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**RESEARCH ON INNOVATION DESIGN OF
INTANGIBLE CULTURAL HERITAGE MORTISE
AND TENON**

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Abstract

The traditional mortise and tenon technique, a hallmark of Oriental craftsmanship, has been widely used across China and Asia, significantly influencing the evolution of Chinese science and technology. However, with the rise of globalization and mass production, traditional methods like mortise and tenon are increasingly overshadowed, posing a threat to their survival. This thesis explores the revitalization of mortise and tenon craftsmanship through innovation, emphasizing its potential to address contemporary challenges in design while preserving cultural heritage and promoting sustainability.

Guided by Roberto Verganti's theory of meaning-driven innovation, this study investigates how mortise and tenon craftsmanship, beyond its functional use, can act as a symbol of cultural identity and sustainable design. By examining its applications in humanistic architecture, eco-friendly furniture, and cultural products like the Luban lock, the research redefines the value of this ancient technique in modern contexts. The study highlights the adaptability of mortise and tenon in addressing ecological responsibility, advocating for green design practices to reduce environmental impact.

Within the framework of social design, the study focuses on solutions that meet modern needs while prioritizing humanistic care, sustainability, and cultural confidence. It argues that mortise and tenon craftsmanship offers principles that go beyond functionality, providing a sustainable and culturally resonant alternative to modern mass production. Special attention is given to its application in temporary structures and furniture, where its modularity and eco-friendly nature align with contemporary demands for flexibility and environmental responsibility. Additionally, the study reinterprets the Luban lock, blending traditional craftsmanship with contemporary aesthetics to create culturally meaningful products.

By combining Verganti's innovation theory with social design principles, this research explores how mortise and tenon can address social challenges, promote sustainable development, and encourage community participation. The study highlights three key areas: temporary architecture focused on humanistic care,

sustainable furniture design, and the cultural reinterpretation of traditional craftsmanship. Through this, it offers new perspectives on the revival of mortise and tenon in modern society, balancing innovation with ecological and cultural preservation.

This research, grounded in both practice and theory, demonstrates how mortise and tenon craftsmanship can adapt to modern needs, bridging tradition and innovation. It provides designers with a roadmap for integrating cultural continuity with ecological responsibility, offering theoretical and practical support for the modernization of traditional craftsmanship. The revival of mortise and tenon in contemporary design is not merely a technological resurgence but a cultural renaissance, ensuring its relevance in a rapidly changing world.

Keywords: Intangible Cultural Heritage, Mortise and Tenon, Innovation of Meaning, Social Design, Industry-Academia-Research

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Chapter 1 Introduction

1.1 Research Purpose and Significance

This research aims to bridge the gap between traditional craftsmanship and modern design by exploring the innovative applications of mortise and tenon techniques. The significance of this study lies in its potential to contribute to sustainable design practices, cultural preservation, and the advancement of craft-based innovation. The following subsections will outline the specific purpose and broader significance of the research.

1.1.1 Research purpose

On October 17, 2003, the 32nd General Conference of UNESCO adopted the Convention for the Safeguarding of the Intangible Cultural Heritage, which defines "intangible cultural heritage" as: various practices, performances, expressions, knowledge systems and skills that are regarded as their cultural heritage by groups, groups or individuals, as well as related tools, objects, crafts and cultural sites. Intangible cultural heritage continues to evolve with the changes in its environment, its relationship with nature and historical conditions, and is passed down from generation to generation. It maintains its cultural identity and sense of history in innovation, thereby promoting cultural diversity and stimulating human creativity. Intangible cultural heritage covers: oral traditions and expressions, traditional performing arts, social practices, rituals, festivals, knowledge and practices about nature and the universe, and traditional handicrafts.¹

The intangibility of intangible cultural heritage refers to its spiritual production aimed at meeting people's spiritual needs, as opposed to material production that meets material needs. Although intangible cultural heritage is often presented in a materialized form, its core lies in the creative activities and crystallization of the spiritual field in an intangible form. Intangible cultural heritage is mainly manifested in people's production and lifestyle. Although many items are presented in a materialized form, its essence is a living existence that is constantly moving,

¹ UNESCO - text of the convention for the safeguarding of the intangible cultural heritage. Intangible Cultural Heritage. (n.d.). <https://ich.unesco.org/en/convention>

and it mainly relies on the oral transmission and heart-to-heart teaching of the inheritors.

The greatest role of intangible cultural heritage is to confirm national identity. It is "the identity card of a nation", because the traditions and expressions of each nation are the most effective means to prove its existence, and each culture represents a self-contained, unique and irreplaceable value concept. Intangible cultural heritage is a witness to Chinese history and an important carrier of Chinese culture. It contains the unique spiritual values, thinking methods, imagination and cultural awareness of the Chinese nation, and embodies the vitality and creativity of the Chinese nation. The rich and colorful intangible cultural heritage created by the people of all ethnic groups in the long-term production and life practices of our country is the crystallization of the wisdom and civilization of the Chinese nation, the bond connecting national emotions and the foundation for maintaining national unity. Protecting and making good use of intangible cultural heritage is of great significance to inheriting and carrying forward the excellent cultural traditions of the nation, enhancing national self-confidence and cohesion, and realizing the comprehensive, coordinated and sustainable development of the economy and society.

Traditional arts and crafts refer to the manual techniques and crafts handed down from history, and are an important part of Chinese traditional culture.² Handicrafts are closely related to people's daily life and social production labor, and have obvious life value and economic value. They also have high aesthetic and artistic value, scientific and humanistic value and historical value. In 2009, the "Chinese Traditional Wood Structure Construction Technique" declared by the Architecture Research Institute of the Chinese Academy of Arts was selected as the UNESCO Intangible Cultural Heritage of Humanity, including mortise and tenon technology. Mortise and tenon technology is a traditional woodworking technology, known for its precision and ingenuity, and occupies an important position in the field of intangible cultural heritage. As a time-honored construction method used in ancient architecture, furniture making and other woodworking traditions, it not only embodies professional technology, but also contains profound cultural and historical value.

The history of mortise and tenon technology can be traced back thousands of years. There are traces of mortise and tenon technology in structures such as ancient

² Chen Shujiao, Bai Xuxuan. Introduction to Intangible Cultural Heritage [M]. Beijing: Renmin University of China Press, 2016.

Chinese wooden pagodas and medieval European wooden structures. Its durability and adaptability make it a cornerstone of the world's architectural heritage. However, the significance of mortise and tenon is not limited to architecture. It is also a symbol of human wisdom and cultural continuity, connecting contemporary people with their ancestors through centuries of craftsmanship. As an intangible cultural heritage, mortise and tenon craftsmanship represents the inheritance of knowledge, skills and values, and is an integral part of cultural identity.

The philosophical and ethical significance of mortise and tenon craftsmanship lies in the fact that it embodies the principles of balance, interdependence and harmony with nature, which are deeply rooted in cultures such as Confucianism and Taoism. Its aesthetic and artistic expression showcases the artistic creativity of craftsmen through complex designs. In addition, the sustainability and resource efficiency of mortise and tenon construction eliminates the need for nails or adhesives, minimizes waste, and emphasizes the use of renewable materials, which is in line with contemporary environmental priorities.

With the rapid development of industrialization and mass production, mortise and tenon craftsmanship faces the challenge of a decrease in skilled craftsmen and reduced demand due to modern construction technology. Initiatives such as the Lu Ban Workshop in China aim to revitalize this craft through a combination of educational programs, digital documentation and public engagement to ensure its survival. Incorporating mortise and tenon technology into modern design will not only ensure the protection of this heritage, but also promote its adaptation to contemporary needs. The durability, modularity and craftsmanship principles inherent in mortise and tenon are increasingly being used in areas such as sustainable construction, circular design practices and cultural product innovation.

(2) Research Significance

With the changes in the modern lifestyle of mankind, many of the crafts that were once so familiar have been lost to us. However, these crafts are the culture of craftsmanship that is at the very beginning of human civilisation. Essentially, handicrafts are the art of making things that satisfy the needs of people's material and spiritual lives. As the Japanese scholar Yanagi Soetsu said, 'We can only live if crafts exist. From morning to night or at work or at rest. We feel warm in our clothing, rely on sets of utensils to organise our diet, and prepare furniture and

utensils to enrich our lives. Therefore, if craftsmanship is impoverished, life will be empty with it.’³

In the face of the decline of traditional handicrafts, a wide-ranging ‘handicraft revival movement’ has been under way in the West since the 1960s and 1970s. Although the revival of handicrafts, as a cultural trend, could not fundamentally change the general trend of social production, it fully affirmed the status and role of handicrafts in people's lives, and at the same time inspired people to think further about how to avoid the hazards of industrialisation on the social and cultural environment.

Traditional handicrafts are used in all aspects of production and life to meet the needs of people's lives. Fei Xiaotong⁴ pointed out that: these things have been handed down because they can meet the needs of people's life at present. Since they can satisfy the needs of current life, they are part of current life, and they are still alive. This is the same as saying that the reason why an object or a way of behaving becomes a tradition in today's culture is that it still has a ‘function’, i.e., it can satisfy the needs of the current people.

Innovation is the best inheritance and preservation of culture, because only innovation can give culture lasting vitality.⁵ The vitality of art lies in innovation. Innovation in traditional crafts is inevitable. Because whether it is from the style, material or style and other aspects, traditional crafts have become a stereotype, some have been closed as a tradition and norms. With the development of the times, consumer market demand, aesthetic taste, consumer behaviour will change. Those crafts with single varieties and repetitive styles are no longer in line with the requirements of the times, and must be based on consumer demand and the latest scientific and technological developments, and new technologies, new materials and new techniques must be reasonably applied to the production of specific handicrafts. Traditional culture can only be integrated into modern society through recombination with modern elements.

The 21st century is marked by a growing awareness of cultural preservation, sustainability, and resource-efficient design. As society faces environmental and resource challenges, there is an urgent need for design approaches that integrate

³ Yanagi Soetsu. *Craft Culture* [M]. Translated by Xu Yiyi. Guilin: Guangxi Normal University Press, 2006.

⁴ Fei Xiaotong, "Rereading the Preface to Jiangcun Economy," in Pan Naigu and Ma Rong, eds., *Community Research and Social Development*, Tianjin People's Publishing House, 1996, p. 26.

⁵ Yang Hong. *Intangible cultural heritage: from inheritance to dissemination* [M]. Beijing: Tsinghua University Press, 2019.

these values with cultural heritage. Mortise and tenon craftsmanship, an ancient woodworking technique celebrated for its structural elegance and environmental compatibility, holds valuable lessons for contemporary design. This research explores the technique not only as a cultural artifact but as a design method adaptable to sustainable, modern applications.

Through this thesis, I aim to bridge the gap between traditional craftsmanship and contemporary design challenges, positioning mortise and tenon as a viable model for sustainable construction and furniture making. The thesis investigates how mortise and tenon's unique features—glueless joinery, durability, and aesthetic integrity—can inspire modern eco-conscious design while contributing to the preservation of intangible cultural heritage. This dual focus on sustainability and cultural continuity aligns with global trends toward green design and cultural awareness, emphasizing the potential of mortise and tenon to serve both ecological and cultural objectives in the age of mass production and globalization.

This study aims to explore innovative design methods to protect, reinterpret and promote mortise and tenon craftsmanship as a valuable component of intangible cultural heritage. As a traditional joinery technology that can be traced back thousands of years, mortise and tenon is not just a construction method, it also embodies the deep-rooted concepts of harmony, simplicity and durability in Chinese culture. This study aims to bridge the gap between historical craftsmanship and modern design, and pave the way for the thriving development of mortise and tenon in modern environments. By applying sustainable and culturally responsible design principles, this study seeks to answer how mortise and tenon joints can become a model for environmentally friendly, aesthetically meaningful and culturally rich products in the contemporary world.

The significance of mortise and tenon joint craftsmanship as an intangible cultural heritage is:

1. Cultural continuity and heritage protection: Mortise and tenon joint craftsmanship carries knowledge, techniques and values that have been passed down from generation to generation. It embodies the wisdom and aesthetic preferences of ancient Chinese society and reflects the ideals of harmony, balance and respect for natural materials. However, with the rise of mass production and the emergence of modern building technology, the relevance of mortise and tenon joint construction has diminished, leading to the risk of extinction of the craft and the potential loss of cultural knowledge. This study highlights the importance of

preserving this traditional craft, not only as a technical skill, but also as a cultural heritage that connects the previous generation to the present.

2. Symbol of sustainable design practice: Mortise and tenon joint construction is inherently in line with sustainable design principles because it requires minimal materials, is fully biodegradable, and is durable and repairable. Unlike construction methods that rely on screws, adhesives or synthetic materials, mortise and tenon joint construction uses natural wood and achieves stability through precision and technology rather than redundant hardware. This sustainable construction method exemplifies how traditional methods can address today's environmental issues and is a model for reducing waste, improving resource efficiency, and extending product life.

3. Relevance to modern ecological and cultural needs: In an era where sustainability is paramount, mortise and tenon construction offers valuable lessons on how craftsmanship can be both functional and environmentally conscious. Modern society urgently needs eco-friendly crafts to replace resource-intensive manufacturing processes. Mortise and tenon technology, by its very nature, offers inspiration for making durable, sustainable products. This study argues that mortise and tenon craftsmanship can be adapted to modern needs to ensure its continued relevance, make a positive contribution to ecological sustainability, and provide consumers with products that respect tradition while maintaining modern functionality.

4. Cultivating cultural awareness and self-confidence: Revitalizing traditional crafts such as mortise and tenon is not only an act of conservation, but also a manifestation of cultural confidence. In today's world where globalization is increasingly dominant, local craftsmanship and heritage are powerful tools for highlighting cultural identity. By incorporating mortise and tenon craftsmanship into modern design, this study aims to rekindle people's pride in China's cultural heritage. This approach aligns with the concept of cultural confidence, encouraging people to recognize and celebrate their rich traditions and valuing the relevance and adaptability of these skills to today's needs.

5. Research significance for sustainable design and cultural preservation: This study contributes to the field of sustainable design by illustrating how ancient techniques can provide references for contemporary ecological practices. Mortise and tenon structure embodies the principles of a circular economy - it is designed to be durable and repairable, and its craftsmanship is timeless. By developing new

applications for mortise and tenon in sustainable furniture and architecture, this study demonstrates the practical and aesthetic advantages of sustainable design rooted in traditional craftsmanship. This approach encourages the design industry to consider traditional practices as viable, scalable solutions to modern environmental problems.

6. Drawing a blueprint for cultural innovation: This study provides a framework for how traditional crafts can inspire meaningful innovation. Rather than viewing cultural heritage as static artworks, this approach views it as a dynamic source of inspiration that can be combined with modern design concepts such as meaningful innovation and user-centered design. If mortise and tenon craftsmanship is thoughtfully adapted, it can enhance product design by adding cultural depth, unique structural qualities, and timeless beauty. Through this study, mortise and tenon craftsmanship can serve as a blueprint for other cultural heritage practices, encouraging designers to use heritage as a springboard and innovate on the basis of respecting heritage.

7. Enhance cultural and educational awareness: As an intangible cultural heritage, mortise and tenon structures are valuable educational tools for transmitting cultural, historical and environmental knowledge. This study raises awareness of mortise and tenon craftsmanship through educational and cultural products, experiential learning opportunities and interactive design. By promoting hands-on learning, this study aims to encourage appreciation and respect for craftsmanship in academia and the wider society. In addition, the digital preservation strategies highlighted in this study can make mortise and tenon techniques more accessible, ensuring that these skills are recorded, shared and passed on to future generations.

8. Lay the foundation for responsible design practices: This study highlights the importance of responsible design practices by showing how mortise and tenon craftsmanship can be combined with socially and environmentally conscious design. Responsible design requires that the life cycle, environmental impact and cultural significance of products be taken into account when creating them. With its advantages such as long service life, strong repairability and low environmental damage, mortise and tenon craftsmanship is an ideal foundation for developing beautiful and environmentally friendly products. This study advocates a responsible design philosophy that not only respects the environment but also respects and revitalizes cultural heritage, providing a holistic model for sustainable product development.

The significance of this study lies in its dual focus on cultural preservation and sustainable innovation. By exploring the integration of mortise and tenon craftsmanship with modern design, this study aims to protect the intangible cultural heritage of mortise and tenon construction while promoting it as a viable and desirable modern practice. Through this perspective, mortise and tenon craftsmanship is not only seen as a traditional construction method, but also as a model of sustainable, responsible design that meets both ecological and cultural needs. This study aims to demonstrate that traditional practices are not only relevant but also essential to promote a sustainable and culturally rich future, thereby laying the foundation for a design approach that values tradition, innovation, and ecological balance.

1.2 State of the Art

This section reviews existing research and practice in mortise and tenon craftsmanship, including academic literature, current innovation strategies in craftsmanship, and advances in design for sustainable and circular economies. It provides a basis for understanding the challenges and opportunities in integrating traditional craftsmanship into contemporary design. Current research in mortise and tenon joinery is highly interdisciplinary, combining knowledge from fields such as architecture, heritage studies, sustainable design, and digital technology. Innovations aim to both preserve traditional craftsmanship and integrate it into contemporary design and manufacturing systems, ensuring that mortise and tenon remains relevant in the modern context. Judging from the data collected so far, the fields involved in the research on intangible culture heritage mortise and tenon craftsmanship can be roughly divided into the following categories.

(1) Basic technology and mechanics of mortise and tenon joints

This subsection would cover the most important technical publications on the joints in different materials and for different purposes. For example, Meng Yang's paper on the mortise and tenon mechanism of traditional folk wood structures in southern China⁶, distinguishing between types of mortise and tenon structures and analyzing their principles. A monograph on the study of mortise and tenon, an important book in its time. *Woodwork Joints: How They Are Set Out, How Made*

⁶ Meng Yang. *Mortise and Tenon Mechanisms of Traditional Folk Wooden Structures in Southern China* [D]. Southeast University, 2022.

and Where Used⁷, a detailed introduction to the design, making and use of mortise and tenon construction.

The mortise and tenon joinery technique, a hallmark of traditional Chinese craftsmanship, has been widely studied for its unique structural and aesthetic qualities. Studies reveal that this technique exemplifies traditional design principles of harmony, balance, and resource efficiency, embodying values from Confucian and Daoist philosophies. Historical analyses show that mortise and tenon structures in ancient Chinese architecture, like temples and wooden pagodas, illustrate the durability and adaptability of this craft.

A Mechanical Perspective on Seismic Function in Mortise and Tenon Structures. Mortise and tenon joints have played a crucial role in traditional wooden structures, particularly in the construction of ancient Chinese buildings. Recent studies have explored the static force and seismic performance of these joints, highlighting their mechanical properties and potential for contemporary applications.

Sui Yan⁸ focuses on the energy dissipation and shock absorption properties of mortise and tenon joints in ancient Chinese wooden structures. This study analyzes how the flexible, semi-rigid connections of these joints contribute to the seismic resilience of traditional buildings. Through controlled movement, friction, and rotational dynamics, the joints absorb and dissipate seismic energy, reducing stress concentration and enhancing the structure's overall durability. The research highlights how these traditional techniques can inform modern earthquake-resistant designs.

Cai et al.⁹ focuses on the static and seismic behavior of mortise-and-tenon block structures. Through simulation and experimental testing, the research reveals how these joints can efficiently dissipate energy during seismic events, providing insights into their resilience and stability. The summary concludes with the mechanical properties of mortise and tenon joints, particularly their flexibility under stress, are key to their earthquake-resistant capabilities.

⁷ William Fairham, *Woodwork Joints: How They Are Set Out, How Made and Where Used*. London: Evans Brothers, 1920

⁸ Sui Yan. (2009). *Mechanism and Dynamic Characteristics Analysis of Ancient Chinese Wooden Structures for Energy Dissipation and Vibration Damping* (Doctoral dissertation, Xi'an University of Architecture and Technology).

