiency and carbon reduction. Woltjer and Horsting (2024) explain that transitioning to timber construction could substantially reduce carbon emissions while addressing the housing crisis, providing a sustainable solution for expanding the Dutch housing stock. Similarly, the Tree House in Rotterdam, a 37-story hybrid timber building currently under development, represents the potential of timber to redefine urban skylines while achieving exemplary sustainability targets (UBM Timber Pioneer, 2024).

conclusion

The historical evolution of timber in Dutch architecture highlights its adaptability, resilience, and enduring significance. From its foundational role in pre-industrial construction, supporting Amsterdam's iconic canal houses and enabling Dutch maritime dominance, timber has shaped the country's architectural identity. Despite the decline of timber during the Industrial Revolution, driven by the rise of fire-resistant materials like brick and steel, its presence in rural and maritime applications preserved traditional craftsmanship.

Modern developments have ushered in a resurgence of timber, spurred by its environmental benefits and advancements in engineered wood products like CLT. This revival underlines timber's dual role as a sustainable construction material and a cultural importance, bridging the past with contemporary design innovation. By integrating timber with circular economy principles, the Netherlands positions itself at the forefront of sustainable architecture. As urban environments increasingly demand low-carbon solutions, timber emerges not only as a functional material but also as a symbol of the country's ingenuity and commitment to ecological balance.

Timber's revival in Dutch architecture is not merely functional, it is also cultural. By bridging the past and the future, timber reconnects communities with their architectural heritage while embracing technological innovation. This duality positions timber as a material that navigates both nostalgia and progress, creating a unique architectural language. Its natural warmth and aesthetic appeal support biophilic design principles, enhancing occupant well-being and strengthening connections to nature. As the Netherlands continues to pursue ambitious sustainability goals, timber offers both practical and symbolic solutions, reclaiming its place at the heart of Dutch architectural identity.



Fig. 15

7.0

genius loci – timber in a local context

The concept of genius loci, or spirit of place, has long been a cornerstone of architectural thought, emphasizing the unique qualities that connect a building to its environment, culture, and community. Traditionally, genius loci has been understood as a deeply rooted connection to a specific location, defined by historical, environmental, and societal factors. However, in an increasingly globalized and technologically advanced world, the boundaries of "local" are shifting, requiring a redefinition of what genius loci means in contemporary architecture.

In this evolving context, timber emerges as a material that bridges the gap between tradition and modernity. Its historical significance in architecture, combined with its adaptability to advanced digital tools, positions timber as an ideal lens through which to explore the interplay between the local and the global. In the Netherlands, for example, while most of its timber is imported, the use of nearby waterways to transport wood from Germany highlights how the term locality can be defined through environmental and logistical efficiencies rather than geographic proximity.

To fully understand genius loci, it is essential to explore its diverse interpretations across different contexts and eras. Architects from various cultural and historical backgrounds have approached this concept through unique perspectives. These case studies illustrate the interplay between tradition and innovation, emphasizing how context-specific approaches can lead to meaningful, responsive architecture.

perspectives across time and place

Francis Kéré, a Burkinabé architect and 2022 Pritzker Prize laureate, exemplifies the profound impact of integrating local materials and traditional construction techniques to create architecture that is both environmentally responsive and culturally resonant. His work underscores the significance of genius loci, or the spirit of place, by harmonizing design with the unique environmental and cultural contexts of his projects. Kéré's architectural philosophy emphasizes the transformative potential of working within the constraints of a place. Kéré (n.d.) emphasizes that only individuals actively involved in the development process can truly appreciate the results, build upon them, and safeguard their value. By embracing local materials and construction methods, Kéré not only creates sustainable and cost-effective buildings but also builds a sense of ownership and pride among community members. His projects all reflect a deep understanding of local needs and environmental conditions. Kéré's work illustrates that limitations in resources can become strengths when approached with creativity and a deep respect for local context. His architecture serves as a testament to how culturally and environmentally attuned design can enhance

the quality of life, promote sustainability, and reinforce the identity of a place (Divisare, 2013).

Sigfried Giedion, a prominent architectural historian, profoundly examined the relationship between technology and human environments. In his seminal work, *Mechanization Takes Command*, Giedion explores how mechanization has transformed daily life and the built environment, emphasizing the profound impact of technological advancements on society (Giedion, 1948).

Giedion's analysis delves into the evolution of mechanization, tracing its influence on various aspects of life, from household appliances to industrial processes. He argues that mechanization has led to a separation between thought and feeling, creating a dichotomy that affects human perception and interaction with the environment (Lozanovska, 2018).

This perspective is particularly relevant in the context of digital fabrication in architecture. As mechanization once redefined production and daily life, contemporary digital tools are reshaping architectural design and construction. Much like the mechanization of

the 20th century, the rise of computational tools such as parametric design and robotic fabrication is reshaping how buildings are conceived, constructed, and experienced (Willmann et al., 2016). For instance, the integration of CNC milling and robotic assembly in timber construction does not just improve efficiency, it introduces new formal and functional possibilities that influence the everyday experience of architecture (Wagner et al., 2020).

Giedion's work invites a reflection on how digital tools, as the modern equivalents of mechanization, might shape the spirit of place. Just as the assembly line revolutionized construction techniques and social practices, digital fabrication is set to redefine how materials like timber are utilized to create adaptable, responsive, and sustainable environments. His exploration emphasizes that the genius loci of a place is not static but evolves with the tools and technologies that shape it. Giedion's work serves as a reminder that technological advancements in architecture should be approached with a critical understanding of their potential to influence human experiences and societal structures.

