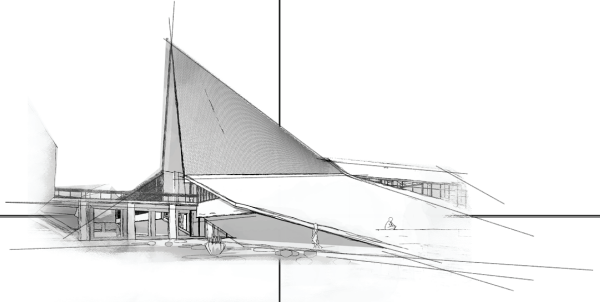
Intersections in Timber, Technology And Cultural Typologies: Finding the Balance Within Architecture



Kayla S. McKinney

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Kayla S. McKinney

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James R. Jones, Chair
Luis R. Borunda-Monsivais
Kay F. Edge

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ABSTRACT:

Architecture walks a fine line between the mediums of scientific discovery, artistic nature, and analysis of culture. When one of these factors becomes more prioritized over others, there becomes an imbalance. One of the most common critiques of contemporary architectural practice is that this imbalance has caused an increasing divide between architecture in academia, practice and research. While technological innovation within the discipline of architecture is the future, this exacerbates many of architecture's already existing imbalances.

When trying to solve the issues of the modern practice of architecture through AI, algorithms, and computer technology, much of the actual "architecture" and craft of design is lost. This prompts the question: can there be a medium where both innovative technology and craft can coexist within design?

By embracing a more transformational concept of combining both legacy and material conditions, we can innovate through critical reason and tradition in a "fusion of new horizons" as coined by German philosopher, Hans Georg Gadamer (1960). As stated in *Studies in Tectonic Culture,* all architecture comes through "processing what exists in the present, and what has come before", (Frampton, 1995). Unlike technology that regards the past as obsolete and always aims at a non-perceptible future in search of progress, a more reflective, critical theory is needed for advancing architecture. It is a humanistic science that must not only acknowledge the past but cherish and embrace it.

This research seeks to re-discover the human balance within the architectural discipline: space-making while being knowledgeable of cultural sensibilities and continually advancing the discipline through technological innovations.

GENERAL ABSTRACT:

Architecture balances science, art, and cultural understanding. When one dominates, it disrupts the harmony, as seen in the growing divide between contemporary architectural practice and research. While technological innovation is essential, relying solely on computer automation and algorithms risks losing the craft and essence of design. Through the synthesis of material conditions (timber), culture/history (the vernacular), and technological innovation, we can create a new typology of architecture that responds to modern conditions and sensibilities.

This research aims to restore balance in architecture (utilizing the medium of timber), fostering thoughtful space-making that respects cultural heritage while embracing technological advancements.

Thank You To:
My wonderful partner, who pushes me to be
the best version of myself,
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My committee, for the time they took to
help this project be the best version possible,

And to those who truly want to
rediscover the intention of craft,
design, and architecture.

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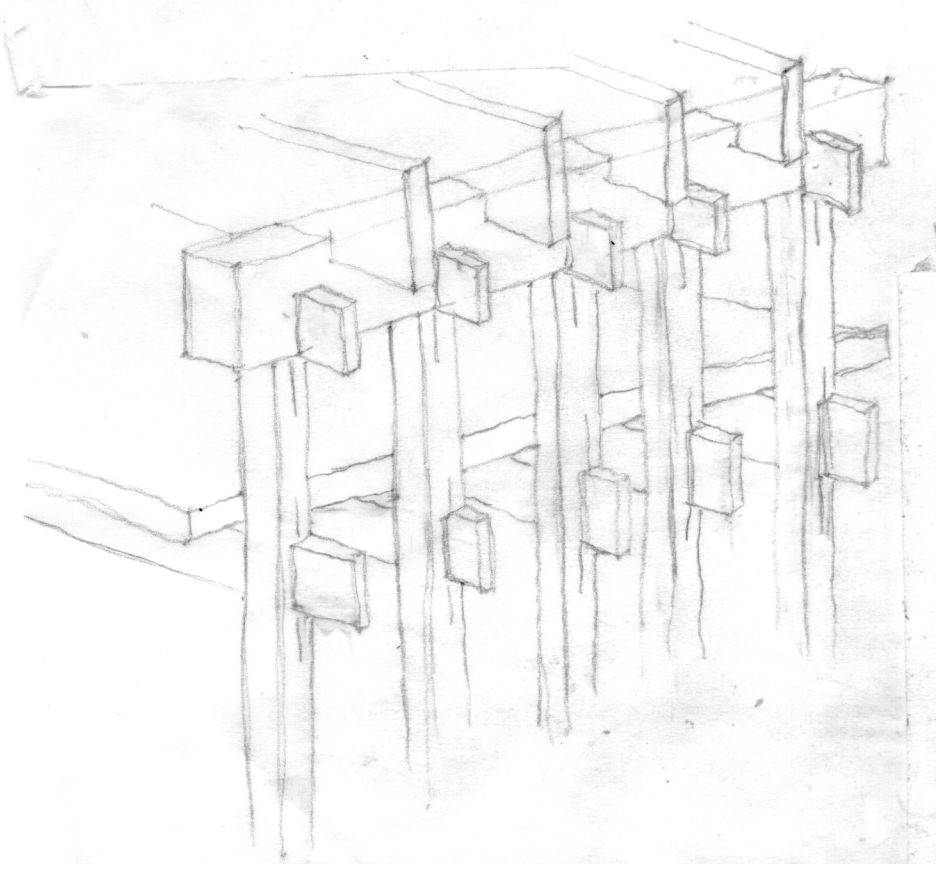
"Architecture is an expression of

cultural values,

societal aspirations

and technical possibilities"

-Kenneth Frampton (1995)



1.0.- Existing Architectural Theory

Architectural theory encompasses the principles, philosophies, and conceptual frameworks that inform the design and interpretation of the built environment. It serves as a fundamental connection between human experience and the technical, aesthetic, and functional dimensions of architecture. The study of human experience is central to architectural discourse, prompting critical inquiries into how spaces accommodate the needs of their occupants and how phenomenology, the sensory perception of architecture, shapes spatial engagement. Additionally, architectural theory examines the ways in which structural form conveys the underlying intentions of architects and how materiality contributes to the realization of conceptual and experiential objectives. The breadth and complexity of architectural theory presents a vast and multifaceted intellectual landscape, inviting continuous exploration and reinterpretation.

One critical theoretical framework within architectural discourse is the analysis of architecture through the lens of culture. Architecture is linked to the sociocultural, historical, and geographical contexts in which it is conceived and constructed. It serves as both a physical manifestation and a symbolic representation of the values, traditions, and collective identity of a civilization. The architectural character of a place is shaped by its cultural heritage, influencing material choices, spatial organization, and design motifs that reflect the beliefs and customs of the society that inhabits it. As a result, architecture functions as a dynamic dialogue between past and present, continuity and transformation, preserving historical narratives, while adapting to contemporary needs and innovations. Through this lens, the built environment becomes a living record of human experience, reinforcing the intricate relationship between architecture and cultural identity.

1.0- 1- Theory of Cultural Tectonics:

Many questions arise from the architectural analysis of culture: how does the structure represent itself, what is it's program and function, and what role does it fulfill within the human context? Studying the trajectory of architecture through time and place provides us with an insight into the human condition, cultural evolution, and tectonics of craftsmanship. Kenneth Frampton's *Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture* (Frampton, 1995), describes the analysis of "tectonics" within vernacular architecture throughout history. Frampton frames the meaning of tectonics within the architectural context as: "Associated with particular use and application of structure, space, and materiality". Utilizing the gradual metamorphosis of construction techniques throughout time, with various cultures as precedent, Frampton gives technical background to various architectural contexts, theories, and movements throughout history. Employing case studies that feature illustrations and descriptions of various building techniques, structural layouts, photographs of intricate carvings, and more, these are referenced to make sense of the contemporary landscape and dialogue within modern architecture.

In contrast to historical examples, modern construction techniques are examined in relation to each case study, highlighting the evolution of contemporary architectural methodologies, building practices, stylistic developments, and regulatory frameworks. By analyzing these precedents, a clearer understanding emerges of how architectural conventions and construction standards have evolved over time. Juxtaposition of historical and modern approaches provides critical context for the progression of architectural thought, illustrating the influence of past innovations on contemporary design and engineering. Furthermore, this comparative analysis offers insight into the rationale behind the establishment of modern building codes and regulatory measures, shedding light on the factors that have shaped architectural practice in the 20th century and beyond.

Additionally, Kenneth Frampton's concept of Critical Regionalism, as outlined in his essays such as *Towards a Critical Regionalism: Six Points for an Architecture of Resistance*, offers a framework for architecture that balances global modernism with local cultural and geographical contexts (Frampton, 1981). His writings propose an architectural approach that resists the homogenization of global modernism while remaining engaged with contemporary design principles. He argues that architecture should be deeply rooted in the cultural, geographical, and climatic specifics of a place, rather than succumbing to placeless, universal aesthetics. Unlike purely vernacular revivalism, Critical Regionalism does not seek to recreate the past but rather to reinterpret traditional elements in a way that is meaningful for modern life. Frampton emphasizes the importance of tactile experience over visual spectacle, advocating for the use of local materials and construction techniques to create buildings that resonate with their surroundings. This approach also serves as a form of cultural resistance against the commercialization of architecture, countering the dominance of mass-produced, consumer-driven design. Ultimately, Critical Regionalism offers a nuanced balance between global modernity and local identity, ensuring that architecture remains both contextually relevant and forward-thinking.

1.0-1.1- Architecture as Artifact

Frampton emphasizes architecture as tangible and culturally significant constructs- shaped by materiality, construction techniques, and historical context. He argues that architecture should be understood as more than just a functional or aesthetic pursuit- is a physical manifestation of cultural and technological evolution. A critical focus on handcrafted detailing, the human-centered programming of architectural spaces, and the significance of materiality plays a fundamental role in the analysis of historically and aesthetically distinctive concepts. Prior to the widespread industrialization and globalization of architectural practice, the acknowledgment of historical precedents—through the study of local, vernacular, and culturally significant buildings—was essential in understanding the relationship between architecture, culture, and climate. These contextual influences shaped architectural expressions that were deeply rooted in their natural and cultural environments. This emphasis on the origins of architectural form is a recurring theme in the works of Kenneth Frampton, where he explores the intrinsic connection between materiality, construction, and place. His theoretical framework serves as a foundational reference in the broader discourse on architecture, reinforcing the importance of historical continuity and regional specificity in architectural exploration.

Figure 1- *Joinery concept sketch*, (McKinney, 2025).

1.1- Problem Statement- The Lost Art of Architecture

Kenneth Frampton emphasizes the deliberate preservation and advancement of the tectonic tradition as a fundamental aspect of architectural evolution. He posits that this approach is crucial to the continued development of architectural form, offering a critical reassessment of modernity and its implications. Through this lens, Frampton reevaluates the architectural discourse surrounding the avant-garde, contemporary modernist approach to architecture, challenging conventional categorizations and highlighting the enduring significance of materiality, construction techniques, and structural expression in shaping contemporary architectural practice.

As argued in *Studies in Tectonic Culture*, this culturally informed- aspect of architecture has been lost to time, in favor of efficiency, standardization, and profit-driven development.

The "lost art" of architecture refers to the decline of certain traditional principles, craftsmanship, and design philosophies that were once central to architectural practice but have been diminished due to industrialization, mass production, and modern construction techniques. This term is often used to critique contemporary architecture's shift away from handcrafted detailing, material authenticity, regional identity, and human-centric design.

1.1-1.- Industry Standardization

The widespread adoption of prefabrication and mass production has led to the decline of traditional craftsmanship, replacing intricate, handcrafted detailing with standardized, cost-effective solutions. Contemporary construction practices frequently prioritize artificial materials, diminishing the sensory and emotional connection between individuals and the built environment. Additionally, the globalization of architectural styles has contributed to a homogenization of design, often overlooking the cultural and environmental specificity of a given context. In the contemporary era, functionalist and corporate-driven design tends to emphasize efficiency and economic viability over the psychological and experiential well-being of occupants. While minimalist and abstract modernist approaches have introduced innovative spatial and formal strategies, they have resulted in architecture that lacks cultural narrative, historical continuity, and deeper symbolic meaning.

1.1-1.1- State of the Art

Boundaries within the architectural discipline are being pushed with the implementation of novel technologies. Computer-Aided Design (CAD) processes are at the forefront of architectural academia research. An interdisciplinary approach to design combining material sciences, robotics engineering, and design expertise is being explored and expanded upon. Coined by Neumann and Schmidt, "Re-evaluation of the context of design and building" within the architectural discipline has shifted towards efficacy, efficiency, and sustainability- technology has become the driving force behind these developments (2007).

Manufacturing methodologies are "poised to transform building construction," with robotics, mainly Computer Numerical Control (CNC) machining, driving the bulk of this transition (Timberlake & Kieran, 2003). As stated in *Refabricating Architecture*, Kieran and Timberlake argue that due to modern industrialization, the scope of making has been segregated from the designer/architect and subdivided into various, isolated steps. The process of designing and manufacturing a building has become a linear process, but with the introduction of technology, the designer has begun to reclaim a collective insight over the entire design/build process, therefore maintaining creative vision over the project from conception to construction.

In practice, but mostly in academia, modern architects concede to the idea of "transcending tradition". As if cultural context is something to be thought of only in the very beginning design stage and not referenced throughout a project. Specifically, in the 21st century, there has been a shift to reinvent "state-of-the-art" in architecture. State-of-the-art refers to the most recent stage of technological development within a specific discipline (State-of-the-Art, Adj. & n. Meanings, Etymology and More | Oxford English Dictionary, n.d.). While technological innovation within the discipline of architecture is the future, this exacerbates many of architecture's already existing problems, whereby trying to solve the issues of the modern practice of architecture through AI, algorithms and computer technology, much of the actual "architecture" and craft of design is lost. Perhaps there can be a medium where both cutting edge technology and craft can coexist within design. Kenneth Frampton contends that architecture cannot solve every problem, and that attempting to do so through entirely "radically new" processes often results in solutions that are neither effective nor enduring, (Frampton, 1995).

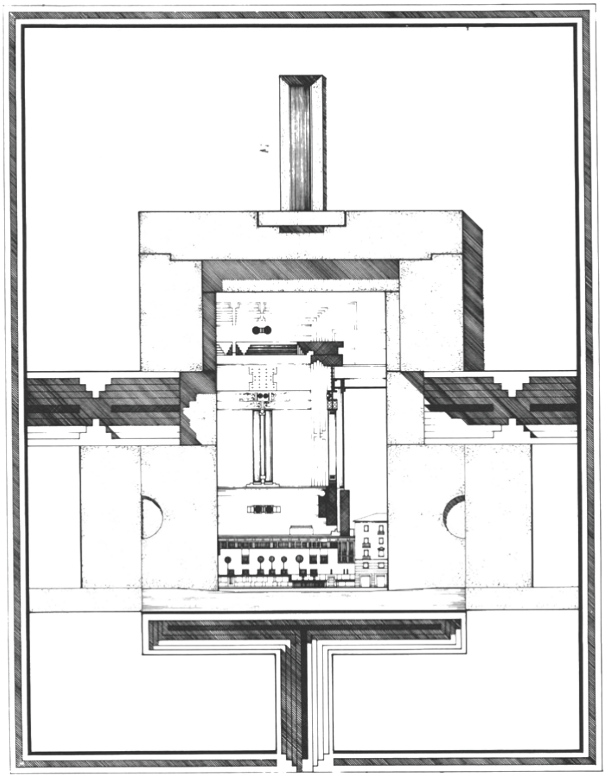


Figure 2- *Carlo Scarpa's principal of 'Analytique'*, (Frascari, 1983).

1.2- The Tell-The-Tale Detail

"In the Work of Carlo Scarpa

Beauty

At the first sense

Art

The first Word

Then wonder

Then the inner realization of form

The sense of wholeness of inseparable elements.

Design consults Nature

To give presence to the elements.

A work of art makes manifest

The wholeness of Form of the

Symphony of the selected shapes

Of the elements. In the element

of the Joint inspires ornament, its

celebration.

The detail is in the adoration of nature."

-Excerpt from The Tell-the-Tale Detail (Frascari, 1983)

Detail is the seminal distinction in what makes an architect separate from others within the practice of construction: appropriate and informed selection, placement of details, and the relationship of part-to-whole. A well-designed architectural detail, according to Marco Frascari, should integrate "function, materiality, and cultural significance",(-Frascari, 1983). This approach ensures that even the smallest elements of a building contribute to a cohesive and meaningful architectural experience. More than just a technical component of a building, the detail is an essential narrative that communicates the architect's intentions, cultural references, and design aspirations.

1.2.1- Detail and its Influence upon Architecture

'Detail" in this sense, not only is regarded in a material "part-to-whole" sense, but also in a spatial relationship. Building upon the tectonic theory and ideas of Critical Regionalism from Frampton, Frascari emphasizes that details express the pure and idealized essence of architecture, revealing the relationship between materials, structure, culture and craftsmanship.

As referenced within the text of *The Tell-The-Tale Detail*, the more classically influenced designs of the Beaux-Arts style are comprised of many small details, (columns, ornaments, sculpture, etc.) comprising the whole of the building- creating a dialogue between elements. Drawings of the time depict these details and relationships, in varying scales and compositions. This 'analytique' representation of architecture focuses on interlocution between details, often featuring a drawing of the whole building as a small depiction, another "detail" within the drawings rather than the modern depiction of construction documents today (**Figure 2**). Expertly skilled craftsmen prepared the physical depictions of these details, while it was the architect's role to procure and select these men to execute his designs. The architect is the master of translation- synthesizing the part to whole- crafting the "tale" from the individual details.

1.2.1.1- The Concept of Vernacular

In addition to the concepts of intention, perception, and the analytical examination of details, another crucial factor emerges—collocation. The evolution of architecture is fundamentally derived from nature, or more precisely, an interpretation of nature shaped by human craftsmanship, experience, and perception. According to the *Merriam-Webster Dictionary*, architecture that is concerned with domestic and functional structures, instead of public or monumental buildings is classified as "vernacular" (VERNACULAR Definition & Meaning - Merriam-Webster, n.d.). This classification underscores the significance of handcrafted detailing, human-centered design, and materiality- each of which plays a crucial role in analyzing the aesthetic, historical, and conceptual uniqueness of architectural works.

Before the onset of industrialization and globalization in the architectural domain, acknowledging the past was essential. The study of local, historic, and vernacular buildings provided critical insights into how culture and climate influenced distinctive architectural forms, shaped fundamentally by nature. This pursuit of a "timeless origin" and an "eternal present"- terms coined by Gottfried Semper, serves as a conceptual grounding of architecture in its primitive roots (Semper, 2004). His ideas, particularly regarding the origins of architecture, resonate throughout Kenneth Frampton's *Studies in Tectonic Culture* and Marco Frescari's *Tell-the-Tale Detail* and serves as a foundational reference for this thesis.

1.3- Objectives

As previously discussed, the integration of resilient and naturally occurring architectural typologies into contemporary practice has the potential to enhance industry standardization by fostering a pragmatic and dynamic interplay between various domains- global and regional, human and environmental, traditional and contemporary, as well as symbolism and materiality. This interplay is not confined to architecture alone but extends deeply into cultural identity, shaping the way societies negotiate the pressures of globalization while maintaining a connection to their historical and geographical roots. In this sense, Critical Regionalism serves as a broader cultural strategy, resisting the erosion of local traditions while engaging in a meaningful dialogue with modernity. It underscores the importance of place-specific narratives, ensuring that cultural expression remains adaptive rather than static. By emphasizing sensory experience, material authenticity, and contextual relevance, this approach fosters a cultural landscape that is neither purely nostalgic nor wholly dictated by globalized aesthetics. Instead, it cultivates a living tradition, one that evolves in response to contemporary needs while safeguarding the unique character of regional identities.

Through a series of comparative analyses, informed by Kenneth Frampton's examination of cultural case studies (which will be explored in the following chapter), a coherent and structured discourse will emerge, linking vernacular tectonics, detailing, and design technology. By incorporating technological methodologies within a culturally informed framework of construction, it is possible to drive innovation. The synthesis of these elements holds the potential to establish a genealogically transcendent design methodology- one that introduces an unprecedented aesthetic and structural identity within contemporary architectural practice.

1.3- 1. - Balanced Relationships in Architecture

Development and application of technologically aided modern manufacturing processes have existed in a "design bubble" and have been frequently treated as independent case studies, devoid of site and context. These technological aides that readily accommodate custom features and digitally mediate design processes "afford designers and builders a new formal and spatial vocabulary" according to Neumann and Schmitt, (2007). At its core, architecture is an expression of place, and with place comes history. By adopting a more transformative approach—one that integrates both inherited legacies and material realities—we can foster innovation that transcends mere novelty, guided by critical reasoning and tradition. This idea resonates with Hans-Georg Gadamer's notion of a "fusion of new horizons," where past and present engage in meaningful dialogue (Georg- Gadamer, 1960). As Frampton further explores in Studies in Tectonic Culture, architecture is always shaped by both its historical foundations and contemporary conditions. Unlike technology, which often dismisses the past as obsolete in its relentless pursuit of an imperceptible future, architecture requires a more reflective, critical approach. It is a humanistic discipline—one that must not only acknowledge history but actively embrace and honor it.

1.3- 1.1.- Integration into the Contemporary

Utilizing integrated component assemblies in BIM software enables smart material knowledge, component implementation into accurate models, and a catalog of manufacturable parts that can be sent straight to the manufacturing source. By having more insight into building assemblies' parts and processes, a greater control and understanding of quality can be achieved by the architect, creating respondent designs that pull from context, site, and cultural precedence. This conceptual system exists in research and academia yet has not fully integrated itself into the architectural industry for a myriad of reasons. Ironically, this practice is commonly used in many other industries, such as automotive, shipbuilding, and aeronautical manufacturing.

Additionally, digital fabrication tools such as CNC processors & routers, laser cutters, and 3D printers provide a "direct link" between computer aided modeling and physical form. Scale physical models, digital models with integrated systems, and two-dimensional plans are all integrated and can be developed simultaneously. Integration of technology in contemporary timber construction illustrates the potential of a design culture that seeks innovation in a broader understanding of ecology rooted in regional culture, environmental conditions, material availability and tradition. Traditional labor-intensive manufacturing techniques are redefined, aided by computer-controlled machines for democratized/ widespread adoption. Virtual modeling of complex geometries is translated into simple operations. Previous mass-production processes are now replaced with mass customization, which has given way to the ability to differentiate each building component without affecting the efficiency of the production process. The result is a more sensible and accurate response to the context of design intervention.

2.0- Architectural Research Methodologies

Architectural research is inherently multifaceted, drawing upon a wide range of disciplines and methodologies. It extends beyond conventional scientific inquiry, engaging with both qualitative and quantitative approaches to generate new knowledge. While it may not always conform to the rigid framework of the scientific method, architectural research remains a critical pursuit aimed at advancing understanding, innovation, and practice within the field.

2.0.-1.- Immersion through Research

Architecture is both a visual and tactile discipline, requiring a synthesis of conceptual thought and physical manifestation. The creative process involves the translation of ideas from the mind to the hand and ultimately to a tangible medium, such as paper or digital representation. As previously discussed, the role of the architect encompasses conception, ideation, and translation, necessitating a deep understanding of both artistic and technical principles. To effectively fulfill this role, architects must possess proficiency in two- and three-dimensional drawing, spatial geometry, and an acute awareness of material properties and their interactions within a given environment. Additionally, a comprehensive understanding of the principles of physics is essential to ensuring the structural integrity and functional performance of architectural designs. Through this multidisciplinary expertise, architects bridge the gap between abstract vision and built reality, shaping the spatial and material experiences of the built environment.

An architect is consistently an active participant

2.0.-1.1- Qualitative vs Quantitative

Depending on current global trends, funding and technological developments, the ebb and flow of research topics has changed from one to the next. Particularly within architectural research attention is on how "process/methodology" is conducted; focusing on how knowledge is collected, clarified and summarized. There are two distinct methodologies, a.k.a. types of research: Qualitative and Quantitative- as shown in **Figure 3**. At its most rudimentary level, Groat and Wang define quantitative research by "the manipulation of phenomena that can be measured by numbers; whereas qualitative research depends on non-numerical evidence" ... citing that it can be verbal (oral or written), experiential (film or notes about people in action) or artifactual (objects, buildings, or urban areas).