⁹ Cai, J., Zhu, Y., Yao, W., Li, Y., Zhou, Y. & Zhang, Qian. (2024). Study on the static and moonquake-resistant performance of tongue-and-groove block structures. *Building Structures*,54(24),46-53.DOI:10.19701/j.jzjg.ZJ230069.

Teng Jia-Nan et al.¹⁰ investigates the seismic performance of tongue and groove nodes in wooden structures. The study analyzes the mechanical behavior of these nodes under various seismic forces and presents reinforcement techniques to improve their strength. It offers valuable data on how traditional joinery techniques can be reinforced to meet modern seismic safety standards.

The stability and seismic response of tongue-and-groove hub-node structures in spherical mesh shells are the focus of Wang, Xing et al.'s study¹¹. It highlights the semi-rigid nature of these joints, providing an analysis of how they behave under seismic conditions. The research shows that these joints contribute to both stability and flexibility, making them suitable for structures requiring high seismic performance.

Pan Yi et al.¹² provides a detailed analysis of the progress made in understanding the mechanical properties of mortise and tenon nodes in ancient wooden structures. It focuses on advancements in testing methods and materials used to reinforce these joints, particularly in the context of earthquake-resistant design.

Dong Jinshang et al.¹³ through experimental study examines the seismic properties of asymmetric mortise and tenon joints in ancient dilapidated wooden buildings. The research reveals how these joints, even in their deteriorated state, exhibit unique seismic behaviors, providing important implications for the conservation and restoration of heritage structures.

These studies collectively illustrate the significant role mortise and tenon joints play in the seismic performance of wooden structures, both historical and modern. Through mechanical analysis, they provide valuable insights into the resilience, flexibility, and potential for reinforcement of these traditional joints,

¹⁰ Teng Jia-Nan, Su He-Shian, Pan Wen & Zhu Chuan-Wei. (2024). Experimental analysis of seismic performance and reinforcement of tongue-and-groove nodes in wood structures. *Journal of Xi'an University of Architecture and Technology (Natural Science Edition)*,56(05),773-781.DOI:10.15986/j.1006-7930.2024.05.016.

¹¹ Wang, Xing & Zhang, Xian. (2024). Stability and seismic response analysis of mortise-and-tenon hub-node semi-rigid single-layer spherical mesh shell. *Journal of Civil Engineering*,57(10),1-10.DOI:10.15951/j.tmgcxb.23100857.

¹² Pan Yi, An Renbing & You Wenlong. (2024). Progress of mechanical properties of mortise and tenon nodes in ancient wooden structures. *Journal of Building Structures*,45(07),226-241.DOI:10.14006/j.jzjgxb.2023.0295.

¹³ Dong Jinshang, Gao Chenxu, Peng Shizhen & Gong Yanru. (2024). Experimental study on seismic performance of asymmetric mortise and tenon joints in wooden structures of dilapidated ancient buildings. *Earthquake Disaster Defence Technology*,19(02),326-333.DOI:10.11899/zzfy20240212.

suggesting their continued relevance in contemporary design and earthquake-resistant architecture.

In the mechanics technology section, another important area of research focuses on the geometric characteristics of aluminum mortise and tenon structures. Zong Zhijian¹⁴ explores how the geometric design of these joints influences their mechanical behavior, such as load-bearing capacity and resistance to deformation. The research highlights the adaptability of traditional mortise and tenon joints when applied to modern materials like aluminum, showcasing their potential in lightweight, high-strength structural applications. The findings underscore how geometric precision in the design of aluminum joints enhances mechanical performance in contemporary contexts.

(2) Ancient history of mortise and tenon technology

This subsection would describe and comment upon historical scholarship on the use of mortise and tenon joints in ancient boatbuilding, ancient Chinese building, and so on.

Historically, mortise and tenon joinery has been a core component of Chinese architectural tradition, seen in structures like the Forbidden City, ancient temples, and traditional wooden pagodas that have withstood centuries. The technique reflects principles of Chinese philosophy, such as harmony with nature, simplicity, and respect for material integrity. In the West, mortise and tenon joinery has been equally significant, seen in medieval European cathedrals, traditional Japanese teahouses, and Egyptian furniture from antiquity. Its application across these regions highlights the universal appeal and adaptability of the method, as well as its centrality to global architectural and cultural heritage.

Li Jie's *Yingzao Fashi*¹⁵ as a Cornerstone for Mortise and Tenon Research. *Yingzao Fashi* (Treatise on Architectural Methods), written during the Song Dynasty in 1103, is an essential reference for understanding the historical and technical foundations of mortise and tenon joinery. As one of the earliest comprehensive manuals on construction and craftsmanship, this seminal work provides a detailed account of building techniques, including the sophisticated use of mortise and tenon joints. It serves as an indispensable resource for contemporary

¹⁴ Zong Zhijian, Long Feiyong, Xian Jinzhang, Liu Huarong & Wang Fei. (2024). Geometric characteristics of aluminium mortise and tenon structures. *Mechanical Design*,41(06),1-6.

¹⁵ Li Jie. Liang Sicheng's annotations on " *Yingzao Fashi*" [M]. Tianjin: Tianjin People's Publishing House, 2023.

studies, offering insights into the technical, cultural, and philosophical dimensions of this traditional craft. Li Jie's work both a historical artifact and a practical guide for modern applications. The enduring relevance of *Yingzao Fashi* underscores its value as a cornerstone in the study of mortise and tenon joinery, bridging the gap between tradition and innovation. In exploring the current status of mortise and tenon research, *Yingzao Fashi* not only provides a technical foundation but also enriches the discourse with its philosophical emphasis on harmony and sustainability—a perspective that continues to inspire meaningful design in the 21st century.

Liang Sicheng's *Writings on the History of Chinese Architecture*¹⁶ with Focus on Mortise and Tenon Joinery. Liang Sicheng, a renowned architectural historian and scholar, is widely regarded as the father of modern Chinese architectural history. His extensive writings provide in-depth analysis and documentation of traditional Chinese architecture, focusing on its structural techniques, cultural significance, and aesthetic principles. Liang's meticulous study of mortise and tenon joinery—one of the essential features of traditional Chinese wooden architecture—offers valuable insights into how this ancient craft embodies the principles and philosophy of Chinese design.

Historical Documentation of Chinese Architectural Heritage. Liang Sicheng's foundational work, such as *A Pictorial History of Chinese Architecture*, is one of the first comprehensive studies to chronicle the evolution of Chinese architecture across different dynasties. In his research, Liang meticulously documents architectural sites, including temples, pagodas, and palaces, highlighting the durability and unique structural techniques used. His writings argue that the traditional wooden framework in Chinese architecture, relying heavily on mortise and tenon joints, reflects an approach to construction that balances aesthetic and functional requirements. Liang emphasizes the importance of preserving these historical methods, which he believed were rapidly disappearing under modernization efforts in the early 20th century.

Mortise and Tenon Joinery as a Core Structural Element. Liang's work on mortise and tenon joinery explores the technique's role in achieving structural stability in wooden architecture without the use of metal fasteners. He analyzes how the tenon-and-mortise connections allow for flexibility and resilience, particularly in earthquake-prone regions. This method, according to Liang, is not merely a practical solution but also a reflection of Chinese philosophical ideals—embodying

¹⁶ Liang Sicheng. *History of Chinese Architecture* [M]. Beijing: Life-Study-New Knowledge Bookstore, 2023

harmony with nature and a preference for non-invasive construction. In his architectural surveys, Liang measured and drew precise details of mortise and tenon joints, providing technical insights into their dimensions, orientation, and configurations. His findings underscore the sophistication and engineering precision of ancient Chinese builders.

Cultural and Philosophical Context of Mortise and Tenon in Liang's Writings. Beyond technical descriptions, Liang Sicheng's writings delve into the cultural and philosophical significance of mortise and tenon joinery in Chinese architecture. He interprets the technique as an expression of Chinese aesthetic principles rooted in Confucian and Daoist philosophy, which value balance, adaptability, and durability. According to Liang, the mortise and tenon structure illustrates a harmonious relationship between man and nature—each joint reflects a careful consideration of the properties of wood, minimizing waste and allowing for natural expansion and contraction. Liang's interpretation of mortise and tenon thus elevates it from a construction technique to a cultural symbol, embodying traditional values in physical form.

Preservation of Chinese Architectural Heritage and Mortise and Tenon Craftsmanship. Liang was deeply invested in the preservation of Chinese architectural techniques, and his writings often advocate for the safeguarding of mortise and tenon craftsmanship. He was instrumental in efforts to document and protect ancient buildings, which he viewed as critical cultural assets. Liang argued that traditional Chinese joinery methods like mortise and tenon must be preserved as part of China's intangible heritage. His documentation efforts laid the groundwork for subsequent preservation initiatives, and his work continues to serve as a primary reference for conservationists aiming to protect these techniques and integrate them into modern preservation practices.

Influence on Modern Architecture and Sustainable Design. Liang Sicheng's exploration of mortise and tenon joinery has inspired architects and designers interested in sustainable and culturally informed design. Liang believed that traditional Chinese architecture offers timeless lessons in resourcefulness and ecological harmony. Today, his research is referenced by sustainable designers seeking to apply traditional methods in ways that respect both environmental and cultural principles. Liang's insights into mortise and tenon joinery have thus contributed to a broader appreciation of sustainable construction practices and heritage-based design.

Liang Sicheng's writings provide a comprehensive view of Chinese architecture's structural, cultural, and philosophical foundations, with mortise and tenon joinery occupying a central role in his studies. His work continues to be influential, offering an indispensable resource for understanding and preserving Chinese architectural heritage. By documenting and interpreting mortise and tenon as a multifaceted symbol of Chinese values, Liang Sicheng not only highlighted its technical virtues but also reinforced its significance as a cultural asset deserving of preservation and study in the modern age.

This summarizes Liang's unique contributions, positioning his studies as essential readings for anyone researching traditional Chinese architecture, structural techniques, or heritage conservation.

Wang Shixiang's seminal work, *Classic Chinese Furniture: Ming and Early Qing Dynasties*¹⁷ (1986), explores the elegance, structural integrity, and cultural significance of Ming furniture, with a special focus on the craftsmanship that underpins these pieces. In his research, Wang meticulously documents the use of mortise and tenon joinery, an age-old construction method that involves interlocking wooden components without the need for nails or glue. This technique, praised for its strength and durability, is integral to the minimalist and elegant aesthetic of Ming furniture.

One of Wang's key contributions is his deep analysis of the precision and artistry behind mortise and tenon joints. He highlights how these joints reflect not only functional design but also the philosophical underpinnings of traditional Chinese furniture, including harmony with nature, simplicity, and balance. Wang's comparative analysis with Western carpentry also sheds light on the uniqueness of Chinese joinery, where the aesthetic value of an invisible yet crucial joint underscores the craftsmanship's subtlety.

In his numerous studies, Wang also discusses how mortise and tenon joints allowed for flexibility and disassembly of large furniture pieces, an aspect that catered to the frequent relocation needs of Ming households. His work remains a cornerstone in the study of traditional Chinese furniture, providing both technical insights and cultural context to the continued appreciation and conservation of these timeless pieces.

¹⁷ Wang, S. (1986). *Classic Chinese furniture: Ming and early Qing dynasties*. Han-Shan Tang Books.

Wang's scholarship has influenced a broad spectrum of fields, from design history to contemporary furniture making, by reviving interest in sustainable, hand-crafted techniques like mortise and tenon. His work inspires both modern designers and cultural preservationists to engage with traditional craftsmanship while also incorporating innovative design principles.

Zhang Yao¹⁸ traces the origins of mortise and tenon, introduces the main applications of mortise and tenon - architectural mortise and tenon for furniture, lists the different applications of mortise and tenon, and describes the evolution of modern mortise and tenon.

(3) Mortise and tenon joints in craftsmanship

This subsection would reflect on previous literature on the craft aspects of this technology, including discussion of the cultural and aesthetic values that were propagated thereby.

The literature surrounding mortise and tenon craftsmanship reveals an in-depth exploration of both the technical and cultural-aesthetic dimensions of this ancient construction method. By examining the evolution of this craft from Ming dynasty furniture construction to its application in modern solid wood furniture, researchers highlight the legacy of mortise and tenon as a durable, adaptable, and technically beautiful form of construction.

Zhan Xiuli et al.¹⁹ emphasize the precision and intricacy involved in creating mortise and tenon joints. The method allows for a seamless combination of aesthetic and functional elements in wooden structures, particularly in the design of modern furniture, where the natural beauty of wood and the skill of craftsmanship remain vital.

Pan Xi²⁰ delves into the regional variations and unique technical characteristics of mortise and tenon craftsmanship. These studies illuminate how cultural and environmental factors shape the craft and contribute to the development of distinct techniques that reflect the local context.

¹⁸ Zhang Yao. *The Charm of Mortise and Tenon* [M]. Beijing: Chemical Industry Press, 2020

¹⁹ Zhan Xiuli, Wang Tao, Dai Xiangdong, Li Minxiu. The inheritance of mortise and tenon - from the craftsmanship beauty of Ming furniture structure to the technical beauty of modern solid wood furniture structure[J]. *Forest Industry*,2017,44(6):39-4362

²⁰ Pan Xi. Analysis of mortise and tenon craft and characteristics of Naxi wood-frame dwellings[J]. *Central China Architecture*,2017,35(6):124-129

The cultural and aesthetic values transmitted through mortise and tenon craftsmanship are also prominent in the literature. For example, Guo Shijun²¹ and Zhang Jincai²² explore how symbolism and heritage are embedded in the craft. These works demonstrate how mortise and tenon's cultural significance extends beyond architecture and furniture into other design fields like jewellery, where it continues to inspire contemporary innovation. Similarly, Guo Hong's study²³ reflects the deep integration of mortise and tenon within China's imperial architectural heritage, underscoring the cultural weight of this construction method as part of the nation's artistic and architectural identity.

Another notable intersection of aesthetics and technical prowess is evident in studies like LIU Qingqiu et al.²⁴ who examines the seismic properties of mortise and tenon joints and their aesthetic forms. This shows that mortise and tenon craftsmanship was not only an engineering solution but also one deeply rooted in cultural traditions of beauty, harmony, and structural elegance.

Researcher such as Qiang Sun²⁵ and Miao Tongqiang²⁶ reveals how modern designers are reinterpreting the craft's legacy in contemporary architecture and product design. They preserve the core aesthetic values of the mortise and tenon joint while incorporating new materials and technologies, thus bridging the gap between ancient craftsmanship and modern design methodologies.

These reflections on the existing literature show the multifaceted nature of mortise and tenon craftsmanship, where technical skills, cultural identity, and aesthetic principles coalesce to form a construction method that is as relevant today as it was centuries ago.

(4) Innovation and modern design

²¹ Guo Shijun. Craftsmanship: mortise and tenon craft awakens the historical sentiment of jewellery[J]. *China Gold Jewellery*,2017,0(11):30-32

²² Zhang Jincai. Analysis of the innovative application of traditional wooden mortise and tenon craft culture in jewellery design[J]. *Art Review*,2017,0(13):161-162

²³ Guo Hong. Craft characteristics and mortise and tenon construction of the inner eaves wood decoration of the Fuwangge in the Forbidden City[J]. *Ancient Architecture and Garden Technology*,2012,14(4):8-17F0002,I0001

²⁴ LIU Qingqiu, GAO Yingqiang. Aesthetic study of wooden components in Chinese and Western ancient architecture from the perspective of seismic characteristics--Taking 'mortise and tenon' and 'Pombal cage' structure as an example[J]. *Industrial Design*, 2022(10):122-124

²⁵ Qiang Sun. Structure-Paradigm-Symbol-Aesthetic Turn of Traditional Mortise and Tenon Structure[J]. *Journal of Hebei University of Science and Technology (Social Science Edition)*,2021,21(1):37-4397

²⁶ Miao Tongqiang. Research on innovative application of mortise and tenon culture in modern architecture[J]. *Fujian Light Textile*,2023(4):23-28

This subsection would review the main publications that discussed modern uses and variants of mortise and tenon technology, including modern fabrication methods, sustainability aspects, and so on.

Technological Integration and Digital Preservation. With the rise of digital technologies, recent research has explored how modern tools can preserve and adapt traditional crafts like mortise and tenon. Digital modeling, augmented reality, and 3D scanning now allow precise documentation and reconstruction of ancient joinery techniques. For instance, digital museums and databases have begun to catalog intricate mortise and tenon structures to facilitate virtual learning and global access, ensuring these techniques are not lost with generational shifts²⁷; Jiang Qiqiao²⁸, et al, through the study of the creation of a digital communication and education platform for traditional mortise and tenon craftsmanship, the protection of intangible cultural heritage mortise and tenon culture is studied.

Craftsmanship in the Digital Age²⁹ explores a craft approach to incorporating digital fabrication into architecture. Rather than arguing that digital tools are incompatible with craft, the book argues that the digitization of architectural design can actually strengthen certain craft-specific skills and principles, bringing benefits to both the construction and manufacturing industries, including: more efficient building materials and spatial typologies, closer working relationships between architects and manufacturers, and an assertion of values that are critical to the construction industry at this historical moment, particularly in terms of energy and resource sustainability.

Recent studies highlight innovative applications of mortise and tenon joinery in fields such as sustainable architecture, modular furniture design, and eco-friendly construction. This technique has shown potential in modern, temporary architectural designs where modularity, flexibility, and ecological considerations are prioritized. Using mortise and tenon, contemporary architects and designers can create structures with minimized environmental impact due to reduced need for metal fasteners and adhesives, aligning with green building standards .

²⁷ Lai, Z., Xiao, Y., Chen, Z., Li, H., & Huang, L. (2024). Preserving woodcraft in the digital age: A meta-model-based robotic approach for Sustainable Timber Construction. *Buildings*, 14(9), 2900. <https://doi.org/10.3390/buildings14092900>

²⁸ Jiang Qiqiao, Wang Weibao, Chen Xuan, et al. Research on the digital dissemination of traditional mortise and tenon craftsmanship and the creation of an educational platform [J]. *Progress in Education*, 2024, 14(10): 49-60. DOI: 10.12677/ae.2024.14101828.

²⁹ AA.VV, *Craftsmanship in the digital age: architecture, values and digital fabrication*, edited by ANCB - The Aedes Metropolitan Laboratory, Series: ANCB Edition #4, Berlin, 2019.

In the context of modern design, mortise and tenon joinery faces both challenges and opportunities. The rise of industrialization and mass production has led to the decline of traditional handcraft methods, with modern construction largely favoring quicker, less labor-intensive techniques using metal fasteners, adhesives, and prefabricated components. However, the values embedded in mortise and tenon craftsmanship—sustainability, durability, and harmony with natural materials—align closely with the growing global emphasis on sustainable design and responsible production.

Modern consumers, especially in global urban markets, are showing a growing preference for products that offer both cultural significance and environmental responsibility. Mortise and tenon craftsmanship fulfills these demands by providing products with high durability, cultural depth, and a lower ecological footprint. This trend is supported by a broader societal interest in cultural preservation and an increasing awareness of sustainability. For example, Wu, et al.³⁰ explores the innovative applications of the mortise and tenon structure within modern design, emphasizing sustainability and environmental considerations under the concept of “green reduction.” The authors investigate how traditional woodworking techniques can be adapted to meet contemporary design challenges, particularly in terms of reducing material waste and improving structural efficiency. The study highlights the potential of combining mortise and tenon craftsmanship with modern materials and digital technologies, advocating for a design approach that preserves cultural heritage while aligning with the principles of sustainable development. Key findings include the enhanced durability and eco-efficiency of mortise and tenon joints when reinterpreted with modern design methods, contributing to the growing trend of environmentally conscious architecture and product design. As a result, mortise and tenon joinery is being reintroduced into high-end furniture, lifestyle products, and cultural creative products as a unique selling proposition that appeals to culturally conscious and eco-friendly consumers.