Fritz Haller, a Swiss architect and designer, is widely celebrated for his innovative approach to modular systems and their profound implications for architecture and design. His work exemplifies how genius loci can be reinterpreted through adaptable and scalable solutions that respond to changing needs, environments, and contexts. Haller's systems-based thinking invites us to consider genius loci not as static but as something dynamic, evolving with the tools and systems we use to shape our environments.

Haller's most iconic contribution, the USM Haller system, serves as a prime example of his philosophy. Designed initially for his office, the modular system became a universal framework adaptable to various settings and functions. The system's ability to evolve with its user reflects a new interpretation of genius loci: one that is not rooted in a singular, fixed place but in the adaptability of design to its surroundings. Bachmann and Haller (2002) note that USM embodies a vision of architecture and design that moves beyond static solutions, providing forms that adapt and evolve with their environment.

In architecture, Haller's modular building systems pushed the boundaries of prefabrication, allowing for structures that

could be assembled, disassembled, and reconfigured to suit different places and times. This flexibility echoes a more fluid understanding of genius loci, one that aligns with the principles of sustainability and reuse. By enabling architecture to respond to evolving functional and cultural needs, Haller's systems challenge the notion that genius loci must be tied to historical or geographic permanence. Instead, his work suggests that locality can be defined by the adaptability of systems to their context.

Timber, as a renewable and versatile material, resonates deeply with Haller's modular approach. Prefabricated timber components, when combined with parametric design and digital fabrication, enable precision, efficiency, and scalability in modular systems. Wagner et al. (2020) highlights that the integration of digital workflows into timber construction facilitates the seamless adaptation of modular solutions to diverse contexts, reinforcing Haller's vision of adaptable architecture.

Haller's work illustrates that genius loci can emerge from the relationship between design systems and their ability to respond to environmental, societal, and technological constraints. This perspective offers valuable insights for contemporary timber construction, where modularity and digital tools allow architects to create adaptable designs that respect the unique qualities of their surroundings while addressing global challenges like sustainability and resource efficiency.

These diverse interpretations of genius loci underscore its multifaceted nature, reflecting the interplay between tradition, innovation, and the specific contexts in which architecture is created. From Francis Kéré's deeply rooted material sensitivity and community engagement, to Sigfried Giedion's examination of how technology redefines our interactions with space, to Fritz Haller's modular systems that challenge the static notion of place, each perspective reveals a unique approach to responding to the spirit of place. Together, they highlight that genius loci is not just a historical or geographical concept but one that evolves dynamically with societal, environmental, and technological shifts. This broader understanding provides a critical foundation for examining how timber, digital fabrication, and parametric design can reinterpret locality in contemporary architecture, particularly within the Dutch context.

redefining local in a global context

In today's globalized world, the concept of "local" has become increasingly fluid and complex. Traditionally, locality was defined by geographic, cultural, and environmental boundaries, with architecture responding directly to the materials, climate, and traditions of a specific place. However, in today's globalized world, this understanding of locality is becoming increasingly fluid. Materials, labour, and knowledge now cross borders, challenging the traditional notion that architecture must be tied to the immediate surroundings. This shift invites a reevaluation of what it means for a building to be "local" and opens new possibilities for integrating sustainability, technology, and material efficiency into design practices.

Global trade networks have fundamentally altered how materials and resources are sourced for construction. In the Netherlands, for example, most of construction timber is imported, primarily from Germany and Belgium (Fig.17). While this might appear to contradict the idea of local architecture, the use of waterways for transportation offers a sustainable alternative to overland freight, reducing emissions and environmental impact (Government of the Netherlands, n.d.).

This redefinition of locality extends beyond materials to include the global exchange of knowledge and technology. Digital tools like parametric design software and robotic fabrication have enabled architects to collaborate across borders, sharing expertise and optimizing designs with site-specific data. For instance, parametric workflows allow architects to simulate local environmental factors, such as wind loads and solar orientation, ensuring that buildings respond dynamically to their context regardless of where the design expertise originates (Doxiadis & Konstantinidis, 2021).

Timber provides a compelling case for how a material can embody the fluidity of locality. Traditionally tied to nearby forests and immediate surroundings, timber has evolved into a global material that seamlessly integrates advanced technologies, international trade, and sustainable practices. Its inherent renewability, carbon-sequestering properties, and compatibility with modern construction techniques make it uniquely suited to address architectural challenges that span environmental, cultural, and geographic boundaries.



Fig. 16

One of timber's most significant attributes is its ability to store carbon throughout its lifecycle. This property situates timber at the heart of the sustainability debate, enabling it to contribute to global climate goals while maintaining a tangible connection to its biological origins. It also helps offset some of the CO₂ emissions generated during transportation, effectively expanding the feasible export radius of the natural source.

Timber also embodies locality through its lifecycle. Unlike materials such as concrete or steel, which are often associated with linear production and waste-heavy processes, timber aligns with circular economy principles. Its ability to be reused, recycled, burned for energy or composted at the end of its life underscores its potential to remain embedded in local and regional economies. For instance, modular and prefabricated timber systems designed for disassembly ensure that timber retains its utility across multiple building cycles.