The qualitative model involves an inductive process of inquiry, meaning that there must be a procedure to detect evidence of critical factors affecting the topic of research. This method of discovery would be best suited for this research topic, as the subject matter is less quantifiable. There must be a focus on qualitative processes, such as interpretation, meaning and potential integration, all with the basis of critically reflective and reflexive practice models as guidance. verbal (oral or written), experiential (film or notes about people in action) or artifactual (objects, buildings, or urban areas).

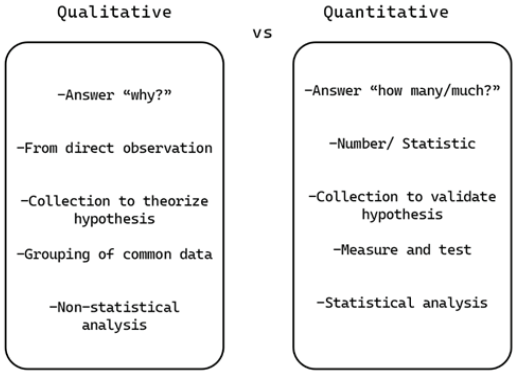


Figure 3- *Table showcasing differences in research methods*, (McKinney, 2025).

2.0.-1.1.1- Reflection & Experiment

The architectural design process can be examined through the lens of Ostermann and Kottkamp's *Metaphor of the Theatre Critic*, wherein architects simultaneously act as both subject and object- observing, analyzing, and refining their own creative decisions, (2004). This reflective practice aligns with the seven steps of Argyris' (1982) *Ladder of Inference*, seen in **Figure 4**, which outlines the process by which individuals form assumptions and act. Initially, an architect experiences a design challenge and selectively observes specific aspects of the site, context, and programmatic requirements. These observations are then filtered through cultural and personal perspectives, leading to the addition of meaning. Based on these meanings, assumptions are formed, conclusions are drawn, and beliefs about architectural space, form, and materiality are developed. Ultimately, these beliefs inform the architect's design decisions and subsequent actions.

Following this analytical process, where assumptions are critically examined, Ostermann and Kottkamp propose the third phase- Abstract Re-conceptualization- where new insights and understandings emerge, reshaping the architect's design approach. The final phase, Active Experimentation, involves testing these newly developed ideas in practice, refining them through iterative processes of modeling, prototyping, and construction. This cyclical method of reflective practice not only enhances the architect's ability to make informed, contextually responsive decisions but also fosters innovation by continuously challenging preconceived notions within architectural discourse.

2.1- Research Design & Goals

A prevailing contemporary tendency is to overlook the past; however, engaging with historical context remains essential for a more profound comprehension of the present. Freud posited, an "awareness of the past enables a deeper introspection, which, in turn allows for a reconfiguration of future possibilities"- despite their inherent constraints and uncertainties (Freud, 1923).

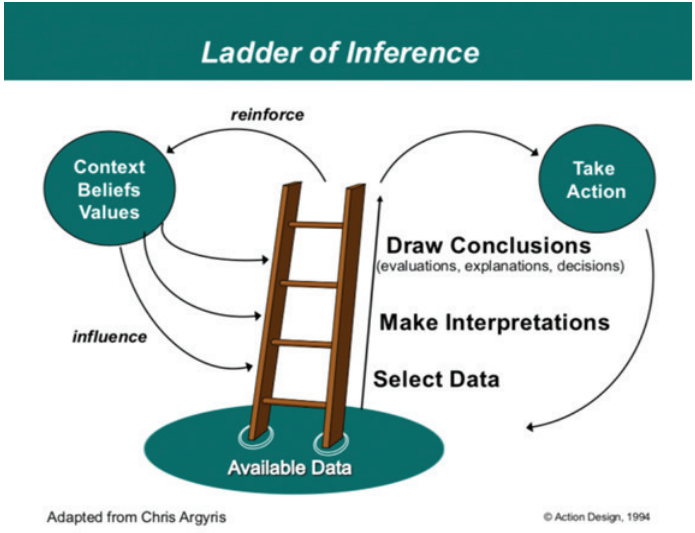


Figure 4 *The Ladder of Inference is the process by which individuals form assumptions and act*, (Action Design, 1994).

2.1.-1.- Scope of Research

This research seeks to redefine the role of the architect by integrating more nuanced, culturally informed design responses that emphasize contextual awareness. Additionally, it explores the implementation of advanced computational tools, such as parametric design and Building Information Modeling (BIM), which introduces transformative possibilities to respond faster, and eliminate the use of the human hand: creating a synthesized workflow that does not sacrifice the intent of detail or craftsmanship, all within the scope of contemporary architectural practice. Through this methodology, the research reexamines and redefines the interrelationship between materials, structure, and cultural heritage, ultimately proposing a more integrated and responsive approach to design.

2.1-1.1.- Process Design and Mind Mapping

Drawing from the model of reflexive practice, the architect operates as both subject and object in the design process—simultaneously engaging in creative action and critical self-analysis. As shown in **Figure 5**, this begins with an experiential phase, where the architect immerses themselves in the site context, cultural history, and environmental conditions. Observations are selectively made based on personal and disciplinary biases, followed by the addition of meaning drawn from cultural and personal perspectives. By questioning assumptions and drawing conclusions through critical analysis, the architect engages in abstract re-conceptualization, where new insights emerge. Secondly, these insights are then actively tested through iterative experimentation, incorporating both traditional design methodologies and digital modeling. Frampton's theory of critical regionalism provides a guiding framework for ensuring that architectural design remains sensitive to local culture, climate, and materiality while resisting the homogenizing effects of globalized architecture. The architect, through this lens, prioritizes tectonic expression, material authenticity, and sensory engagement with the built environment.

To explore new modalities of technical design, the architect incorporates computational tools such as Computer-Aided Design (CAD) and BIM. These technologies enable a precise and data-driven approach to design development, allowing for parametric modeling, real-time environmental simulations, and the optimization of structural and material systems. Through CAD, complex geometries and spatial relationships are tested and refined, while BIM facilitates the coordination of construction detailing, material efficiency, and lifecycle analysis. This integration ensures that the project not only aligns with contextual and cultural considerations but also meets the technical and performative demands of contemporary architecture.

The final phase of the process involves synthesizing insights gained from reflexive practice, critical regionalist principles, case study research, and computational design tools into a cohesive architectural proposal. This entails iterative prototyping, digital simulations, and material explorations that refine the spatial, structural, and environmental aspects of the project. By continuously evaluating the relationship between materials, construction techniques, cultural narratives, and technological advancements, the architect discovers new design modalities that redefine the intersection of tradition and innovation.

Through this comprehensive approach, the architect not only responds to contemporary architectural challenges but also contributes to a broader discourse on how technology and cultural specificity can coexist within an evolving design methodology.

2.1-1.1.1.- Qualitative Inquiry in Immersive Case Studies

A fundamental aspect of this process involves the study of architectural precedents through detailed case study analysis. Gathering data qualitatively, one can reflect on the processes mentioned above. By examining both historical and contemporary case studies that align with the principles of critical regionalism, the architect identifies design strategies, material applications, and tectonic innovations that can inform the project. This analytical phase includes studying spatial configurations, structural solutions, and construction methodologies that have successfully responded to specific climatic and cultural conditions. The insights gained from these case studies serve as a foundation for conceptual development and the refinement of design proposals.

Rather than merely examining architectural styles or typologies, Frampton dissects how construction techniques and material choices shape architectural meaning, grounding his analysis in both technological advancements and cultural contexts. As seen in **Figure 5**, this methodological approach can serve as a valuable framework for a self-directed case study on vernacular architecture. By analyzing traditions not only through their formal and aesthetic qualities but also through their construction methods, material logic, and cultural significance, one's study can mirror Frampton's approach—situating architecture within a broader discourse that bridges regional craftsmanship with contemporary relevance. Both Norwegian and Japanese vernacular traditions emphasize a deep connection between structure, environment, and cultural symbolism, making them particularly rich subjects for exploring the intersection of tectonic expression, local identity, and modern adaptation.

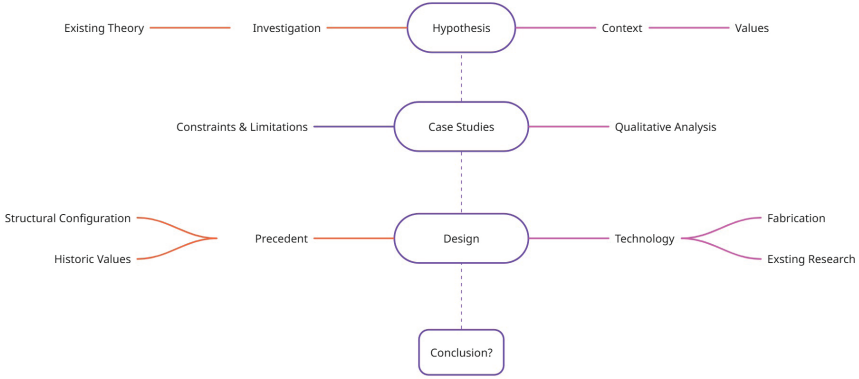


Figure 5- *Mind Mapping of Hypothesis Generation and Expected Methodological Process*, (McKinney, 2025).

3.0- Introduction to Timber

Timber, as a renewable, rapidly regenerating, and highly adaptable construction material, played a foundational role in the genesis of architecture. Its widespread historical use can be attributed to its availability, ease of processing, and inherent structural properties, making it a fundamental building material across many cultures and time periods. The evolution of architectural works has been significantly influenced by wood, as societies have continuously refined techniques to harness its natural characteristics for structural and aesthetic purposes.

The exceptional craftsmanship exhibited in timber-based architectural traditions is a testament to the mastery of builders who, over generations, refined construction methods and passed down knowledge through artisanal traditions. As a result, distinct timber tectonics have emerged across different regions, reflecting variations in cultural practices, environmental conditions, and technological advancements. These diverse approaches to timber construction not only highlight the material's versatility but also underscore its enduring significance in architectural history and contemporary practice.

Despite timber's potential as a sustainable building material, much of modern residential construction relies on suboptimal building techniques, inefficient heating and cooling systems, and petroleum-based exterior products, which ultimately diminish the ecological benefits of timber use.

As discussed earlier, the widespread adoption of standardized construction methods, often detached from regional contexts and environmental considerations, perpetuates a disconnect between material selection, design development, and architectural practice. A reevaluation of industry norms is necessary to integrate timber more effectively into construction methodologies that align with both ecological responsibility and high-performance building standards. By advancing innovative timber-based technologies and optimizing hybrid structural systems, architecture can move toward a more sustainable and contextually informed future.

3.0-1.- Timber as Culture

Wood has long been regarded as one of the most essential and renewable raw materials worldwide. Since prehistoric times, human societies have relied on their ability to harvest trees and shrubs, transforming wood into firewood, tools, artifacts, and, most notably, timber for constructing dwellings and other structures. As stated in *From Forests to Heritage: Unravelling the Journey of Historical Timbers and Wooden Cultural Heritage*, due to the widespread availability of trees across diverse environments, timber has been a fundamental element of vernacular architecture in numerous cultures, and the craftsmanship exhibited in timber-based cultures reflects artistic and technical expertise, (Domínguez-Delmás, M., Daly, A., & Haneca, K. (2023).

Beyond its utilitarian and aesthetic functions, the use of timber in vernacular dwellings reveals significant insights into the spatiotemporal configurations and societal values of ancient communities. The selection, processing, and application of timber reflect not only environmental constraints but also cultural traditions, resource management strategies, and technological adaptations. The spatial organization of timber structures- ranging from domestic spaces to communal buildings- embodies the social structures, hierarchies, and communal interactions within these societies. Furthermore, the transmission of timber construction techniques across generations and regions underscores patterns of knowledge exchange, trade, and innovation.

By integrating analytical results with ethnographic, vernacular, and architectural documentation, scholars can gain a more profound understanding of how ancient societies engaged with their landscapes, structured their built environments, and embedded cultural symbolism into their dwellings. Timber, as both a structural and cultural medium, serves as a crucial lens through which past human behaviors, values, and identities can be interpreted, offering insights into the intricate relationships between material culture and societal evolution.

3.0-1.1.- Mass Timber

Timber remains a widely utilized material in light-frame residential construction across the United States. Its continued prevalence is largely attributed to its ease of processing, lightweight nature, standardization for efficient construction, and renewable properties, including its capacity to store embodied carbon. While timber serves as a foundational element in sustainable design, timber's mechanical limitations- such as a lower strength-to-weight ratio and reduced shear strength- render it less viable for large-scale commercial applications, where steel and concrete remain dominant, contributing to increased carbon emissions. Mass timber, however, presents a compelling alternative to conventional materials, offering numerous advantages over steel and concrete, including reduced weight, ease of manufacturing and handling, and the potential to create carbon-negative structural systems. The adoption of mass timber in construction has expanded rapidly, with over 1,502 buildings in the United States either proposed, under construction, or completed. This highly renewable construction method aims to replace carbon-intensive predecessors, marking a shift toward more sustainable building practices.

The growth of the mass timber market has been significant, with the North American market valued at $106.3 million in 2020 and projected to reach $304.6 million by 2026 (IMARC, 2020), reflecting substantial industry transformation within a short period. Several landmark mass timber buildings exemplify this shift, including the 25-story *Ascent* building in the United States, which integrates both concrete and mass timber, the 18-story *Brock Commons* in Vancouver, Canada, and the 85-meter-tall *Mjøstårnet* in Norway. Notably, these projects primarily focus on housing, demonstrating mass timber's increasing role in residential high-rise construction.

Seen in **Table 1**, among the most used mass timber products are Cross-Laminated Timber (CLT) panels, Glue-Laminated Timber (GLT or Glulam), and Laminated Veneer Lumber (LVL) beams. These engineered wood products leverage the anisotropic properties of timber, strategically layering thin wood sections to enhance strength in both tension and compression. CLT has emerged as the dominant material within the mass timber sector, with a majority of new construction utilizing these panels. Originally popularized in Europe, CLT has recently gained traction in North America. Typically composed of three, five, or seven layers of lumber boards arranged crosswise, CLT panels vary in thickness from 5/8 inch to 2 inches, with widths ranging from 2.4 to 9.5

inches. They can also be manufactured in custom dimensions, allowing for versatile applications in structural walls, floors, and roofing.

Despite its promise as an advanced and sustainable building material, mass timber faces several challenges, including high costs, limited design complexity, and strict code regulations that discourage widespread investment. According to the *National Association of Home Builders*, rising wood and timber product prices have increased the cost of multi-family homes by 81% in the past year ,("Volatile Lumber Prices Add More Than $14,000 to Home Prices - NAHB," n.d.).

Furthermore, many existing mass timber projects adhere to relatively simplistic design principles, characterized by uniform rectangular sections. Currently, mass timber is primarily utilized as a direct substitute for traditional materials like steel and concrete, rather than as a distinct architectural material in its own right. This limitation stems, in part, from the hyper-industrialization of commercial architecture, the prioritization of rapid construction timelines, and cost-driven material selection, all of which hinder mass timber's full potential as an innovative, high-performance building solution.

3.1- Case Study Overview

Achieving high verticality in urban environments, all the while maintaining sustainability, acknowledgement of the material, and structural efficiency are key to the future of timber in architecture. The overall goal of this study is to take findings from smaller, more intimate works of vernacular architecture and implement contemporary technology, culminating in a synthesis of findings and a new methodological, analytical approach to contemporary application of mass timber.

Delving into the architectural context of site, surrounding availability of building materials, and the human phenomenological experience of interaction with nature is integral to this study. Adaptive case studies examining culturally iconic and architecturally relevant timber structures are the primary modality of study for this thesis.

The utilization of Frampton's *Studies in Tectonic Culture* is an integral basis of this research- modeled by firsthand accounts of exploration and discovery. A thorough examination of case studies and the identification of common themes, whether tectonic, cultural, or otherwise- is essential for a comprehensive understanding of architectural principles. Engaging with these case studies require an immersive approach that includes analytical methods such as sketches, drawings, physical and digital models, and other forms of architectural representation.

CLT	GLT	LVL
Layered Dimensional Lumber stacked at 90 degrees crosswise- structural panels.	Layered Dimensional Lumber bonded with durable, waterproof adhesive- grain runs parallel with member length- beams and spans	Layered Veneers- grain is oriented lengthwise- versatile functions
		

Table 1- *Table showcasing mass timber configurations and functional roles,* (Fact Sheet, 2024).

3.1.-1.- Organization of Study

An in-depth study of spatiotemporal characteristics of vernacular timber work can be achieved through the analysis of sections, elevations, and detailed drawings, which provide critical insights into structural articulation, materiality, and construction techniques. Sections reveal the vertical relationships between spaces, structural systems, and the interplay of light and volume, while elevations offer an understanding of facade articulation, contextual integration, and aesthetic composition. Detail drawings further enhance this exploration by illustrating the intricacies of material junctions, construction methods, and tectonic expression. By employing these representational tools, architects and researchers can systematically analyze spatial characteristics, uncover patterns across case studies, and develop a deeper understanding of architectural and cultural narratives. Criteria for choosing details to interpret will be based on cultural significance, importance within the construction process and architectural program needs.

The ability to investigate spatial metaphors, design intent, and the interaction between the built environment and its occupants is critical to this study. The examination of detailed wood carvings, material assemblies, and craftsmanship contributes to a deeper understanding of construction techniques and the decision-making processes that inform architectural design. Through the study of form and structure, hands-on exploration facilitates problem-solving and enhances material literacy. Both digital and physical models will be developed to depict structural systems, construction detailing, and materiality, fostering a dynamic relationship between digital fabrication methods and traditional craftsmanship. The integration of computer-controlled processes, such as CNC-milled components, provides increased precision and control over material manipulation while expanding the understanding of overall architectural forms. Structural systems, joinery techniques, and spatial organization, including floor plans- are equally integral to this analysis.

The culmination of these studies will be imported into CAD software, aligning with industry standards to bridge the gap between analog and digital workflows. *Autodesk Revit*, a collaborative BIM platform, will be utilized to model shapes, structures, and systems in three dimensions with parametric accuracy, (Revit for Architecture & Building Design | Autodesk, n.d.). By integrating insights gained from physical exploration—such as drawing, model-making, and prototyping into a digital framework, designers can broaden their perspective from small-scale material studies to fully integrated architectural experiences. This digital translation facilitates the generation of renderings, detailed assembly documentation, and environmental simulations, ultimately enabling the simultaneous development of both analog and digital methodologies.

As previously outlined in this thesis, reducing reliance on manual labor is achieved through the transformation of traditional hand-crafted techniques into CNC-based timber fabrication processes. The selection of timber details for digital translation will be based on their cultural significance, functional role within the initial construction process, and structural importance. Intricate hand-carved details, timber joinery, post-and-beam frameworks, and other traditionally handcrafted elements will be digitally reconstructed and interpreted using advanced modeling techniques. Furthermore, the digital translation of these physical components allows for the precise documentation of material assemblies, multi-scalar visualization, and the development of virtual simulations. This approach not only preserves and reinterprets traditional craftsmanship but also advances architectural practice (specifically, the advanced implementation of mass timber systems) through the integration of computational design and fabrication technologies.

3.1-1.1.- Expectations and Logistics

This thesis seeks to culminate with a combination of research and lab studies pertaining to vernacular timber construction typologies found throughout timber- based societies displaying significant vernacular work: Japan and Norway. As stated previously, the proposed research and explorations into these mediums presents an opportunity to document timber construction and design processes (through multiple means), cultural precedence behind these design decisions, and integration of traditional techniques to produce state-of-the-art mass timber structures made from sustainable wood materials.

Depicted in **Figure 5**, the case studies primarily employ qualitative data collection through immersion and documentation, with the overarching goal of synthesizing a distinct architectural language that merges Japanese and Norwegian timber traditions. By translating a typology of timber details into the digital realm and analyzing the findings, the study craftsmanship with contemporary construction technologies.

The research methodology is structured around three core objectives. First, it examines timber architecture across Japanese and Norwegian cultural contexts, exploring both historical and modern frameworks to understand how vernacular design principles are deeply tied to cultural heritage, environmental conditions, and a connection to nature.
The second objective focuses on compiling and categorizing these typologies of timber construction details to develop advanced mass timber applications. This involves contextualizing mass timber within the United States, identifying cutting-edge global construction technologies, and exploring the integration of traditional craftsmanship into modern building practices through process technification and robotics.

Finally, these insights will be translated into the conceptualization of a "proof of concept"- a mass timber high-rise that draws inspiration from vernacular timber structures while incorporating robotic fabrication processes such as CNC machining and CAD-based methodologies. This hybridized workflow aims to redefine contemporary timber construction by merging traditional craftsmanship with state-of-the-art digital technologies.

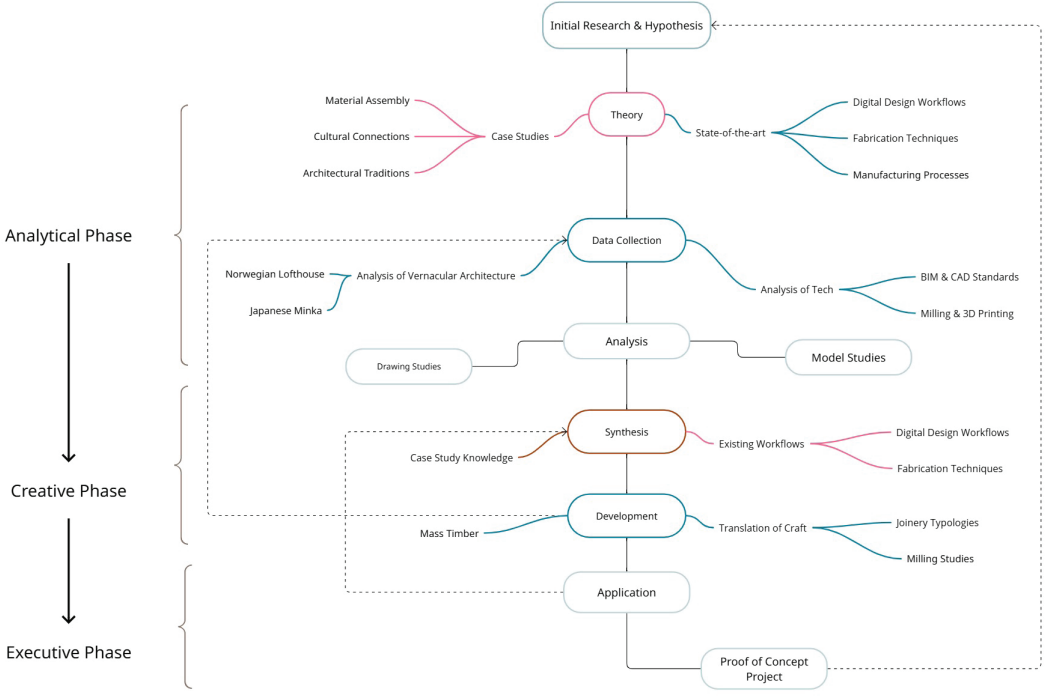


Figure 6- *Mind Mapping depicting case study implementation and the proposed multi-phase plan of study,* (McKinney, 2025).

"Living in harmony with nature is a uniquely

Japanese culture"

-Tadao Ando



3.2- Japanese Minka

Japan's unique and geographically isolated position, coupled with deeply ingrained local customs and the enduring influence of Zen and Taoist philosophy, has fostered a distinct architectural aesthetic. Japanese architecture are remarkable achievements in both construction and artistic craftsmanship, characterized by their subtle elegance and seamless integration with the natural environment. These structures embody a philosophy of coexistence with the surrounding landscape, where trees, earth, and stone merge to form dwellings that harmonize with the forests, rivers, and wildlife. Rooted in the belief that humanity exists in unity with nature, deities, and a divine presence, the Japanese approach to craftsmanship reflects a profound reverence for the materials and processes involved in everyday life. Whether constructing homes, weaving textiles, or preparing meals, these activities were imbued with a sacred significance, elevating the ordinary into a spiritual practice.