Mortise and tenon joints have long been celebrated for their elegance, durability, and historical significance in traditional woodworking and architecture. In recent years, however, these joints have seen renewed interest from contemporary designers and engineers, particularly in areas such as furniture design, product innovation, and sustainability. This section examines major publications that explore modern uses and variations of mortise and tenon technology, with a

³⁰ Wu, W., J. Zhu, W. Xu, F. Han, X. Wu, and X. Wang (2021). “Innovative Design of Modern Mortise and Tenon Structure under the Concept of Green Reduction,” *BioResources* 16, pp. 8445-8456.

focus on innovative applications, modern manufacturing methods, and sustainability aspects.

Li YB et al.³¹ investigates the application of detachable mortise and tenon structures in new Chinese furniture design. The research demonstrates how these joints are being reimagined for contemporary furniture that emphasizes modularity and ease of assembly. The authors discuss how the traditional mortise and tenon design can be adapted to suit modern consumers' preferences for flat-pack furniture, allowing for efficient transportation and assembly without compromising aesthetic values. The detachable feature introduces flexibility into furniture design, where users can easily disassemble and reassemble pieces, contributing to the furniture's longevity and reducing the environmental impact of disposal.

Tian H³² focuses on the integration of digital technologies with mortise and tenon structures in the design of cultural and creative products. By utilizing computer-aided design (CAD) and digital fabrication methods such as CNC machining, the authors demonstrate how mortise and tenon joints can be customized for a range of products, from cultural artifacts to modern consumer goods. This digital approach allows designers to achieve high precision, maintain the traditional aesthetic appeal, and incorporate cultural heritage elements into contemporary designs. The study highlights the fusion of technology and craftsmanship, offering a model for sustainable, culturally resonant product design.

Sun Yuying et al.³³ explores the application of mortise and tenon technology in educational toys, specifically the design of Chinese character building blocks. The study demonstrates how the modular nature of mortise and tenon joints can be applied to toy design, creating durable, interlocking blocks that can be assembled into various Chinese characters. This innovative approach combines cultural education with play, offering an interactive way for children to learn Chinese characters while also fostering an appreciation for traditional craftsmanship. The toy's structure not only emphasizes mechanical stability but also promotes cultural transmission through design.

³¹ Li YB, Han WG & Zhong GM. (2021). Study on the application of detachable mortise and tenon structure in the design of new Chinese furniture. *Furniture and Interior Decoration*, 28(09), 17-21. DOI:10.16771/j.cn43-1247/ts.2021.09.005.

³² Tian H. (2024). Research on the application of digital mortise and tenon structure in cultural and creative product design. *Screen Printing Industry*, (08), 102-104.

³³ Sun Yuying & Zhang Xun. (2024). Research on the design of Chinese character block toys based on mortise and tenon structure. *Toy World*, (08), 28-30.

Xia Shengjia³⁴ further examines the use of modular mortise and tenon structures in children's toys, focusing on creating safe, flexible, and sustainable designs. The authors highlight how the inherent simplicity of mortise and tenon joints makes them suitable for modular toy systems, where different components can be easily swapped, connected, and reassembled. The focus is on sustainability, as the toys are made from wood, a renewable resource, and the modular design reduces waste by extending the toy's lifespan through reconfiguration. The research suggests that traditional joinery techniques can provide innovative solutions to the growing demand for eco-friendly children's products .

Li Ting³⁵ examines how traditional mortise and tenon elements can be expanded beyond furniture and architecture to influence modern product design. The study highlights the adaptability of these joints in creating sustainable, modular products across different industries, from consumer electronics to household items. By reinterpreting traditional craftsmanship in the context of modern industrial design, the study provides examples of how mortise and tenon structures can be applied in mass-produced products while maintaining ecological and aesthetic values.

Wei Jianbo³⁶ innovatively explores how the principles of mortise and tenon joinery can be translated into the field of fashion design, particularly in men's clothing. The authors propose a clothing design where fabric pieces are joined using interlocking techniques inspired by mortise and tenon joints. This approach not only introduces a unique aesthetic but also reflects the possibility of creating garments with minimal stitching or adhesives, aligning with sustainability trends in fashion. The study highlights the versatility of mortise and tenon design in influencing creative industries beyond woodworking and architecture.

He Yanru et al.³⁷ emphasizes the role of mortise and tenon joints in preserving and promoting traditional cultural heritage. By analyzing case studies where mortise and tenon structures are used in modern design, the authors argue that these joints serve as a bridge between traditional craftsmanship and contemporary innovation. The study focuses on how designers can integrate cultural values into

³⁴ Xia Shengjia. (2022). Research on the design application of modular mortise and tenon structure in children's toys (Master's thesis, Huaqiao University).DOI:10.27155/d.cnki.ghqiu.2022.000474.

³⁵ Li Ting. (2023). Research on the Expansion of Traditional Mortise and Tenon Elements in Product Design (Master's thesis, Shenyang University of Technology).DOI:10.27323/d.cnki.gsgyc.2023.000060.

³⁶ Wei Jianbo. (2023). Research and application practice of mortise and tenon elements in modern men's fashion design (Master's thesis, Jilin College of Arts).DOI:10.27164/d.cnki.gilyc.2023.000344.

³⁷ He Yanru, Li Qingsong, Guan Pei. The application of mortise and tenon structure under the perspective of excellent traditional cultural inheritance[J]. Beauty and Era (Creativity) (above),2024(5):14-18

modern products, thereby ensuring that the craft is passed on to future generations while adapting to modern consumer preferences.

Yang Sha et al.³⁸ takes a modern approach to mortise and tenon design by applying the SCAMPER method to contemporary products. Using award-winning mortise and tenon designs from the Italian A-design competition, the study highlights how traditional joint techniques can be adapted for modern purposes, including furniture and architectural elements with enhanced mechanical properties.

These studies demonstrate the versatility and enduring relevance of mortise and tenon joints in contemporary design. Whether in furniture, toys, packaging, or fashion, modern designers are finding innovative ways to incorporate this ancient technology into their work. The combination of traditional craftsmanship with modern manufacturing methods such as digital fabrication and modular design not only enhances the functionality and sustainability of products but also ensures the continued evolution of mortise and tenon technology in the 21st century.

To sum up, at present, scholars' research on mortise and tenon mostly focuses on the performance analysis from the mechanical point of view, the protection and inheritance development strategy of mortise and tenon craft has not been fully discussed from the perspective of intangible cultural heritage. Although there is research on the innovative design and application of mortise and tenon structure, but there are fewer articles on the innovative design of mortise and tenon structure, and there is insufficient innovative design practice.

Design research and design practice regarding the sustainable aspects of mortise and tenon construction is less. The article *Innovative Design of Modern Mortise and Tenon Structures in the Context of Green Reduction*³⁹ uses the green design reduction principle to simplify and redesign mortise and tenon structures in line with the concept of green design. However, the design practice is limited to the optimized design of a certain type of mortise and tenon structure, which cannot represent all mortise and tenon structures. This shows that the design research and design practice on the sustainable aspects of mortise and tenon craftsmanship are not systematic and comprehensive enough.

³⁸ Yang Sha & Ruan Tao. (2024). Research on the contemporary application design of Chinese traditional mortise and tenon based on the SCAMPER design method--Taking the Italian A design mortise and tenon award-winning products as an example. *Decoration*,(09),142-144.

³⁹ Wu, Wei; Zhu, Jiangang; Xu, Wei; Han, Fei; Wu, Xinghuan; and Wang, Xu. (2021). *Innovative Design of Modern Mortise and Tenon Structure under the Concept of Green Reduction*. *BioResources*. <https://doi.org/10.15376/biores.16.4.8445-8456>

The redesign of mortise and tenon joints from the perspective of intangible cultural heritage includes jewelry design, clothing design and other fields. Most of them are derivative applications of mortise and tenon joints as cultural symbols, rather than direct applications of mortise and tenon joint craftsmanship. Although they are promoted as cultural symbols, their true value has not been fully applied and demonstrated.

Insufficient innovation. Today's redesign is more of an adaptive design that redesigns the structure of mortise and tenon joints to adapt to the large-scale production mode, which provides technical support for the contemporary development of mortise and tenon joints. Today's mortise and tenon joint designs are mostly limited to imitating and copying the tradition, only conveying its form but not its spirit, and lacking the use of modern design thinking to explore and redesign its cultural value.

Overall, the existing research on the innovative design of mortise and tenon craftsmanship highlights the potential of this traditional craft to contribute to sustainable design, cultural heritage, and the application of digital technologies. However, there is still much work to be done to fully realize these potential benefits, including the need for further research, education, and collaboration across different fields and disciplines.

As the soul of traditional Chinese architecture and furniture, mortise and tenon joints have accumulated a unique cultural heritage over thousands of years of history. It is not only the perfect combination of strength and beauty, but also the crystallisation of the Chinese people's exquisite skills and wisdom. The mortise and tenon technique has evolved and enriched since ancient times, but the impact of modern industrialisation has brought it the challenge of inheritance and innovation. Ancient craftsmen realised the solid connection of wooden components without the use of nails and glue, through precise design and handcrafted techniques. The value of this technique is not only limited to its practicality, but also lies in its profound humanistic connotation and artistic expression. The innovation of mortise and tenon in modern design aims to combine the traditional craftsmanship with modern needs to revitalise it functionally, structurally and aesthetically.

The structural aesthetics and mechanical properties of mortise and tenon are important references in modern design. With the development of computer-aided design technology, designers are able to more accurately simulate and analyse the stresses on mortise and tenon structures to ensure their stability and safety while

achieving more complex innovations. Modern design should not only inherit the essence of traditional mortise and tenon joinery, but also innovate in material selection and processing technology. The combination of mortise and tenon techniques and sustainable design concepts provides a new way of thinking about modern architecture and furniture design in a world where environmental protection is increasingly important. In addition, the application of mortise and tenon in furniture design has brought about works with unique oriental aesthetics, enabling traditional craftsmanship to gain more attention on the international stage.

The innovative design of mortise and tenon not only involves the technical level, but also needs to be explored deeply in the cultural level. The fusion of cultural heritage and modern lifestyle is an important direction for innovative design of mortise and tenon. The philosophical thoughts and aesthetic concepts in traditional culture are reinterpreted in modern design and become part of the design language. Through the study of traditional mortise and tenon techniques, designers not only resurrect the memory of history, but also highlight the uniqueness of regional culture in the context of globalisation. The innovation of mortise and tenon in modern design embodies the dialogue and fusion of tradition and modernity, East and West. Only on the basis of in-depth understanding of its historical value and cultural connotations can innovative design truly realise the modern transformation of traditional craftsmanship.

As an important connection method in traditional Chinese wooden architecture and furniture making, mortise and tenon construction contains deep cultural connotation and unique aesthetic value. Its origin can be traced back to thousands of years ago, and through the baptism of time and the evolution of technology, mortise and tenon structure not only physically realises the stable connection of components, but also carries the concepts of 'harmony', 'craftsmanship' and 'nature' in culture. The concept of 'harmony', 'craftsmanship' and 'nature' is also carried culturally. With the integration of modern design concepts and traditional craftsmanship, the innovative design of mortise and tenon has gradually become the focus of researchers' attention.

In recent years, researchers have explored the design innovation of mortise and tenon from different perspectives, trying to introduce modern design elements and humanised care while retaining its traditional flavour. Some scholars focus on the mechanical properties of mortise and tenon, and through the perspective of material science and engineering mechanics, they have systematically analysed the mortise and tenon structure, revealing its performance and applicability under different

loading conditions. Meanwhile, designers are also exploring the application of mortise and tenon in modern furniture and architecture, trying to find the best balance between functionality and aesthetics. With the emphasis on sustainable development, mortise and tenon design has gradually been endowed with the concepts of environmental protection and energy saving. Based on the renewable nature of wood and the nail-less connection of mortise and tenon, the innovative design of traditional craftsmanship has begun to show its unique value in the modern society. In addition, the rapid development of digital technology provides new possibilities for the innovation of mortise and tenon design. Through the combination of computer-aided design (CAD) and 3D printing, many designers are able to simulate mortise and tenon joints in a virtual environment, thus speeding up the design process and improving accuracy. This fusion of technology and traditional craftsmanship has contributed to the diversification and development of innovative mortise and tenon design. Research shows that the innovative design of mortise and tenon is not only a continuation of traditional craftsmanship, but also a dual embodiment of cultural heritage and innovation.

In the context of globalisation, mortise and tenon, as a representative of traditional Chinese culture, faces the opportunity and challenge of establishing a unique identity in the international design community. Exploring the innovative path of mortise and tenon in modern design not only helps to promote the revival of traditional craftsmanship, but also promotes cultural exchange and integration, and realises the harmonious symbiosis between tradition and modernity. The researchers' exploration and practice not only enriches the theoretical system of mortise and tenon design, but also provides new perspectives and ideas for the future development of related industries. In this process, the wisdom and aesthetics of mortise and tenon will continue to influence the evolution of modern design and provide a constant source of inspiration and insight for contemporary and future design practice.

1.3 Research Objectives and Scope

This thesis investigates the integration of mortise and tenon craftsmanship into contemporary design practices, focusing on sustainability, cultural heritage preservation, and adaptability. The research aims to bridge traditional craftsmanship with modern design principles, addressing the growing demand for environmentally conscious and culturally significant design solutions. The study is structured around three core themes: historical and cultural significance, sustainable design applications, and innovative modernization strategies.

Research Objectives

1. Historical and Cultural Analysis

- Examine the historical evolution of mortise and tenon craftsmanship, tracing its development from ancient Chinese architecture to its global adaptations.
- Analyze the cultural and philosophical underpinnings of the craft, emphasizing its role in embodying harmony, durability, and simplicity.
- Identify key technical attributes that contribute to its structural resilience and adaptability across different applications.

2. Sustainable Design Integration

- Explore how mortise and tenon techniques align with circular economy principles, emphasizing waste reduction, material efficiency, and product longevity.
- Investigate its potential in sustainable furniture design, focusing on modularity, disassemblability, and repairability.
- Assess its applicability in temporary and mobile architecture, highlighting its environmental compatibility and reusability.

3. Innovative Modernization Strategies

- Develop methodologies for adapting mortise and tenon craftsmanship to contemporary design needs, leveraging digital tools such as 3D modeling, CNC machining, and augmented reality (AR).
- Propose design strategies that preserve the craft's cultural essence while enhancing its relevance in modern markets.
- Explore its integration into cultural creative products, such as educational tools and interactive designs, to foster cultural appreciation and heritage preservation.

4. Global Dissemination and Commercialization

- Investigate strategies for promoting mortise and tenon-based products in international markets, emphasizing their cultural and environmental value.

- Develop frameworks for scaling traditional craftsmanship while maintaining its authenticity and quality.
- Evaluate the role of digital platforms in preserving and disseminating knowledge about the craft to a global audience.

Research Scope

The research encompasses both theoretical and practical dimensions, structured around the following areas:

1. Cultural Heritage and Preservation

- Study the philosophical roots and symbolic value of mortise and tenon craftsmanship within Chinese cultural heritage.
- Conduct a comparative analysis of similar joinery techniques in other cultures to situate the craft within a global context.
- Explore its role in fostering cultural self-confidence and heritage preservation in the face of globalization.

2. Sustainable Design Applications

- Investigate the use of mortise and tenon in sustainable furniture design, emphasizing its potential to reduce waste and extend product lifecycles.
- Examine its application in modular and temporary architecture, focusing on its adaptability and environmental benefits.
- Analyze its alignment with circular economy principles, including material selection, production processes, and end-of-life considerations.

3. Meaningful Innovation and Consumer Engagement

- Apply Roberto Verganti's theory of meaningful innovation to reinterpret mortise and tenon craftsmanship for modern consumers.
- Study consumer perceptions of traditional craftsmanship and its emotional, aesthetic, and cultural appeal.

- Develop design strategies that foster a connection between consumers and cultural heritage through innovative product experiences.

4. Digital and Educational Tools

- Explore the use of digital tools, such as 3D modeling, AR, and virtual reality (VR), for preserving and documenting mortise and tenon designs.

- Develop educational frameworks, including DIY kits, workshops, and interactive content, to facilitate knowledge transmission and skill development.

- Investigate the role of digital platforms in promoting the craft to a broader audience, including designers, educators, and policymakers.

5. Contemporary Applications and Case Studies

- Analyze successful case studies of mortise and tenon applications in modern design, including architecture, furniture, and cultural products.

- Develop prototypes and models to demonstrate the craft's potential in addressing contemporary design challenges.

- Propose scalable design methodologies that balance cultural authenticity with modern functional and aesthetic requirements.

Research Questions

1. How can mortise and tenon craftsmanship be adapted to meet modern design requirements without compromising its cultural and historical significance?

2. What role can digital tools play in preserving, innovating, and disseminating traditional craftsmanship?

3. How can mortise and tenon techniques contribute to sustainable design practices in architecture, furniture, and cultural products?

4. What strategies can ensure the commercialization and global dissemination of mortise and tenon-based products while maintaining their cultural integrity?

Expected Outcomes

- A comprehensive framework for integrating mortise and tenon craftsmanship into contemporary sustainable design practices.

- Prototypes and models demonstrating the craft’s potential in modern applications, including furniture, architecture, and cultural products.

- Strategies for preserving and promoting the craft through digital tools, educational initiatives, and global commercialization.

- Insights into how traditional craftsmanship can inspire meaningful, sustainable, and culturally resonant design solutions for the future.

This research aims to position mortise and tenon craftsmanship as a model for sustainable and culturally significant design, bridging the gap between tradition and innovation in a rapidly evolving global landscape.

1.4 Research Methods and Approach

This research employs a mixed-methods approach, combining qualitative and quantitative methodologies to explore the innovative design potential of mortise and tenon craftsmanship. The study integrates historical analysis, case studies, and qualitative interviews to provide a comprehensive understanding of the craft’s cultural, technical, and practical dimensions. The interdisciplinary nature of the research draws on insights from architecture, design, sociology, anthropology, and sustainability studies, ensuring a holistic exploration of mortise and tenon’s role in contemporary design.

Research Methods

1. Literature Review

- Purpose: To establish a theoretical foundation by reviewing existing scholarship on mortise and tenon craftsmanship, innovative design, sustainable practices, and cultural heritage preservation.

- Process:

- Conduct keyword searches (e.g., “mortise and tenon,” “innovative design,” “sustainable craftsmanship”) across academic databases such as Google Scholar, CNKI, and university libraries.

- Analyze historical texts, including Li Jie’s “Yingzao Fashi” and Liang Sicheng’s “A Pictorial History of Chinese Architecture”, to understand the craft’s historical and cultural context.

- Review contemporary studies on digital preservation, sustainable materials, and cultural product design to identify research gaps and opportunities.

- Outcome: A synthesized understanding of mortise and tenon’s historical evolution, technical characteristics, and current trends in innovative design.

2. Comparative Analysis

- Purpose: To examine mortise and tenon craftsmanship across different cultural and historical contexts, identifying universal principles and regional variations.

- Process:

- Historical Comparison: Compare traditional Chinese mortise and tenon techniques with similar joinery methods in Western and Japanese architecture, focusing on structural principles, material use, and cultural significance.

- Contemporary Comparison: Analyze modern applications of mortise and tenon in sustainable design, modular architecture, and cultural products across different regions.

- Outcome: Insights into the adaptability and cultural specificity of mortise and tenon, informing strategies for its integration into contemporary design practices.

3. Case Studies

- Purpose: To provide real-world examples of mortise and tenon craftsmanship in both traditional and modern contexts, highlighting its practical applications and challenges.