However, timber's relevance extends far beyond its technological adaptability. As one of the oldest materials used by human societies, timber has long-standing cultural significance across many crafts, from carpentry and boatbuilding to fine furniture and sculpture. These traditions demonstrate how timber has

been a fundamental medium for creativity and innovation throughout history, deeply embedded in local customs and practices. By integrating these centuries-old traditions with modern digital tools, architects can bridge the gap between heritage and cutting-edge design. This combination allows timber to transcend its geographic origin and adapt to diverse contexts and challenges, all while retaining its ecological and cultural significance. As a result, timber serves not only as a connection to natural ecosystems but also as a symbol of innovation and resilience, uniting local traditions with global design methodologies in a way that honours its rich history while advancing its future potential.

In redefining timber as a global-local material, architects and designers are expanding traditional notions of locality to encompass broader ecological and systemic considerations. Timber's journey from forest to fabrication, and eventual reuse, demonstrates how a material can transcend geographic boundaries while remaining deeply tied to the spirit of place. Its renewability, adaptability, and integration into circular economies make it an enduring example of

how architecture can harmonize global ambitions with local sensitivities.

The evolving definition of locality has significant implications for architecture. It challenges architects to consider not only the physical characteristics of a place but also the broader systems that connect it to global networks. By embracing the fluidity of locality, architects can integrate advanced technologies, sustainable practices, and global knowledge into designs that remain contextually relevant. This approach aligns with Giedion's assertion that technology shapes human environments and highlights the potential of digital fabrication and parametric design to respond to contemporary architectural challenges.

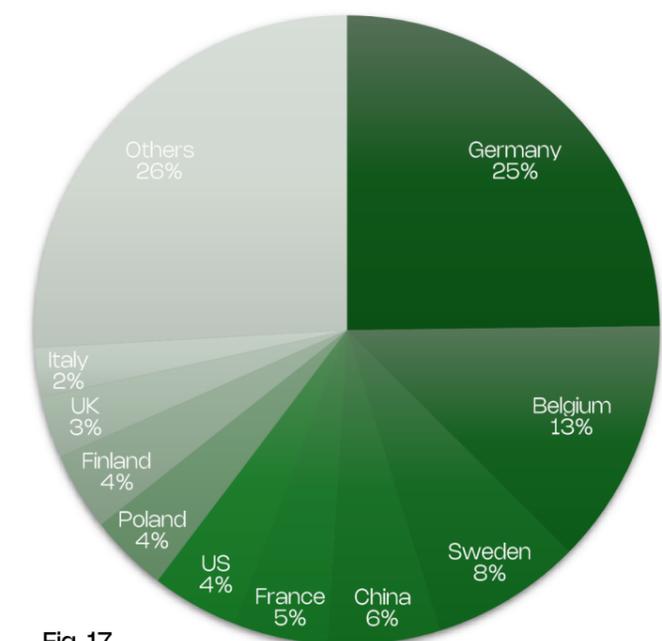


Fig. 17

wood import by countries (2022)
source: World Integrated Trade Solution

8.0

timber tectonics evolving design and construction logic

Tectonics, derived from the Greek word *tekton*, meaning "builder" or "carpenter", refers to the art and science of construction. In architecture, it encompasses the relationship between materials, structure, and form, emphasizing how a building's physical components express its purpose, method of assembly, and engagement with its environment. Tectonics is not just about the mechanics of construction but also about the poetics of making, how the materiality and logic of construction convey meaning and connect to cultural, historical, and environmental contexts (Maulden, 1986).

When applied to wood, tectonics takes on a unique approach. Timber is a material deeply rooted in human history, valued not only for its functional properties, such as strength, workability, and renewability, but also for its ability to express craft, warmth, and connection to nature. Timber tectonics explores the language of wood in architecture, considering how its inherent properties and structural logic shape design. Unlike materials such as steel or concrete, wood's organic qualities, grain patterns, and hygroscopic behavior demand a different approach to construction, one that respects its natural rhythms and limitations.

In modern architecture, timber tectonics has gained renewed relevance due to advancements in digital fabrication and parametric design. These technologies enable architects to move beyond traditional forms and methods, unlocking new possibilities for precision, efficiency, and expression.

the evolution of timber tectonics

Timber has been a fundamental building material throughout human history, with its tectonic expression evolving significantly over time. According to Hermann Kaufmann this evolution can be delineated into three pivotal eras: the Wooden Age, the Industrial Age, and the Digital Age (Kaufmann, 2011).

In the Wooden Age, timber construction was characterized by traditional craftsmanship, where builders relied on empirical knowledge and manual skills to create structures. Joinery techniques, such as mortise and tenon joints, were developed to connect wooden elements without the use of metal fasteners, showcasing a deep understanding of the material's properties. This period emphasized the natural aesthetics of wood, with designs that harmonized with the environment and local cultural practices. The spatial language of this era was defined by timber's inherent properties, lightweight, flexible, and organic, leading to the creation of intimate, warm, and tactile environments. Timber-framed houses and barns, for instance, often reflected the cultural identity of their regions, blending seamlessly with the landscape and emphasizing the connection between architecture and nature.

The advent of the Industrial Age brought about significant changes in timber construction. The development of engineered wood products, such as plywood and glulam, allowed for greater standardization and mass production. This shift enabled the construction of larger and more complex structures but often at the expense of traditional craftsmanship. The tectonic language of timber during this era became more utilitarian and less expressive, driven by the need for efficiency and uniformity. Architectural spaces grew larger and more standardized, with less focus on timber's natural qualities. However, this period also introduced new typologies, such as large-span structures and modular systems, that expanded timber's architectural applications. For example, glulam beams allowed architects to design expansive, open spaces in buildings like sports halls and industrial warehouses, showcasing timber's structural potential while aligning with the functional demands of modernity.