Japanese artisans possess a deep understanding of timber's essence and embrace its natural imperfections as an inherent part of its beauty. From the early use of Japanese cypress in vernacular dwellings to the grand structures of Shinto shrines, meticulous attention to detail and material character defines traditional Japanese architecture. Beyond religious architecture, the use of timber in traditional Japanese residential buildings, particularly Minka farmhouses of the Edo period, exemplifies the enduring principles of natural harmony, craftsmanship, and adaptability. These structures encapsulate a design philosophy that values the organic integration of architecture with its environment, reinforcing the spiritual and aesthetic ideals that continue to shape Japanese timber construction.

3.2-1.- Summary and Overview

Analyzing the domestic architecture of Minka is a way to truly extract knowledge of value, culture, and everyday life. According to *House Architecture and Family Form: On the Origin of Vernacular Traditions in Early Modern Japan*, examining typologies in Minka may be one of the best ways to track cultural changes within the lives of "ordinary people", aka farmers, craftsmen and other peasant class, (Cornell, 1997). Tracking configurations of the household form broadens understanding of social and economic conditions of the era. While Minka broadly refers to the domestic-typology of farmhouses across the country, there are many distinct styles metamorphized-mainly from climate differences. For this reason, the focus of this study will be on the homes from the village of Miyama Kayabuki no Sato, a UNESCO world heritage site in Nantan, Japan.

Miyama Town, situated in the central region of Kyoto Prefecture, is renowned for its well-preserved traditional landscape, embodying the historical and cultural essence of rural Japan. Enveloped by lush natural surroundings, Miyama serves as a living testament to Japan's vernacular architecture, with "over 250 extant thatched-roof houses", (Miyama's thatched village (Kayabuki no Sato), n.d.) (JAANUS / Kayabuki, n.d.). These structures, (as shown in **Figure 8**) seamlessly integrated into the mountainous terrain—including peaks such as Mount Mikuni—stand in harmony with the Yura River, which meanders through the town's center. The village's picturesque scenery evokes the timeless imagery of Japanese folklore, offering an immersive glimpse into the architectural and environmental heritage of Japan's past. Miyama's thatched-roof dwellings, constructed using traditional techniques that emphasize sustainability and climatic adaptability, represent an enduring example of the gassho-zukuri and other regional construction styles. Their preservation reflects a commitment to maintaining cultural heritage while sustaining a deep-rooted connection between human habitation and the natural world. Many Minka Architecture-style houses, such as the ones in Miyama Kayabuki no Sato, are preserved by the Japanese government to this day. There are several locations where Minka Architecture-style houses can be found, like the ones in open-air museum in Kawasaki, Shirakawa-go in Gifu Prefecture, or Gokayama in Toyama Prefecture, (**Figure 7**), (Shirakawa-Go's Gassho-Zukuri Style Architecture, n.d.).

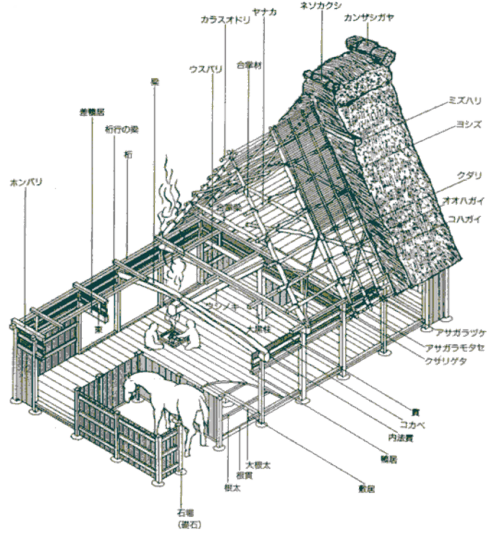


Figure 7- *Illustrated collage graphic of traditional Japanese Minka*, (McKinney, 2024).

Figure 8- *Diagram of the Gassho-zukuri style Minka*, (Shirakawa-Go's Gassho-Zukuri Style Architecture, n.d.).

3.2-1.1.1.- Typologies of Construction

Although traditional construction is a time-intensive process, its very methodology is integral to the vitality and authenticity of the architecture. This approach prioritizes a symbiotic relationship between humans and nature, fostering a meaningful and harmonious connection between people and timber. To uphold this ideal, the design and construction phases must be viewed as an interconnected whole, rather than separate processes. Centuries of tradition have demonstrated that this cohesion relies fundamentally on the expertise of the carpenter- an artisan who's deep knowledge of wood and intuitive understanding of structural composition are essential to the craft. Beyond merely assembling a building, the carpenter is responsible for shaping each element in accordance with the natural properties of the material, carefully marking and preparing the lumber, and constructing the structure with precision and reverence. This profound respect for nature not only preserves traditional construction methods, but also ensures that each wooden structure embodies a timeless craftsmanship, resulting in architectural works of exceptional beauty and cultural significance.

Traditional Japanese construction is rooted in centuries of craftsmanship, using interlocking wooden joints to create flexible and durable structures. Carpenters "develop and design the entire building plan, cut the timber themselves, and then work together with teams of specialists to erect the structure", ("Traditional Architecture," 2019). These buildings are made from cedar, cypress, chestnut, pine, and other woods, joined using traditional techniques such as shiguchi (multi-angled joints) and tsugite (straight joints for length extension). The exploded framework in **Figure 9** framework includes elements like sashikamoi, which "connect pillars at the top, providing resistance against lateral forces," and ashigatame, horizontal ties that increase stability. For walls, builders apply tsuchikabe (earthen plaster) over takekomai, or woven bamboo laths, to form strong, resilient surfaces (Seyseysha: Traditional Japanese Wooden Architecture, n.d.).

These traditional construction methods prioritize the ability of the wooden framework to respond dynamically to external forces, allowing the structure to adapt fluidly while resting atop foundational cornerstones. This approach not only enhances structural integrity but also reflects the enduring principles of craftsmanship and material efficiency in Japanese architecture.

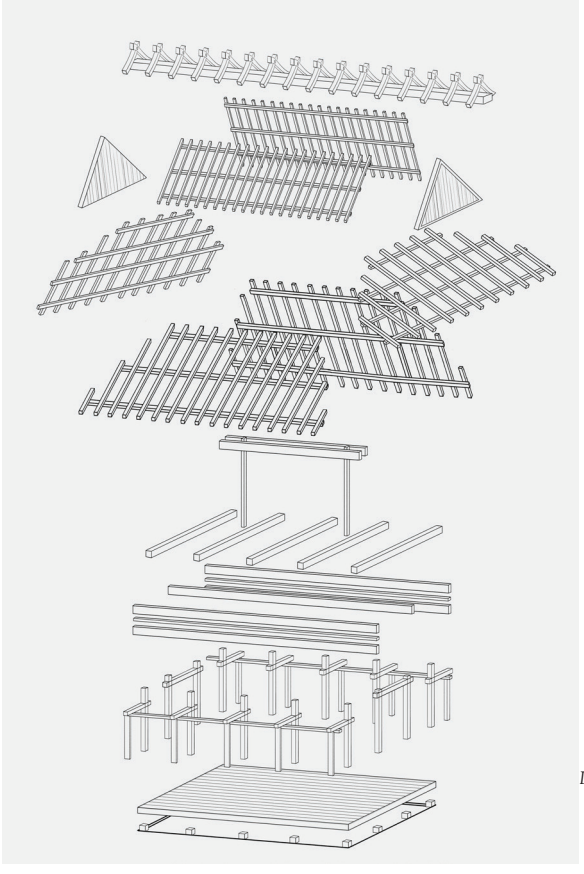


Figure 9- *Exploded Axonometric Drawing Study of a more traditional Minka*, (McKinney, 2024).

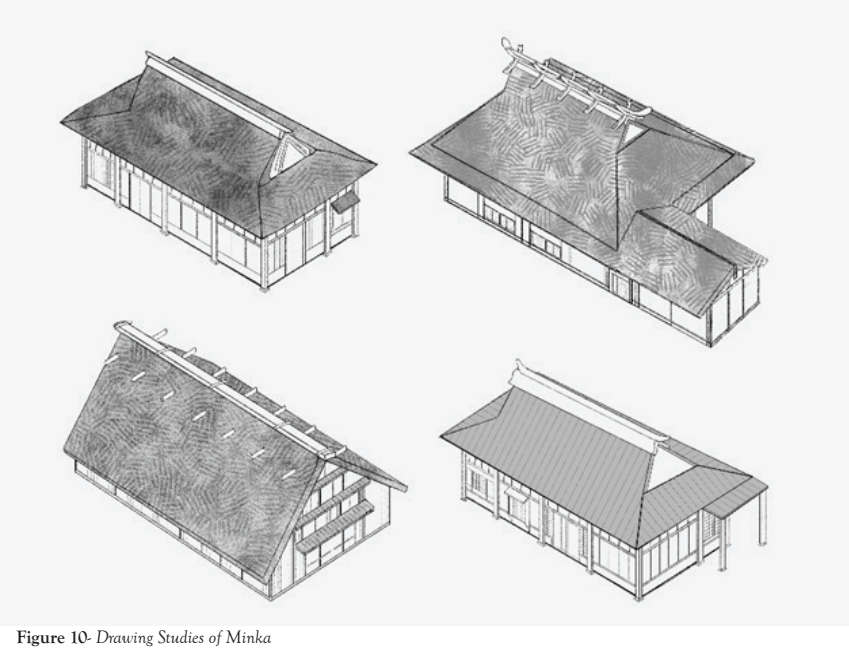


Figure 10- *Drawing Studies of Minka Typology,* (McKinney, 2024).

3.2.-1.1- Studies

This study involves an in-depth exploration of Minka detailing and typologies **(Figure 10)** through a series of interpretive two-dimensional sketches, axonometric projections, and detailed architectural drawings. The investigation emphasizes the analysis of spatial metaphors, design intent, and the dynamic interaction between the built environment and its occupants. Equally significant are the examination of intricate wood carvings, overall structural systems, traditional joinery techniques, and floor plan configurations. Through these visual and analytical methods, the study aims to gain a deeper understanding of the craftsmanship and design principles that define Minka architecture, highlighting its integration of materiality, structural logic, and cultural significance.

3.2-1.1.a Drawings

The metamorphosis and refinement of the Minka exterior happened for several reasons, both climates based and socio-political. The gassho-zukuri architectural style is specifically designed to accommodate the climatic conditions of Shirakawa, particularly its heavy snowfall. Consequent to this is the large, overbearing form of the thatched roof, depicted in **Figure 12**. Commonly described as a 'praying hands" form, this is one of the most distinctive elements of the gassho-zukuri style Minka. Additionally, these structures are strategically oriented along a north-south axis to minimize wind resistance and enhance structural stability. The positioning is carefully considered to regulate solar exposure, ensuring thermal comfort throughout the year. During the summer, this orientation helps mitigate heat gain by reducing direct sunlight, while in the winter, it maximizes solar absorption to retain warmth within the interior spaces. Through these adaptive design strategies, gassho-zukuri houses exemplify a sophisticated integration with environmental responsiveness.

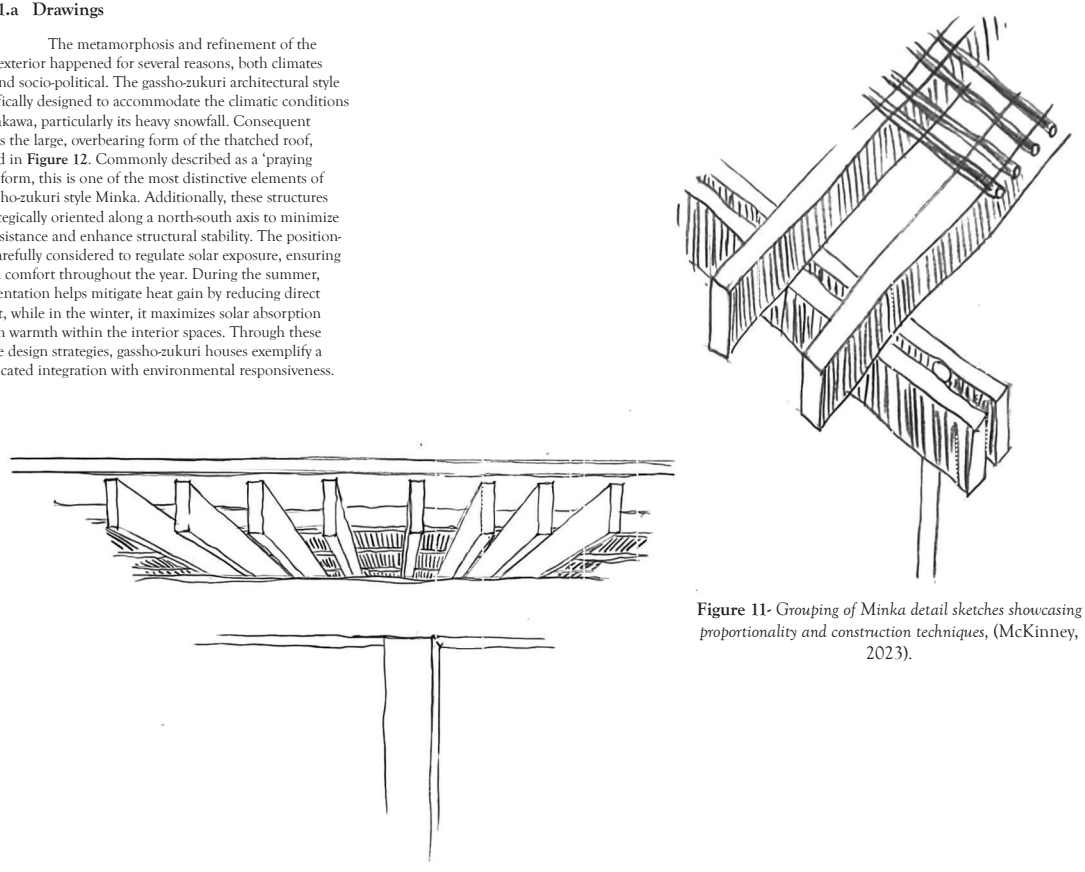
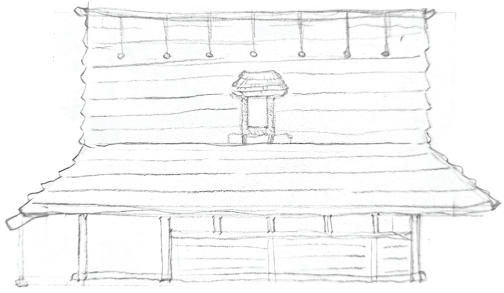


Figure 11- *Grouping of Minka detail sketches showcasing proportionality and construction techniques,* (McKinney, 2023).





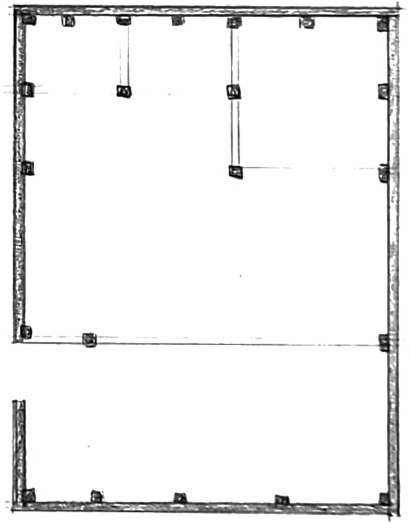


Figure 12- *Minka sketch of exterior elevation,* (McKinney, 2023).

Figure 13- *Minka floorplan sketch,* (McKinney, 2023).

Unlike residential structures in many other regions of the world, traditional Japanese dwellings exhibit a distinct emphasis on floor level differentiation rather than rigid room separation. Within gassho-zukuri houses, spatial organization is typically divided into three primary zones: the workspace, the living space, and the sleeping area. The latter- constitutes the largest section of the house, featuring an earth- en floor that maintains a transitional quality between interior and exterior environments. Although sheltered beneath the roof, this space functions as a principal work area where raw materials are processed, food is preserved, and farm equipment is stored. In households that owned livestock, the doma also served as a stable. Additionally, many homes incorporated a traditional earthenware stove, known as irori, within this area. This stove provided warmth, a place to cook, and a gathering spot for families, and would be active throughout the day- even on the hottest days of summer. As it ascends through the large openings on each floor, the smoke effectively dries out any residual dampness, thereby preventing mold formation and prolonging the longevity of the roof. The integration of these elements reflects the multifunctional nature of gassho-zukuri dwellings, where spatial arrangements (**Figure 14**) prioritize both practicality and environmental adaptability.

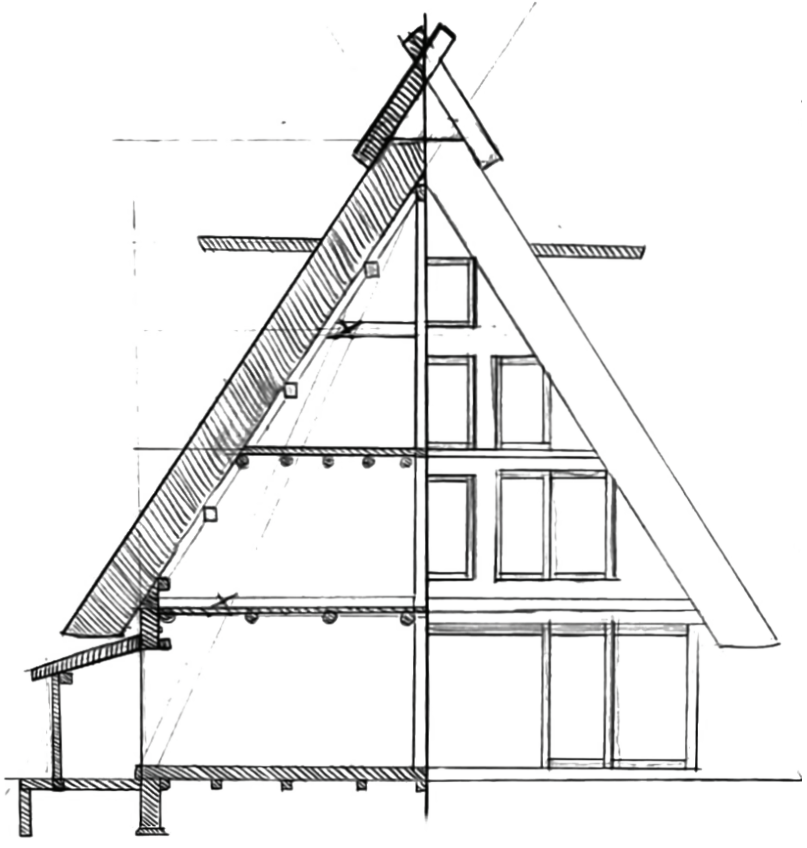


Figure 14- *Minka section sketch*, (McKinney, 2023).

3.2-1.1.b Models

Gaining expertise in material assemblies, refining problem-solving skills through construction techniques, and exploring craftsmanship through the study of form are essential for developing a comprehensive understanding of design decision-making. To facilitate this process, both digital and physical models will be produced, illustrating structural systems, construction detailing, and material properties. These models, one depicted in **Figure 15**, will serve to enhance the dialogue between digital and physical methodologies, provide greater control over robotic fabrication processes (such as CNC-modeled components), and contribute to a more nuanced comprehension of overall architectural forms.



Figure 15- *Minka scale model, front view,* (McKinney, 2024).

Fundamentally, the framing system of gassho-zukuri structures shares many similarities with the widely used sasugumi construction method. However, gassho-zukuri houses distinguish themselves through their expansive, steeply pitched roofs, which accommodate three to five attic levels designed for sericulture. The practice of raising silkworms necessitates ample natural light and ventilation, requiring these roofs to adopt a gabled form with multiple large openings in the gable walls. This structural approach contrasts with the hipped roofs typically associated with the tripod configuration found in conventional sasu-gumi framing.

Minka architecture employs a distinct spatial structuring principle **(Figure 16)** that fundamentally differs from the construction style of traditional Japanese houses. This spatial organization is particularly evident in farmhouses and townhomes, where the chigagumi (framework system) serves as the primary structural element. However, identifying the specific framework type often requires disassembly and restoration. Such so that a methodological study of model making must take place to achieve the understanding of the structure's spatial interrelationship. The hierarchical composition of minka architecture reflects the balance between impermanence and durability, as certain materials and components have limited lifespans, contrasting with the enduring structural framework. This cyclical replacement process mirrors the reconstruction traditions of Shinto shrines from the same era.

A defining characteristic of minka is the accumulation of centuries of smoke coating on the interior structure and roof. Unlike modern homes where surfaces are regularly cleaned, the retained smoke creates a natural preservative layer, safeguarding the thatch and lighter bamboo substructure. This practice contributes to the longevity of the wooden framework, reinforcing its durability over generations. The structural integrity of minka is largely dependent on its posts, which serve as the primary load-bearing elements. Typically square in shape, their size and finish vary depending on their structural function, location, and the economic means of the owner. In remote mountainous regions, such as Gifu, access to specialized tools was limited, leading to the use of an adze, (an ancient, versatile cutting tool resembling an axe, but with a perpendicular cutting edge to the handle), for shaping hardwood structural members. Sumptuary laws also influenced material selection, with farmers being restricted from using prized wood like cypress and cedar. Instead, they relied on pine or hemlock posts, which were set upon sill beams or



Figure 16, 17, 18- *Minka scale model, details,* (McKinney, 2024).

foundation stones to mitigate ground moisture damage. These foundation stones were left in their natural state, similar to the aesthetic approach used in Japanese gardens, with most of the stone buried beneath the surface for stability.

In terms of proportionality, minka construction exhibits minimal variation in beam width and depth, with round beams being particularly common, **(Figure 17)**. At the time, it was believed that heavier beams would help stabilize the structure, prompting carpenters to use oversized members, often exceeding the necessary dimensions. Additionally, the prevalence of uneven snow loads contributed to the development of a double-beam system, designed to counteract buckling and twisting forces within the framework, **(Figure 18)**.





In some minka, curved logs arching over the interior of the ground floor is a notable feature. These curved timbers, shaped by soil slippage during tree growth, were carefully aligned to increase room height and enhance the structural integrity of the space. Due to the scarcity of straight timber, these naturally deformed logs were highly utilized, transforming interior spaces into intricate, woven arrangements of beams. Rather than viewing this material limitation as a disadvantage, artisans embraced it as an opportunity for aesthetic expression. The resulting architecture reflects an ingenuity born from necessity, where imperfections highlight the craftsmanship and authenticity of handcrafted wooden structures.

Minka also feature intricate joinery, a hallmark of Japanese construction that emphasizes the artistry of structural connections. While the joinery in minka shares similarities with those found in traditional Japanese homes, adaptations were necessary due to the natural irregularities in log size and shape, shown in the model, **(Figure 19)**. These variations required craftsmen to modify and customize standardized connections, reinforcing the adaptability that defines minka architecture.



Figure 19, 20, 21- *Minka scale model, details,* (McKinney, 2024).



3.2-1.1.1.1.- Findings

From one's own perspective, the process of conducting studies and drawings- such as floor plans, exterior elevations, sections, and perspectives- is not merely an act of documentation but a means of deeply engaging with taxonomy and of part to whole. Reflexive practice is fundamental to this process, enabling architects to extract critical insights and develop a nuanced understanding of Minka architecture. Through these analytical drawings, a dynamic cultural relationship with nature and timber elements is revealed.

One of the most profound architectural insights derived from these studies is the hierarchical composition of Minka, particularly the transition from earth to sky, (**Figure 20**). The material expression shifts from the base upward, with each level contributing to the structural and aesthetic language of the dwelling. This stratification, from foundation to roof, defines the spatial identity of the structure. The gradual transition is expressed through the layering of materials, from stone foundations to timber frameworks and thatched roofs. This architectural language mirrors broader Japanese traditions, where structures are seen as living entities that evolve over time. Furthermore, the delineation of boundaries within Minka appears to be culturally embedded- while floor levels establish a hierarchy, the spatial organization remains cohesive, reinforcing the singular unity of the dwelling. Verticality emerges as a key design principle, shaping both form and function.

Ultimately, the true beauty of Minka lies in the interplay of individual components assembling into a coherent whole. Unlike Western construction, which often relies on nails and adhesives, traditional Japanese joinery employs intricate interlocking wooden connections that create structurally sound buildings without the need for metal fasteners. This technique not only enhances the durability and flexibility of the structure- allowing it to withstand earthquakes and environmental stressors- but also exemplifies the Japanese ethos of working in harmony with materials rather than imposing force upon them.