- Process:

- Traditional Case Study: Examine historical structures, such as the Forbidden City or Ming-style furniture, to analyze construction techniques, material choices, and cultural symbolism.

- **Contemporary Case Study:** Investigate modern design projects, such as modular furniture or eco-friendly architecture, that incorporate mortise and tenon techniques.

- **Cross-Case Analysis:** Compare traditional and contemporary examples to identify recurring themes and opportunities for innovation.

- **Outcome:** Concrete examples of how mortise and tenon can be preserved, adapted, and innovated upon in modern design.

4. Qualitative Interviews

- **Purpose:** To gather firsthand insights from artisans, designers, and cultural heritage experts on the challenges and opportunities associated with mortise and tenon craftsmanship.

- **Process:**

- **Participant Selection:** Engage a diverse group of stakeholders, including traditional craftsmen, contemporary designers, and sustainability experts.

- **Interview Design:** Use open-ended questions to explore participants' experiences, perceptions, and ideas for innovation. Example questions include:

- *What cultural or personal significance does mortise and tenon craftsmanship hold for you?*

- *How can traditional techniques be adapted to meet modern design needs?*

- *What role can digital tools play in preserving and innovating this craft?*

- **Data Analysis:** Employ thematic analysis to identify key patterns and insights from interview responses.

- **Outcome:** A nuanced understanding of the cultural, technical, and experiential aspects of mortise and tenon craftsmanship.

5. Field Investigation

- **Purpose:** To collect firsthand data on traditional mortise and tenon craftsmanship and its contemporary applications.

- Process:

- Visit workshops and studios of master craftsmen, such as Xin Quansheng, to document techniques, tools, and processes.

- Conduct interviews and observations to gather insights into the craft's preservation and innovation.

- Outcome: Primary data on the current state of mortise and tenon craftsmanship and its potential for modernization.

Integration of Methods

The research methods are designed to complement each other, providing a multi-faceted understanding of mortise and tenon craftsmanship:

- Literature Review and Comparative Analysis establish the historical and cultural context.

- Case Studies and Field Investigation provide real-world examples and practical insights.

- Qualitative Interviews offer personal perspectives and expert opinions.

- Design Experimentation tests the feasibility of integrating traditional techniques into modern design.

This integrated approach ensures a balanced exploration of mortise and tenon's cultural heritage, technical potential, and practical applications, bridging the gap between tradition and innovation.

Expected Contributions

- A comprehensive framework for integrating mortise and tenon craftsmanship into contemporary design practices.

- Practical insights into the craft's potential in sustainable architecture, modular furniture, and cultural products.

- Strategies for preserving and promoting mortise and tenon through digital tools, educational initiatives, and global commercialization.

- A deeper understanding of how traditional craftsmanship can inspire meaningful, sustainable, and culturally resonant design solutions for the future.

By combining these methods, the research aims to position mortise and tenon craftsmanship as a model for sustainable and culturally significant design, ensuring its relevance in a rapidly evolving global landscape.

1.5 Key Innovations and Contributions

This research introduces a novel paradigm by integrating Roberto Verganti’s “meaningful innovation” theory with social design methodologies to revitalize traditional mortise and tenon craftsmanship. By doing so, it seeks to realize the social value of this craft in the contemporary era, promoting the protection and inheritance of intangible cultural heritage. The study proposes a comprehensive framework for applying mortise and tenon techniques in modern design, including temporary architecture, sustainable product design, cultural and creative industries, and digital preservation strategies. Below are the key innovations and contributions of this research:

(1) Bridging Traditional Craftsmanship and Contemporary Design Needs

The research innovatively connects the centuries-old mortise and tenon craftsmanship with the evolving demands of modern design. Traditional craftsmanship often struggles to remain relevant in an era dominated by mass production and rapid technological advancements. This study, however, demonstrates that mortise and tenon techniques are highly adaptable to contemporary needs, particularly in areas such as durability, sustainability, and cultural authenticity. By exploring applications in modular architecture, sustainable furniture, and cultural products, the research highlights the craft’s potential to offer eco-friendly, repairable, and aesthetically simple solutions. This approach not only preserves the cultural essence of mortise and tenon but also establishes a model for modernizing other traditional crafts.

(2) Applying Verganti’s “Meaningful Innovation” to Intangible Cultural Heritage

A significant contribution of this research is its application of Roberto Verganti’s “meaningful innovation” framework to mortise and tenon craftsmanship. This approach goes beyond functional or aesthetic considerations, emphasizing the cultural, emotional, and symbolic meanings embedded in design. The study

redefines mortise and tenon as a design practice that resonates with modern values such as sustainability, authenticity, and cultural connection. For example:

- **Cultural Depth:** The research highlights the craft's alignment with sustainability and harmony with nature, positioning it as a meaningful choice for environmentally conscious consumers.
- **Emotional Connection:** By emphasizing the durability and heritage of mortise and tenon products, the study fosters a deeper emotional bond between users and their belongings, encouraging cultural appreciation and preservation.
- **Educational Value:** The research explores the integration of DIY elements and experiential learning into mortise and tenon products, enabling users to engage directly with the craft and understand its historical and cultural significance.

Through this framework, mortise and tenon craftsmanship is recontextualized as a timeless and versatile practice that offers both cultural and functional value.

(3) Redefining Design as a Vehicle for Cultural Preservation

This research redefines design as a tool for cultural preservation and continuity. It challenges conventional design practices that prioritize short-term profit and rapid consumption, advocating instead for a model that values cultural depth, sustainability, and longevity. Mortise and tenon joinery is presented not merely as a construction technique but as a cultural artifact with inherent values that align with sustainable and thoughtful design. This approach encourages designers to act as stewards of cultural heritage, creating products that respect and celebrate their origins while meeting contemporary needs.

(4) Developing Practical Design Frameworks for Sustainable Innovation

The study contributes practical design frameworks that leverage mortise and tenon craftsmanship as a model for sustainable and modular product innovation. These frameworks include:

- **Modular Architecture:** Exploring the use of mortise and tenon in modular and temporary structures, such as pavilions and portable homes, where its assembly and disassembly benefits are particularly valuable.

- Sustainable Furniture Design: Prototyping modular furniture that utilizes mortise and tenon joinery to achieve flexibility, repairability, and aesthetic appeal, aligning with circular economy principles.

- Cultural Creative Products: Designing educational kits, DIY products, and cultural creative items that incorporate mortise and tenon, fostering a deeper understanding of its significance and encouraging hands-on engagement.

These frameworks demonstrate how traditional craftsmanship can inspire sustainable product development, promoting responsible consumption, modularity, and waste reduction.

(5) Creating a Model for Craftsmanship Preservation and Transmission

The research introduces a model for preserving and transmitting mortise and tenon craftsmanship through digital tools, experiential learning, and educational product design. Key components of this model include:

- Digital Documentation: Utilizing 3D modeling and virtual archives to document mortise and tenon techniques in high detail, ensuring their accessibility for future generations.

- Educational Product Design: Developing interactive products, such as assembly kits and workshops, that allow users to engage with mortise and tenon joinery hands-on. This approach makes learning accessible and enjoyable, reinforcing skill transmission in a way that appeals to modern learners.

- Research-University-Industry Partnerships: Establishing collaborations between academic institutions, designers, and cultural organizations to support the ongoing preservation of mortise and tenon craftsmanship. This research advocates for institutional support as a critical component of cultural heritage preservation, ensuring that craftsmanship continues to be valued and practiced.

This model for preserving and transmitting craftsmanship demonstrates the importance of engaging a wider audience with mortise and tenon joinery, making it relevant to today's consumers and accessible for future generations. By creating products and educational tools that allow users to learn through doing, this research supports a more inclusive and experiential approach to cultural heritage.

In summary, the innovations and contributions of this research lie in its holistic approach to redefining mortise and tenon craftsmanship as both a cultural artifact and a practical design solution. Through meaningful innovation, this study reinterprets mortise and tenon joinery in ways that address contemporary needs for sustainability, cultural authenticity, and responsible consumption. By offering practical design frameworks, promoting cultural preservation, and advocating for the integration of craftsmanship into modern design, this research lays the foundation for a new paradigm in which intangible cultural heritage is preserved and enhanced through thoughtful, human-centered, sustainable, and culturally enriched design practices.

Chapter 2 Historical and Technical Overview of Mortise and Tenon Craftsmanship

The mortise and tenon technique is one of the oldest and most enduring woodworking methods, renowned for its precision, strength, and cultural significance. This chapter provides a comprehensive historical and technical overview of mortise and tenon craftsmanship, tracing its origins and development across different cultures while highlighting the structural and philosophical aspects that have contributed to its longevity. Through this historical and technical lens, this chapter aims to underscore the enduring relevance of mortise and tenon craftsmanship, both as a cultural heritage practice and as a technique that continues to offer practical solutions in modern design contexts.

2.1 Historical Evolution

The mortise and tenon technique is one of the oldest and most enduring woodworking methods, deeply rooted in East Asian cultural heritage. Its evolution reflects the interplay between craftsmanship, architecture, and cultural values. This section traces the historical development of mortise and tenon joinery, highlighting its origins, development, dissemination, and influence. By examining its journey from ancient times to the modern era, we can better understand its cultural significance and technical resilience, as well as its potential to inspire sustainable and resource-efficient design practices today.

2.1.1 Origins

Mortise and tenon craftsmanship is a testament to the ingenuity of ancient artisans, embodying both technical mastery and cultural wisdom. Its origins can be traced back to ancient China, where it emerged as a revolutionary woodworking technique during the Neolithic period. This section explores the historical roots of mortise and tenon joinery, its early applications, and its enduring legacy as a symbol of traditional craftsmanship.



Figure 2.1 Mortise and Tenon⁴⁰

(1) The Origin of Mortise and Tenon Technology

Mortise and tenon technology originated in ancient China, as a traditional woodworking technology, its history can be traced back to the pre-Qin period thousands of years ago.⁴¹ Early Chinese craftsmen created a nail-less and glue-less joining method based on their deep understanding of wood properties and structural mechanics, fully reflecting the respect and wisdom of ancient people for natural materials. This process not only functionally ensures the stability and durability of the structure, but also aesthetically demonstrates the harmony and delicacy of the art form. The basic principle of mortise and tenon construction is to achieve a tight fit between the parts by means of interlocking mortises and tenons, forming a balance between the transmission and dispersion of force. Over time, the use of mortise and tenon has gradually penetrated into all aspects of architecture, furniture and daily life, and has become one of the important symbols of traditional Chinese culture. It not only carries practical functions, but also conveys deep cultural connotations and historical deposits in each exquisite work. As a technique that embodies the wisdom of ancient craftsmen, mortise and tenon joinery not only demonstrates the unique charm of ancient Chinese architecture and design, but also provides a rich source of inspiration for craft innovation in later generations. Its profound techniques and philosophies still take on new vigour and vitality in modern design. Mortise and tenon joinery is not only an ancient technique, but also the crystallisation of the wisdom of the Chinese nation and a symbol of its culture.

There are also more earlier accounts of mortise and tenon. For example, the underground wooden well discovered in Altscherbitz near Leipzig, Germany. The

⁴⁰ Wikimedia Foundation. (2025, January 7). 魯班鎖. Wikipedia. <https://zh.wikipedia.org/zh-cn/%E9%AD%AF%E7%8F%AD%E9%8E%96>

⁴¹ Wang, S. (1986). *Classic Chinese Furniture: Ming and Early Qing Dynasties*. Han-Shan Tang Books.

wooden box at the bottom of the well is buried more than 20 feet underground. It has been preserved for thousands of years in cold, moist, and oxygen-free conditions. It has a history of 7,000 years and is the oldest in the world. The oldest known form of mortise-and-tenon structural woodwork.⁴² A Stonehenge archaeological analysis report mentions the use of mortise and tenon joints in the prehistoric monument of Stonehenge⁴³. The uprights and lintels of Stonehenge were locked together by means of a joint more commonly used in woodwork – the mortise and tenon⁴⁴.



Figure 2.2 Corners of the Base-Frame of the Well Held Together by a Keyed Mortise and Tenon Joint^{4546 47}

Mortise and tenon, a traditional wood-joining technique, emerged as one of the earliest structural methods in Chinese woodworking. This technique, characterized by a protruding tenon that fits into a corresponding mortise, avoids the need for nails or glue, ensuring durability through precise craftsmanship. Archaeological findings trace its origins back to the Neolithic period, revealing its foundational role in early Chinese architecture and furniture. Mortise and tenon

⁴² Wikimedia Foundation. (2024, December 7). 榫卯. Wikipedia. <https://zh.wikipedia.org/zh-cn/%E6%A6%AB%E5%8D%AF>

⁴³ Marcus Abbott and Hugo Anderson-Whymark, Stonehenge Laser Scan: Archaeological Analysis Report. Swindon: English Heritage, 2012.

⁴⁴ Guardian News and Media. (2020, April 14). Like Lego: Rare Photo shows stonehenge construction technique. The Guardian. <https://www.theguardian.com/uk-news/2020/apr/14/like-lego-rare-photo-reveals-stonehenge-construction-technique-stones>

⁴⁵ Altscherbitz well [Bandkeramischer Brunnen Altscherbitz] holy well or sacred spring : The Megalithic Portal and Megalith map: (n.d.-a). <https://www.megalithic.co.uk/article.php?sid=33580>

⁴⁶ Elburg, Rengert. (2010). A Neolithic treasure chest. *The European Archaeologist*. 33. 4-6.

⁴⁷ Tegel, W., Elburg, R., Hakelberg, D., Stäuble, H., & Büntgen, U. (2012). Early neolithic water wells reveal the world's oldest wood architecture. *PLoS ONE*, 7(12). <https://doi.org/10.1371/journal.pone.0051374>

embodies the ingenuity of ancient Chinese artisans, who utilized their deep understanding of wood properties and structural stability.

Over the centuries, mortise and tenon has been integral to traditional Chinese architecture, furniture, and religious structures. Iconic structures, such as the Forbidden City, showcase the resilience and adaptability of this technique in large-scale construction. As Chinese culture evolved, mortise and tenon persisted, symbolizing harmony and natural order, principles embedded in the philosophy of Confucianism and Daoism. This period saw enhancements in mortise and tenon forms to address diverse needs in residential, ceremonial, and imperial architecture .

The component mortise and tenon is a traditional technology of joining two or more components in woodworking. Among them, the protruding part of the component is called tenon, and the concave part is called mortise (which is commonly known as Mao in Chinese). The most basic mortise and tenon structure consists of two components, one of which is inserted into the mortise of the other to connect and fix the two components. The part where the tenon extends into the mortise is called the tongue, and the rest is called the shoulder. Its functional feature is that it does not use nails on the object, and uses mortise and tenon to reinforce the object so that the two parts of the structure can be tightly fastened.

(2) The development of mortise and tenon technology

As a unique technique in traditional Chinese architecture and furniture making, mortise and tenon technology has a long historical background that has injected a deep cultural heritage into its continuous development. As early as the Neolithic Age, mortise and tenon construction was already in its infancy, and over time it gradually evolved into an exquisite way of joining, reflecting the ancient people's deep understanding of the characteristics of wood and the flexible use of it. In the Han Dynasty, there were detailed records of mortise and tenon in the Zhou Li, marking the entry of this technique into a systematic stage. During the Tang and Song dynasties, mortise and tenon craftsmanship reached unprecedented heights, and the mastery of the craft and the pursuit of aesthetics complemented each other, forming a style with strong local characteristics and further enriching its forms of expression. During the Ming and Qing dynasties, with the prosperity of furniture design, mortise and tenon craftsmanship found a perfect balance between utility and decoration, and many classic mortise and tenon structures, such as 'cross tenon'(Figure 2.1) and 'mortise and tenon', not only demonstrated their excellent functionality, but also contained deep philosophical ideas and cultural connotations.

It not only demonstrates its excellent functionality, but also contains deep philosophical thoughts and cultural connotations. In modern times, mortise and tenon craftsmanship has taken on a new lease of life, with designers respecting tradition and incorporating modern materials and techniques to promote the innovative development of this ancient craft. Mortise and tenon craft not only carries the memory of history, but also demonstrates its unique vitality and artistic value in continuous exploration and innovation, becoming an important part of traditional Chinese culture.

(3) The spread of mortise and tenon technology

As an important technique in ancient Chinese architecture and furniture making, the spread of mortise and tenon craft is rich in cultural exchanges and technical inheritance. With the opening of the Silk Road, mortise and tenon craft gradually expanded outward, influencing the development of handicrafts in neighbouring countries. As early as during the Han Dynasty, the Silk Road was not only a channel for the circulation of material goods, but also a meeting point for culture and technology. Against this background, mortise and tenon construction, with its unique craft aesthetics and practicality, was gradually introduced to Japan and Korea. In Japan, traditional wooden buildings, such as shrines and temples, have been deeply influenced by mortise and tenon technology, and the stability and beauty of their structures reflect the essence of mortise and tenon technology. Ancient wood crafts in Korea also show similarities with Chinese mortise and tenon crafts, such as the construction of hanok (Korean houses), which to a certain extent borrowed from Chinese mortise and tenon construction, creating a unique regional style. The spread of mortise and tenon craftsmanship was not only limited to the transfer of technology, but also to the fusion of cultural identities and aesthetic standards. Through the introduction of this craft, the art of woodworking in Japan and Korea gradually developed a unique local character, retaining the core concept of mortise and tenon technology while integrating their own cultural characteristics, thus promoting the development and change of handicrafts in the region. As a cross-cultural art, mortise and tenon craft demonstrates the spirit of human beings' continuous exploration and innovation in the pursuit of technology and beauty.

(4) Influence of mortise and tenon technology

As an important technique in traditional Chinese architecture and furniture manufacturing, mortise and tenon technology has a profound and wide influence, covering many levels of craftsmanship, culture and art. This unique connection not

only reflects the ancient people's deep understanding of structural stability, but also contains a wealth of philosophical ideas and aesthetic pursuits. The construction principle and design concept of mortise and tenon reflect the harmonious relationship between heaven and man, emphasising the beauty of interdependence and collaboration between man and nature, and man and things. In furniture making, the mortise and tenon process not only enhances the sturdiness and durability of the work, but also adds dynamism and vitality to it, making each piece of work a witness of time. The use of mortise and tenon has contributed to the formation of a unique aesthetic style, inheriting the finesse and elegance of traditional Chinese culture and becoming a symbol of traditional craftsmanship. More importantly, mortise and tenon craftsmanship is equally revelatory in modern design. Its principle of not relying on adhesives is in line with the modern concept of sustainable development, and has inspired designers to think about the use of materials and structural innovation. This not only provides a wealth of inspiration for contemporary architecture and furniture design, but also allows mortise and tenon joinery to blossom on the international stage, highlighting the modern value of a traditional treasure. As a technique with a rich history, mortise and tenon craft has not only influenced the construction and production in ancient times, but has also taken on a new lease of life in contemporary society, becoming an important bridge between the past and the future.