The current era has revolutionized timber tectonics through the integration of digital design and fabrication technologies. Parametric design tools and computer-aided manufacturing systems enable architects and

builders to explore complex geometries and customized solutions that were previously unattainable. Robotic fabrication allow for precise and efficient production of intricate timber components. This era has reintroduced timber as a material of artistic and structural expression, allowing architects to create spaces that are both highly functional and visually dynamic. The ability to optimize designs based on performance data has also influenced the spatial logic of timber architecture, resulting in more adaptive, efficient, and sustainable buildings. For instance, curved timber gridshells and freeform structures made possible by digital tools evoke a sense of lightness and fluidity, redefining how timber interacts with its surroundings.

Kaufmann (2011) highlights how the digital age has introduced unprecedented opportunities for timber construction by seamlessly integrating design and fabrication processes, allowing architects to push the material's boundaries. Similarly, Menges et al. (2016) discuss how digital technologies have redefined timber's tectonic potential, enabling innovative structural and architectural expressions.

the role of craftsmanship and tradition

Craftsmanship has historically been at the heart of timber construction, with master carpenters and joiners playing a pivotal role in both the design and execution of structures. In traditional timber construction, craftsmen were not just builders, they were designers, engineers, and artisans, responsible for conceiving and realizing intricate details that defined the tectonic language of wood (Kaufmann, 2011).

Historically, craftsmen were integral to every stage of the design and construction process. Working without detailed architectural drawings, they often relied on rule-of-thumb knowledge, practical geometry, and scale models to develop their designs. Tools like wooden mallets, hand planes, and chisels were their primary means of shaping timber, and their mastery of joinery techniques, such as mortise and tenon or dovetail joints, ensured the durability and stability of structures. These techniques were a direct reflection of the material's properties, marrying form and function in a way that harmonized with the surrounding environment. The knowledge was passed from master to apprentice through hands-on training. This transmission of tradition ensured consistency in construction methods while



Fig. 18

allowing regional variations, creating a diverse architectural language grounded in local resources and cultural contexts. Craftsmen also preserved cultural heritage, embedding their identity and artistry into the buildings they created.

The advent of mass production and engineered wood products like plywood and glulam diminished the need for individualized craftsmanship. Prefabricated components and standardized construction processes prioritized efficiency over artistic expression, reducing the craftsman's role in design and innovation. Their responsibilities shifted from creators of bespoke details to assemblers of pre-manufactured parts. While traditional hand skills have diminished in importance, craftsmen now engage with computational tools, CNC machines, and robotic systems to achieve precision and complexity in timber construction. This evolution requires new skillsets, including proficiency in software, alongside an understanding of machine operation and maintenance (Matthias Elsässer, personal communication, December 14, 2024).

Today, the craftsman occupies a hybrid role, balancing traditional knowledge with technological expertise (Menges et al., 2016).

In projects that emphasize precision and sustainability craftsmen collaborate closely with architects, engineers, and fabricators. Their role has expanded to include interpreting digital models, troubleshooting machine-based fabrication processes, and ensuring that the final assembly retains the material's intended expression.

Looking ahead, craftsmen will be vital in preserving traditions while integrating new technologies into their practice. Their knowledge of historical techniques provides a rich foundation for innovation, offering opportunities to reinterpret joinery methods or adapt traditional construction principles to modern contexts. For example, robotic fabrication can replicate the complexity of traditional joints with greater precision, creating a bridge between past and future practices. However, sustaining this balance will require intentional efforts to document and teach traditional skills, ensuring that these techniques are not entirely lost. The preservation of craftsmanship depends on its continued relevance in modern construction. While digital tools offer efficiency and scalability, they must not supplant the cultural and historical significance of traditional methods.

case studies: learning from timber tectonics

Examining specific projects offers invaluable insights into how timber's tectonic logic can be harnessed to achieve architectural and structural goals. Each project reflects a nuanced understanding of timber's material properties, employing innovative approaches to construction, detailing, and design.

The Bauernbogen pavilion in Austria by Studio Precht (Fig.20) exemplifies how timber can bridge tradition and innovation through its tectonic expression. Inspired by traditional agricultural forms, the design reinterprets the classic barn roof into a sweeping, curved structure. Timber's natural flexibility and lightness were key to achieving this organic geometry, which was developed through parametric design workflows. The curved wooden elements emphasize the craftsmanship inherent in timber construction, yet they were made feasible only through advanced digital tools. The project highlights the importance of respecting timber's natural properties while embracing the precision offered by digital fabrication. Architects can learn from the Bauernbogen how traditional forms can be revitalized through modern technology, creating architecture that resonates with

both cultural heritage and contemporary design language (Studio Precht, 2024).

Herzog & de Meuron's headquarters for the Christoph Merian Stiftung in Basel (Fig.19) demonstrates how timber tectonics can balance transparency, sustainability, and structural efficiency. The design celebrates timber's natural aesthetic while integrating its structural logic into the architecture. One key innovation lies in the way the timber structure integrates with the building's envelope, creating seamless connections between interior and exterior spaces. The tectonic language emphasizes minimalist joints and clean lines, showcasing timber's ability to serve as both a structural and visual element. The project underscores how timber can be used to create visually striking yet highly functional architecture that gets translated honestly from inside to outside and doesn't try to hide any features or functions (Herzog & de Meuron, 2024).