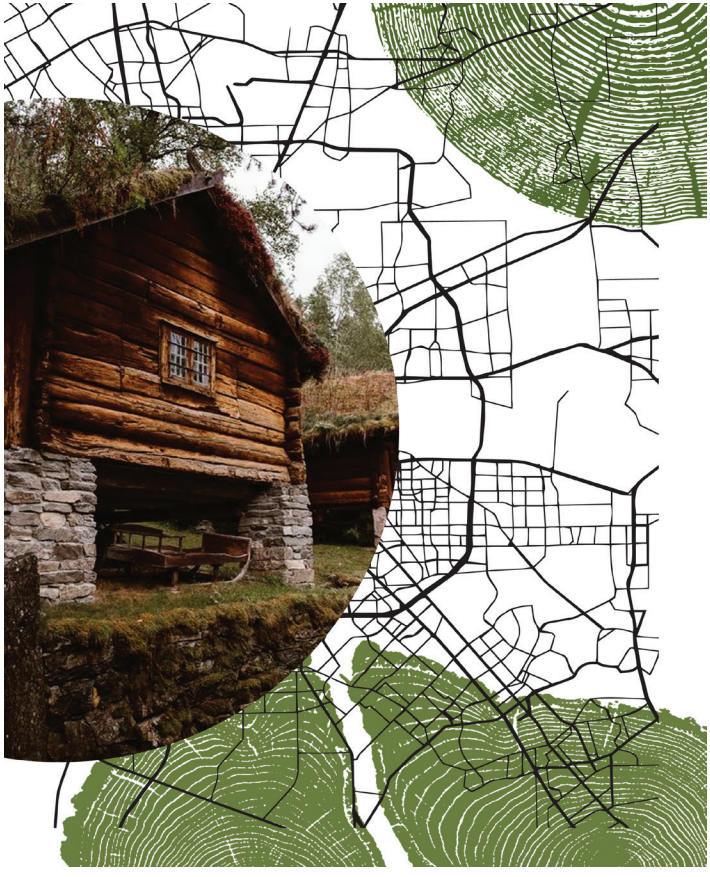
The act of joinery-making (Tsugite) is deeply connected to the broader artistic and philosophical traditions of Japan. Much like calligraphy, pottery, or ink painting, joinery is guided by precision, restraint, and an intuitive understanding of materials. The carpenter, much like a master artisan, respects the wood's natural grain and properties, allowing these characteristics to inform the structural design. This approach reflects the Japanese principle of *shokunin kishitsu*- the spirit of mastery- where craftsmanship is not just a technical skill but a lifelong pursuit of refinement and excellence.

Minka construction embodies this sensibility, where the articulation of joints and the seamless integration of elements serve as a visual and structural expression of craftsmanship. Every beam, post, and connection is a deliberate act of design, reinforcing the belief that architecture is not merely about shelter, but about creating an experience, as seen in **Figure 21**. The precision and craftsmanship evident in the connections between structural elements highlight a deep appreciation for joinery, materiality, and spatial harmony. Through these studies, one gains not only technical literacy but also an enriched understanding of Minka's architectural ethos.



"Architecture, in other words, is a form of understanding of the given environment. As such, it consists in explanation of the unity of life and place, in order that we may understand where we are, how we are, what we are. When successful, architecture becomes the art of building and thereby representation of an inhabited landscape".

- Christian Norberg-Schulz, (1996)



3.3- Norwegian Lofthouse

Christian Norberg-Schulz, a prominent architectural theorist, is best known for his contributions to the philosophy of phenomenology in architecture. His work emphasizes the experiential and existential qualities of built environments, advocating for an architecture that resonates with human perception, memory, and cultural identity. In *Genius Loci: Towards a Phenomenology of Architecture,* Norberg-Schulz explores the idea that architecture should embody the spirit of place, shaping not just physical space but also evoking a deep connection between people and their surroundings. Christian Norberg-Schulz identifies the structure of the loft as Norway's "most important contribution to the history of architecture" (Nightlands, 1996).

Characterized by its distinctive top-heavy form, it reflects both practical needs- and a deeper cultural sensibility tied to the Nordic landscape. The materiality of the loft house, with its untreated wood that weathers overtime, embodies the passage of seasons and the relationship between human habitation and nature. Within the global architectural consciousness, the Norwegian loft has become emblematic of the country itself. Deeply rooted in a cultural tradition that emphasizes harmony with nature, Norwegian architecture evolved in response to the country's harsh climate, necessitating structurally resilient dwellings that resonate with the dramatic landscape. This profound relationship with nature is reflected in the poetic craftsmanship of wood construction, evident in both the structural logic and the intricate carvings that define the architectural language of the Norwegian loft. The lofthouse, through its spatial organization, material expression, and adaptation to climatic conditions, exemplifies the phenomenological principles of dwelling and place-making.

3.3-1.- Summary and Overview

Norwegian traditional architecture has historically consisted of two primary building types: farms and stave churches, each reflecting distinct construction methods, material use, and cultural significance. These structures predominantly utilized logs and staves, demonstrating an evolved understanding of wood as a primary building material suited to Norway's harsh climate. In residential farmhouses, known as stue, horizontal log construction created a protective wooden shell suited for insulation and durability in extreme weather conditions. In contrast, stave churches employed vertical staves, symbolizing a connection between earth and heaven, reinforcing their spiritual significance. This differentiation in construction techniques illustrates how materiality was both a functional adaptation to climate, and a symbolic representation of belief systems. Farms were carefully designed for their functional needs, and one of the most distinctive structures within these farmsteads was the loft. This two-story structure served both storage and sleeping purposes, existing in Norway since the early Middle Ages. Lofts were often the most prominent and elaborate buildings on a farm, showcasing exquisite wood carving and advanced construction techniques that reflected the wealth and status of the owner.

Unlike stave churches, which were built using post-and-lintel techniques, lofts were constructed using log-notching methods. The technique of log notching exists in many cultures across the globe, but no culture is as synonymous with this technique as Norway (**Figure 22**). There exist a variety of lofthouse forms across Norway. The upper level of the loft was typically reserved for fine textiles, clothing, and other valuables, often doubling as a prestigious guest room. In contrast, the lower level functioned as a storage space, particularly for dry food such as grain.

Lofts were integral to Norwegian farmsteads, which could consist of 10 to 30 separate buildings, each with a distinct function. Unlike the main residential buildings (stue), lofts did not have heating, as only the primary living spaces contained a fireplace. This separation of storage and living quarters was a strategic approach to fire safety and thermal efficiency. One of the defining characteristics of Norwegian lofts was their portability. The log-based construction allowed these buildings to be easily dismantled and relocated, a common practice in rural Norway. This mobility was particularly significant for inheritance and dowries, as young brides were sometimes gifted a loft upon marriage.

Overall, the Norwegian approach to wood construction- from stave churches to lofts- demonstrates an intricate understanding of building traditions, where material efficiency, climate adaptation, and cultural expression seamlessly intersect. The loft stands as an enduring example of Norway's architectural ingenuity, blending functional necessity with artistic craftsmanship.

3.3-1.1.- Typologies of Construction

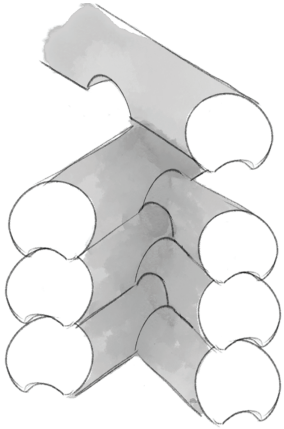
Lafte, the traditional Norwegian log construction technique, involves the interlocking of structural timbers through precisely notched joints at their intersections. This method, which has been an integral part of Norwegian cultural heritage for over a thousand years, demonstrates a refined carpentry tradition rooted in both function and form. The construction of traditional Norwegian lofthouse relies heavily on precise full-scribe notching techniques, which have evolved over centuries to ensure structural integrity, thermal efficiency, and aesthetic refinement. In recent years, lafte has experienced a resurgence, reflecting a renewed appreciation for its historical significance and structural efficiency.

While the fundamental principles of lafte construction remain consistent, variations in building styles, decorative elements, and functional applications have evolved over time to accommodate needs. Various corner notching systems have been developed for log structures, each serving distinct functional and cultural purposes. These methods, deeply rooted in vernacular traditions, are integral to the resilience and longevity of lafte construction in Norway. Among the most notable joinery techniques are the Saddle Notch, Scandinavian Notch, and Dovetail Notch. These systems arose from the tools used themselves: a variety of axes, adzes, wedges, chisels, and gouges. The saw was not used until at least the 15th century, therefore, a craftsman had to be acutely aware of the wood grain and nature of the logs he was working with.

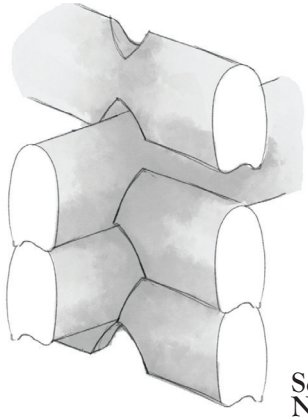
The Saddle Notch, a widely used system, belongs to a family of notches designed to provide compression fit, tightening as logs shrink over time. This technique, particularly the shrink-to-fit variation, is characteristic of handcrafted log homes and is often combined with the full-scribe method, ensuring airtight connections without the need for chinking.

The Scandinavian Notch, also known as "Norway's Notch", is one of the most labor-intensive and structurally effective corner joints. This method is particularly well-suited for beveled-edge timbers but can also be applied to rounded logs. Like the Saddle Notch, the Scandinavian Notch belongs to the "shrink-to-fit" category, ensuring a durable and weather-tight construction over time.

Figure 22*- Illustrated collage graphic of traditional Norwegian Lofthouse*, (McKinney, 2024).



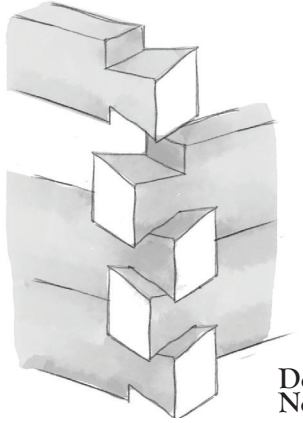
Saddle Notch



Scandinavian Notch

The Dovetail Notch, often employed in both handcrafted and milled log homes, is notable for its interlocking design, where log ends are shaped into a dovetail-like form to secure the structure. This method ensures superior structural stability while maintaining a high degree of material efficiency, as it minimizes unnecessary log overhang. The aesthetic symmetry and clean joinery of the dovetail notch make it a preferred technique in traditional timber-framed dwellings.

These advanced joinery techniques, seen in **Figure 23,** are crucial to the longevity and adaptability of Norwegian lofthouses, where wood construction embodies both practical ingenuity and cultural identity. The intricate craftsmanship of corner notching is a testament to the enduring principles of vernacular architecture, where structural resilience, material efficiency, and aesthetic sensibility define the built environment.



Dovetail Notch

Figure 23- *Full-scribe notch details,* (McKinney, 2025).

3.3.-1.1.1.- Studies

3.3-1.1.1. a Drawings

Across Norway, lofthouses exhibit regional variations in design and spatial configurations (**Figure 24**), influenced by local climate, customs, and material availability. Despite these differences, certain architectural principles remain consistent, particularly the emphasis on high-quality carpentry and ornamental detailing, which highlight the loft as the most significant structure on the farm.

In coastal regions, Lofthouse are characterized by large timber cores with significant front overhangs, providing structural protection against harsh coastal weather, such as heavy rainfall and strong winds. In southern Norway, most lofts were elevated on stabbor, or raised storehouses, to prevent moisture buildup and protect against pests- a design essential for preserving dry goods, grains, and textiles in humid environments. These regional adaptations reflect a deep understanding of environmental conditions, demonstrating how vernacular Norwegian architecture evolved in response to both climatic challenges and functional needs.

Hallingdal is a mountainous valley, enclosed by hills and peaks on all sides except to the southeast, where the terrain opens around Lake Krøderen. Extending approximately 200 kilometers in length, the valley has historically served as a vital passageway between eastern and western Norway. Due to its strategic location, Hallingdal has long facilitated trade and cultural exchange between its inhabitants and the communities of western Norway. Farmers from the valley regularly traveled westward to participate in markets, reinforcing economic and social ties across regional boundaries. Established in 1899, the Hallingdal Folk Museum in Nesbyen (central, south Norway) is one of Norway's earliest open-air museums, preserving the region's rich architectural and cultural history. The museum comprises 29 historic buildings and houses a collection of approximately 11,000 artifacts, spanning from the Middle Ages to the 20th century, (Visit Nesbyen | Friluftsmuseet Hallingdal Museum, 2021). One of the most significant structures within the museum is a medieval stave loft, originally from Ål, Hallingdal. *Staveloftet* stands as a testament to Norway's enduring woodworking traditions. According to The Hallingdal Museum, circa 1344, this "684-year-old structure is among the oldest surviving non-ecclesiastical wooden buildings in the world", (Staveloftet, n.d.). This loft serves as a prime example of Norway's vernacular building traditions,

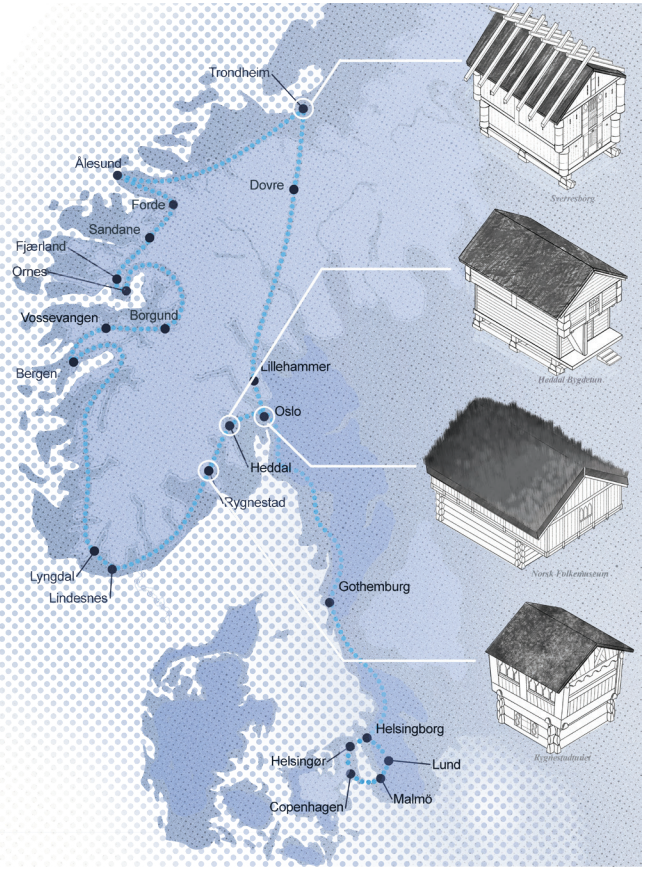
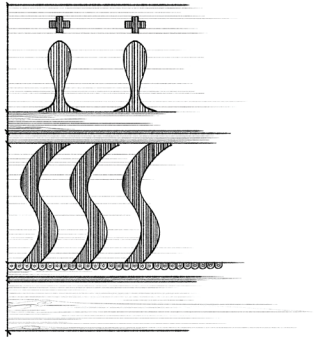


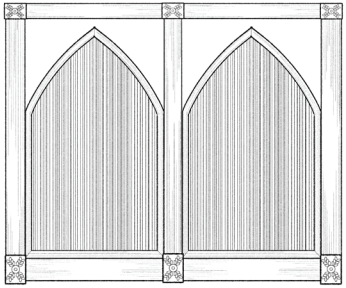
Figure 24- *Map depicting typologies and locales of common Lofthouse configurations*, (McKinney, 2024).

showcasing exceptional carpentry techniques and intricate decorative details, as seen in **Figure 25**. Delving into spatial conditions within the exterior and interior of the Lofthouse is essential to extract understanding.

An analysis of the exterior construction of the *Staveloftet* reveals two distinct building techniques: the lower level employs traditional log stacking, resting on a stone foundation- an architectural practice typical of the Middle Ages, while the upper-level transitions to lighter framing techniques that resemble stave architecture. The design of the gallery openings and doors reflects Romanesque, stylistic influences from stave church architecture, particularly in their intricate detailing. The loft exhibits a strong vertical emphasis, with a clear transition between the structural systems of each level. As exhibited in the sketch **Figure 26,** the differentiation in function between the two stories is evident in the construction: the lower level, traditionally used for grain storage, is characterized by solid log walls with minimal openings for insulation and security, while the upper level, designed as living quarters or guest accommodations, features increased fenestration and a shift from horizontally to vertically oriented wooden elements. The loft consists of two stories and includes a spacious gallery wrapping around three sides.

The first-floor room, retaining its original wall-mounted benches, historically functioned as a guild hall or meeting space, though in some cases, such spaces were also utilized for guest lodging. The ground floor, primarily dedicated to food storage, now serves as a display area for historical storage containers, including those used for meat salting and grain preservation.





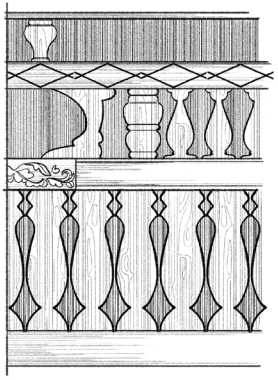
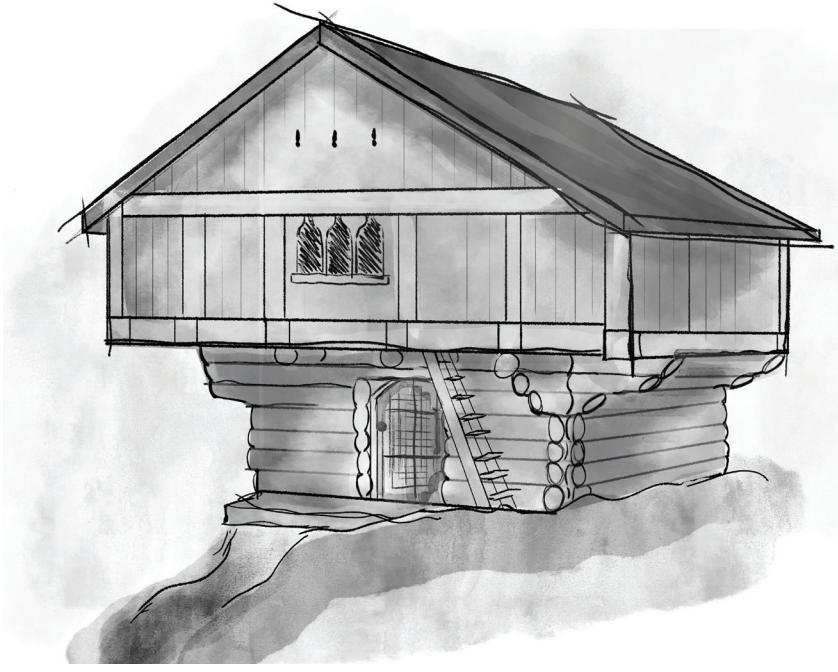


Figure 25- *2D renderings of Lofthouse details,* (McKinney, 2023).

Figure 26- *Staveloftet 2D rendering,* (McKinney, 2023)



3.3-1.1.1. b Models

The distinctive oval shape of finished log members in Norwegian loft construction emerged from a deep familiarity with the material and its structural properties. These logs were carefully smoothed to facilitate rain runoff, preventing water absorption and thereby enhancing durability. The oval form mitigated grain separation in the wood and improved resistance to vertical loads, demonstrating a highly functional adaptation. This structural efficiency was coupled with an awareness of aesthetics, as the exposed log ends were often shaped with ornamental considerations that seamlessly reinforced their structural purpose. The frequent use of oval logs in Norwegian vernacular buildings underscores the refined craftsmanship of their builders, who balanced technical precision with aesthetic intent.

Norwegian lofts exhibit a remarkable level of refinement in their joinery compared to other Scandinavian examples. The structural integrity of log buildings relied on meticulously interlocking corner joints, which were crafted with great care to ensure the rigidity of the walls. Builders developed a variety of notching techniques to achieve tight-fitting joints, and the complexity of these methods elevated their construction to an art form. The demanding nature of this work inspired artisans to incorporate decorative motifs into their joinery, blending structural necessity with ornamental refinement.

In Norwegian loft construction, the identity of the building is most clearly expressed in its methods of joining and binding. The craftsmanship of Norwegian woodworkers is particularly evident in loft structures, where the use of both log and stave construction-integrated within the timber frame demonstrates an elegant synthesis of techniques. The interplay of these distinct construction methods, and their counterbalancing structural forces, defines the essence of Norwegian loft architecture.

One of the most critical aspects of Numedal lofts is the transition between these two construction languages, particularly in the distinctive loft overhang. As shown in the scale model study, depicted sequentially in **Figure 28**, the upper logs of the first story flare outward to support the gallery, carefully shaped rather than merely placed in position. This seamless adaptation to structural and environmental demands epitomizes the ingenuity of Norwegian loft construction, where technical skill and an intuitive response to material properties converge into a refined architectural tradition.

Beyond the structural system, there is an inherent emphasis on doors, portals, and openings in loft architecture. The threshold naturally became a focal point for craftsmen, who refined their doorposts with intricate wood carvings. These carvings, shaped in accordance with the longitudinal fibers of the wood, accentuated the vertical and sometimes bulging form of the posts. Through the use of shallow relief techniques, artisans emphasized proportional relationships.

The presence of grass on traditional Norwegian sod roofs is primarily a by-product of the construction method, rather than an intentional design choice, (**Figure 27**). In Norway's wet, windy, and snowy climate, the most cost-effective way to construct a durable, weather-resistant roof was to utilize locally available materials. Birch, which is both abundant and naturally resistant to water and decay, was commonly used. Strips of birch bark were layered over wooden roof boards to create a waterproof barrier. To secure the birch layers and prevent them from being displaced by wind or other elements, additional weight was necessary. Sod emerged as the ideal solution due to its availability, insulating properties, and effectiveness in stabilizing the roof structure. The sod was typically applied in two layers: the first placed upside down to enhance drainage and insulation, followed by a second layer positioned right side up. Over time, the soil provided a natural environment for grass to grow, resulting in the characteristic green rooftops seen in traditional Norwegian and other nordic architecture.

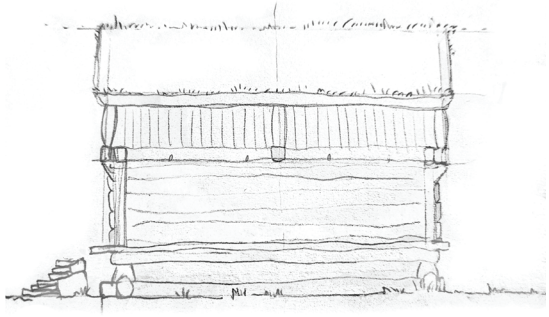
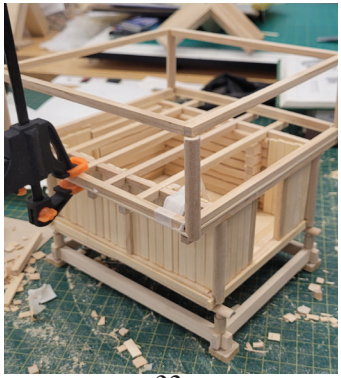




Figure 27- *Lofthouse elevation sketches*, (McKinney, 2023).