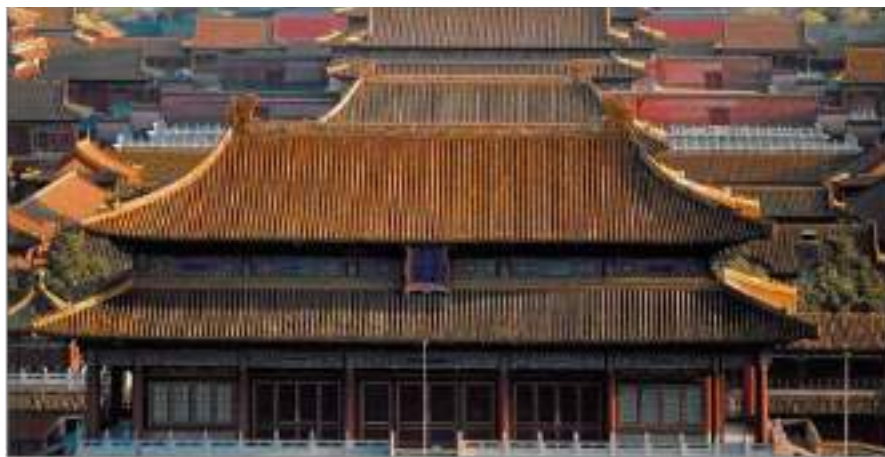


Figure 2.3 Forbidden City⁴⁸

2.1.2 Development Across Cultures

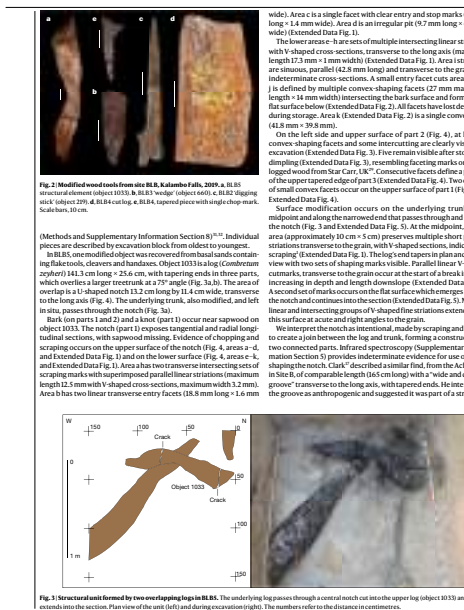
The mortise and tenon joint, one of the oldest and most enduring woodworking techniques, has a rich history that spans cultures and millennia. Its origins can be

⁴⁸ China Intangible Cultural Heritage Website - Digital Museum of China's Intangible Cultural Heritage. (n.d.-a). *Chinese traditional wooden building construction techniques*. https://www.ihchina.cn/directory_details/11785

traced back to the Paleolithic Age, predating even the Neolithic period, as evidenced by rudimentary notches found in ancient wooden structures (Barham, 2023). These early examples, though simple, laid the foundation for the sophisticated mortise and tenon techniques that would later emerge across civilizations. This section explores the development of mortise and tenon joinery across cultures, highlighting its historical significance, technological evolution, and cultural impact.

Early Evidence and Archaeological Discoveries

The earliest known examples of mortise and tenon joinery can be found in ancient wooden structures and tools. For instance, the prehistoric monument of Stonehenge in England features upright stones and lintels connected using mortise and tenon joints, a technique more commonly associated with woodworking (Figure 2.4). This suggests that the principles of mortise and tenon were adapted to stone construction, demonstrating the technique's versatility and enduring appeal.



Article



Fig. 4. Annotated images of the BLB5 upper log (object 1033) showing areas of intentional modification. From left to right, the location of the central notch in profile, shaping marks in and on the margins of the notch (a-k), the notch in profile from the opposite side, the image on the right shows the upper surface of the log, and the three parts of the log (l-o) separated by cracks. White arrows indicate the location of shaping facets on the sides and upper surface of the log.

The excavation of two interlocking logs in BLB5, with shaped ends on both objects supports this interpretation. We know of no comparable construction in the early archaeological record.

In BLB3, two wood-objects were found among plant material beside a large unmodified tree trunk. Flake tools, cleavers, handaxes and cores occur in this deposit. Object (a) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (b) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (c) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (d) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (e) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (f) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (g) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (h) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (i) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (j) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (k) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (l) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (m) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (n) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (o) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (p) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (q) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (r) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (s) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (t) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (u) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (v) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (w) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (x) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (y) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration). Object (z) is a V-shaped piece of branch, lenticular in cross-section with no visible shaping marks (see illustration).

Figure 2.4 Notch

In China, the Weiqiao archaeological site revealed the remains of an ancient wooden ship dating back thousands of years, showcasing the use of mortise and tenon joints in early shipbuilding (Figure 2.5). Similar techniques were employed in the Mediterranean region during the Roman period, where mortise and tenon joints were used to construct sewn-plank boats. The transition from lacing to mortise and tenon joinery in late Archaic Greek shipbuilding further underscores the technique's global influence and adaptability.



Figure 2.5 Weiqiao Wooden Ship⁴⁹

Ancient Egyptian and Middle Eastern Contributions

The mortise and tenon technique was also integral to ancient Egyptian and Middle Eastern craftsmanship. Egyptian artisans used mortise and tenon joints in the construction of wooden coffins, furniture, and early shipbuilding. These joints were often reinforced with dowels, showcasing a deep understanding of structural mechanics and material properties. In the Middle East, mortise and tenon joinery was employed in furniture and architectural structures, reflecting the technique's efficiency and resourcefulness in arid climates where wood was a scarce resource.

Chinese and East Asian Innovations

⁴⁹ Patrice Pomey and Giulia Boetto, "Ancient Mediterranean Sewn-Boat Traditions", *International Journal of Nautical Archaeology* 48 (2019, pp. 5-51).

In East Asia, mortise and tenon joinery reached unparalleled levels of sophistication, particularly in Chinese architecture and furniture design. Chinese craftsmen developed intricate joints, such as the dovetail and butterfly tenon, which required no nails or glue. These joints were integral to the construction of temples, pagodas, and palaces, which were designed to withstand natural forces like earthquakes. The Ming and Qing dynasties saw the pinnacle of mortise and tenon craftsmanship, with furniture designs that balanced functionality and aesthetics (Figure 2.6). Japanese and Korean woodworking traditions also adopted and adapted mortise and tenon techniques, integrating them into their unique architectural styles.

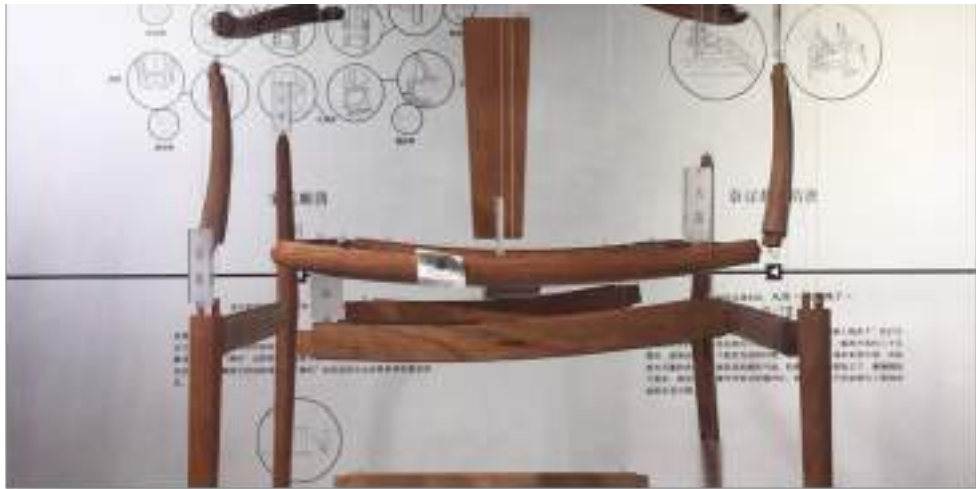


Figure 2.6 Ming and Qing Dynasties Furniture⁵⁰

European Adaptations in Medieval and Renaissance Architecture

In Europe, mortise and tenon joinery became a cornerstone of medieval and Renaissance timber framing. European craftsmen used this technique to construct cathedrals, homes, and public buildings, often combining it with pegging and bracing to create robust, load-bearing structures. The technique's durability and flexibility made it a staple of European woodworking traditions, bridging the gap between medieval craftsmanship and modern carpentry.

Modern Applications and Global Revival

In the modern era, mortise and tenon joinery has experienced a resurgence as designers and architects seek sustainable and culturally resonant construction methods. Contemporary applications range from eco-friendly timber framing in North America to the integration of digital fabrication techniques in East Asia. For

⁵⁰ Daily Global Exhibitions - iMuseum. (n.d.). *Jia Mu: Chinese furniture of the Ming and Qing dynasties*. <https://art.icity.ly/events/qnw7aj3>

example, digital tools like 3D modeling have enabled designers to preserve and innovate traditional mortise and tenon techniques, ensuring their relevance in the 21st century.

Cultural Significance and Global Influence

The development of mortise and tenon joinery across cultures highlights its adaptability and timeless relevance. Each civilization's interpretation of the technique reflects local materials, environmental conditions, and cultural values, resulting in a rich diversity of joinery styles and applications. Today, mortise and tenon joinery serves as a bridge between tradition and innovation, offering a sustainable and aesthetically pleasing approach to construction and design.

The historical evolution of mortise and tenon joinery demonstrates its enduring significance as both a practical construction method and a cultural artifact. From its origins in ancient China to its global dissemination and modern revival, the technique has continuously evolved, reflecting the ingenuity and creativity of craftsmen across cultures. As a symbol of harmony between humans and nature, mortise and tenon joinery remains a testament to the timeless value of traditional craftsmanship in a rapidly changing world.

The development of mortise and tenon joinery across cultures demonstrates its adaptability and timeless relevance. Each culture's interpretation of this technique reflects local materials, environmental conditions, and cultural values, resulting in a rich diversity of joinery styles and applications. Today, as designers and builders seek sustainable, culturally significant methods, mortise and tenon joinery offers a versatile and enduring approach that honors both tradition and innovation.

Evolution of ancient mortise and tenon construction. The evolution of ancient mortise and tenon construction is an important part of the development of traditional Chinese craftsmanship, and its origin can be traced back to the pre-Qin Dynasty. Early mortise and tenon technology was mainly applied to the connection of wooden buildings and artefacts, demonstrating a high level of craftsmanship and scientific principles. Over time, the mortise and tenon structure gradually evolved from simple insertion and biting forms to a variety of complex connections. From the Han Dynasty to the Tang Dynasty, mortise and tenon technology reached its peak of splendour, with innovative designs such as the 'arch' and 'rafter' not only enhancing the stability of the building, but also providing a wealth of inspiration for later craftsmanship. During the Song Dynasty, the technical level of mortise and

tenon joints was further enhanced, combining aesthetic and functional thinking to form the design of homes and crafts with the characteristics of the era. During the Ming and Qing dynasties, mortise and tenon construction was widely used in furniture making, showing high artistic value and practicality, and the shape and structure of furniture showed rich variations, gradually forming the two major styles of 'Ming Furniture' and 'Qing Furniture', and laying down the core of mortise and tenon technology in traditional Chinese culture. The mortise and tenon technology has established its core position in Chinese traditional culture. Through in-depth study of history, mortise and tenon structure is not only the embodiment of craftsmanship, but also contains deep cultural connotations and philosophical ideas, demonstrating the ancient people's profound understanding of natural laws and spatial relationships, and becoming an indispensable soul of Chinese architecture and furniture design.

The evolution of ancient mortise and tenon construction can be traced back to ancient times, and as a system of connecting building components, it carries thousands of years of technical inheritance and cultural infiltration. In the initial stage, mortise and tenon construction appeared in a simple and practical form, making use of the natural shape of wood to achieve the function of connection and fixation. During this period, mortise and tenon construction was mainly used for simple wooden tools and artefacts, and its design principles were mostly practical, gradually accumulating experience and precipitating the beginnings of the craft. With the advancement of society and technology, mortise and tenon construction entered a more complex stage of evolution during the Shang and Zhou periods. The increase in architectural demands gave rise to a diversity of mortise and tenon forms, with increased precision and complexity, reflecting a deep understanding of the principles of mechanics. By the Qin and Han Dynasties, mortise and tenon construction had become an integral part of large buildings, with more diverse and varied forms that balanced the stability and aesthetics of the buildings. From the Sui and Tang dynasties to the Song Dynasty, mortise and tenon construction entered its heyday, with a large number of classic buildings witnessing the maturity of the technique. The craftsmen continued to innovate in the course of inheritance, giving mortise and tenon an artistic aesthetic and spiritual connotation. The structural design became more delicate, and the detailed treatment was especially exquisite, forming a unique architectural style. At this time, mortise and tenon is not only the connection of building components, but also an important expression of architectural art. From primitive to mature, mortise and tenon structure has evolved in the long river of history, and become an important component of the bright treasure of Chinese architectural culture.

(3) Mortise and tenon construction in contemporary times

As a perfect example of traditional craftsmanship, mortise and tenon construction has a long history and contains rich cultural connotations and wisdom. In contemporary times, mortise and tenon construction not only carries the ancient craft traditions, but also takes on a new life under the cultivation of modern design ideas. Through the deep understanding and innovative application of mortise and tenon structure, designers have explored an innovative path of fusion between tradition and modernity. This fusion is reflected in the diversified use of materials, the introduction of modern technology, so that the mortise and tenon structure is not only limited to a single application of wood, but also to expand to new materials such as metal, plastic, and so on, so as to form a wider range of visual and structural performance. At the same time, designers have injected modern minimalist design concepts on the basis of maintaining the original aesthetic characteristics of mortise and tenon structure, making the works more in line with contemporary aesthetic needs. The flexibility and variability of mortise and tenon construction has further deepened its ability to adapt to modern living scenarios, becoming an important part of furniture, architecture and even art installations. Through in-depth study of traditional techniques and the combination of modern technology, mortise and tenon construction is not only a reproduction of traditional craftsmanship, but also a reflection of cultural confidence and innovative awareness. Such integration and innovation has not only liberated mortise and tenon construction in function and form, but also enabled it to continue to play a unique value in the changing times, becoming a bridge connecting history and modernity, carrying the essence of traditional craftsmanship and the inspiration of modern design.

As a treasure of Chinese architectural culture, the contemporary application of mortise-and-tenon joinery not only continues its own practicality and aesthetic value, but also brings new vitality in modern design. Throughout history, mortise and tenon construction has been an integral part of ancient architecture with its unrivalled stability and flexibility. Into the modern era, this traditional technique has been skilfully refined by designers and engineers and has successfully found a place in modern architecture, furniture design and other creative fields. This fusion of tradition and modernity has preserved the basic characteristics of mortise and tenon construction while giving it a new form of expression, becoming a design language that transcends time and space. With its unique connections and hidden mechanics, mortise and tenon is recognised in contemporary design as a sustainable construction method that embodies respect for and use of natural resources. Through digital design and fabrication techniques, designers are able to precisely

control the mortise and tenon joints at a microscopic level, allowing them to excel in carrying gravity and responding to environmental changes. At the same time, mortise and tenon construction has been widely used in the cultural and creative industries as a source of inspiration for modern product design. This dialogue between history and modernity not only inspires deep reflection on traditional culture, but also drives continuous innovation in the field of design.

As a remarkable legacy of Chinese civilisation, mortise and tenon craftsmanship has a long history and has demonstrated its unique structural appeal since ancient times. The early mortise and tenon technique, though simple at the beginning, already contained profound wisdom. Over the course of history, the forms and techniques have become more complex, gradually extending from primitive wooden structures to elaborate buildings and objects. Ancient craftsmen have explored the use of mortise and tenon to achieve a harmony of power and beauty, combining the physical properties of wood with human creativity to create countless heirloom pieces. The evolution of mortise and tenon is not only limited to structural innovations, but also embodies both aesthetic and functional breakthroughs. During the Tang and Song dynasties, craftsmen pushed mortise and tenon technology to its peak, and buildings became museums of mortise and tenon mastery. During the Ming and Qing dynasties, mortise and tenon craftsmanship penetrated into the production of furniture, forming the unique Ming and Qing furniture styles. Modern designers have given new life to mortise and tenon by combining contemporary materials and techniques with traditional craftsmanship, bringing it to the forefront of global design. Whether it is ancient wooden architecture or modern innovative design, mortise and tenon craftsmanship has always been writing the poetry of time with its unique charm and deep cultural heritage.

The history of mortise and tenon joinery, as a treasure of traditional Chinese architecture and furniture making, is diverse and rich, demonstrating the outstanding wisdom and innovative spirit of ancient craftsmen. The first hints of mortise and tenon technology can be traced back to the Neolithic period, when the ancestors observed the phenomenon of fit in nature and cleverly combined the wooden components to create a solid structure without the need for nails and glue. This technique evolved throughout history, reaching maturity during the Shang and Zhou Dynasties, when it became a key element of architectural structures, with a diverse range of forms centered on fastening and embedding. During the Han and Tang dynasties, mortise and tenon technology was intertwined with architectural aesthetics, with craftsmen incorporating intricate carvings and decorations into their

fine craftsmanship, making the mortise and tenon not only a structural function, but also an important vehicle for artistic expression. The Song Dynasty was the heyday of mortise and tenon craftsmanship, and as the official architectural normative document, the "Construction Method" provided a systematic theoretical basis for the design and application of mortise and tenon, and established its important position in the field of architecture. During the Yuan, Ming and Qing dynasties, with the change of time and demand, mortise and tenon craft continued to absorb exotic cultural elements, presenting an innovative pattern of diversified integration. Throughout the past and present, the development of mortise and tenon craft in the long history is not only the inheritance of skills, but also the vitality of the traditional technology in the continuous innovation, highlighting the deep heritage and infinite charm of Chinese culture.

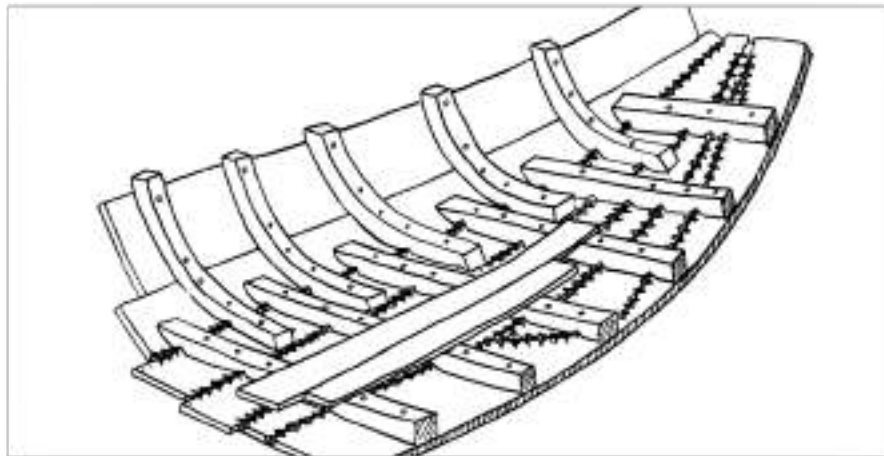


Figure 2.7 Sewn-Boat Technique⁵¹

Boats of the World, from the Stone Age to Medieval Times⁵². In the Roman era⁵³, Mediterranean hull types exhibited significant diversity in construction techniques, particularly in the use of mortise-and-tenon joints. Comparative studies of Mediterranean hulls, such as those from the Jeaume-Garde B wreck at Porquerolles⁵⁴, highlight the evolution of shipbuilding techniques during this period. These construction techniques are also compared with those seen in Northern Vietnam, where Bronze and Iron Age boats featured locked mortise-and-tenon

⁵¹ Pomey, P., & Boetto, G. (2019). Ancient Mediterranean Sewn - Boat Traditions. *International Journal of Nautical Archaeology*, 48(1), 5 - 51. <https://doi.org/10.1111/1095-9270.12337>

⁵² McGrail, S., 2001, *Boats of the World. From the Stone Age to Medieval Times*. Oxford.

⁵³ *Ships in Roman Era*. *IJNA* 42.2, 296–304.