The Tamedia Building in Zurich (Fig.21), designed by Shigeru Ban, is a landmark in timber architecture, showcasing how traditional joinery techniques can be adapted for modern applications. The seven-story building features an entirely timber-framed

structure, constructed without the use of metal fasteners. Instead, traditional Japanese joinery methods, such as interlocking wooden joints, were adapted to contemporary needs. This tectonic approach emphasizes the inherent beauty of timber's structural logic. The building's exposed timber frame is not concealed but celebrated, with the joinery becoming a focal point of the design. The project illustrates how digital tools can revive and adapt traditional craftsmanship, creating architecture that is both expressive and functional (Archdaily, 2024).

These projects collectively demonstrate how timber can transcend its role as a simple construction material to become a medium for architectural innovation and expression. Each example reveals how the careful integration of timber's natural properties with advanced technologies can lead to designs that are both functional and aesthetically compelling. The integration of traditional craftsmanship, as seen for example in the Tamedia Building, proves that heritage and technology can coexist to enhance timber's tectonic expression.

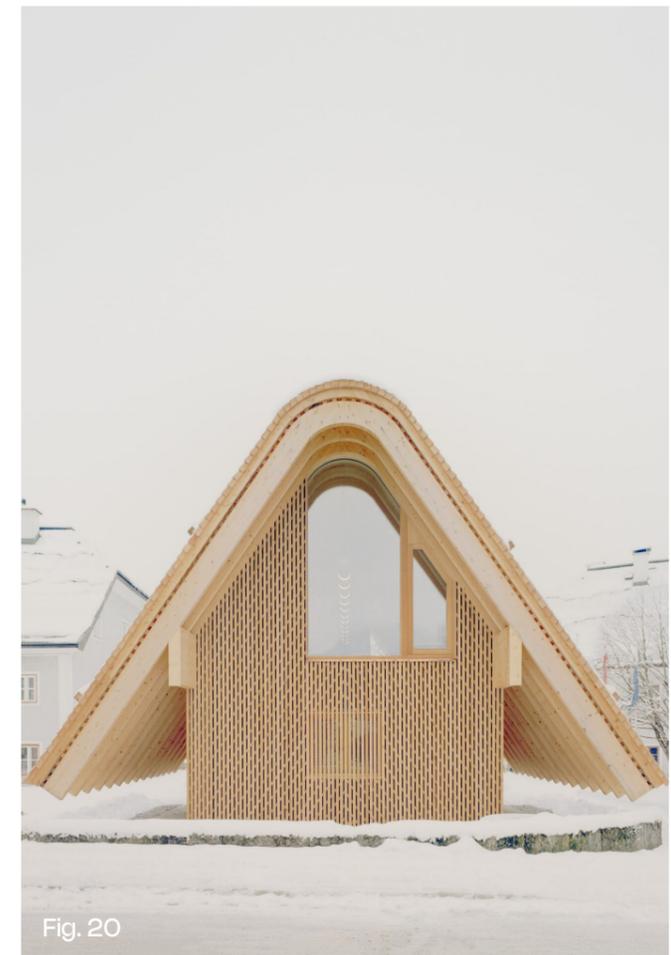


Fig. 20



Fig. 19

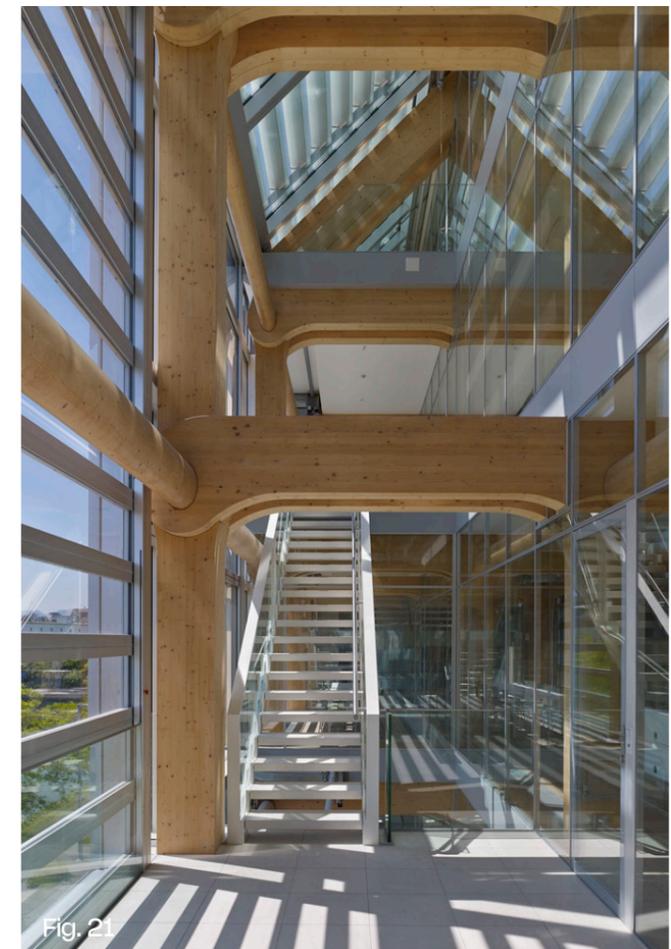


Fig. 21

timber missteps: what not to do

Timber's increasing popularity in contemporary architecture has led to innovative applications, but it has also exposed several missteps that undermine its potential. When timber is treated poorly as a substitute for materials like concrete or steel, its unique properties are often neglected, leading to inefficient, unsustainable, or uninspired outcomes. Understanding these missteps is critical to ensuring that timber's tectonic language is preserved, its benefits maximized and by that making it a competitive material on the current market.