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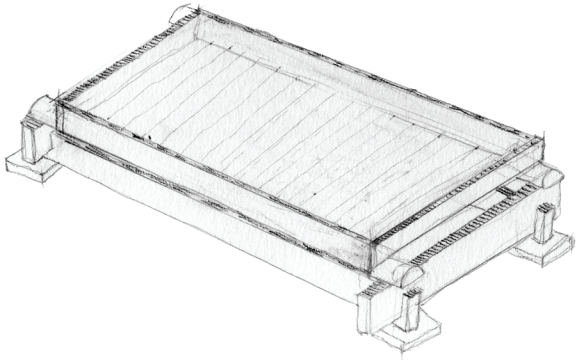
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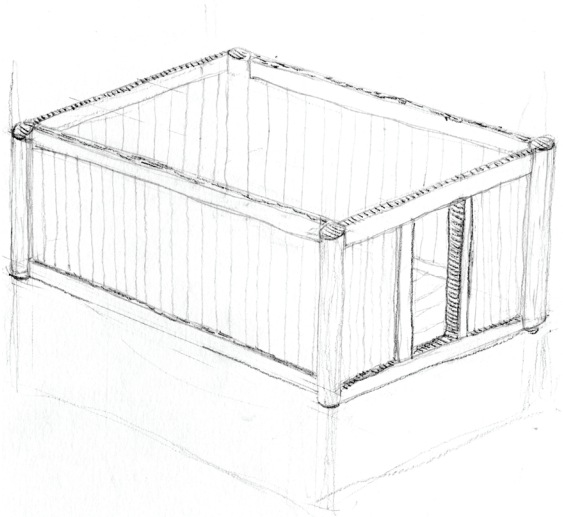


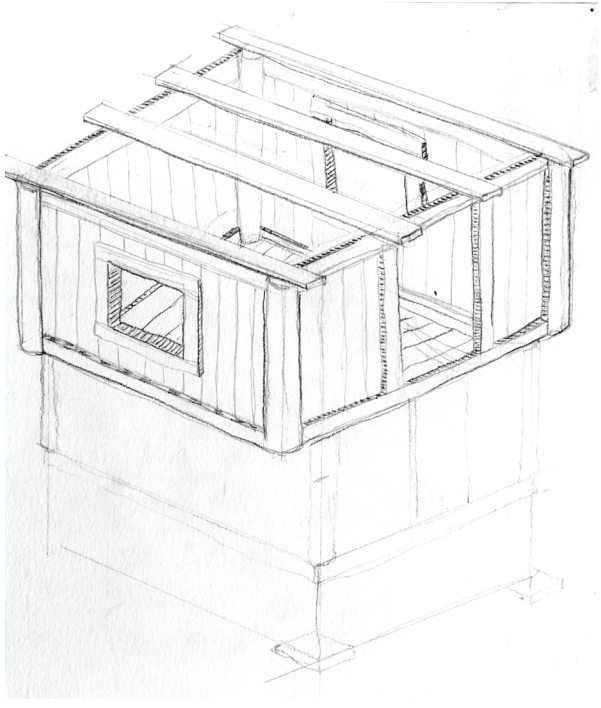
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Figure 28- *Lofthouse scale model construction sequence*, (McKinney, 2024).







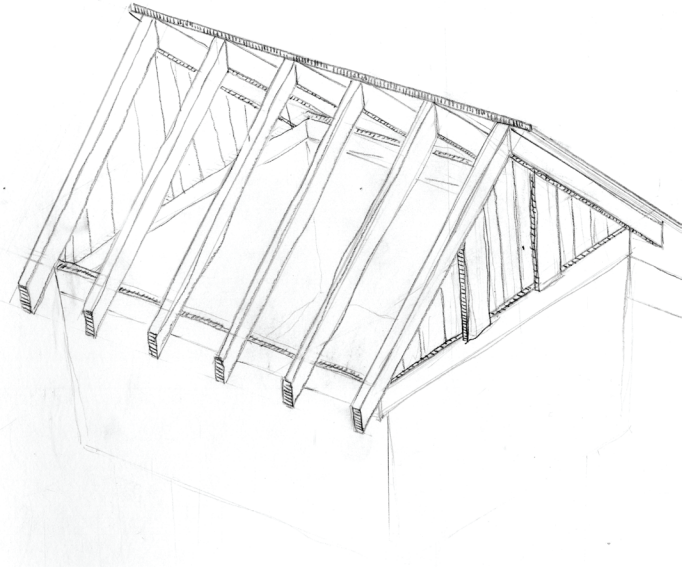


Figure 29. *Lofthouse 2D sketches of construction sequence*, (McKinney, 2025).

3.3-1.1.1.1.- Findings

The Norwegian loft house stands as a profound expression of wooden architecture, embodying a time when building was regarded as both a craft and an art form. Rooted in Norway's vernacular traditions, these structures reflect a deep connection between the natural environment and the aesthetic principles that shaped the built landscape. The lofthouse is guided by an intrinsic understanding of form, informed by both material properties and structural forces. As a product of folk culture, it evolved in response to the specific functional and environmental needs of Norwegian society, seamlessly integrating with the nation's rugged terrain.

It is of no surprise that Norway's traditional architecture shows an unusually long and continuous historical trajectory, extending from before the Middle Ages through the eighteenth century. This enduring architectural tradition is deeply rooted in the rural farming communities, where folk influences shaped both artistic expression and building practices. Despite variations in time and location, these structures share a cohesive architectural language, reflecting a shared cultural heritage. Embedded within them is a collective understanding of beauty and craftsmanship that reinforced cultural unity, ensuring their significance as both functional dwellings and artistic expressions of Norwegian identity.

3.4- Case Study Conclusion

3.4-1.- Findings

By engaging in a multi-faceted representational approach, the study of Minka and Lofthouse architecture not only reveals the nuances of vernacular construction but also reinforces the critical role of visualization in architectural analysis, interpretation, and preservation. These modalities of investigation reveal the barriers and adaptations, connected directly to the people that crafted these structures by an intrinsic knowledge of wood construction passed through generations.

3.4-1.1.- Cultural Similarities

A key insight into the architectural traditions of timber-based societies is the strong emphasis on agrarian living. Over time, these structures evolved in response to the needs of farming communities, adapting to specific functions and cultural practices. This process led to the emergence of distinct building typologies, which served as functional frameworks guiding construction. While the final architectural forms reflect the unique character of each cultural building tradition, they also show an underlying coherence in spatial organization and functional relationships. The interaction between buildings, their role in supporting specific activities, and their collective composition contribute to a cohesive architectural language. This continuity is clear in the enduring typologies of both the Japanese minka and the Norwegian lofthouse, which persist as exemplars of vernacular adaptation and cultural identity.

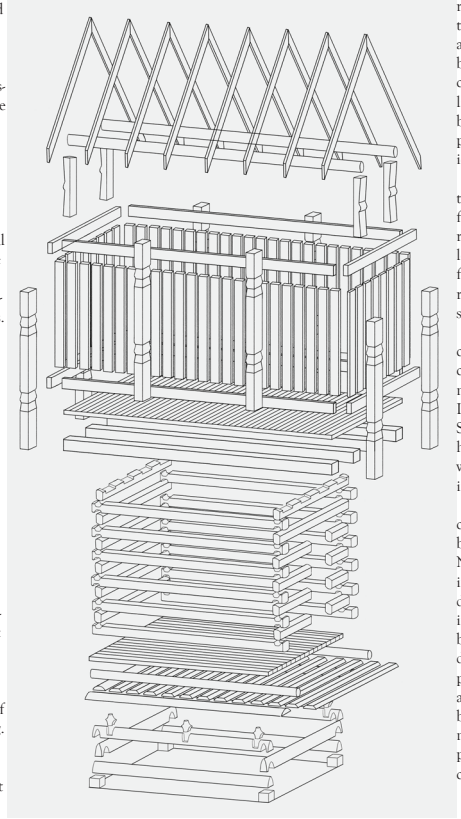


Figure 30- *Lofthouse exploded axonometric drawing,* (McKinney, 2024).

The central hearth played a crucial role in both typologies. In Japanese minka, the sunken hearth served as the focal point for cooking, warmth, and communal gathering, reinforcing social bonds within the household. In Norwegian loft houses, while the loft itself lacked heating, the stue (main farmhouse dwelling) contained the hearth, acting as the primary communal space. In both cases, fire was a unifying element, symbolizing sustenance, protection, and familial connection.

Carved wooden elements in both traditions carried symbolic and spiritual meanings. In Norway, decorative carvings on doorposts, loft galleries, and beams often included motifs inspired by Norse mythology and protective symbols. In Japan, transoms and threshold carvings were imbued with Shinto and Buddhist symbolism, believed to safeguard the household. These traditions indicate a spiritual relationship with craftsmanship, where the act of building was also an act of imbuing cultural meaning.

Rather than a single large dwelling, both cultures favored multi-structure farmsteads, where different buildings served specific agricultural and domestic functions. Norwegian farmsteads featured clusters of separate buildings, including lofts, stables, and dwellings, arranged to accommodate seasonal activities. Similarly, Japanese farmsteads often included separate storehouses, livestock shelters, and auxiliary buildings, ensuring efficiency in agricultural operations. This decentralized organization reflects a shared logic in agrarian planning, where spatial separation optimized functionality and environmental adaptation. The architectural similarities between Japanese minka and Norwegian lofthouses go beyond material and climate adaptations. They reflect a shared philosophy of resourcefulness, adaptability, and deep integration with cultural traditions.

3.4-1.1.1.1.- Construction Commonalities

Both traditions evolved in regions where wood was the most abundant and practical building material. Norway's vast forests of pine and spruce provided durable, weather-resistant timber, while Japan's cypress, cedar, and pine were chosen for their strength and elasticity. Both typologies emphasize exposed structural frameworks, making the craftsmanship of wooden joinery a defining aesthetic element. In Japan, minka featured visible mortise-and-tenon joints and diagonal bracing, which enhanced earthquake resilience. Norwegian lofthouses, particularly in their gallery structures, showcased log corbels and interlocking joints, providing both strength and decorative appeal. This tradition of functional joinery as ornamentation speaks to the artisanal heritage in both cultures.

Elevation as a protective measure appears in both architectural traditions. Depicted in **Figure 30**, Norwegian lofts were raised on posts or stone foundations to protect stored goods from dampness and pests. Similarly, certain types of minka, such as gassho-zukuri farmhouses, incorporated raised storage areas in their steeply pitched roofs to keep rice and silkworm cocoons dry. Both cultures understood the necessity of vertical separation in maintaining agricultural resources.

The Norwegian loft house and Japanese minka reveal a parallel evolution in vernacular timber construction, where material intelligence, joinery mastery, and environmental responsiveness were key to longevity.

4.0- The Modern Architect

Contemporary design practice is neither grounded in research-based theoretical frameworks, nor contextualized by historical precedents. While numerous other disciplines have experienced unprecedented social, technological, and economic transformations- where innovation has become integral- architecture continues to be predominantly driven by commercial interests from large-scale, privatized corporations and firms.

The commercialization of architectural practice stems from the widespread adoption of Computer-Aided Design and the compartmentalization of workflows which inhibit collaboration, impose stylistic limitations, and contribute to the emergence of a homogenized "modern" aesthetic. The integration of automated design technologies was initially driven by the belief that it would enhance efficiency, reduce costs, and elevate construction quality. However, in practice, this shift has led to the standardization of materials, a decline in architectural detailing, and the pervasive adoption of a conformist, capitalist driven discipline.

Previously, artistic elements were prominently integrated into nearly all aspects of architectural design. However, the transition from mechanical drafting to CAD-based drafting has largely eliminated these artistic qualities, replacing them with an emphasis on efficiency and repetition. As a result, the role of the modern architect has been reduced to that of a "mechanized producer", primarily focused on generating standardized, formulaic floor plans within construction drawing sets.

4.0-1.- Industry Standards

It is evident that the corporatization of architecture will remain the dominant paradigm in the foreseeable future. The standardization of design serves as a fundamental strategy for enhancing construction efficiency, optimizing building performance, and further advancing the industrialization of architectural practice. To ensure consistent project delivery and sustained profitability, the field increasingly relies on predictability and systematic control over both the design and construction processes.

By adhering to standardized methodologies, architects and developers can minimize risk, control costs, and maintain uniformity across projects. This approach reduces uncertainties in material procurement, labor requirements, and project timelines, ultimately increasing efficiency. However, it often comes at the expense of creativity and site-specific adaptation. Systematic control over the design process ensures that every stage, from conceptualization to execution, follows predefined protocols and industry standards. This structured approach enables firms to manage large-scale projects with greater precision, ensuring compliance with regulatory requirements, sustainability goals, and client expectations. However, an overemphasis on control can lead to rigid design solutions, discouraging experimentation and innovation in favor of repeatable, commercially viable models. While these principles drive efficiency and economic viability, they also raise concerns about the diminishing role of craftsmanship and artistic ingenuity.

4.0-1.1.- Redefining Contemporary Architecture

Specifically, in the 21st century, there has been a shift to reinvent "state-of-the-art" in architecture. State-of-the-art refers to the most recent stage of technological development within a specific discipline (State-of-the-Art, Adj. & n. Meanings, Etymology and More | Oxford English Dictionary, n.d.). There exists, primarily within academia, a desire to increase "innovation" in architecture and design.

Innovation is commonly defined as the "process of implementing changes to methods, services, or products, with the objective of enhancing their functionality and contributing meaningful value to established practices", (Aksamija, 2017). These changes must not only introduce novelty but also improve existing systems and expand the body of knowledge within a given field. Innovation and technological advancement are inherently complementary, as innovation is often driven by developments in science and technology. However, the concept of innovation in architectural design is not a recent phenomenon. Throughout history, architecture has continuously evolved through the introduction of new ideas, design methodologies, materials, and construction techniques: leading to the emergence of novel building typologies and advancements in both design and construction practices.

Innovation in architectural design is driven by a combination of technological advancements, societal shifts, environmental concerns, and economic factors. These drivers shape the evolution of design methodologies, construction processes, and building performance, ultimately influencing the built environment. From an organizational perspective, innovation enables firms to stay ahead in a competitive industry, enhancing efficiency, improving design quality, and optimizing workflows. The integration of new design tools, materials, building technologies, and construction techniques allows for the creation of structures that are more responsive to both environmental conditions and occupant needs. BIM and other digital tools further facilitate the seamless integration of design and construction, challenging traditional disciplinary boundaries and enhancing project delivery. While systematic prediction can optimize certain aspects of design, its effectiveness has limitations and can lead to the de-prioritization of "good" design that responds to the environment, contributes positively to the discipline, and is optimal for occupant's wellbeing. Architectural practices that embrace technological, societal, and economic transformations- incorporating innovation as a core value- are better positioned to adapt to the evolving demands of the future.

4.0-1.1.1.- Advancements in Timber Architecture

So how does one redefine the contemporary space of architecture and adapt innovative strategies to solve the current design issues that plague the modern architect? A key area of focus in architectural innovation is the development of advanced materials that demonstrate enhanced properties. As these materials gain prominence in contemporary design, they increasingly reflect a commitment to environmental sensitivity in terms of production, application, and long-term sustainability. Notably, advancements in wood composites are expanding the potential of this natural and renewable resource, enabling its unprecedented application in architectural construction.

At present, mass timber is primarily utilized as a substitute for conventional materials such as steel and concrete rather than being fully embraced as a distinct architectural material. This constraint is largely influenced by the hyper-industrialization of commercial architecture, which prioritizes rapid construction timelines and cost efficiency over material innovation. To fully realize the potential of mass timber, the industry must address these challenges by advancing design methodologies, optimizing production processes, and advocating for more flexible building regulations, thereby fostering greater architectural experimentation and widespread adoption.

4.0-1.1.1.1.1.- BIM Integration

The adoption of BIM workflows and computer-aided fabrication processes has significantly enhanced innovation in mass timber design and construction. Traditional construction processes often suffer from inefficiencies due to misalignment between architectural intent and on-site execution. As shown in **Figure 31**, BIM enables architects, engineers, and contractors to work within a fully digital, collaborative environment where every aspect of the building, from material properties to structural integrity and energy performance, can be meticulously modeled, analyzed, and optimized before construction begins. By leveraging parametric design tools, BIM allows for greater precision in customized timber fabrication, reducing material waste and improving structural efficiency.

These trends are the result of increased demand for sustainable structures, increased construction speed and the benefits of repetitive fabrication in a controlled environment. Additionally, these advanced manufacturing techniques enable the production of complex, non-standardized timber geometries, allowing for greater architectural freedom while maintaining structural efficiency and cost control. Computer-automated fabrication processes, such as CNC (Computer Numerical-Controlled) milling, laser cutting, and robotic assembly, have further revolutionized mass timber construction by enabling the efficient production of highly detailed, custom components that fit seamlessly within prefabricated assemblies. These technologies ensure that connections, joints, and load-bearing elements are fabricated to exact specifications, minimizing errors during assembly and significantly reducing on-site construction time.

CNC milling machines are a numerically controlled technology that can manufacture a variety of structural parts to quickly and accurately manufacture timber constructs. Using precise computational control with a raw wood material base, a CNC mill paths layer-based, subtractive cuts on an object, (What Is CNC Milling? – Simply Explained | All3DP, 2019). While more commonly used for manufacturing individual components of machinery, there has been a shift in the architectural industry utilizing large-format milling machines to manufacture timber building components from large sheets of CLT, a type of laminated, layer-based mass timber. Utilizing CAD software (that can utilize BIM), along with CNC machinery to quickly generate a series of custom designed arrays of structural components introduces a level of coordination and flexibility that can meet the rapidly growing demand for sustainable construction.

Furthermore, automation in timber fabrication has opened new possibilities for highly intricate, biomimetic, and parametric designs, which were previously unattainable using conventional construction methods. This synergy between BIM-driven design processes and automated timber fabrication is crucial for overcoming some of the key challenges in mass timber construction, such as cost constraints and standardization limitations. By utilizing digital twins and real-time simulation tools, architects and engineers can optimize structural load distribution, fire resistance, and acoustic performance, leading to more resilient and adaptable mass timber buildings. Additionally, integrating sustainability metrics within BIM platforms allows designers to track carbon sequestration, life cycle assessments, and material sourcing, further reinforcing mass timber's potential as a climate-positive construction method.

As the construction industry continues to embrace digital innovation, the combination of BIM workflows, computational design, and automated fabrication will play a pivotal role in pushing the boundaries of mass timber architecture, enabling greater efficiency, customization, and environmental responsibility. These advancements not only improve design flexibility but also ensure that mass timber construction can compete with and surpass conventional materials in terms of performance, cost-effectiveness, and sustainability.

Despite the promise of innovation that the industry demands, development and application of these technologically aided modern manufacturing processes have existed in a "design bubble" and have been frequently treated as independent case studies, devoid of site and context. These technological aides that readily accommodate custom features and digitally mediate design processes "afford designers and builders a new formal and spatial vocabulary" according to Neumann and Schmitt, (2003). By expanding design possibilities beyond the replication of identical parts, new woodmass-customization technologies challenge conventional notions of modernity within architecture. Timber is no longer contained to repetitive structures of equal parts and repeated connection details. Leaving standardization behind, new configurations of formation offer flexibility and versatility; and perhaps by emulating timber systems observed in other cultural configurations and expressions we can realize these possibilities.

As discussed in *Studies in Tectonic Culture*, architecture is fundamentally an engagement with both the present and the past. In contrast to technology, which often views the past as obsolete and seeks progress toward an imperceptible future, architecture requires a more reflective, critical approach for its advancement. It is a humanistic discipline that must not only recognize the past but also honor and embrace it. By integrating this concept of "cherishing the past" with cutting-edge technologies and cultural studies, a new architectural syntax can emerge- one where the past and present work in harmony. The incorporation of advanced wood processing techniques and robotic construction methods, alongside an awareness of the cultural factors that have shaped the evolution of timber construction, may pave the way for a revolutionary yet familiar future in mass timber design- one that is both deeply rooted in tradition and radically refined by innovation.

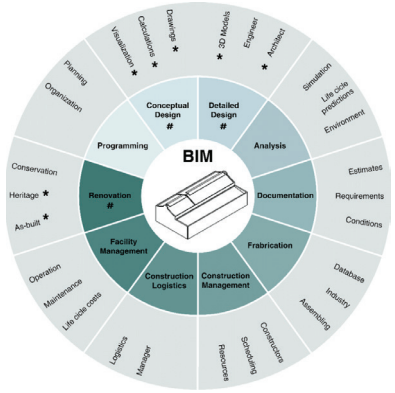


Figure 31- *Overview of BIM scope within the architectural umbrella*, (Diagram of a Building Information Modeling (BIM) Work Process., n.d.).

4.1- Contemporary Integration

Despite the shift away from manual detailing, contemporary architecture does not have to lose its essence in place-making. The need for hand craftsmanship has been largely replaced by automated precision manufacturing, allowing for greater efficiency, accuracy, and scalability while still maintaining architectural integrity and innovation. State-of-the-art CNC machining in mass timber construction enables architects to translate intricate detailing and complex joinery connections from conceptual design into realized, precision-engineered structures. Designers can create highly customized components that would be impossible or excessively labor-intensive to produce by hand. This transition does not diminish the artistry of architecture but rather reinterprets craftsmanship through technological means, ensuring that detailing remains an integral part of architectural expression.

Furthermore, CNC machining allows for the seamless integration of cultural and site-specific influences into mass timber construction. Unlike standardized industrial materials such as steel and concrete, which often prioritize efficiency over contextual relevance, mass timber's adaptability to digital fabrication techniques enables a new form of material expression, where historical detailing, regional design languages, and contemporary aesthetics can coexist within a single architectural syntax. This process ensures that while the direct human touch in fabrication is minimized, the intentionality behind architectural design and place-making remains deeply embedded in the final product.

Ultimately, the elimination of the human hand in detailing does not signify a loss of innovation or architectural identity. Instead, it marks a technological evolution in material articulation, where precision-engineered timber components retain the richness of traditional craftsmanship while embracing the efficiency, sustainability, and scalability of contemporary fabrication methods.

4.1-1- Connected Conditions and Details

Revelations from the two case studies on vernacular architecture in Norway and Japan highlight the profound connection between folk culture and architectural expression within these wood-based traditions. The condition of the joint served as the ultimate act of craftsmanship, embodying both structural integrity and artistic intent. The precise execution of these connections not only defined the construction techniques, but also shaped the identity and character of the built environment. Drawing inspiration from these historical precedents and integrating them into contemporary architectural practice fosters a meaningful dialogue between tradition and modernity. By reinterpreting these sophisticated joinery techniques through advanced digital fabrication methods and mass timber construction, architects can bridge the gap between cultural heritage and cutting-edge innovation, ensuring that the essence of craftsmanship endures within present-day architectural expression. Only by seeking the true essence and connotation of tradition, can we further change and develop in the world's context.

There exists already an inherent connection between mass timber dimensioning and CNC machining fabrication, which plays a critical role in ensuring precision and efficiency in construction. CNC machinery is widely utilized in cutting openings in CLT panels for doors, windows, and service penetrations with tight dimensional tolerances, contributing to improved air-tightness and overall building performance. Beyond its sustainability advantages, one of the key benefits of Cross-Laminated Timber (CLT) construction is its reliance on offsite prefabrication, which enables high-quality, certified production in a controlled environment, independent of weather conditions. Since holes, notches, and other modifications can be pre-cut before panels arrive on-site, assembly methods and building construction timelines are highly streamlined.

One point of concern in mass timber usage is connection details. A plethora of steel screws, plates and fasteners must be used to connect large timber members. According to *WoodWorks*, "Design considerations can include checking the parallel and/or perpendicular-to-grain capacity of the wood members, determining the type, size and quantity of fasteners, and any design checks required for the steel, concrete or masonry components of the connection" (Kinder & Kingsley, n.d.). Additionally, there exists the issue of fire-rating: accounting for the potential of the connectors to conduct heat into the core of the panels undermines the inherent fire-resistant quality of mass timber. Instead of simple steel plates and screws as necessary connections and fasteners, lacking detail and finesse, (depicted in **Table 2**), why not employ more refined timber joints, inspired by the master craftsmen of old?

"Well, the times changed, the demands changed [...] once, there came a time when craftsmen didn't find the time to make a wooden connection anymore. Everything that was left was a straight cut, a steel bracket and some screws"

-Berchtold (Wolfgang, 2020).