⁵⁴ Carrazé, F. (1977). Mediterranean hull types compared: The Jeaume-Garde B wreck at Porquerolles (France). *International Journal of Nautical Archaeology*, 6(4), 299–303.

joints. The analysis of these boats reveals both the technological sophistication and the cross-cultural exchange of shipbuilding methods.⁵⁵

Traditional design and practices for building Chinese wooden arch bridges is Inscribed in 2009 on the List of Intangible Cultural Heritage in Need of Urgent Safeguarding. Wooden arch bridges are found in Fujian Province and Zhejiang Province, along China's south-east coast. The traditional design and practices for building these bridges combine the use of wood, traditional architectural tools, craftsmanship, the core technologies of 'beam-weaving' and mortise and tenon joints, and an experienced woodworker's understanding of different environments and the necessary structural mechanics. The carpentry is directed by a woodworking master and implemented by other woodworkers. The craftsmanship is passed on orally and through personal demonstration, or from one generation to another by masters teaching apprentices or relatives within a clan in accordance with strict procedures. These clans play an irreplaceable role in building, maintaining and protecting the bridges. As carriers of traditional craftsmanship the arch bridges function as both communication tools and venues. They are important gathering places for local residents to exchange information, entertain, worship and deepen relationships and cultural identity. The cultural space created by traditional Chinese arch bridges has provided an environment for encouraging communication, understanding and respect among human beings. The tradition has declined however in recent years due to rapid urbanization, scarcity of timber and lack of available construction space, all of which combine to threaten its transmission and survival.

Braided wood arch bridges still exist in the southeastern coastal provinces of China, such as Fujian and Zhejiang. The traditional wooden arch bridge uses logs, uses traditional wooden construction tools and manual techniques, and uses core technologies such as weaving beams to connect with mortise and tenon and build an extremely stable arch bridge technique system. The construction of the wooden arch bridge is completed by a master carpenter who directs other carpenters to work. The craftsmanship of carpenters follows strict procedures and is passed down orally or from generation to generation between families through a master-apprentice system. These bridge-building families play an irreplaceable role in the construction, maintenance and protection of wooden arch bridges. As a carrier of traditional crafts, the wooden arch bridge is not only a communication tool, but also a main gathering

⁵⁵ Bellwood, P., Cameron, J., Nguyen, V. V., & Bui, V. L. (2007). Ancient boats, boat timbers, and locked mortise-and-tenon joints from Bronze/Iron-Age Northern Vietnam. *International Journal of Nautical Archaeology*, 36(1), 2–20.

place for local residents. People exchange information on the bridge, hold entertainment activities, and perform worship ceremonies, thus deepening feelings and highlighting cultural characteristics. In recent years, due to factors such as rapid urbanization, the reduction of logs, and the lack of available building space, the inheritance and preservation of wooden arch bridge craftsmanship are all threatened, and this traditional craftsmanship is at risk of being lost.



Figure 2.8 Chinese Wooden Arch Bridge⁵⁶

As a brilliant crystallisation of Chinese civilisation, mortise and tenon craftsmanship has lasted for thousands of years. Its unique construction method not only reflects the wisdom and creativity of ancient craftsmen, but also leaves an indelible mark on architecture, furniture and even modern design. The mortise and tenon structure, with its efficient mechanical properties and ultimate aesthetic performance, became a central pillar of ancient architecture, and this technique has been passed down through countless ingenious works, influencing contemporary designers' understanding of structure and space. Whether it's the grand halls of the Forbidden City or the cosy courtyards of traditional homes, mortise and tenon craftsmanship has shaped spaces with unique rhythms, as if it were frozen music, echoing throughout history. Modern furniture designers have also drawn inspiration from this, pursuing the closeness to nature and the true nature of the material, and the application of mortise and tenon is not only limited to the technique itself, but also deepened into a cultural symbol, symbolising the oriental philosophy of harmonious coexistence between man and nature. The international architectural community is gradually paying attention to this ancient technique, combining it with modern technology and exploring new paths to sustainable development. In today's accelerated globalisation, mortise and tenon joinery, as a bridge between tradition and modernity, provides a wisdom that transcends time and space, and evokes a deep reflection on the roots of human civilisation. Its influence is not only

⁵⁶ UNESCO - *traditional design and practices for building Chinese wooden arch bridges*. Intangible Cultural Heritage. (n.d.). <https://ich.unesco.org/en/RL/traditional-design-and-practices-for-building-chinese-wooden-arch-bridges-02156>

limited to the material level, but also lies in the spiritual inheritance and innovation, becoming a cultural link between the past and the future. The long history and far-reaching influence of mortise and tenon joinery will continue to inspire countless successors to explore and innovate.

2.2 Structural Characteristics and Technical Skills

The technical characteristics of mortise and tenon craftsmanship underscore its enduring relevance in architecture and furniture design, both in historical and modern contexts. This section analyzes the structural, aesthetic, and sustainable qualities that define mortise and tenon, particularly its ability to provide stability without nails or glue. By examining these qualities, the section not only highlights the strengths of the technique but also builds a foundation for understanding its modern adaptations. These technical insights will support the thesis's case for integrating mortise and tenon principles into innovative and sustainable design frameworks today.

2.2.1 Types and Applications of Mortise and Tenon Joints

Mortise and tenon joinery, one of the oldest and most versatile woodworking techniques, is characterized by its ability to create strong, interlocking connections. This method has evolved over centuries to include various types of joints, each designed to meet specific structural and aesthetic requirements. The adaptability and strength of these joints make them well-suited for a wide range of applications, from traditional architecture to modern furniture and modular structures.

Basic Types of Mortise and Tenon Joints. The simplest form of the mortise and tenon joint consists of a rectangular or square-shaped “tenon” that fits snugly into a corresponding “mortise” cavity. Variants of this basic form include through tenons, where the tenon passes completely through the mortise, and blind tenons, which fit into a mortise without extending through to the other side. Through tenons are commonly used in applications where visible joinery is desirable, as they showcase the craftsmanship involved. Blind tenons, on the other hand, are preferred in contexts requiring seamless surfaces.

Advanced Variants for Structural Strength. For added stability, advanced versions of mortise and tenon joints are used in load-bearing structures. These include wedged and pegged tenons, which are reinforced with wedges or dowels to prevent loosening over time. Haunched and double tenons are other advanced forms, offering enhanced resistance to twisting and shear forces, which is particularly

useful in heavy-duty applications such as building frames, bridges, and large furniture pieces. These reinforced joints are well-suited for dynamic structures where durability and longevity are essential.

Applications in Architecture and Furniture. In traditional Chinese architecture, mortise and tenon joints are a foundational element, enabling the construction of complex wooden structures without metal fasteners. This technique is used extensively in temples, pagodas, and palaces, where large wooden beams and columns are interlocked to form stable and earthquake-resistant frameworks. In modern architecture, these joints continue to be valued for their aesthetic appeal and sustainability, contributing to eco-friendly designs in both temporary and permanent structures.

In furniture-making, mortise and tenon joints are equally essential, providing a balance of strength and elegance in tables, chairs, cabinets, and beds. These joints allow furniture to withstand heavy use without compromising on aesthetics. Contemporary designers often use exposed mortise and tenon joinery as a design feature, highlighting the beauty of natural wood and the skill involved in traditional craftsmanship.

Modern and Modular Applications. The adaptability of mortise and tenon joints has also led to their use in modular and prefabricated designs, where pieces are constructed to be easily assembled and disassembled. This approach aligns with the principles of sustainable design, as modular mortise and tenon constructions allow for resource efficiency, reusability, and minimal waste. The joints' inherent flexibility makes them ideal for temporary structures, portable furniture, and sustainable building systems that require frequent reconfiguration.

Through these diverse types and applications, mortise and tenon joints demonstrate an enduring versatility that bridges traditional craftsmanship with modern design needs. This ancient technique continues to inspire architects, furniture makers, and designers, serving as a model for both functional and aesthetic excellence in sustainable construction and design.

The most basic mortise and tenon structure consists of two components, one of which is inserted into the mortise of the other to connect and fix the two components. The part where the tenon extends into the mortise is called the tongue, and the rest is called the shoulder. Its functional feature is that it does not use nails on the object, and uses mortise and tenon to reinforce the object so that the two parts of the structure can be tightly fastened.



Figure 2.9 Type of Mortise and Tenon⁵⁷

Through-bucket type. It was matured during the Han Dynasty, and was mostly used in the southern provinces of China. Along the depth of the direction of the columns, the columns are more dense, and the diameter of the columns is a little small, without beams, with "through" through the columns, on which short columns can be set up, and the tops of the columns are directly bearing purlins. Advantage is that the material is small, the wind resistance of the face of the mountain is good; disadvantage is that the indoor columns are dense and the space is not wide enough.

Lifting Beam Style. Matured in the Spring and Autumn Dynasty, and used in the northern provinces of China. Along the depth of the direction of the arrangement of stone base, base on the columns, columns on the frame beams, beams on the melon columns, frame short beams, the top is the ridge melon columns, constituting a roof frame; between the roof frame with transverse square contact columns on top of the beams and the top of the melon columns to do transverse purlin, purlin on the rafters and the roof, so that the roof frame is completely connected to a whole Advantages of the indoor columns or columns less, you can get a larger space;

⁵⁷ smellycat. (n.d.). *Furniture making main structure of mortise and tenon structure II*. Solidworks Tutorials. <http://gocae.com/1972.html>

disadvantage is that the beams and columns and other material, more consumption of timber.

Well dry type. Round or half-round wood at both ends of the concave tongue and groove, combined into a rectangular wooden frame, layers stacked as a wall - the actual wooden load-bearing structure of the wall. It consumes a large amount of wood, the building face broad and into the deep into the timber length limitations, the appearance of heavy, not widely used.



Figure 2.10 Through-Bucket Type; Lifting Beam Style; Well Dry Type⁵⁸

The most common way to display the tenon and mortise structure is the bucket arch.

Dougong is a special component unique to ancient Chinese architecture, which integrates tenon and mortise technology. Liang Sicheng once said: "The status of the bucket arch in Chinese architecture is still like that of Greek and Roman architecture; the change of the bucket arch is also a change in Chinese architecture."

The bucket arch is the transition part between the column and the roof of a large building. Its function is to transfer the weight of the roof to the pillar, and then from the pillar to the base of the column. The bucket arches are stacked vertically and horizontally to form a layer of bucket arches. The bucket arches are diverse, and all kinds have unique functions. For example, in the east hall of Foguang Temple, the bucket arch is ruttuous and dominates all directions, with the largest number of floors and the farthest distance among the existing ancient Chinese buildings. The structure of the East Hall is divided into more than 40 kinds, such as swallow-tailed tenon, square-headed tenon, and oblique-angled tenon.

Located at the top of the column and bearing the whole bucket arch, it is called a sitting bucket. The body is a bow, and the position parallel to the surface of the building is called an arch. The form is consistent with the arch, but the direction is

⁵⁸ 【Chinese Architectural Culture】 Basic Characteristics of Ancient Chinese Architecture (II)_Structure_Beam Type_Frame. _Structure_Beam Type_Frame. (2023, December 8). https://www.sohu.com/a/742505357_121106854

perpendicular to the arch, which is called Qiao (also known as Hua Gong). Outside the upturn, it stretches to one end and slants to soop. It is used for the eaves to pick out. At the intersection of the arch and the warp, and at both ends of the arch, in the upper and lower arches, the bucket-shaped one is called ascending.



Figure 2.11 Dougong⁵⁹

In a word, the combination of the bucket arch is to put the arch on the bucket, the bucket on the arch, and the bucket on the bucket. So repeatedly, two in a lifetime, two in three. The final bucket arch is such a simple piece of parts intricately stitched together. Lin Huiyin once said, "If there is no bucket arch 'all the beauty of the intricate, the change of poor skills', there will be no flying cornices and corners of Chinese architecture, and there will be no flying beauty of Chinese architecture."⁶⁰ Tenon, an oriental wisdom that closely connects nature with life, as the soul of ancient wooden architectural art, condenses the ancient people's perception of the world.

2.2.2 Technical Durability and Sustainability

(1) Design Principles of Mortise and Tenon Construction

Tenon Design Principle. The design principle of mortise and tenon occupies a crucial position in traditional woodworking techniques, the core of which lies in the simplicity of the shape and the stability of the joint. The mortise and tenon is usually presented in a single geometric form, which is cleverly simplified to achieve structural stability. This simplicity not only reduces the use of materials, but also

⁵⁹ YouTube. (n.d.). *[Video]*. YouTube. <https://www.youtube.com/watch?v=cr-4lh61Y1Q>

⁶⁰ Daozhonghua | Mortise and tenon joints, a technical trick played by the ancients - China Nationalities and Religions Network. (n.d.). <http://www.mzb.com.cn/html/report/22110091-1.htm>

allows for a more even distribution of forces in the joints, which effectively enhances the stability of the overall structure. In addition, the aesthetic concept embedded in mortise and tenon design often reflects the craftsman's observation and understanding of natural forms. The fit between the tenon and its matching mortise reflects the perfect unity of form and function. During the design process, the size and angle of the mortise and tenon, as well as the corresponding mortise and tenon fit, need to be repeated and precisely calculated to ensure the strength and toughness of the joint when it is subjected to external forces. The tenon not only assumes the function of load-bearing, but also assumes the task of guiding and positioning in the overall structure to ensure the relative position of each component is stable after connection. Through proper mortise and tenon design, traditional craftsmen are able to achieve more complex structural combinations, giving life to the wood and demonstrating the craftsman's wisdom and skill. The beauty of mortise and tenon design lies not only in its physical properties and durability, but also in its cultural connotations and historical legacy, which makes this design principle significant in the art of woodworking in both ancient and modern times.

The design principle of the mortise and tenon is based on the simplicity of its shape and the solidity of its connection, a design principle that stems from the pursuit of both function and aesthetics. The mortise and tenon, as a prominent part of the mortise and tenon structure, often tends to be simple and geometrically shaped, minus the unnecessary complexity. This design choice is not only an aesthetic consideration, but also based on a rigorous analysis of mechanics. By reducing unnecessary ornamentation and curvature, tenons are able to distribute stresses more evenly in response to external forces, avoiding structural damage caused by stress concentrations.

The solidity of the mortise and tenon connection is reflected in the fit of the mortise and tenon to the eye. The precise combination of tenon and mortise is like a gear that snaps together to ensure the integrity and stability of the structure. During the production process, craftsmen use their skills to ensure that the dimensions of the mortise and tenon are precisely matched to the eye of the mortise and tenon to achieve a 'tight fit'. This fit is not just a physical connection, but also an art of mechanical balance, where friction and compression are used to achieve stable structural support.

The formation of this design principle is inextricably linked to the evolution of history. Ancient craftsmen expressed their deep understanding of the relationship between nature and construction in simple forms, and the design of mortise and

tenon became a cultural and technical inheritance. Each mortise and tenon carving is a gaze into time and a continuation of tradition, a crystallisation of skill and wisdom.

Mortise Design Principle. As an important part of the traditional mortise and tenon structure, the design principle of the bottom of the tenon embodies the craftsman's deep understanding of the mechanical properties during the design process. The protruding shape of the mortise base is not only an aesthetic pursuit of form, but also an inevitable choice of function. Under stress, the bottom of the tenon can effectively disperse and transfer the pressure, avoiding the loosening or breaking of the connection caused by the local concentration of stress. This design concept originates from the ancient observation and experience on the characteristics of wood, the structure of the mortise and tenon base is closely related to the direction of the wood fibre, taking into account the elasticity and strength of the wood. The projection of the mortise base not only enhances the contact area between the mortise and tenon, but also improves the stability of the structure, and makes the joints resistant to torsion when subjected to external forces. Through the shape of the mortise base, traditional craftsmanship has to some extent realised a self-adjusting mechanism, which is able to adapt to different temperature and humidity conditions by deforming moderately in response to changes in the environment. This unique design gives mortise and tenon construction an intrinsic resilience that allows it to maintain lasting stability and structural integrity in a variety of applications. Because of this, the design of mortise and tenon base is not only an inheritance of the wisdom of traditional craftsmanship, but also provides a rich source of inspiration for the innovation of mortise and tenon structure, fully demonstrating the value and significance of traditional craftsmanship in modern design.

The design of the mortise and tenon base is a crucial part of mortise and tenon construction, and its design principle is deeply rooted in the subtle combination of mechanics and material science. The projection of the bottom of the mortise and tenon is designed to appropriately share and transmit the multiple pressures on the structure, a feature that not only increases the load-bearing capacity, but also greatly enhances the solidity of the joint. When the tenon is fitted into the mortise, the subtle protrusion of the mortise base acts as a cushion and transmitter of force, preventing the possibility of slippage and loosening. It is like the earth to the mountain, carrying everything without fatigue.

In timber frame construction, the projection of the mortise and tenon base allows it to effectively dissipate vertical loads from above, spreading them in all directions across the mortise and tenon joint. This transfer of forces avoids over-concentration at a single point of stress and prolongs the service life of the structure. This design principle not only reflects the ancient craftsmen's deep understanding of material properties, but also reflects the pursuit of long-lasting stability of the building and a deep insight into the laws of nature.

The design of the mortise and tenon base is not only a physical consideration, it also carries the pursuit of harmonious aesthetics in the evolution of history. Every fit of mortise and tenon is a symphony of function and beauty, a perfect fusion of skill and art. Under the skillful hands of craftsmen, the design of the mortise and tenon base becomes a solid cornerstone of the structure, interpreting an architectural legend that transcends time and space.

Mortise and tenon connection principle. The principle of mortise and tenon joint is the core of the traditional connection technology of wooden components, and its design not only reflects the aesthetics of space and mechanics, but also reflects the ancient craftsmen's deep understanding of material properties and mechanical properties. Spatial mortise and tenon construction interconnects components through geometric relationships in three-dimensional space, often using mortise and tenon joints to provide stability and load-bearing capacity of the jointed surfaces in multiple dimensions. Tenons come in a variety of shapes, including straight, slanted, and dovetailed, while the design of the mortise and tenon varies according to the shape of the tenon and its functional needs, resulting in a high-strength joint. This design allows the wood to deform freely under stress, reducing the risk of cracking or warping due to changes in temperature and humidity. In addition, planar mortise and tenon construction emphasises the form of the joint in a two-dimensional plane and is commonly used for joining components in furniture and architecture. The design principle of planar mortise and tenon focuses on the close fit of the mortise and tenon joints, which is achieved through a clever geometric design that makes the joints secure and easy to use. This type of construction is not only about the physical connection, but also about the design concept that gives life to the wood. The subtlety of the mortise-and-tenon joint lies in its demand for craftsmanship and respect for the properties of natural materials, and it is this intrinsic harmony that makes mortise-and-tenon construction a treasure of traditional craftsmanship, one that has retained its unique charm and value through the ages.

Mortise and tenon joints exhibit remarkable variety, each designed to address specific structural requirements. Common types include the straight tenon, angled tenon, and the dovetail tenon, each providing unique strengths. These variants are customized based on factors such as load distribution, angle of joints, and overall design requirements, which enable mortise and tenon to meet diverse architectural and furniture design needs .

Mortise and tenon joinery is celebrated not only for its structural integrity but also for its inherent sustainability, making it a valuable technique in both traditional and modern contexts. This joinery method, which involves the interlocking of two wood components, demonstrates remarkable durability and aligns with principles of sustainable design. By analyzing its technical resilience and environmental advantages, we can better appreciate why mortise and tenon joinery continues to be relevant in an era increasingly focused on eco-friendly building practices.

Structural Integrity and Longevity. One of the most distinguishing features of mortise and tenon joinery is its durability. This technique relies on the precision of its interlocking parts, which fit together tightly to create a robust, load-bearing structure. Mortise and tenon joints are designed to withstand significant stress and movement, distributing weight evenly across the joint rather than concentrating it at a single point, as is common with screws or nails. This structural resilience makes mortise and tenon joinery ideal for applications that demand longevity, such as in furniture, framing, and heavy wooden structures. Many historic buildings and furniture pieces constructed with mortise and tenon joints have survived for centuries, testifying to the technique's lasting strength.