A common misstep is the over-reliance on CLT in ways that mimic the logic of concrete construction. While CLT is an excellent material for achieving large spans and load-bearing capacities, its widespread use in flat panel systems often ignores timber's natural strengths, such as its tensile properties and capacity for lightweight, adaptable structures. Kaufmann (2011) notes that such applications risk reducing timber to a surface material, stripping it of its tactile and expressive qualities. In these cases, the material is pushed into roles better suited to concrete, creating inefficiencies and undermining the arguments for using wood in the first place.

Another issue arises from ignoring timber's material-specific behaviors, such as its hygroscopic nature. When timber is sealed excessively or over-engineered, its natural ability to regulate humidity and interact with the environment is lost. Projects that disregard these properties often struggle with long-term durability or indoor climate performance, negating some of the key benefits of timber as a natural material. Timber's behavior should be a design driver, not an obstacle to be neutralized.

The trend toward standardization in timber construction also poses a risk to the material's architectural richness. While prefabrication and modularity are critical for efficiency, overly standardized designs can strip timber of its cultural and tectonic expression. The uniqueness of wood, its grain patterns, natural imperfections, and adaptability to organic forms, often becomes secondary to the demands of mass production. This approach risks creating a disconnect between the material and its architectural expression, making timber indistinguishable from other standardized materials like metal or concrete, again weakening the reasons for its use in this highly economical driven market.

Additionally, the improper use of adhesives and synthetic components in engineered timber products can compromise timber's alignment with circular economy principles. Many CLT panels, for instance, rely heavily on petrochemical-based adhesives, making them difficult to recycle or repurpose at the end of their lifecycle. This not only reduces timber's sustainability but also creates a false narrative. To address this, architects and engineers should explore bio-based adhesives and design for disassembly, ensuring that timber's lifecycle is considered from the beginning.

Finally, there is a risk of treating timber as a trend rather than a material with its own logic and potential. When projects adopt timber just to signal sustainability without thoughtfully integrating it into the design, the result is often superficial and counterproductive. For example, decorative timber cladding on otherwise conventional steel or concrete structures may improve aesthetics but does little to nothing to address environmental performance or material logic. This shallow approach can undermine timber's credibility as a sustainable solution and reduce its impact on advancing architectural innovation.

how timber should be used: a conclusion

To use timber effectively, architects and engineers must first move beyond treating it as a substitute for concrete or steel. Timber has its own unique qualities that lend themselves to distinct architectural languages and structural solutions. Designs that leverage these properties, not only optimize performance but also showcase timber's capacities.

Sustainability must remain central to timber's use. Projects should prioritize lifecycle thinking, ensuring that timber components are designed for disassembly and reuse. Reducing the reliance on synthetic adhesives and exploring bio-based alternatives are key steps toward aligning timber construction with circular economy principles. Architects should also recognize that timber's sustainability is not just about its renewability but about how it is sourced, transported, and implemented. Local and regional supply chains, combined with digital workflows that optimize material use, can help reduce environmental impact while maintaining timber's connection to place.

The integration of traditional craftsmanship with modern technology is another crucial aspect of using timber effectively. Reviving and adapting traditional joinery techniques through digital tools offers a way to honor

timber's cultural heritage while pushing its tectonic boundaries. Craftsmen, architects, and engineers must work collaboratively to ensure that timber construction balances innovation with the preservation of traditional knowledge and skills.

Finally, the architectural application of timber should prioritize thoughtful expression. Timber must not be reduced to decorative cladding or treated as an aesthetic afterthought. Instead, it should serve as a core element that informs the structure, spatial logic, and identity of a building. By designing with timber's natural behavior in mind, architects can create spaces that are both functional and emotionally resonant.



Fig. 22

9.0

implementing new timber tectonics in the netherlands

The successful integration of timber into Dutch construction requires a systemic approach addressing the material's journey from sourcing to application. As the Netherlands strives to meet ambitious sustainability goals, timber offers a compelling alternative to conventional building materials like concrete and steel. However, this transition is not without challenges. Limited domestic forestry, reliance on imports, and stringent regulatory frameworks present barriers that must be navigated to unlock timber's full potential.

This chapter explores how new timber tectonics can be implemented effectively in the Netherlands, focusing on three scales: system, building, and detail. It examines the adaptations required in supply chains, construction practices, and design detailing to create a framework for timber's widespread adoption. By addressing challenges such as fire safety regulations, sound insulation, and the development of circular systems, this chapter aims to demonstrate how timber can redefine the Dutch architectural landscape while advancing ecological and economic sustainability.

system scale: timber's journey

Timber Supply Chains in the Netherlands

The Netherlands relies heavily on imported timber. This dependency is driven by the nation's limited domestic forestry, as agricultural land use historically outweighed the need for large-scale timber production. While importing timber allows access to sustainably managed forests, it creates vulnerabilities in pricing, availability, and transportation logistics.

One significant challenge lies in the lack of local processing facilities, requiring imported timber to arrive in a ready-to-use state. This dependency raises transportation emissions and costs, especially for engineered wood products like CLT and glulam. Expanding domestic processing facilities would reduce reliance on external markets, lower environmental impacts, and strengthen local economies (Helmond, 2022). Additionally, a better understanding of timber supply fluctuations could help stabilize the market and encourage wider adoption.