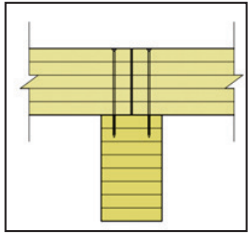
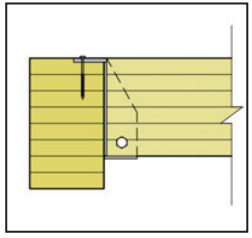
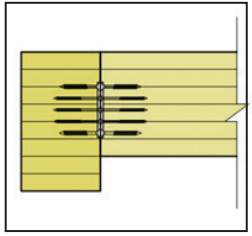
Class 1 Connection	Class 2 Connection	Class 3 Connection	Class 4 Connection
Requires only mass timber elements and fasteners	Utilizes steel fabricated elements with components such as angles and plates, and includes fasteners	Prefabricated proprietary connectors	?
			?

Table 2- *Examples of mass timber classes/ connections,* (Mass Timber Connections, 2021.).

4.1-1.1.- Translation of Typologies

The goal of reviving these traditional manufacturing techniques is to reinterpret them through a contemporary lens, blending heritage craftsmanship with modern innovation. Similar methodologies have been employed to translate historical knowledge into advanced manufacturing processes, demonstrating the potential for integrating traditional techniques within a technologically-driven framework. However, further research and development are required to enhance the knowledge transfer between human expertise and machine automation, ensuring that technological advancements preserve and refine the intricacies of traditional craftsmanship while optimizing efficiency and precision in modern construction practices.

Berchtold, a carpenter from Schwarzenberg, Vorarlberg, is recognized as an expert in wooden construction techniques, particularly in the manufacturing processes characteristic of his region. As documented in Volume 2 of *Traditional Knowledge on Modern Milling Robots*, Berchtold conducted an independent case study on the fabrication of a traditional log home using a five-axis 'Hundegger' CNC machine. He emphasized that this method of construction draws upon a rich historical foundation, offering numerous precedents, particularly in corner joinery techniques, such as the Dovetail joint, Scandinavian Notch, and Saddle Notch.

Ironically, the CNC machine he used was pre-programmed with standardized dovetail solutions intended for simple log construction. However, according to Berchtold, these automated solutions lacked crucial structural and functional details that, while seemingly minor at first glance, proved essential when working with large timber elements. Rather than relying on the pre-set options, he developed an optimized and improved version of the dovetail corner joint, translating traditional craftsmanship into the language of modern CNC machining. While the result exhibited slight modifications-such as rounded corners and fabrication constraints inherent to the milling tool, the construction of a small family home utilizing this joinery method was a successful integration of historical joinery techniques with advanced digital fabrication, demonstrating the potential for bridging tradition and technological innovation in timber construction.

Another notable example is Tsugite, a digital program developed by researchers at the University of Tokyo to facilitate the design and fabrication of custom wood joints. This interactive system enables users to create tailored joinery solutions, drawing inspiration from traditional Japanese Tsugite techniques. The software features an intuitive modeling interface, allowing users to input custom parameters, dimensional specifications, and performance metrics, while providing real-time graphical feedback on the joint's design. Once a joint is finalized, it can be fabricated using a three-axis CNC milling machine, employing a specialized path-planning algorithm that ensures precise assembly by accommodating corner rounding constraints. This system significantly streamlines the transition from digital design to physical construction, enhancing both efficiency and adaptability in wood joinery production. However, despite its advantages, the implementation of Tsugite has presented challenges, particularly in refining

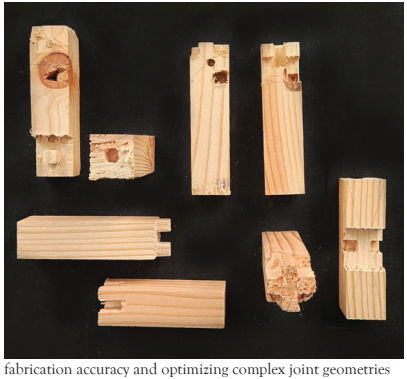


Figure 32- *Iterations of Tsugite Test Mills* (McKinney, 2024).

fabrication accuracy and optimizing complex joint geometries for structural performance.

Tsugite, available on GitHub, is accompanied by YouTube tutorials and supplementary documentation outlining best practices for effective implementation of this software. The software allows users to engage in a virtual trial-and-error process, adjusting parameters to assess how modifications in dimension or axis orientation influence the feasibility and structural integrity of joint designs. While a small three-axis CNC machine cannot yet replicate the aesthetic refinement and craftsmanship of hand-carved Japanese joinery **(Figure 32)**, the system at hand demonstrates significant potential. By utilizing design and digital fabrication, Tsugite provides valuable insights to those not familiar with joinery or construction, how forces and grain orientation affect joint performance, and the fabrication constraints associated with CNC machining. This platform serves as a tool for both education and innovation.

Through the evaluation of both the software and output test mills, the development of this set of joints, (as shown in **Figure 34)** effectively demonstrated the possibilities and potential of designing connections for large-scale mass timber members. However, it also provided deeper insight into the limitations of both fabrication processes and software capabilities. In particular, constraints arose from the inherent properties of wood purchased for this study, as well as the limitations of CNC machining, tools used, and its associated production workflows **(Figure 33)**. While the software serves as a valuable introduction to processing joinery using modern fabrication techniques, it lacks the precision and depth necessary to fully integrate traditional Japanese joinery typologies. Notably, it does not account for the nuanced structural roles of tsugite based on their hierarchy and placement within a building, thereby limiting its capacity to authentically replicate traditional construction logic.

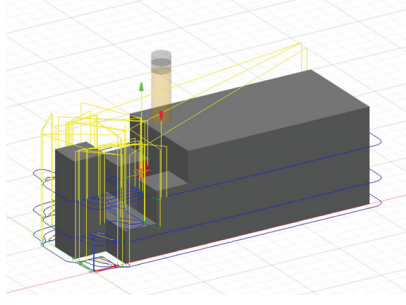


Figure 33- *CNC path generated in Fusion360, derived from a Tsugite output* (McKinney, 2025).

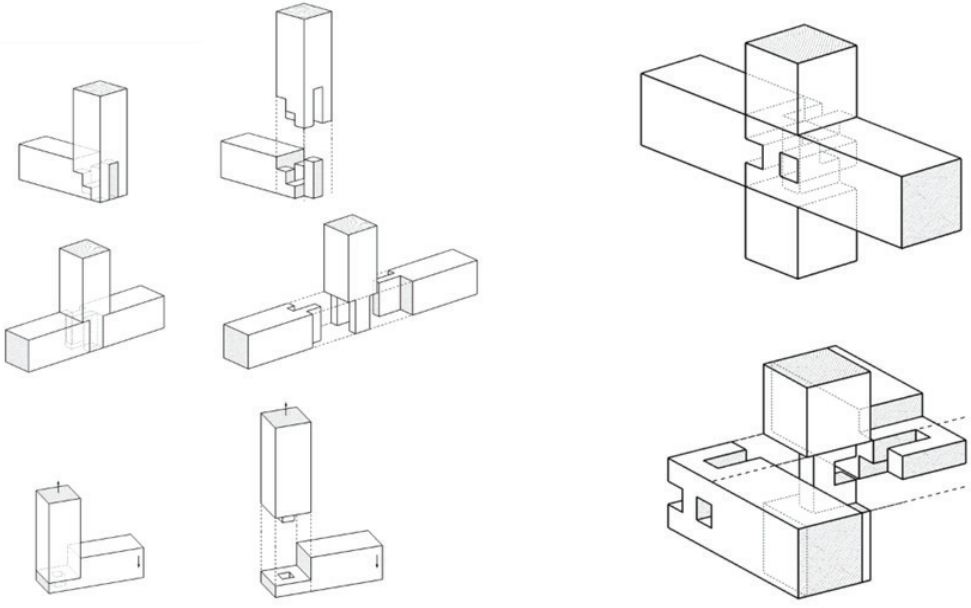


Figure 34 *Iterations of in-program Tsugite joinery configurations*, (McKinney, 2025).

5.0- A New Language of Architecture

The process of research and acquiring practical knowledge extends beyond technical learning to include reflection and synthesis, allowing for deeper comprehension and the formation of new conceptual frameworks. In the context of culturally-informed mass timber construction, this involves applying newfound insights from these case studies to develop a specialized architectural vocabulary that responds to evolving technologies and fabrication methods. As researchers seek to further advance their understanding, what strategies can be employed to elevate knowledge acquisition to the next level? Additionally, how can designers effectively communicate and showcase their findings to contribute to the evolving discourse in architecture and construction?

These studies and cultural explorations of architecture have culminated in a new language of mass timber typology. What is proposed is a new type of connection series, utilizing synthesized versions of minka and lofthouse tectonics, cultural embodied knowledge, and state-of-the-art technology. By deeply studying historical joinery techniques and the role of connection details as both structural and expressive elements, a new class of mass timber connections emerges- one that leverages the material's inherent strength, precision milling, and digital fabrication to create interlocking systems that are both performative and poetic. These connections move beyond metal fasteners and adhesives, instead embracing engineered timber components that connect through friction, geometry, and a sensibility of craft, allowing the wood to speak its own structural language while embedding tradition within the digital future of architecture.

Architecture demands an ongoing engagement with questions of materiality, technique, and spatial organization, prompting a critical exploration of the relationship between technology, space, craft, and locale. Few contemporary wood structures exemplify this dynamic, where technological innovation and cultural expression intersect to inform new design possibilities. One of the most effective ways to apply findings and new knowledge is to provide a "proof of concept" project- showcasing this new configuration of a more sensible, informed language of architecture and connections. This project serves as an investigation into the technical, spatial, and cultural dimensions of CNC fabrication, positioning itself within a broader discourse on material science, manufacturing processes, and assembly techniques that shape the evolving landscape of architectural practice.

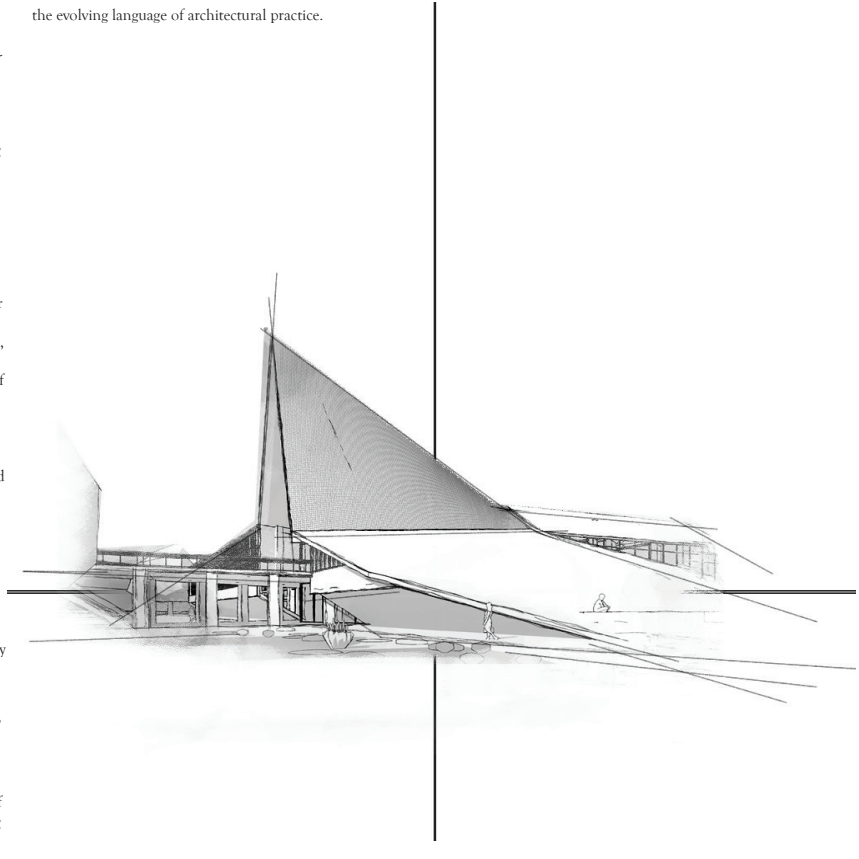


Figure 35- Revit rendering of Project, (McKinney, 2025).

5.1- "Proof of Concept"

As in the words and findings of Marco Frascari, the "true essence of being an architect involves translating theoretical insights into tangible architectural interventions" (2003). This can be achieved through the development of "proof of concept" projects, exhibitions, and publications that articulate new spatial and structural languages. Digital and physical models, detailed technical drawings, and interactive installations can effectively communicate design innovations, while inspiring others and engaging with current architectural discourse.

The Museum of Craft and Design, **(Figure 35)** a conceptual design situated in the Washington, D.C. Tidal Basin area, explores the interdependent relationships between technology, fabrication, context, and place. Its engagement with the immediate environment extends beyond architecture's fundamental role in mediating landscape and human activity. Given its reliance on modern technology and material resources, the project's physical characteristics- specifically those shaped by digital wood fabrication and mass customization- establish a direct connection to the geographic, economic, and cultural conditions in which it is situated. Located within West Potomac Park in Washington, D.C., the Tidal Basin serves as both a significant cultural landmark and a functional infrastructure element, originally constructed to filter sediment from the Washington Channel. Renowned for its annual Cherry Blossom Festival, the area attracts over 1.5 million visitors each spring. A small, relatively undisturbed plot of land, situated a few hundred meters from the official Tidal Basin Trail and currently used as a soccer field, was selected as the project site. This location was chosen for its proximity to the cherry blossoms, the absence of museums in the immediate vicinity, and its exceptional views of the Tidal Basin and the Washington Monument.

This urban mass timber project embodies the concept of an "ancient future," seamlessly integrating the sensibilities of wooden architecture with advancements in contemporary digital fabrication and construction technologies. By drawing inspiration from traditional timber craftsmanship while leveraging cutting-edge computational design and manufacturing processes, the project establishes a dialogue between the past and the future. The resulting architectural expression, seen in **Figure 36**, fosters an atmosphere of reflection, encouraging a deeper engagement with the built environment and its relationship to nature. By situating itself at the intersection of heritage and innovation, the design seeks to cultivate a renewed appreciation for the enduring qualities of timber architecture while addressing contemporary needs.

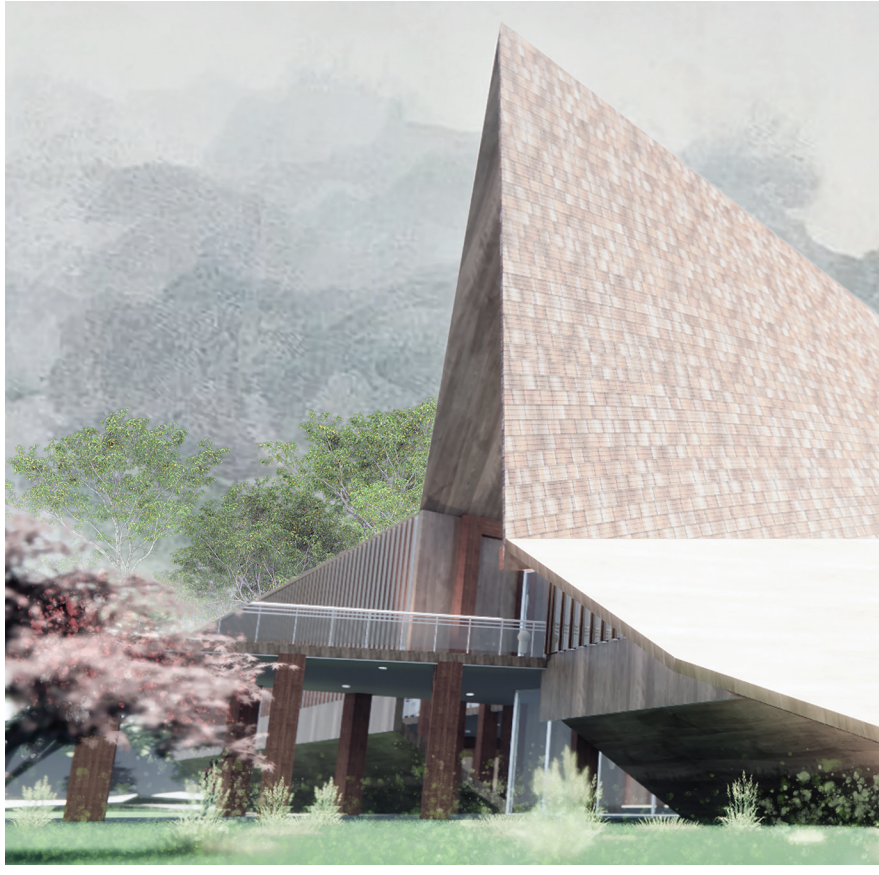


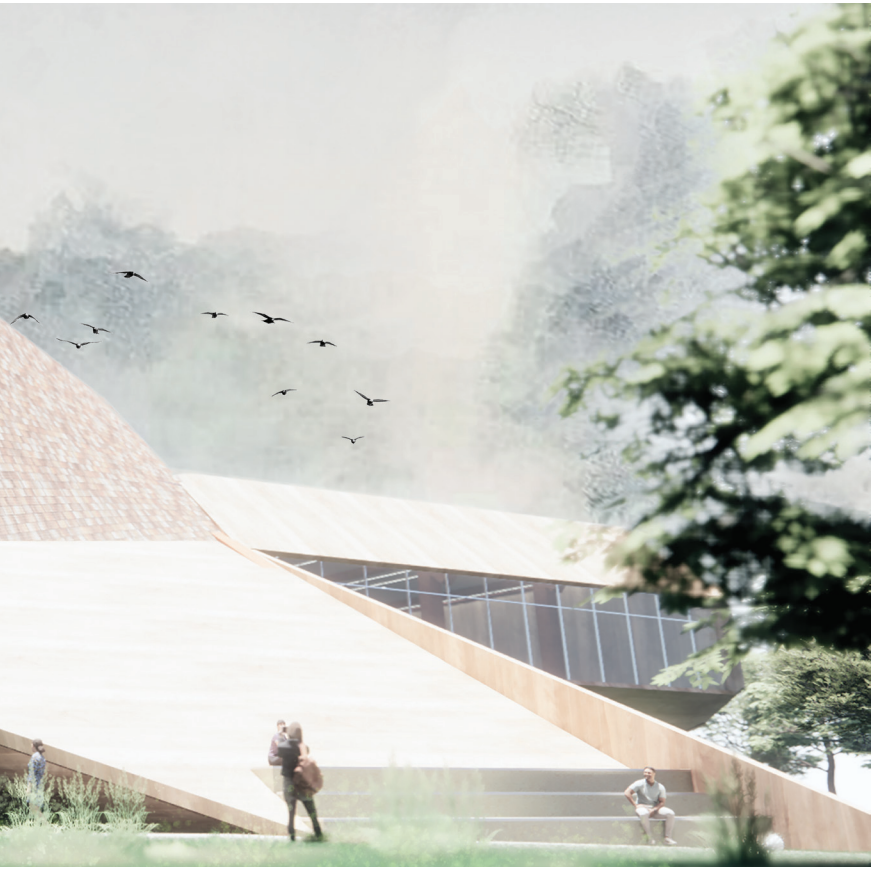
Figure 36- *Exterior Perspective Rendering of Northmost Façade- 'Museum of Craft and Design'*, (McKinney, 2025).

5.1-1- Parts in Relation to Whole

As demonstrated in its structural model, the defining characteristic of the building is its innovative roof structure and structural connections. Supported by robust glulam columns, the parametrically designed CLT framework creates a striking vertical presence, appearing to reach skyward. The pitched roof form, shown in **Figure 37**, is referential to the traditional Japanese gassho-zukuri style minka, and serves as a deliberate nod to the cultural origins of the Cherry Blossom Festival- an enduring symbol of goodwill between Japan and Washington, D.C. In contrast to the predominant neoclassical stone and concrete architecture of the surrounding context, this timber construction introduces a new architectural dialogue, challenging conventional material expressions within the urban fabric.

Beneath this distinctive roof structure, the main lobby serves as the central space of the museum, defined by expansive glass facade that maximizes natural daylight and transparency. This design strategy allows for continuous visual engagement with the roof's structural framework, both from within the interior and the surrounding exterior environment. The emphasis on verticality not only accentuates the spatial experience but also reveals the museum's hierarchical organization, with its three floors arranged in a gradient of programmatic functions—ranging from the most public spaces at the ground level to more private areas on the uppermost floor. This spatial arrangement draws inspiration from the functional stratification found in the vernacular architecture of Japan and Norway, whereas distinctions between public and private domains are carefully delineated through vertical organization.





As depicted in the sequential flooplan, **(Figure 38)**, visitors are presented with two distinct pathways to navigate their journey through the gallery spaces. One route leads to the right, guiding visitors into the first gallery, which features a curated selection of smaller, more intimate works by local artists. This sequence then transitions into a double-height atrium space, crowned by a glass canopy that enhances natural illumination and spatial openness. Visitors are drawn to the striking presence of the massive intersecting glulam columns and beams that elegantly support the space, serving as a profound testament to the precision and artistry of Japanese craftsmanship. These structural elements not only exemplify advanced timber engineering, but also evoke a sense of timeless tradition, seamlessly blending innovation with the rich heritage of wooden architecture. Their intricate joinery and monumental scale create a dynamic interplay of light and shadow, further enhancing the spatial experience and reinforcing the connection between materiality, structure, and cultural legacy.

Figure 37- *Exterior Perspective Rendering of East Façade,* (McKinney, 2025).

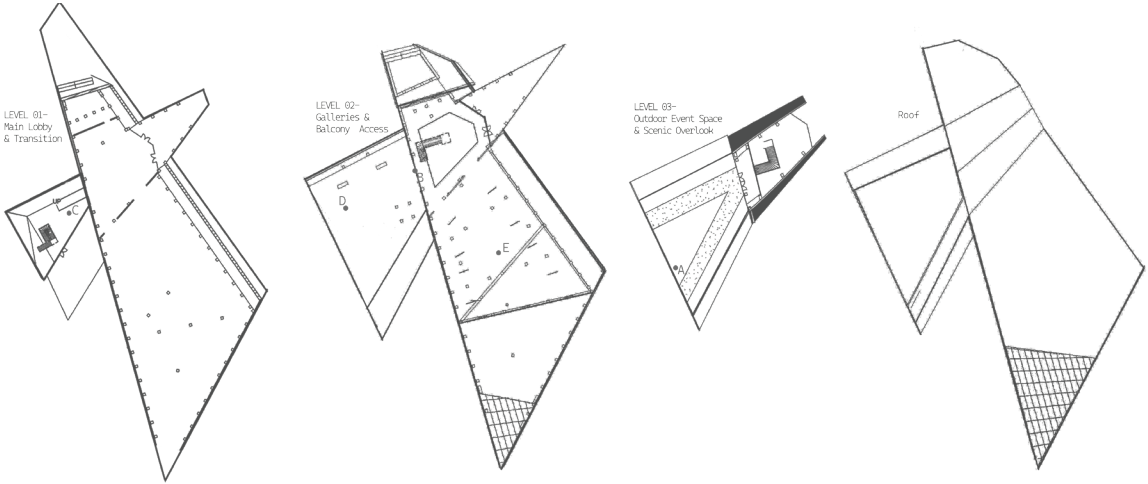


Figure 38- *Sequential Floorplan,* (McKinney, 2025).

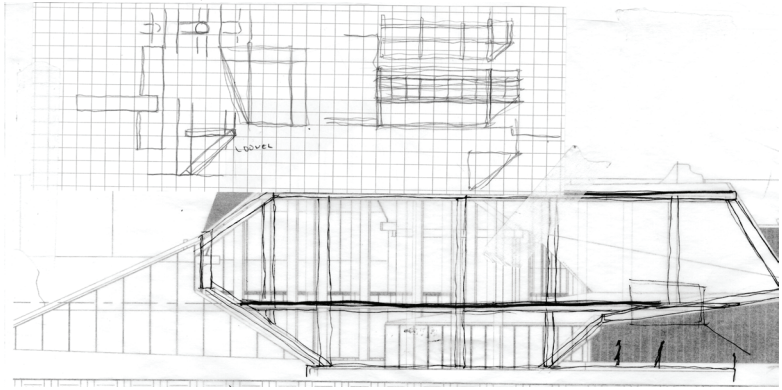


Figure 39- *Sketches of potential joint configurations in strucutral system,* (McKinney, 2024).