Sustainable, Glue-Free Construction. A key sustainability benefit of mortise and tenon joinery is its glue-free and nail-free assembly. This method eliminates the need for chemical adhesives, reducing the emission of volatile organic compounds (VOCs) and minimizing the environmental impact associated with synthetic binders. In contrast to construction methods that rely on metal fasteners or glue, mortise and tenon joints offer a non-invasive, natural approach to wood joining. This glue-free construction also contributes to easier recycling and disassembly, as the components can be separated and repurposed without damaging the wood, supporting principles of circular design and minimizing waste.

Efficient Use of Natural Materials. Mortise and tenon joinery traditionally utilizes solid wood, making use of its natural strength and adaptability. Since the joints are tailored to the properties of the wood, this technique minimizes the need

for additional reinforcement or materials, leading to efficient use of natural resources. Furthermore, the adaptability of mortise and tenon joints allows for the use of reclaimed or locally sourced wood, aligning with sustainable forestry practices. By prioritizing high-quality, durable wood, mortise and tenon joinery supports a longer life cycle for wooden structures and reduces the frequency of material replacement, thus conserving resources over time.

Repairability and Modularity. Another sustainability advantage is the repairability and modularity of mortise and tenon structures. Because these joints can be disassembled and reassembled with relative ease, it is possible to repair or replace individual components rather than discarding entire structures. This repairability extends the life of products and buildings, reducing the demand for new materials and lowering waste generation. Additionally, mortise and tenon joinery lends itself well to modular design, enabling structures to be adapted or expanded over time in response to changing needs, which aligns with sustainable building practices.

Environmental Resilience. Mortise and tenon joinery also offers enhanced environmental resilience. The flexible nature of wood allows mortise and tenon joints to adjust to changes in humidity and temperature, reducing the likelihood of cracking or warping. This adaptability makes mortise and tenon joinery suitable for a variety of climates and environments, from humid tropical regions to arid zones. In seismic-prone areas, the inherent flexibility of mortise and tenon joints enables structures to absorb and dissipate energy, enhancing their earthquake resistance compared to rigidly fastened alternatives.

Alignment with Contemporary Sustainability Goals. In an era where sustainable design and construction practices are paramount, mortise and tenon joinery aligns seamlessly with these goals. Its low-impact construction process, reliance on renewable materials, and extended life cycle make it a model for eco-friendly building techniques. By embracing mortise and tenon joinery, modern architects and designers can create structures that embody both technical durability and environmental stewardship, contributing to a more sustainable and resilient built environment.

In summary, mortise and tenon joinery exemplifies a sustainable approach to construction and design. Its technical durability, combined with its minimal environmental impact, makes it a valuable technique for contemporary applications that prioritize sustainability and resource efficiency. This enduring technique serves

as a bridge between traditional craftsmanship and modern eco-consciousness, offering a practical and aesthetically pleasing solution for durable, sustainable design.

This interlocking technique provided a robust and stable structure, demonstrating the ingenuity of early woodworking.

Building upon these traditional foundations, contemporary designers and architects have rediscovered mortise and tenon as a versatile solution for sustainable construction. Today, its durability and environmental advantages are increasingly applied in eco-conscious furniture and green building projects, where minimal use of synthetic materials is preferred.

In addition to structural stability, mortise and tenon joints enhance aesthetic value by seamlessly connecting wood pieces, offering an elegance that complements its practical strengths.

These combined structural and aesthetic properties have led to mortise and tenon's revival in high-end furniture design, where visible craftsmanship and durability are prized. For instance, designers apply this technique in furniture that prioritizes both longevity and visual harmony.

(2) The traditional skills of mortise and tenon technology

As the essence of traditional Chinese woodworking techniques, mortise and tenon technology carries deep cultural connotations and historical deposits, and its inheritance and development can be said to be robust and dynamic. The traditional mortise and tenon technology not only embodies the rationality of construction and stability of structure in practicality, but also highlights the concept of harmonious coexistence with nature in aesthetics. The diversified techniques of mortise and tenon, including cross tenon, dovetail tenon, round tenon, etc., reflect the complexity and refinement of the technique. The flexible use of these techniques allows wood to be joined in a way that ensures strength and reduces material waste, in line with the principle of sustainable development. The passing on of skills relies heavily on face-to-face teaching between masters and apprentices, and the skills and experience of traditional craftsmen are perpetuated time and time again. At the same time, the cultural renaissance of modern society and the renewed interest in craftsmanship have given new impetus to the spread and innovation of mortise and tenon craftsmanship. Despite the impact of modern industrialisation, the traditional mortise and tenon technique has maintained its unique charm and become an

important symbol of cultural identity. Through museum displays, craft exhibitions and related courses, the traditional skills of mortise and tenon craft have not only been preserved, but also taken on a new lease of life in contemporary society, attracting more and more young people to devote themselves to the study and inheritance of this traditional art. The traditional art of mortise and tenon craft, while remaining true to its roots, is also exploring and seeking innovation, allowing this ancient art to show new possibilities in a modern context.

Ancient mortise and tenon structure has unique design features, fully reflecting the harmony of simplicity and practicality. Its construction often maximises function with a minimum number of parts, reflecting the ancient people's deep understanding and clever use of materials and structures. In the design of mortise and tenon, the natural properties of wood are fully respected, and the mutual fit of mortise and tenon not only ensures the solidity of the connection, but also makes the overall structure show excellent performance in load-bearing and pressure resistance. The clever design of mortise and tenon avoids excessive metal fittings, making furniture and buildings lighter in use and easier to dismantle and transport, which was particularly important in the living environment at that time. In addition, the durability of ancient mortise and tenon construction is one of its major highlights. Due to the close co-ordination of mortise and tenon components, the overall structure is not easy to loosen or deform in the baptism of time, showing excellent stability and durability, and even the survival of a century or a thousand years is not uncommon. This unique structural form not only meets the dual needs of function and aesthetics, but also carries rich cultural connotations in the long history of evolution, making mortise and tenon become an important symbol of traditional Chinese craftsmanship. The beauty of ancient mortise and tenon design lies in its simplicity and practicality, and it is this unique structural feature that has made the mortise and tenon unfading throughout history, and an important revelation for future generations.

Mortise and tenon is a process that uses a concave-convex structure to stabilise the overall structure, where the convex part is the tenon and the concave part is the mortise. Mortise and tenon construction is a combination of tenons and dowels, a clever combination of more and less, higher and lower, longer and shorter pieces of wood, which can effectively limit the twisting of the wood in all directions. In its most basic form, mortise and tenon construction consists of two members, the tenon of one being inserted into the mortise of the other to join and secure the two members. The part of the tenon that extends into the mortise is called the tongue, and the rest is called the shoulder. Mortise and tenon can be broadly classified into

three categories according to the way the tenon and mortise are combined, one is the point-to-point combination, which is used for horizontal and vertical timber dingbats and crossbats; the second is the surface-to-surface combination, such as "dovetail tenon" and "groove tenon"; and the third is the combination of more than one member together. The third type is to combine multiple members together.



Figure 2.12 Earthquake Resistance Test⁶¹

2.2.3 Cultural and Philosophical Values

Mortise and tenon joinery, an ancient Chinese woodworking technique, embodies profound cultural values and philosophies that extend far beyond its functional purpose in construction. This unique technique has been refined over millennia to create strong, stable, and aesthetically pleasing structures, seamlessly connecting materials. The cultural connotations embedded within mortise and tenon joinery resonate deeply with traditional Chinese values such as harmony, balance, respect for nature, and an appreciation for the inherent beauty of materials. This section explores the cultural and philosophical meanings behind mortise and tenon craftsmanship, highlighting themes of yin-yang balance, the harmony between humans and nature, the aesthetic of natural materials, and the ingenuity of Chinese craftsmanship.

(1) Yin-Yang Balance: Unity in Duality

In traditional Chinese philosophy, the concept of yin-yang represents the balance of opposing yet complementary forces. Mortise and tenon joinery is a

⁶¹ "Ancient mortise and tenon joints" and "prefabricated" are similar in nature! . (n.d.). <http://m.precast.com.cn/index.php/Home/Zl/ct/id/13861>

physical manifestation of this principle, as it requires the precise interlocking of two parts—the mortise (a hole or recess) and the tenon (a protruding piece)—to create a stable, unified structure. The mortise, often seen as the “yin” component, embodies receptiveness and stability, while the tenon, or “yang,” symbolizes activity and support. Together, they form a balanced whole that is stronger and more resilient than either part alone.

This interplay between yin and yang within mortise and tenon structures highlights the principle of interdependence, emphasizing that opposing forces are not only compatible but essential to each other’s existence. This philosophical balance teaches us about the value of cooperation and the importance of finding harmony within diversity. It reflects a broader worldview that values moderation, interconnection, and harmony, providing a symbolic foundation for the design and construction of structures that respect and embody balance.

(2) Harmony Between Humans and Nature

Chinese culture places great emphasis on the harmonious relationship between humans and the natural world. Mortise and tenon joinery, with its reliance on natural materials and its focus on seamless connections, aligns perfectly with this value. Traditional Chinese carpentry respects the integrity and natural form of the wood, allowing its qualities to shine rather than attempting to overpower or alter it. By working with the grain and natural characteristics of each piece, mortise and tenon structures honor the unique properties of the material and integrate it into a harmonious whole.

In this way, mortise and tenon joinery exemplifies the Daoist view of wuwei, or “effortless action,” where one works in accordance with the natural world rather than imposing human will upon it. This respect for nature’s rhythm and flow, embodied in every mortise and tenon structure, reflects a broader cultural belief that humans should live in balance with the environment. Through mortise and tenon joinery, we learn to value sustainability, resourcefulness, and humility—qualities that are essential for living in harmony with the natural world.

Joseph Needham, the renowned British sinologist, once remarked, “No other regional culture is so enthusiastic about the great ideological principle that ‘man cannot live without nature’ as the Chinese.” This observation highlights the unique reverence for nature that underpins Chinese thought, where harmony between humans and nature is deeply ingrained in philosophy, culture, and practices. In

contrast, Western perspectives on nature often center on the idea of dominion and control, viewing nature as a resource to be utilized for human progress. These differing perspectives on nature have shaped Eastern and Western approaches to design, craft, and resource use. In particular, the Eastern view of harmony with nature aligns closely with the green design concept of mortise and tenon joinery, a technique that minimizes waste, respects natural materials, and embodies sustainability.

This section explores the contrasting worldviews of the East and the West concerning nature, focusing on how Eastern philosophies of harmony with nature have influenced sustainable design practices in mortise and tenon joinery. This approach to craftsmanship underscores a design ethos that values natural materials, respects ecological balance, and promotes sustainability.

(3) The Beauty of Materials: Celebrating Natural Aesthetics

Mortise and tenon craftsmanship celebrates the inherent beauty of natural materials, particularly wood, which is valued in Chinese culture for its warmth, character, and connection to nature. Unlike construction techniques that rely on paint or decoration to conceal materials, mortise and tenon joinery showcases the grain, color, and texture of wood in its natural state. This appreciation for the material itself is a significant aspect of Chinese aesthetics, which values simplicity and authenticity.

The beauty of mortise and tenon structures lies in their unadorned elegance and organic appeal. The natural grain of the wood becomes an integral part of the design, creating patterns that are unique to each piece. This aesthetic approach aligns with the principle of “returning to the essence” (返璞归真), an appreciation for simplicity and the authentic beauty found in nature. By celebrating the material’s intrinsic beauty, mortise and tenon craftsmanship honors the uniqueness of each piece of wood and its role within the larger structure.

(4) Ingenious Craftsmanship: The Art of Precision and Innovation

One of the most remarkable aspects of mortise and tenon joinery is the sheer ingenuity required to create structures that are both functional and beautiful. This craftsmanship requires a high level of skill, precision, and understanding of the materials. Each joint must be carefully measured and executed to fit seamlessly,

requiring a profound understanding of geometry, wood behavior, and structural principles.

This meticulous craftsmanship reflects the Chinese cultural ideal of *gong* (工), which represents skill, dedication, and excellence in craft. Mortise and tenon structures are a testament to the ingenuity of Chinese artisans who, through centuries of practice, developed sophisticated joinery techniques to achieve both stability and aesthetic harmony. These techniques, perfected over generations, exemplify the spirit of craftsmanship and creativity that lies at the heart of Chinese cultural heritage.

The skillful design of mortise and tenon structures also reflects the value of craftsmanship as an evolving form of knowledge. Chinese carpenters were not only practitioners but also innovators, refining and expanding upon traditional techniques over time. This respect for skill and creativity as an evolving practice highlights the dynamic nature of Chinese craftsmanship, where innovation is guided by tradition, and tradition is enriched by continuous improvement.

(5) The View of Creation: Transcendence through Craft

In traditional Chinese culture, the process of creation is seen as a journey that brings an artisan closer to nature and self-understanding. Mortise and tenon joinery, with its reliance on simple yet effective design principles, encourages a meditative approach to craftsmanship, where the act of creation becomes an expression of the artisan's dedication, patience, and respect for the natural world. This view aligns with Confucian and Daoist ideals, which emphasize self-cultivation, humility, and harmony in all aspects of life.

Creating a mortise and tenon structure requires an understanding of the wood's natural tendencies and an ability to foresee how different parts will interact over time. This act of creation requires not only technical skill but also a philosophical mindset that values adaptability and resilience.

Eastern and Western Perspectives on Nature

The Eastern and Western views of nature have evolved differently, largely influenced by distinct philosophical and religious traditions.

The Western View: Dominance and Utilization of Nature. Western perspectives on nature have often been influenced by Judeo-Christian beliefs, which

suggest that humans are distinct from and have dominion over nature. Rooted in the biblical idea that humans were given stewardship over the Earth, this worldview has historically promoted the idea that nature exists primarily to serve human needs. With the Enlightenment came a further emphasis on science and reason, leading to advancements in technology and industry that allowed humans to reshape their environment extensively.

Consequently, Western industrial development has largely viewed nature as a resource to be controlled, harnessed, and transformed to meet human desires. This perspective has led to incredible innovations and growth, but it has also resulted in a disregard for ecological impacts, environmental degradation, and resource depletion. The industrial focus on efficiency and mass production often comes at the cost of environmental health and sustainability.

The Eastern View: Harmony and Coexistence with Nature. In contrast, Eastern traditions—particularly Confucianism, Daoism, and Buddhism—promote a worldview where humans are an integral part of nature. These philosophies advocate for a harmonious relationship between humans and the natural world, encouraging respect, balance, and coexistence. Daoism emphasizes following the natural way (Dao) and living in alignment with the rhythms of nature, while Confucianism encourages moderation, respect for natural cycles, and a balanced society that considers the well-being of both people and the environment. Buddhism adds to this view with its teachings on interconnectedness, compassion, and non-harm, encouraging individuals to live with minimal impact on other beings and the environment.

These philosophies encourage a holistic view that sees humans as part of a larger ecosystem, where maintaining balance is essential for long-term well-being. Rather than seeking to dominate or exploit nature, Eastern thought values living in harmony with it, respecting natural processes, and recognizing that human well-being is directly tied to environmental health. This approach results in practices and lifestyles that prioritize sustainability, resourcefulness, and ecological balance.

Harmony with Nature in Mortise and Tenon Joinery

The philosophy of harmony between humans and nature has profoundly influenced Chinese craftsmanship, especially in the art of mortise and tenon joinery. This woodworking technique exemplifies sustainable and eco-friendly design principles, as it respects natural materials and utilizes them with minimal waste or

alteration. The mortise and tenon joint, by interlocking two pieces of wood without nails, screws, or adhesives, relies solely on the inherent properties of the material. This approach aligns with the Eastern view of harmony, as it embraces the natural qualities of wood and respects its structure, grain, and resilience.

Mortise and tenon joinery embodies several green design principles rooted in Eastern thought:

Minimal Environmental Impact: Traditional mortise and tenon joinery involves only wood and does not require any synthetic or non-biodegradable materials, which can harm the environment. Unlike other construction methods that rely on nails or adhesives—materials that often have a high environmental cost—mortise and tenon joints use only natural materials, which are renewable and biodegradable. This minimalistic approach aligns with the Daoist philosophy of *wu wei* (无为), or “effortless action,” which encourages using resources in their natural form and minimizing unnecessary interventions.

Resource Efficiency and Waste Reduction: Mortise and tenon joinery requires a careful selection of materials, ensuring that each piece of wood is used optimally and waste is minimized. This attention to resource efficiency reflects the Eastern value of moderation (中庸), which is central to Confucian teachings. The technique itself is highly resource-efficient, as it relies on precisely crafted joints rather than external fasteners. This method demonstrates respect for the wood’s natural form and is a practical application of the Eastern ethos of making the best use of available resources.

Respect for Natural Materials: In mortise and tenon joinery, artisans work with the wood’s natural grain and characteristics rather than forcing it into shapes that go against its structure. This respectful approach celebrates the material’s intrinsic qualities, mirroring the Daoist principle of embracing nature’s inherent beauty. The wood’s natural grain, color, and texture are central to the aesthetic of mortise and tenon designs, showcasing the wood in its purest form. This reflects an Eastern aesthetic that values simplicity, authenticity, and an appreciation for natural beauty.

Longevity and Durability: Mortise and tenon structures are known for their durability, often lasting for generations. This emphasis on longevity is central to sustainable design, as it reduces the need for replacements and conserves resources over time. Eastern cultures have historically valued durability and continuity, seeing them as integral to the harmony between humans and their environment. The

creation of structures that endure aligns with the belief in sustaining resources for future generations, a principle echoed in both Confucian and Daoist thought.

The Influence of Eastern Philosophies on Sustainable Design

The Eastern view of harmony with nature continues to shape sustainable design practices today. As the world faces pressing environmental challenges, the Eastern approach to living in balance with nature offers valuable insights. By treating nature as a partner rather than a resource to be controlled, this philosophy encourages design principles that respect natural limits, emphasize resource efficiency, and minimize environmental impact. Mortise and tenon joinery is an embodiment of this perspective, as it demonstrates that sustainable design is possible when human ingenuity works in alignment with natural processes.

In recent years, the resurgence of interest in green design and sustainable architecture has led to a renewed appreciation for traditional practices like mortise and tenon joinery. The Eastern philosophies of harmony, balance, and respect for nature that underlie this technique resonate with modern efforts to create eco-friendly designs that reduce carbon footprints and preserve ecosystems. The mortise and tenon joint, which requires minimal environmental resources and yields enduring structures, is a fitting example of how ancient wisdom can inform contemporary sustainability practices.

Mortise and Tenon as a Model for Modern Green Design

In the context of green design, mortise and tenon joinery serves as a model for sustainable practices in several ways:

Biodegradability and Minimalism: The use of all-wood components in mortise and tenon joinery ensures that structures are biodegradable and can return to the earth at the end of their life cycle. This contrasts with modern construction materials that often contribute to pollution and waste. The technique's minimalistic nature, relying on natural interlocking instead of external hardware, further highlights its environmental benefits.

Inspiration for Sustainable Architecture: As sustainable architecture gains momentum worldwide, mortise and tenon joinery offers inspiration for creating buildings that are eco-friendly, durable, and aesthetically pleasing. This technique, with its emphasis on natural materials and long-term durability, provides a blueprint for building methods that honor ecological principles while meeting human needs.

Cultural Relevance and Ecological Wisdom: Mortise and tenon craftsmanship embodies the ecological wisdom of Eastern culture, showing that traditional techniques can be relevant in addressing modern environmental challenges. By drawing on these cultural values, designers today can create products and structures that are not only functional but also meaningful, reinforcing a worldview that values both nature and heritage.

The mortise and tenon joinery technique exemplifies the principles of Eastern philosophy, particularly the harmonious relationship between humans and nature. This method's green design aspects—minimal resource use, respect for natural materials, durability, and biodegradability—demonstrate how an ancient craft can serve as a model for sustainable practices today. By embracing the Eastern values of harmony, respect, and balance, mortise and tenon joinery showcases the enduring wisdom of traditional practices and their potential to inspire sustainable solutions in the modern world.