To address these issues, strategic forestation efforts could help diversify domestic timber sources. Initiatives like planting fast-growing species, such as poplar or Douglas fir, in

underutilized agricultural areas can boost local availability (Probos, 2009).

Moreover, the smart utilization of existing resources, as highlighted at the Anatomy of Timber forum, could include innovative practices such as repurposing urban trees felled during city maintenance for construction purposes. This approach redefines the concept of "stock" and encourages thinking creatively about the circular wood chain (BK-Wood Group, 2024).

Regulatory Frameworks and Policies

Dutch building regulations play an important role in timber adoption. Fire safety standards, for example, often require additional protective layers for timber, increasing costs and complicating project approvals (Helmond, 2022). Structural performance standards, are still largely calibrated for conventional materials, limiting timber's acceptance in large-scale projects.

Recent government efforts, such as Amsterdam's initiative to build 20% of new housing with timber by 2025, showcase progressive steps toward change (Netherlands Green Building Council, 2020). National frameworks like the Circular Economy Action Plan have further emphasized timber

as a key material in reducing embodied carbon in construction. However, these policies often lack unified implementation, leading to fragmented adoption across regions and project types.

Successes thus far include pilot projects like HAUT and Sawa, which have demonstrated the feasibility of timber in high-rise construction. However, scaling such projects will require updates to building codes, particularly for fire safety and structural integrity, to better accommodate mass timber products like CLT and glulam. Providing financial incentives, such as subsidies for timber-based construction or streamlined permitting processes for sustainable projects, could further support timber's adoption at scale (European Commission, 2021).

Industry and Infrastructure Adaptation

The successful integration of timber tectonics in the Netherlands depends on the construction industry's ability to adapt its practices and infrastructure. While some Dutch firms have embraced prefabricated timber systems, the sector at large faces skill shortages and knowledge gaps. The transition from conventional materials to timber requires specialized training in areas such as

parametric design, digital modelling, and timber-specific assembly techniques (Wageningen University, 2023).

Infrastructural limitations also pose challenges. For example, the Netherlands has limited facilities for processing engineered wood products, making it reliant on importing prefabricated components. Expanding domestic production capacity for materials like CLT and glulam would not only reduce costs but also strengthen local supply chains. Collaboration between academic institutions, like TU Delft's timber research programs, and industry stakeholders can help bridge this gap by fostering innovation and expertise.

Future steps to address these challenges include establishing dedicated training programs for timber construction, incentivizing investments in local production facilities, and creating platforms for knowledge sharing. Additionally, public-private partnerships could accelerate the development of timber-specific infrastructure, ensuring that the industry is equipped to meet growing demand for sustainable construction solutions (Satim, n.d.).

building scale: adapting processes

Integrating Timber into Dutch Construction Culture

The Netherlands has a long-standing reliance on brick and concrete as the primary construction materials, deeply ingrained in its architectural identity and building practices. While these materials have proven durable and versatile, their environmental impact has become a growing concern (Helmond, 2022).

Timber offers an opportunity to align with existing construction methods while addressing sustainability challenges. Prefabricated timber systems, for instance, complement the Dutch tradition of modular construction, which emphasizes efficiency and adaptability. Additionally, timber's lightweight nature makes it particularly suitable for retrofitting existing buildings and constructing on sites with limited load capacity.

Construction Challenges and Solutions

Despite its advantages, integrating timber into Dutch construction faces significant challenges, particularly in meeting fire safety regulations. While these measures are essential for safety, they can negate some of timber's natural aesthetic and environmental benefits. Advances in treated CLT and other

engineered wood products are addressing these concerns by enhancing fire resistance without compromising timber's integrity (European Commission, 2021).

Structural performance is another critical barrier. Timber must meet strict standards to ensure durability under the Netherlands' climatic conditions, such as high humidity and wind loads. Hybrid timber systems, which combine timber with materials like steel or concrete for reinforcement can help with specific problems if timber construction reaches its limits (Wageningen University & Research, 2023). Nonetheless this solution should ideally be avoided by designing the space with the material constraints already in mind. Additionally, cost competitiveness remains a significant hurdle. Timber's higher initial costs relative to conventional materials often scares developers away. Government incentives, such as subsidies for timber projects or tax benefits for sustainable construction, can play a crucial role in helping the economic playing field (Netherlands Green Building Council, 2020).

Sustainability at the Building Scale

A key advantage of timber in circular construction is its compatibility with modular

and prefabricated systems. Integrating circular principles into timber construction not only enhances sustainability but also supports economic resilience. Once sufficient timber exists within the system, dependence on imports will decrease, stabilizing costs and reducing carbon emissions associated with transportation. This shift would create opportunities for local industries to focus on processing, reusing, and adapting timber, pushing economic activity while minimizing resource extraction. Expanding timber infrastructure, such as recycling facilities and knowledge hubs, can further strengthen this circular model and reduce waste. Moreover, designing buildings with lifecycle thinking ensures that timber is valued as a long-term resource rather than a disposable material. Bio-based adhesives and non-toxic treatments make timber easier to recycle and reuse, closing the loop in its lifecycle and enhancing its economic viability (European Commission, 2021).

detail scale: rethinking facades and structures

Facades: Timber as a Climate-Responsive Material

Timber facades offer significant advantages in addressing environmental challenges, particularly in the Netherlands, where temperate maritime conditions demand energy-efficient building solutions. Timber's inherent thermal insulation properties effectively reduce heat transfer, minimizing reliance on artificial heating, cooling systems and artificial insulation materials. This characteristic makes timber facades a key component of sustainable building envelopes, lowering energy consumption and operational costs (Mainini et al., 2024).