Alternatively, visitors may choose to enter "The Hull," a transitional passageway aligned along the main axis of the structure. This space stands in stark contrast to the other areas on the main floor, offering visitors a journey through a darker, more angular, and atmospheric passage. Shown in **Figure 41**, the interplay of shadow and form creates an immersive, almost sculptural experience, heightening a sense of introspection and mystery. Overhead, massive, log-like beams provide structural support while simultaneously shaping a dynamic interplay of angles, reinforcing the space's dramatic and immersive quality. A break from the interior program exists, integrating an exterior courtyard and sculpture garden to foster moments of reflection and engagement with the surrounding environment, and a moment to pause and notice the sharp, angled exterior of the museum's structure. From this space, the journey continues upward to the second floor, seen in **Figure 40**, further expanding the museum's spatial and programmatic experience.

A striking contrast to the preceding dark, enclosed space unfolds as natural light pours through expansive floor-to-ceiling storefront windows, offering a panoramic view of the Tidal Basin. The scene is framed by the delicate beauty of cherry blossoms in full bloom, with the Washington Monument emerging beyond the canopy of trees. Sunlight filters into the interior, casting dynamic patterns across the floor and walls, cultivating a warm and inviting atmosphere. The second floor of the museum offers a more open and dynamic environment, inviting exploration and discovery. As seen in **Figure 42**, this space serves as a repository of cultural heritage, displaying a diverse collection of artifacts, including textiles, pottery, paintings, and models of early architectural works. While the exhibits celebrate the rich traditions of Native American culture, American immigration, and Appalachian folk heritage- collectively encapsulating the essence of "Americana"- the expansive view of the Tidal Basin and the Washington Monument provides a compelling juxtaposition, symbolizing the continuum from the past to the present and the future. Enhancing this reflective experience, a parametrically designed series of seating arrangements is strategically positioned to encourage visitors to pause, contemplate, and engage with the view of the surrounding landscape. This intentional integration of design and view lends the space its evocative name, "The Reflection Room," reinforcing its role as a place for both cultural appreciation and introspection.

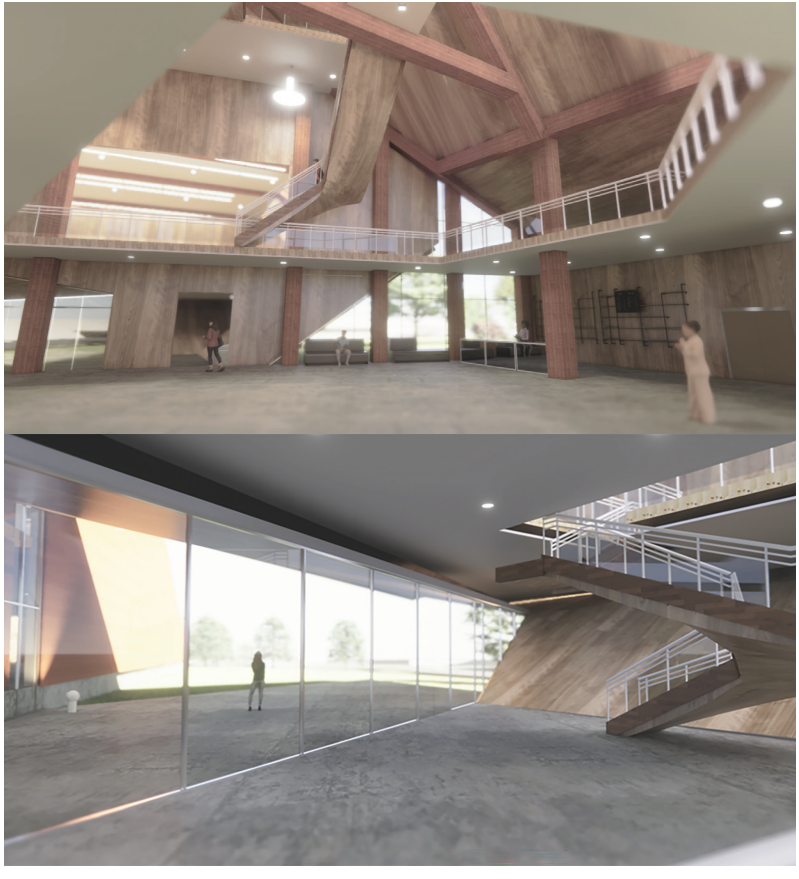


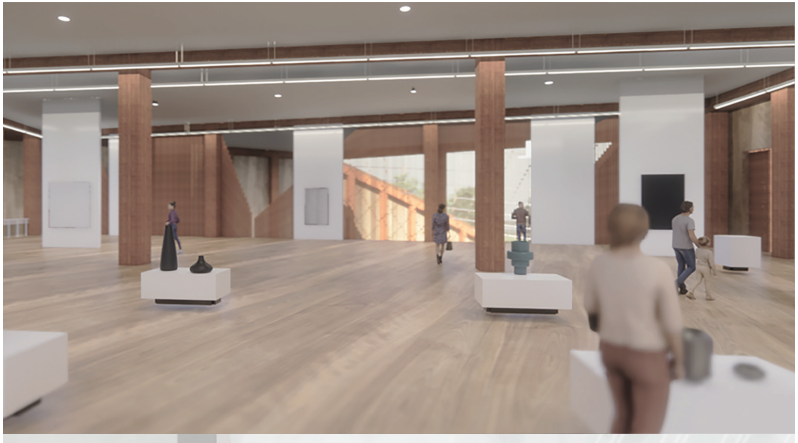
Figure 40, 41- *Interior Rendering of Lobby Space, "The Hull"*, (McKinney, 2025).

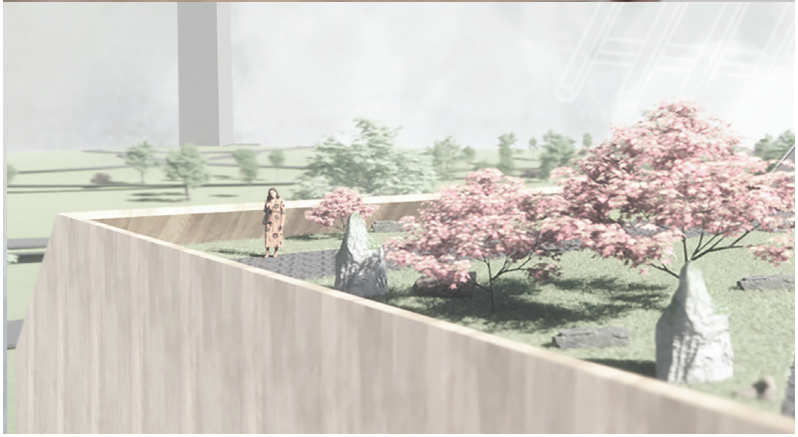
Visitors traverse the lobby space once again, now from the vantage point of the second floor (**Figure 43**). Encircling the perimeter, a series of elevated walkways and staircases provide access to the third level, offering a layered circulation experience that enhances spatial connectivity. Additionally, this level grants entry to the exterior balcony, an extension of the architectural form that projects outward from the glass curtain wall. This overhanging balcony serves as both a transitional threshold between interior and exterior and a vantage point from which visitors can engage with the surrounding landscape, further reinforcing the museum's dialogue between built space and natural context.





Figure 42, 43- *Interior Rendering of 2nd Floor, including views towards surrounding landscape and Washington Monument, View of Interior Lobby,* (McKinney, 2025).





As visitors move through the lobby and into the final gallery space, they encounter the museum's most expansive collection of artwork, depicted in **Figure 44**. Dedicated to contemporary American artists, this gallery is distinguished by its soaring ceilings and an architectural language that emphasizes openness and structural expression. Towering glulam beams pierce through the floor and extend upward, seamlessly connecting the space to the lofty ceiling above, reinforcing a sense of vertical continuity. The expansive glazed front façade is punctuated by a series of smaller timber members functioning as louvers, serving both as practical sunshades and as a visual element that fragments the incoming light. This interplay of light and shadow animates the gallery throughout the day, creating a dynamic and immersive atmosphere that changes throughout the day.

An alternate route up to the private outdoor event area, a visitor must climb a staircase, expertly cantilevered above the tall lobby space. Exiting out onto the roof of "The Hull", one is greeted with a 360 view of theTidal Basin and the Washington Monument to the right. (**Figure 45**).

Figure 44, 45- *Interior rendering of second floor gallery space, Exterior rendering of Level 3- outdoor event space,* (McKinney, 2025).

"In God lies the detail."

-Marco Frascari, The Tell-The-Tale Detail.



5.1-1.1- The Tell-The-Tale-Detail: Revisited

From an architectural perspective, this structure emerged as a result of the exploration and extrapolation of details, underscoring the fundamental principle that the detail constitutes a core aspect of architectural theory and practice. Within these details lie the potential for innovation and invention, serving as the means through which one can challenge technological and cultural constraints, investigating this new methodological approach towards timber construction. This idea of 'detail orientation' reinforces a well-established axiom in architectural criticism: "That might have been great architecture, if only someone had worked out the details."

While the previous chapter briefly addressed the structural hierarchy of the Museum of Craft and Design, this discussion will now engage with the connection language in greater depth, emphasizing process work and case study inspirations. As Marco Frascari asserts in *The Tell-the-Tale-Detail*, the application of the 'analytique' highlights that the detail or joint is not merely a unit of construction, but embodies the very essence of the architectural work itself.

The process of discovery through hands-on craftsmanship remains one of the most effective methods of experiential learning, embodying the principle of "learning by doing." The construction of a scale model in **Figure 46 & 47**, commenced following the development of a general concept, program, and spatial configuration using Revit. As an industry-standard architectural software, Revit facilitates the "simultaneous generation of plans, 3D models, renderings, and other essential project components", (Revit for Architecture & Building Design | Autodesk, n.d.). Despite its robust capabilities, Revit lacks the precision required for modeling intricate, highly discretized elements such as wood joinery- which is necessary to exhibit the true nature and complexity of this project. However, as previously noted, the overall program is secondary to the significance of detailing. As the scale wood model took shape, critical spatial considerations, including the arrangement of elements such as columns and beams, as well as means of egress- became more apparent. Additionally, the defining characteristics of the overall form were further emphasized, with the intersecting axes of the gallery spaces and expansive spans of glulam beams, cantilevering and joining together to create the angular edges of the building. Thus, the scale model was beginning to embody the craftsmanship and attention to detail integral to the architectural expression within the museum.

As the scale model approached its final stages, new complexities and critical inquiries emerged. How does one accurately model a curvilinear, parametrically designed surface composed of CLT for the roof structure? What precise methods can be employed to articulate and refine the intricate joints essential to the entire building's construction? Furthermore, how can these connections be effectively iterated upon to optimize both structural integrity and aesthetic coherence? Finally, what fabrication techniques must be considered to translate these digital explorations into tangible architectural components? These questions underscored the intricate interplay between computational design, material behavior, and the realities of architectural fabrication, necessitating a deeper investigation into advanced modeling strategies and construction techniques.

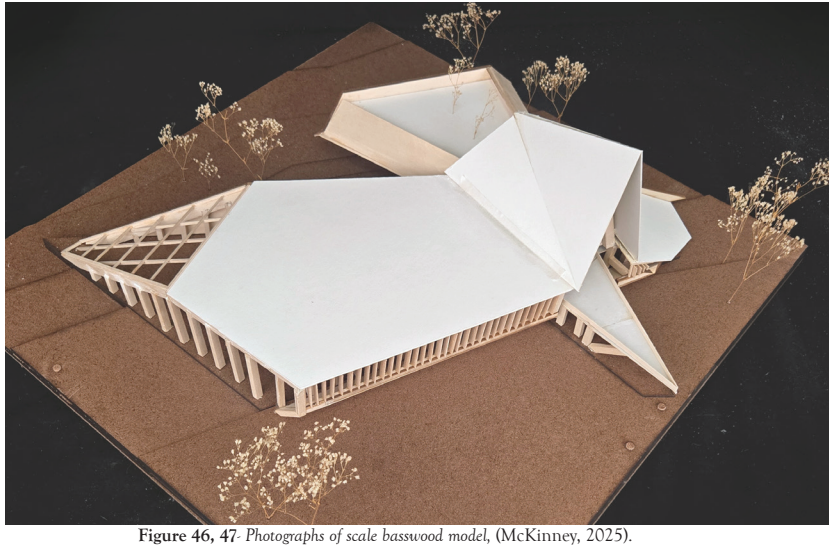


Figure 46, 47- *Photographs of scale basswood model,* (McKinney, 2025).

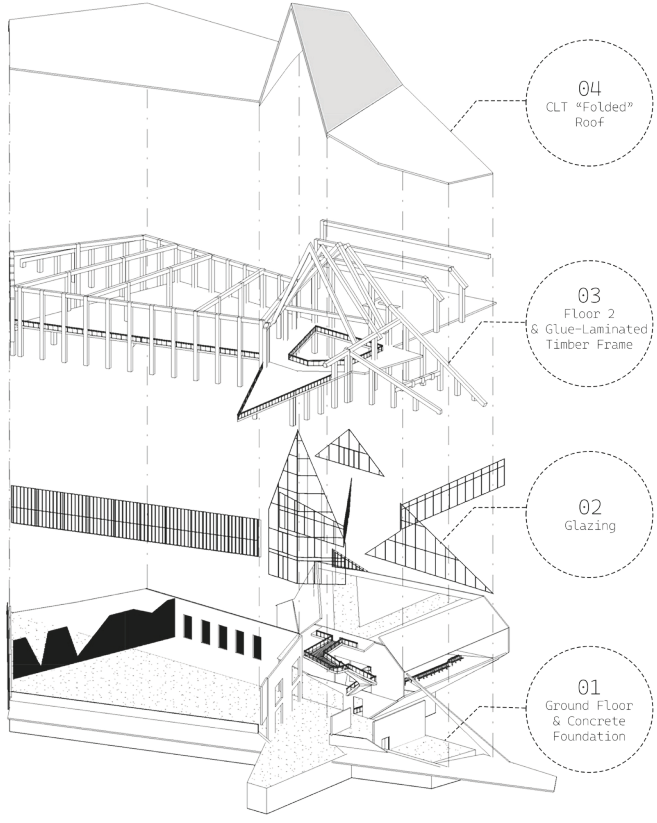


Figure 48- *Exploded Axonometric Projection of Structure and Connection Characteristics,* (McKinney, 2025).

5.1-1.1. - Translating Typologies

As referenced in *The Tell-the-Tale-Detail*, the reverence for the architectural joint in Carlo Scarpa's work epitomizes the perfect realization of Leon Battista Alberti's concept of concinnitas- the harmonious synthesis of proportion, ornamentation, and craftsmanship. The meticulous articulation of each detail is not merely an aesthetic pursuit, but a testament to its inherent polyfunctionality- a term coined by Frascari- where form, structure, and materiality converge to serve multiple purposes simultaneously. Each joint, far from being a mere connective element, becomes an expressive device that encapsulates the architect's intent, embodying both technical precision and poetic sensibility. Scarpa's mastery lies in his ability to transform the junctions of materials into moments of architectural significance, where structural necessity and artistic vision are seamlessly intertwined.

A fourth class of mass timber connection, one that leverages the intrinsic capabilities of the material itself, is now emerging- moving beyond traditional dowel, mechanical, and steel connection systems. This new approach explores the potential of wood as both connector and structure, utilizing precision CNC milling and algorithmic modeling **(Figure 48)** to achieve complex, interlocking geometries without reliance on foreign materials. It proposes a typological synthesis: a fusion of culturally rooted tectonics, such as the expressive joinery of Japanese minka and the adaptive modularity of the Norwegian lofthouse, reinterpreted through contemporary fabrication techniques.

The result is a system of three singular connection details, each one developed as a distilled response to spatial, cultural, and structural needs. The first detail concept, reimagines the lofthouse's stacked wall logic into a corner joint as a cantilevered hinge, The second, echoing minka's expressive layering and expertly crafted stress distribution. The third, seen in **Figure 49,** introduces a dynamic floor-to-ceiling column and beam connection that integrates adaptability and stress deflection. Together, these details create a new syntax of assembly, where the language of tradition is not replicated, but transformed- speaking fluently through mass timber and modern technology.

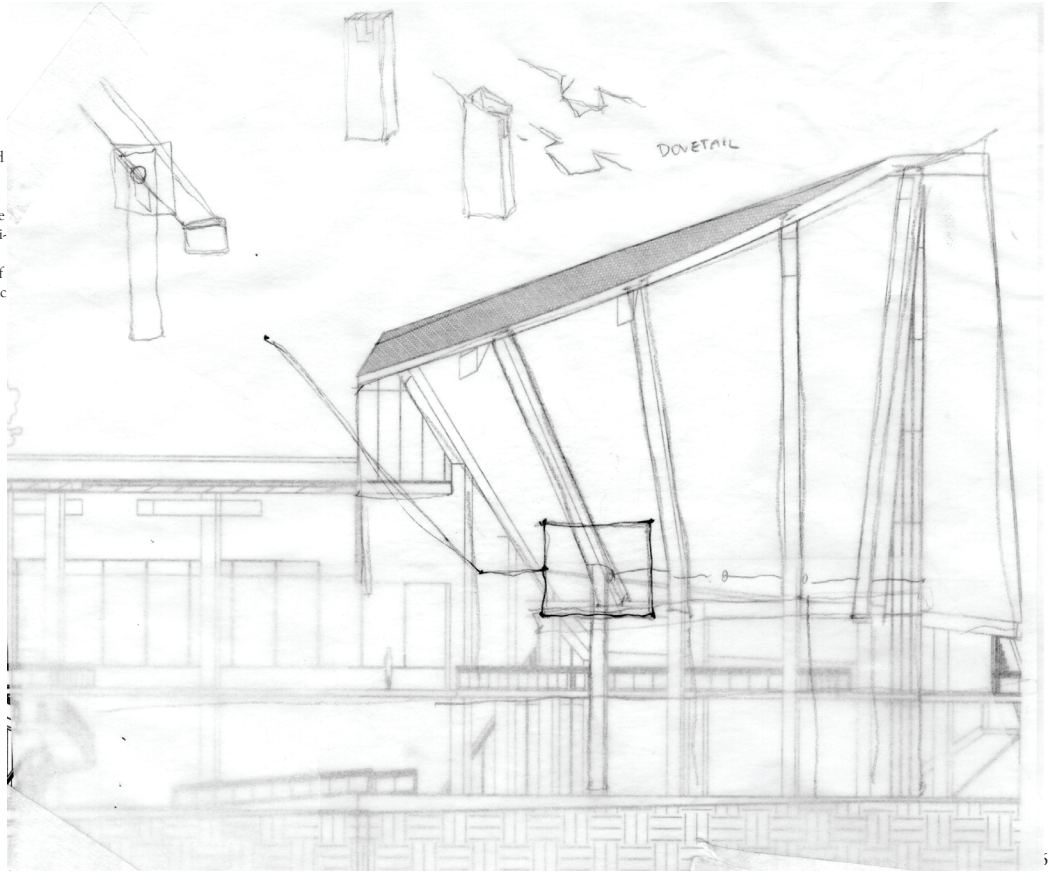


Figure 49- *Section sketch of possible joinery iterations in project,* (McKinney, 2025).

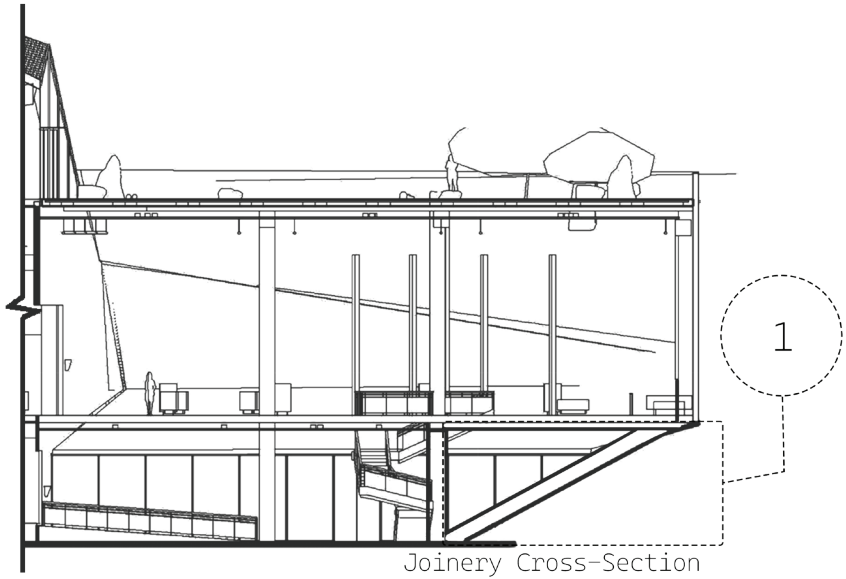


Figure 50- *Cross section of building structure to showcase joinery 01 location and function,* (McKinney, 2025).

5.1-1.1.1a- Joint 01

The secondary, transitional structure known as "The Hull" (shown in **Figure 50**) is composed of structural members of sufficient thickness to support substantial cantilevers of CLT slabs. The joinery system in **Figure 51** was specifically developed for this corner condition, and was carefully tailored to align with the construction methodologies characteristic of the lofthouse typology. This approach ensured both structural efficiency and material coherence, facilitating integration between traditional notching techniques and contemporary timber engineering. As seen in **Figure 52,** combining a round notch with a peg-and-dowel connection, this refined joint facilitates the effective transfer of structural loads from the CLT floor slab to the foundation. By ensuring an even distribution of stress, this connection enhances both structural stability and load-bearing efficiency, contributing to the overall integrity and durability of the construction.

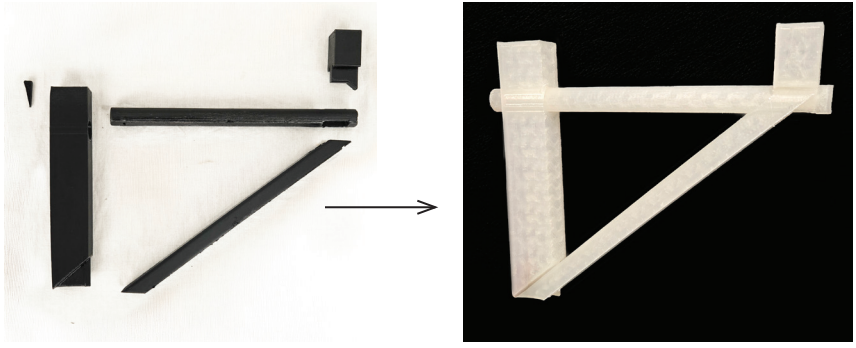


Figure 51- *Photograph of 3D Printed joinery 01 pieces, - pre and -post assembly,* (McKinney, 2025).

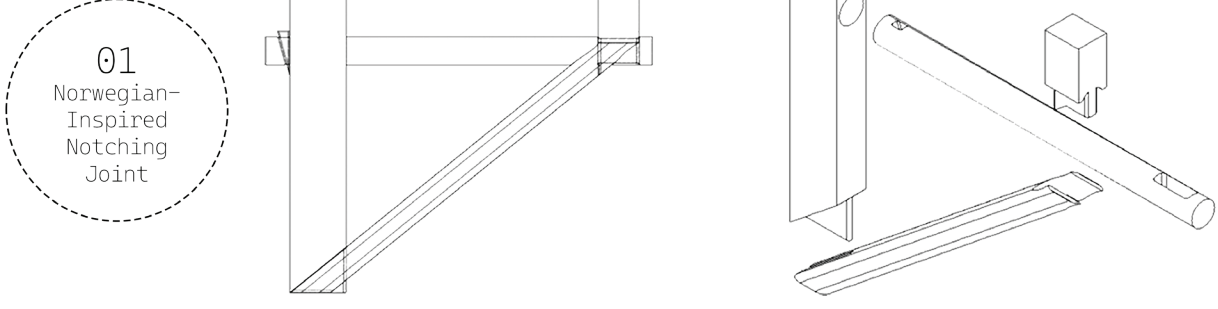


Figure 52- *Fusion 360 Graphic model of Joint 01,* (McKinney, 2025).

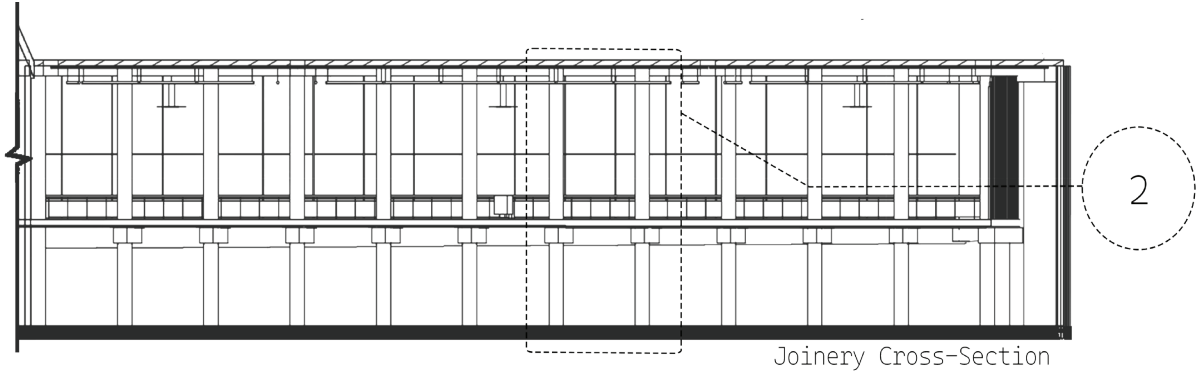
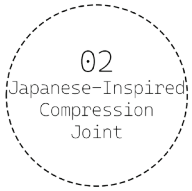
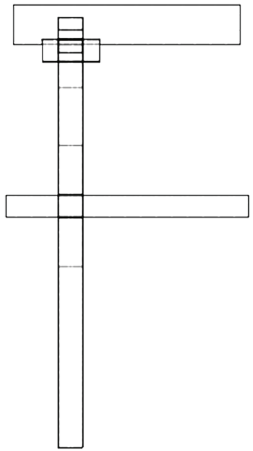


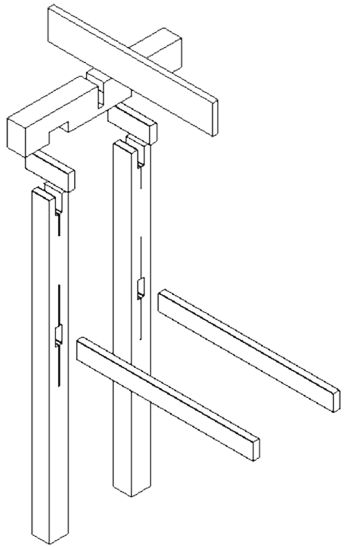
Figure 53- *Cross section of building structure to showcase joinery 02 location and function,* (McKinney, 2025).

5.1-1.1.1b- Joint 02

The integration of various examples of Japanese joinery, particularly within the gassho-zukuri style minka was instrumental in the development of a bespoke glulam joint. This custom joint was designed to accommodate extensive structural roof spans while providing the necessary support for a substantial CLT floor system. By synthesizing traditional techniques with contemporary engineering principles, this design sought to achieve both structural efficiency and architectural refinement, ensuring a seamless fusion of heritage craftsmanship and modern material innovation. At the core of this custom joint (seen in **Figure 53**) is a compression-based joining methodology, closely resembling a hybrid of a wedging joint and double plug. In this system, the primary structural elements- specifically the column and girder- are precisely milled and assembled under tight dimensional tolerances. The connection in **Figure 54** relies on friction and mechanical interlock, where members are driven together through controlled hammering, enhancing both load transfer efficiency and overall structural stability. This approach not only honors the principles of traditional Japanese timber construction, but also optimizes the performance of engineered wood products, creating a joint that is both resilient and expressive of its material logic. Notice the hierarchy of joints in **Figure 55,** and the transition of large, load bearing columns to lighter, more expressive girders and beams. Also note the repitition of elements- meant to provide mechanical stability and predictability.







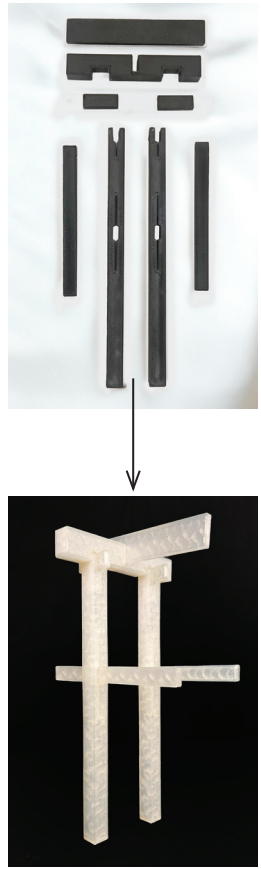


Figure 54- *Photograph of 3D Printed joinery 02 pieces, - pre and -post assembly,* (McKinney, 2025).

Figure 55- *Fusion 360 graphic model of Joint 02,* (McKinney, 2025).

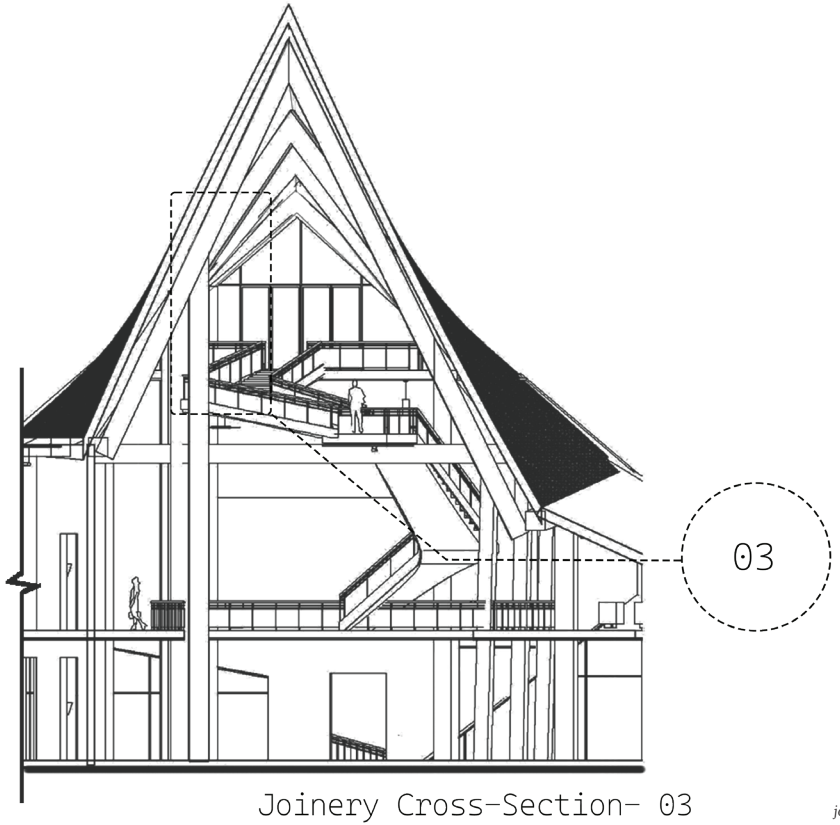
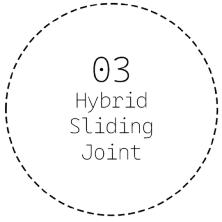
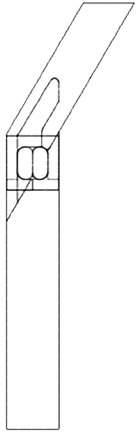
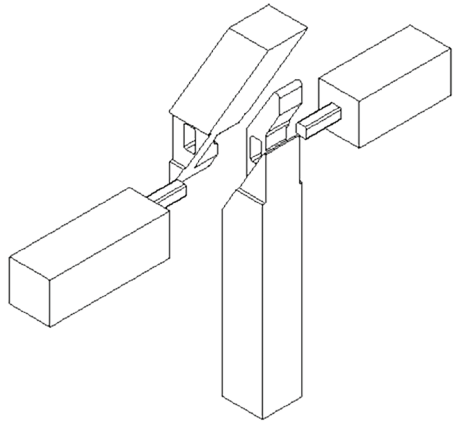


Figure 56- *Cross section of building structure to showcase joinery 03 location and function,* (McKinney, 2025).







5.1-1.1.1c - Joint 03

This connection can be characterized as a "hybrid joint" in the truest sense, as seen in **Figure 58**, this exemplifies the principles of traditional joinery from both cultural systems. It functions as a refined sliding mechanism, designed to efficiently transfer forces from the parametrically designed CLT roof (as seen in **Figure 56**), through a specialized angled joint. The inspiration for the interlocking dowels, depicted in **Figure 57,** which seamlessly slide into place, derives from the Chidori joint—a traditional Japanese wooden puzzle composed of a three-member interlocking system.





Figure 57- *Fusion 360 Graphic model of Joint 03*, (McKinney, 2025).

Figure 58- *Photograph of 3D Printed joinery 03 pieces, - pre and -post assembly,* (McKinney, 2025).

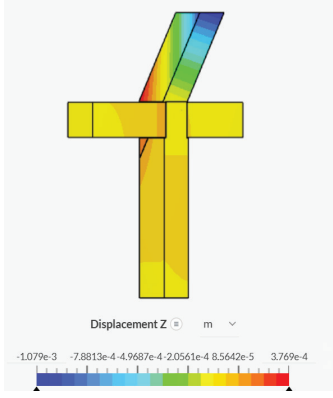
5.1-1.1.1.1- Construction Technologies

All of these joints were meticulously designed in Fusion 360, with a primary focus on optimizing them for milling-based manufacturing processes- something that must translate in the final iteration of these designs. The utilization of Fusion 360, a comprehensive CAD modeling software, facilitated rapid iteration and real-time design modifications, enabling a highly adaptive workflow, (Autodesk Fusion | 3D CAD, CAM, CAE, & PCB Cloud-Based Software | Autodesk, n.d.). Moreover, the software's capability to generate precise mechanical toolpaths allowed for a seamless translation from digital modeling to physical fabrication, ensuring accuracy and efficiency in the manufacturing process.

An effective method for evaluating structural designs within a virtual environment is through the simulation of active stresses and gravitational forces that will act upon them in situ. By accurately modeling material properties, it becomes possible to predict the structural behavior of various geometries, including their load distribution and deformation under stress. Additionally, simulating joinery connections allows for a more precise analysis of their mechanical performance, including rigidity, flexibility, and failure thresholds. This computational approach ensures that the structural integrity and functional efficiency of the designs are rigorously assessed before physical fabrication. SIMScale was selected for its comprehensive material library and its capability to accurately simulate orthotropic materials such as wood. Orthotropy, a specific form of anisotropy, refers to "materials whose mechanical properties vary depending on direction" (Engineering at Alberta Courses » Classification of Material Mechanical Response, n.d.). Given that wood exhibits anisotropic behavior, its structural response is highly dependent on the orientation of the wood grain. By utilizing SIMScale's advanced simulation tools, it was possible to model these direction-dependent properties with precision, ensuring a more accurate analysis of wood's mechanical performance under various loading conditions. A rigidity analysis of the full-scale Joint 3 was conducted to ensure that the applied forces did not induce excessive deflection in the structural member. This evaluation was critical in assessing the joint's capacity to maintain structural integrity and load-bearing performance under real-world conditions (**Figure 59**).

The accurate translation of these Glulam joints from the digital environment to the physical realm was essential to ensuring their functionality as designed. Additive manufacturing, specifically 3D printing, was employed to test tolerances and dimensional accuracy, providing a rapid and cost-effective method for evaluating joint performance. According to BuiltIn, 3D printing "uses computer-aided design to create three-dimensional objects through a layering method... Sometimes referred to as additive manufacturing, 3D printing utilizes layering process with materials like plastics, composites or bio-materials to create objects that range in shape, size, rigidity and color" (3D Printing: What It Is, How It Works and Examples | Built In, n.d.). This approach enabled iterative refinement, allowing for quick physical prototyping to assess fit, structural behavior, and assembly feasibility. By leveraging 3D printing, potential design issues could be identified and addressed early in the process, enhancing the overall precision and efficiency of the final manufacturing workflow

Beyond the extensive research and integration of novel technologies required for joint design, the parametrically conceived roof structure posed additional challenges, particularly in its translation from conceptual design to physical realization within Revit. The software's limitations in handling complex curvilinear geometries further complicated this process. However, existing research and precedent studies provide valuable methodologies for constructing curved structures using CLT slabs, offering potential solutions for overcoming these computational and fabrication challenges.



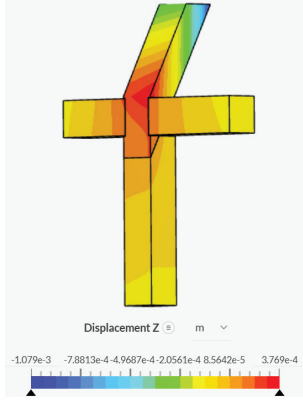


Figure 59- *SIMScale rigidity tests of Joint 03 in full scale,* (Rigidity In Wood Joinery | SimScale Workbench, 2025.)

5.2- Mass Timber Logistics Analysis

Mass timber construction remains relatively novel along the eastern seaboard, necessitating careful consideration of logistical planning and supply chain infrastructure. As highlighted in the article *Comparative LCAs of Conventional and Mass Timber Buildings in Regions with Potential for Mass Timber Penetration*, geographic context plays a critical role in accurately assessing a building's Life Cycle Analysis (LCA) and its potential for carbon sequestration. Regional variations in embodied carbon can be attributed to factors such as differences in electricity grids, transportation distances, and native wood species, (Puettmann et al., 2021). Notably, several flagship mass timber projects in the continental United States-such as the Ascent in Milwaukee and the Gibbons Center for Arctic Studies in Brunswick, Maine- have sourced their timber from Austria. According to *Green Building Advisor*, this reliance on international suppliers results in significantly higher upfront emissions, primarily due to transportation-related impacts (Jacques, 2024). This reliance on foreign supply chains underscores the current gap in domestic mass timber manufacturing, with the United States lagging behind European nations by approximately two decades in production capacity and technological integration.

Nonetheless, recent advancements have emerged in the development of locally grown and manufactured mass timber within the United States, particularly along the East Coast. Efforts are underway to cultivate and manage large tracts of sustainably harvested, fast-growing yellow pine forests for structural timber use. In support of this regional supply chain, new production facilities such as the SMARTLAM North America's plant in Dothan, Georgia, and Timberlab's manufacturing expansion in Greenville, South Carolina, mark a significant shift toward domestic mass timber manufacturing capacity. These facilities not only reduce reliance on imported products but also substantially lower transportation-related emissions by decreasing the distance between production and construction sites. This evolution in infrastructure directly contributes to lower embodied carbon in building projects and strengthens the resilience and sustainability of the supply chain.

Utilizing local supply chains and materials aligns with the broader goals of this thesis- emphasizing the integration of regionally grounded construction practices and culturally embedded building logics. This not only reduces the carbon intensity associated with long-distance transportation, but also stimulates regional economies, encourages investment in forestry stewardship, and fosters a more adaptive and responsive mass timber industry capable of meeting site-specific environmental and cultural conditions. By building local expertise and infrastructure around mass timber, the region is better positioned to support sustainable architectural practices that are both technically viable and culturally resonant.

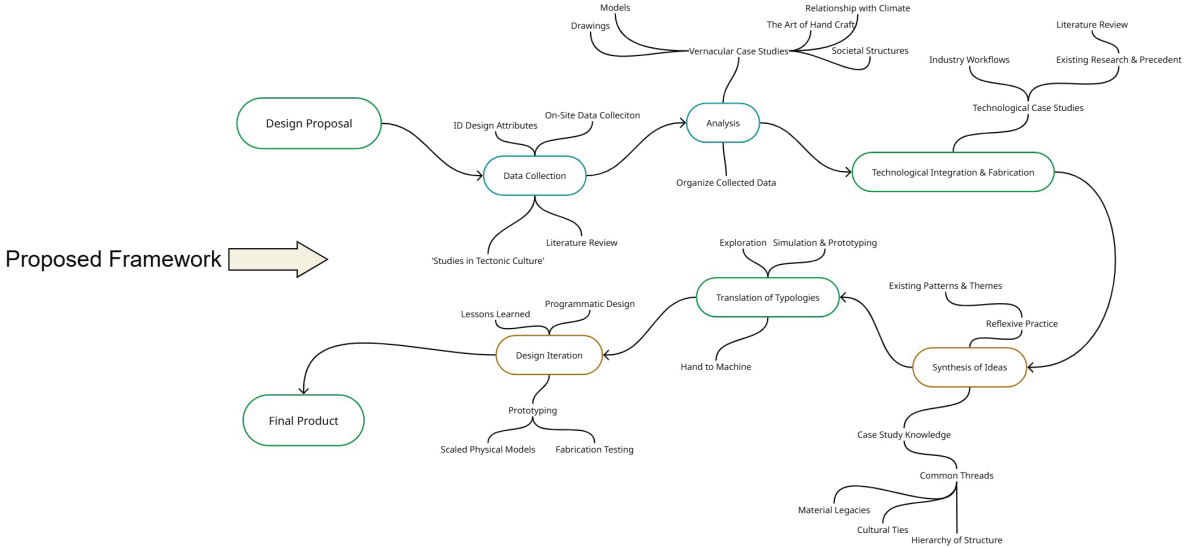


Figure 60- *Final contribution framework proposal map*, (McKinney, 2025).

6.0- Contribution

The proposed framework shown in **Figure 60** offers a comprehensive overview of the sequential stages involved in formulating a language of mass timber architecture through cultural precedents, clarifying the relationship between each phase and the overarching objective of achieving an informed and contextually responsive design. It underscores the significance of vernacular and cultural contexts in architectural practice, emphasizing the role of precedent analysis in guiding design professionals. Additionally, the framework highlights the integration of advanced tools and technologies to facilitate the accurate translation and implementation of design concepts.

A key component of this methodology is the systematic examination of case studies, ensuring that architectural practice remains well-informed and aligned with historic and contemporary examples. More broadly, the thesis framework illustrates the inherently multidisciplinary nature of architectural design, demonstrating its intersection with cultural studies, material sciences, and engineering. By drawing from these diverse disciplines, the framework provides architects with a flexible and adaptable tool for incorporating culturally informed, responsive design into various projects, fostering an innovative and contextually grounded approach that is increasingly essential within the contemporary architectural industry.

6.1- Future Work

This research not only proposes a new way of exploring and creating contemporary architecture, but it also introduces a fourth typology of mass timber connection conditions- one that bridges craft, culture, and computation. It defines a new language of domain, where the act of making is not secondary to design but central to architectural inquiry. In an industry increasingly distanced from the tactile and the tangible, this work repositions fabrication and joinery as primary drivers of architectural meaning. The act of joining becomes a dialogue- between material and method, between past and future- reviving architecture's essential role as both cultural artifact and built logic. Reflection becomes a tool not just for understanding history, but for constructing new futures. Through a multidisciplinary framework that draws from historical case studies, digital technologies, and cultural narratives, this research offers a new design methodology that is both deeply grounded and highly adaptable. It forms a language that can be spoken across disciplines, accessible to both academic researchers and industry experts, inviting a shift in architectural production: from assembly to authorship, from component to connection.

Instead of imposing force and drilling connections- an approach that often undermines the integrity and natural behavior of the material- this new methodology calls for a return to the sensitivity and intentionality of traditional craftsmanship. Just like the master craftsmen of old, one must begin by understanding and respecting the properties of wood itself: its grain direction, moisture content, elasticity; and the way it expands, contracts, and ages over time. In this approach, the act of connection is not an act of domination, but of collaboration. The material is not forced into compliance but guided into alignment. Working with the wood, not against it, fosters a deeper engagement with material intelligence, an ethos that prioritizes the inherent strengths and behaviors of timber rather than resisting them. This leads to connection details that rely on friction fits, self-locking geometries, and fiber-conscious load paths, all enabled by advanced digital tools, yet rooted in age-old wisdom. By synthesizing this understanding with modern computational design and robotic fabrication, we can develop joints that are not only structurally robust but also expressive of a new architectural domain of knowledge- one that sees the connection as an opportunity for dialogue between the hand, the machine, and the tree.

6.2- Critical Regionalism, Revisited

In his seminal essay *Towards a Critical Regionalism*, Kenneth Frampton argues for an architecture that resists the placelessness of universal civilization by grounding itself in the tactile, the tectonic, and the culturally specific. His concern is not with rejecting modernity or technological advancement outright, but rather with resisting their deployment in ways that erode local identity, environmental responsiveness, and historical continuity. Critical Regionalism advocates for a mode of architectural production that re-engages with the "poetics of construction," wherein the material, structural, and spatial logics of a building reflect both the culture of its context and the intelligence of its making. This thesis is not a simple homage to construction techniques of old- neither is it a proposal of new ways to "build" with mass timber- it is simply a call to action, a methodology for resistance of the placelessness of globalized modern architecture. It proposes a synthesis: using modern technology while staying rooted in local culture, materiality, and climate. This synthesis allows for the revival of culturally embedded construction logics, such as timber joinery and climatic responsiveness, reinterpreted through digital fabrication and modern adaptability.

This convergence does not romanticize the past, but reactivates it as a living source of design intelligence, enabling an architecture that is both regionally grounded and technologically advanced. Mass timber, with its expressive materiality and capacity for prefabrication, becomes a vehicle for reasserting the ethical and poetic dimensions of construction in a globalized era. As an engineered material, mass timber is emblematic of contemporary production: it is prefabricated, optimized for commercialized construction, and highly performative. Yet its materiality- its grain, its scent, its character- carries deep cultural and sensory associations. More significantly, its assembly logic has a potential to recall pre-industrial timber construction, where the articulation of joints, connections, and tectonic clarity were not merely functional, but also expressive of craftsmanship and cultural value.

By reconfiguring findings derived from traditional wood joinery through CNC machining and digital fabrication, architects can recast historical knowledge within contemporary forms of precision. These intersections enable a design process that is both technologically progressive and culturally resonant. The resulting architecture speaks to a lineage of making that honors place, memory, and human labor, while embracing the efficiencies and capabilities of modern systems. Moreover, mass timber's potential to respond to environmental imperatives- through carbon sequestration, biophilic qualities, and regional sourcing- further aligns with Critical Regionalism's insistence on ecological and ethical rootedness. When paired with local forestry practices and vernacular spatial strategies, (such as hierarchy of use dependent on level, processes of replacement and renewal) mass timber construction can embody a full-circle design philosophy: one in which ancestral practices and advanced methodologies do not exist in opposition, but rather in productive dialogue and advancement of the material.

Thus, the convergence of traditional knowledge and contemporary timber technologies is not merely an aesthetic or technical exercise- it is a critical stance. It reflects a broader architectural ethic that seeks to embed cultural continuity within innovation, to assert the value of situated knowledge within a globalized economy, and to recover the expressive, human dimensions of building within the algorithmic logics of current practice.

6.3- Study Limitations

Within the scope of technological and historical analysis of vernacular case studies, the primary objective was to reintegrate traditional human knowledge into contemporary production technologies, spatial configurations, and the adaptation of connection typologies. While this study provides valuable insights into the reintegration of vernacular knowledge into modern architecture and workflows, certain limitations must be acknowledged. Due to budgetary and equipment constraints, full-scale prototyping of joinery systems and milling of large-scale CLT slabs or glulam timber columns was not feasible, given the constraints of working as an individual with limited access to advanced fabrication machinery and financial resources. Consequently, the final prototypes of the joinery models were produced at a handheld scale, serving primarily as representations of geometric configurations and mechanical actions rather than as full-scale interactive components. Furthermore, while the use of additive manufacturing and 3D printing for the final prototype was not the most optimal method, as it may not fully replicate the material properties and structural behavior of full-scale mass timber components, it was the most viable approach within the constraints of this study.

A distinct aknowledgement of material behavior at large-scale configurations must take place. Large Scale CLT and Glulam structures are built using perscriptive practices, as building code often does not cover the distinct characteristics and material behaviors of wood construction. Despite the more “regular”performing nature of cross-lapped mass timber- joinery conditions at this scale behave in a less-predictable manner than the industry standard steel connections.

Moreover, the study’s focus on a select number of vernacular case studies limits its generalizability across all cultural and regional contexts. Future research could expand the dataset to include a broader range of historic case studies or incorporate more advanced computational simulations to better approximate real-world conditions.

Despite these constraints, the findings contribute to an evolving discourse on the intersection of cultural heritage and contemporary digital fabrication techniques, offering a foundation for further exploration in both academic and professional settings.

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