Beyond its thermal performance, timber exhibits hygroscopic behaviours, allowing it to absorb and release moisture from the environment. This quality naturally regulates indoor humidity levels, improving air quality and reducing the risks of mold growth and material degradation. Such attributes make timber especially suitable for creating healthier indoor environments, aligning with the Netherlands' goals for sustainable urban living (El-Dabaa et al., 2023).

Parametric design tools have further enhanced the functionality of timber facades,

enabling architects to optimize their geometry for energy efficiency. Software platforms allow designers to simulate and adjust facade configurations to maximize natural light while minimizing solar heat gain. This approach also facilitates the integration of shading devices and ventilated cladding systems tailored to site-specific conditions, enhancing overall building performance (El-Dabaa et al., 2023). However, timber facades must also contend with weathering challenges in the Dutch climate. Without appropriate treatments or coatings, prolonged exposure to moisture and UV radiation can lead to deterioration, requiring regular maintenance to preserve aesthetic and structural integrity (Helmond, 2022).

Despite these benefits, timber facades face limitations regarding sound insulation. While timber's hygroscopic properties enhance comfort, its low density compared to concrete or brick can result in inadequate noise reduction. This poses a challenge in urban settings, where external noise pollution is a concern. Addressing this issue requires innovative solutions such as integrating mass timber panels with additional layers of soundproofing materials or combining timber

with acoustic insulation layers to improve performance (Ramage et al., 2017).

Joinery and Connections

Timber joinery has historically relied on techniques like mortise and tenon joints, which create durable, fastener-free connections. These methods reflect a deep understanding of the material's structural behaviour, emphasizing both strength and flexibility. However, as timber construction evolves to allow larger spans and higher loads, traditional joinery must be adapted to meet modern engineering standards. Combining historical techniques with advanced materials and precision tools offers a pathway to maintaining structural integrity while meeting contemporary performance requirements (Menges et al., 2016). By enabling intricate and highly accurate designs, CNC technology reduces the need for additional adhesives or mechanical fasteners, which can compromise recyclability. This precision also minimizes material waste by optimizing cuts and reducing offcuts.

Despite these advancements, challenges persist at the detail level. One significant issue is the long-term durability of connections,

especially in humid climates like the Netherlands. Moisture infiltration can weaken timber joints over time, necessitating the development of moisture-resistant coatings and treatments or design solutions. Furthermore, the use of hybrid connections that combine timber with steel or other materials introduces compatibility concerns, particularly regarding thermal expansion and long-term performance. Addressing these issues requires a balanced approach that integrates traditional craftsmanship with the benefits of modern technology (Kaufmann, 2011).

10.0

key learnings and conclusion

key learnings and conclusion

Timber presents a convincing alternative to conventional construction materials such as concrete and steel, particularly in addressing sustainability and circularity. However, it is crucial to recognize that timber is “a” solution rather than “the” solution to the challenges facing the building industry. While timber offers benefits like renewability, carbon sequestration, and adaptability, it must be used thoughtfully to align with its inherent strengths. Missteps, such as forcing timber to mimic the tectonics of steel or concrete, risk diminishing its potential. Instead, timber’s unique material logic must guide its use, allowing architects to embrace its adaptability, aesthetic qualities, and sustainability. A material- and fabrication-driven design should be the focus.

Advancements in digital fabrication and parametric design have transformed how timber can be used in construction, unlocking new possibilities in precision, optimization, and expression. These tools enable architects and engineers to create complex geometries, minimize material waste, and integrate site-specific data into design workflows. In the Dutch context, these technologies are especially promising for addressing urban density and the need for sustainable building

solutions. By harnessing parametric models and prefabrication, timber structures can be customized to address the specific challenges of Dutch cities, including climate conditions and spatial constraints.

Shifting the public perception of timber is equally important. Misconceptions about fire safety, durability, and maintenance create unnecessary barriers to its adoption. Educating stakeholders about timber’s performance and showcasing projects that fully utilize its potential can help change these perceptions. At the same time, focusing just on timber’s sustainability can overlook its broader benefits. Timber’s warmth, ability to regulate humidity, connection to nature make it a material that enhances user experience while contributing to environmental goals the local market. Simply put, building with timber reflects a commitment to responsibility.

The Netherlands, with its long-standing tradition of timber construction, is uniquely positioned to lead a timber renaissance. However, systemic challenges remain. The reliance on imported timber highlights the need for robust supply chains and local processing facilities. At the same time, regulatory frameworks must evolve to accommodate mass timber construction,

particularly regarding fire safety and structural standards. Encouraging collaboration between architects, engineers, and fabricators is essential to bridge knowledge gaps and accelerate the adoption of advanced fabrication technologies.

Looking to the future, timber’s role in architecture must balance ecological responsibility with innovation. Research into bio-based adhesives and improved lifecycle performance will be critical for enhancing timber’s circular potential. Policy initiatives, such as subsidies for sustainable construction and streamlined permitting processes, can further promote its adoption. In the Dutch context, timber offers a unique opportunity to redefine urban architecture by creating greener, more human-centered spaces.

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