Figure 2.13 Mortise and Tenon Types⁶²

The advantages of mortise and tenon construction are also more obvious compared with the fixing of metal components such as iron nails and screws in modern society:

① If iron nails or screws are used to fix the wooden materials, this way is difficult to ensure the stability of wooden buildings. Once affected by external forces, it will sway and fall apart. If you encounter high-end wood, such as rosewood and huanghuali, the texture of this kind of wood are relatively hard, the use of nails and screws and other metal components for fixing, it is easy to lead to wood cracking. Tongue and groove construction uses a unique concave and convex

⁶² 33 dynamic diagrams of mortise and tenon structures worth appreciating and collecting 1. (n.d.). http://www.3223.net/article/5110_74.html

fixing method to form a resilient frame. Not only can it withstand large loads, but it also allows for a certain amount of deformation.

② With changes in external temperature and humidity, wood materials will expand and contract thermally. Metal components such as nails and screws in the joints of wood are prone to loosening, and with the passage of time will automatically fall off, resulting in the instability of the building. Tongue and groove and wood construction belongs to the same material connection, will tend to be consistent with the thermal expansion and contraction of wood materials, the overall structure and subsequently more solid.

③ Wooden buildings made of metal components such as nails and screws are slightly more troublesome when it comes to dismantling and maintenance, and are not as convenient as mortise and tenon construction. The components connected by mortise-and-tenon joinery can be disassembled and assembled well thanks to the natural way of joining. This disassembly and assembly of parts greatly improves the efficiency of replacement and transport.

Mortise and tenon influenced the architectural design of various countries: Mortise and tenon was not only used in China's own architecture, but also influenced the architectural design of other countries. We can see that in China's neighbouring countries, mortise and tenon construction has also appeared in ancient architecture. Japan and China had a very close relationship in ancient times, and because of their admiration for Chinese culture, Japan often sent delegations to visit and study. The Tang Zhouti Temple in Nara City, Japan, was built under the auspices of the Tang Dynasty monk, Master Jianzhen, after he travelled east to Japan to spread his teachings. The temple highly reflects the techniques and styles of ancient Chinese wooden architecture, and the mortise and tenon structure of the building was influenced by traditional Chinese architecture.

Earthquake resistance

Yingxian Wooden Pagoda (full name of Yingxian Buddha Palace Temple Sakyamuni Pagoda), an outstanding representative of Shanxi earthquake-resistant ancient buildings, is the earliest existing wooden pavilion-style high-rise building in China. It is also known as the French Eiffel Tower and the Italian Leaning Tower of Pisa. The "Three Great Towers of the World" have survived many "natural and man-made calamities" and still stand tall and stand up to this day, which can be called a legend.



Figure 2.14 Yingxian Wooden Pagoda⁶³

The dark layer design of the wooden tower is also very clever. Between every two layers there is a dark layer that actually acts as a solid structural layer. At the same time, in the process of reinforcement in the past dynasties, many chordwise and meridional diagonal braces were scientifically added in the dark layer to form a frame layer similar to modern times. This structural layer has good mechanical properties, which effectively improves the tower body's ability to resist bending, shearing and earthquakes, thus creating the extraordinary stability of the Shakyamuni.

2.3 Current Status and Challenges

The mortise and tenon craft, while deeply rooted in tradition, faces significant challenges in the modern era. Issues such as the decline in skilled artisans, the rise of mass production, and the need for modernization have impacted its preservation and practice.

2.3.1 Preservation Efforts and Education

(1) Analysis of socio-economic benefits

Analysis of the inheritance status of mortise and tenon crafts. The inheritance status of mortise and tenon craft presents a complex pattern of unity and opposition,

⁶³ Wikimedia Foundation. (2022, December 31). 应县木塔. Wikipedia, the free encyclopedia. <https://en.wikipedia.org/wiki/BF%94>

facing the challenge of traditional skills, but also containing valuable opportunities. The rapid development and modernisation of contemporary society has caused an unprecedented impact on traditional mortise and tenon craftsmanship in terms of production methods and design concepts. Large-scale industrialised and mechanised production continues to replace traditional handicrafts, the market's awareness of mortise and tenon construction has gradually faded, the number of craftsmen who have inherited the skills has plummeted, and the younger generation's interest in this exquisite skill has also decreased dramatically, leading to the endangerment of mortise and tenon craftsmanship. This situation not only threatens the continuation of traditional culture, but also puts the innovation and development of this art form in a difficult situation. However, mortise and tenon craftsmanship has also ushered in new opportunities nowadays, as the uniqueness and environmental friendliness of traditional craftsmanship is gradually being re-recognised with the deepening concern for sustainable development and eco-design. More and more designers and craftsmen are exploring the combination of mortise and tenon craft with modern design, and with the help of modern technology and materials, they are promoting the innovative development of traditional skills. In addition, with the enhancement of cultural self-confidence, more and more consumers are beginning to pay attention to the value of traditional culture, and are willing to pay a premium for products carrying traditional craftsmanship, thus providing a new market space for the revival and inheritance of mortise and tenon craftsmanship. The inheritance of mortise and tenon craft is facing challenges, but also obtaining opportunities for development that have never existed before. Society's interest in and re-cognition of traditional skills will ultimately give this ancient craft a new lease of life in the context of modern society.

Tongue and groove is a traditional craft in the production of wooden structures and furniture in ancient China. It is made by interlocking various shapes of tenons and mortises, which firmly connects the wooden parts together without the use of nails and glue. This craft not only reflects the superior skills of ancient Chinese craftsmen, but also contains rich cultural connotations and philosophical ideas.

However, with the development of modern industry and the introduction of western architectural and furniture design concepts, the inheritance of mortise and tenon craft is facing serious challenges. The following are some analyses of the current situation of the inheritance of mortise and tenon craft:

Decrease in the number of inheritors: With the reform of modern education system and the acceleration of industrialisation, there are fewer and fewer young

people willing to learn and pass on the mortise and tenon craft. Many craftsmen of the older generation are gradually withdrawing from the industry due to old age and infirmity or lack of inheritors.

Decline in craftsmanship: Due to the decrease in the number of inheritors, some young craftsmen may not be able to reach the level of the older generation of craftsmen in learning and practice, resulting in a decline in the level of craftsmanship.

Insufficient innovation: mortise and tenon craftsmanship lacks innovation in modern design and application, and many traditional crafts are shelved, failing to combine with modern design concepts, resulting in their limited application in modern architecture and furniture design.

Increased awareness of protection: In recent years, with the increased awareness of the protection of traditional culture, the government and civil organisations have begun to pay attention to the protection and inheritance of mortise and tenon joinery, and have attempted to attract more young people to learn and pass on the craft by organising training courses and setting up inheritance bases.

Insufficient market promotion: The products of mortise and tenon craft are insufficiently promoted in the market, and consumers do not have a high awareness of them, resulting in limited market demand and affecting the inheritance and development of the craft.

Support from the education system: In some education systems, mortise and tenon craft is included in the traditional craft curriculum, providing opportunities for interested students to learn and practice the craft, which helps to cultivate a new generation of inheritors.

In order to better pass on the mortise and tenon craft, it is necessary for the government, educational institutions, enterprises and the public to work together to increase the social awareness and market acceptance of mortise and tenon craft through a variety of means, such as innovative design, marketing, and education, so as to ensure that this traditional craft can be effectively preserved and passed on.

Impact of mortise and tenon craft on local economy. As an important part of traditional Chinese architecture and furniture design, the unique structural aesthetics and practical functions of mortise and tenon craft not only reflect the deep cultural heritage, but also inject new vitality into the development of the local

economy. The revival and innovation of mortise and tenon craft has promoted the modernisation of the traditional craft industry and opened up new paths for local economic growth. By attracting craft enthusiasts and tourists, mortise and tenon craft has become an important part of local cultural tourism, greatly promoting the development of related industries. The inheritance and development of handicrafts has upgraded the skills of local artisans, created a large number of employment opportunities, improved the living standards of local residents, and strengthened community cohesion. At the same time, mortise and tenon craft products have become more and more popular in the market due to their uniqueness and the unique charm of handmade crafts, forming a unique mode of economic benefits. The sale of local handicrafts not only drives the development of related industrial chains, but also promotes people's recognition of and enthusiasm for traditional culture, forming a virtuous circle. With the market's emphasis on environmental protection and sustainable development, mortise and tenon craft, with its excellent characteristics of no nails and no glue, has gradually become an important choice in modern design and production, further expanding new areas of economic growth. The innovative design of mortise and tenon joinery not only passes on the cultural heritage, but also injects a continuous impetus to the sustainable development of the local economy.

The contribution of mortise and tenon craft to social employment. As a technique rich in traditional cultural connotations, the unique structural design of mortise and tenon joinery not only demonstrates exquisite craftsmanship in wood processing, but also creates a sustainable employment model at the socio-economic level. Through the inheritance and innovation of mortise and tenon craft, local industries have been revitalised, and the skills of workers have been upgraded and employment opportunities increased. Particularly in areas where traditional crafts are predominant, mortise and tenon crafts have attracted young people into learning and practising traditional crafts, thus creating an employment ecosystem centred on craftsmanship. The process of traditional mortise and tenon making often requires a high level of skill, which not only puts demands on the professional skills of the practitioners, but also cultivates a group of high-quality craftsmen for the local community. The revival and popularisation of such craftsmanship can effectively drive the development of the surrounding industries, such as timber supply, design consultancy, marketing, etc., forming a benign interaction of the industrial chain, which in turn promotes the revitalisation of the regional economy. More importantly, the promotion of mortise and tenon craft helps to enhance people's sense of identity with traditional culture and strengthen social cohesion. The cultural and economic values behind the crafts are intertwined, making the traditional crafts take on new

vigour in the new era. In the process, mortise and tenon craft not only creates direct employment opportunities for the local community, but also injects new kinetic energy into the diversified development of society and promotes the realisation of sustainable development.

Cultural heritage benefits of mortise and tenon crafts. Mortise and tenon craft not only carries a profound history and culture, but also plays an indispensable role in regional economic development. In today's globalised context, mortise and tenon as an expression of traditional craftsmanship, with its unique structural aesthetics and craftsmanship techniques, has enabled this culture to take on a new lease of life in modern society. The development of local economy is closely related to the inheritance of mortise and tenon culture, and mortise and tenon is not only the construction of the material level, but also the link of the spiritual level. Through the innovative design of mortise and tenon craft, local enterprises can make use of this cultural symbol to create products with regional characteristics, which can attract the attention and recognition of domestic and foreign consumers and promote the prosperous development of local economy. The inheritance of mortise and tenon culture enables local brands to form a unique competitive advantage in the market, and the combination of traditional skills and modern business has become an important driving force for the transformation and upgrading of the local economy. In addition, the revival of mortise and tenon craftsmanship promotes the skills of local craftsmen and increases employment opportunities, strengthens community cohesion, promotes the development of cultural tourism, and enables more people to experience and learn mortise and tenon craftsmanship and feel the charm of traditional culture. Through the establishment of an ecosystem of mortise and tenon culture inheritance, all levels of the local economy can be linked to the development of culture and economy, forming a virtuous cycle that complements each other, and fully embodies the unique value of mortise and tenon craft design from the perspective of sustainable development. In this process, mortise and tenon craft is not only a continuation of the craft, but also a rich soil for the integration of economy and culture, promoting the local economy to create new possibilities in the inheritance.

The preservation of mortise and tenon techniques is challenged by the decline in skilled artisans and the modernization of construction practices. However, efforts are underway to revitalize this heritage through educational programs, apprenticeships, and government initiatives that promote traditional craftsmanship as a cultural asset. Additionally, international collaborations have spurred interest

in mortise and tenon, allowing the technique to be recognized as an intangible cultural heritage .

(2) Prospects for Practical Application and Market Promotion

Analysis of Handicraft Market Demand. In today's society, the handmade market shows an extensive and continuous growth trend, reflecting people's strong demand for personalisation and uniqueness. With the improvement of living standard and the change of consumption concept, more and more consumers start to pursue handicrafts with cultural connotation and artistic value. This is not only a reflection on material consumption, but also the pursuit of emotional and spiritual level. The uniqueness and unrepeatability inherent in handmade products make them unique among mass-produced goods, attracting many consumers in pursuit of unique life experiences. At the same time, handmade products often carry the inheritance and innovation of traditional culture, which can arouse people's concern and love for traditional crafts and promote the revival and inheritance of traditional culture. In the market, the variety of handmade products is extremely rich, covering a wide range of fields from delicate furniture to unique decorations, and this diversity provides the market with a broad space for development. The rapid rise of e-commerce platforms and social media has provided handmade artists and creators with more convenient display and trading channels, enabling handmade products to quickly reach their target consumers, and further boosting the expansion and activation of the market. Against the backdrop of growing environmental awareness, consumer demand for sustainable products is also on the rise, and handmade products are increasingly favoured due to their use of natural materials and environmentally friendly concepts. This combination of factors has resulted in an extensive and growing market for handmade products, which will undoubtedly grow even more promising in the future.

Digital Marketing Strategy Suggestions, As an important means of communication in today's era, digital marketing shows unprecedented broad prospects, especially in the promotion of traditional craft mortise and tenon with unique advantages. Through the digital platform, the beauty and cultural connotation of crafts can be presented in a vivid and intuitive form, attracting a wider audience. The rise of social media has made the dissemination of traditional crafts not only limited to geographical constraints, but also more focused on cultural resonance and emotional resonance. The combination of graphics, video and interactive experience can effectively enhance consumers' knowledge of and interest in mortise and tenon technology, break consumers' stereotypical impression

of traditional craftsmanship, inject modern design elements into it, and stimulate potential market demand. The booming development of e-commerce platforms has facilitated the marketisation of mortise and tenon craftsmanship. With the help of accurate market analysis and big data support, it is possible to deeply understand consumer preferences and formulate more targeted marketing strategies. At the same time, the combination of digital marketing techniques, such as search engine optimisation, content marketing and influencer partnerships, can broaden brand exposure and increase consumers' willingness to buy. Cultivating a loyal customer base is also an essential part of this process. Through membership and online community building, it enhances consumers' sense of engagement and belonging, which in turn creates good word-of-mouth and drives sales growth. Ultimately, digital marketing provides a broad stage for the revival and development of traditional craftsmanship, demonstrating endless possibilities and innovative potential, and helping the mortise and tenon technique to take on new life and vitality in the modern market environment.

Consideration of Sustainable Development Paths. As a traditional way of connecting wooden structures, the application of mortise and tenon joinery in contemporary design is not only related to the inheritance of the craft, but also involves the profound consideration of sustainable development. Firstly, in the use of materials, mortise and tenon craft advocates the selection of renewable high-quality wood, a choice that not only effectively reduces the burden on the environment, but also achieves an ecological balance in the process of growing and extracting wood. The use of local resources and the reduction of carbon emissions during transport are also important directions for the future development of mortise and tenon craftsmanship. Secondly, the uniqueness of mortise and tenon construction gives it a significant advantage in terms of dismantling and reorganisation, a characteristic that offers the possibility of a circular economy. Through the innovative design of traditional mortise and tenon joinery, the reuse of components can be realised, reducing the waste of materials and providing a solid foundation for subsequent sustainable construction. At the same time, technological advances provide new opportunities to modernise mortise and tenon craft, and the combination of digital design and manufacturing technologies will make traditional crafts more compatible with modern lifestyles. Finally, fostering public awareness and appreciation of mortise and tenon craftsmanship and its concept of sustainable development will promote its acceptance and application in the modern market. Through multi-faceted efforts and exploration, mortise and tenon craft can not only survive in traditional culture, but also take on new life in the new era of sustainable development.

(3) Preservation Efforts and Education

Declared by the Architecture Research Institute of the Chinese Academy of Arts was selected as the UNESCO Intangible Cultural Heritage of Humanity, which mentioned the mortise and tenon technique.

Preserving traditional mortise and tenon craftsmanship requires a comprehensive approach that combines documentation, education, and skill transmission across generations. As globalization and mass production methods have led to a decline in traditional craftsmanship, organized preservation efforts are essential to protect and revitalize these culturally significant techniques. Mortise and tenon joinery, with its long-standing history and deep cultural roots, represents a valuable part of intangible cultural heritage. Preservation efforts therefore focus not only on conserving physical artifacts but also on maintaining the skills, knowledge, and cultural meanings associated with this craft.

Educational programs play a pivotal role in these preservation efforts by providing opportunities for individuals to learn, practice, and pass on mortise and tenon techniques. Schools of traditional arts and crafts, vocational training centers, and universities can offer specialized courses and workshops that teach mortise and tenon joinery as part of a broader curriculum on sustainable design and cultural heritage. Such programs not only cultivate craftsmanship skills but also raise awareness of the ecological and cultural values inherent in traditional construction methods. By emphasizing these aspects, educational institutions help foster a deeper appreciation for mortise and tenon joinery, encouraging students and designers to incorporate it into modern applications.

In addition to formal education, community-based initiatives and apprenticeship programs are instrumental in preserving mortise and tenon craftsmanship. Local artisans and master craftsmen are often the custodians of traditional knowledge, possessing skills that have been passed down through generations. By creating apprenticeship opportunities where younger artisans can work directly with experienced masters, communities can ensure that the techniques, nuances, and values of mortise and tenon joinery are preserved. Furthermore, these apprenticeships help strengthen local economies by creating sustainable livelihoods that honor and uphold cultural heritage.

The digital preservation of mortise and tenon craftsmanship is another important component of educational and preservation efforts. High-resolution 3D

scanning, virtual modeling, and online repositories allow for the documentation of joint types, structural variations, and construction techniques. These digital archives serve as valuable resources for both scholars and practitioners, making mortise and tenon joinery accessible to a global audience. Virtual platforms and online courses expand the reach of educational programs, enabling enthusiasts and professionals from various fields to learn and appreciate the craft, regardless of geographic limitations.

Together, these preservation and educational efforts support the survival and evolution of mortise and tenon joinery. By integrating this traditional craft into both formal and informal education, these initiatives ensure that it remains relevant, adaptable, and valued within modern design contexts. Preservation through education thus reinforces the cultural importance of mortise and tenon joinery, while promoting its ecological and aesthetic benefits in a way that resonates with contemporary sustainable practices.

The 1907 issue of *Scientific American* on "The Mortise and Tenon Joint" provides some insight into the spread of knowledge about these joints among educated people in the United States in the early 20th century.⁶⁴

With the high development of modern society, the appearance of the world and the way of life are changing rapidly. In particular, the process of globalization and urbanization not only improves people's overall quality of life, but also destroys many beneficial traditional cultures, certain productions and lifestyles in line with sustainable development.



⁶⁴ Mortise and tenon joints. (1907). *Scientific American*, 96(10), 186.

Figure 2.15 Inheritance Activities of Mortise and Tenon⁶⁵

2.3.2 Challenges in Modernization and Mass Production

The adaptation of traditional mortise and tenon joinery to modern manufacturing processes presents several challenges. While this ancient technique offers exceptional structural integrity, environmental benefits, and cultural significance, its labor-intensive nature and reliance on skilled craftsmanship often conflict with the demands of contemporary mass production. In an era where speed, cost-effectiveness, and scalability are prioritized, mortise and tenon joinery faces multiple barriers to widespread use in industrialized settings.

Labor intensity and skill requirements. One of the primary challenges is the high level of skill required to create mortise and tenon joints with precision. Traditional joinery is typically performed by skilled artisans who have mastered the technique through years of practice, carefully hand-cutting each joint to ensure an exact fit. This skill-intensive process is time-consuming and difficult to replicate on a large scale, limiting the feasibility of mortise and tenon in fast-paced production environments where unskilled or semi-skilled labor is often the norm. Training workers to the necessary level of expertise would require significant investment in both time and resources, which many manufacturers are unwilling or unable to make.

Adaptability to machine production. Another challenge lies in the limited compatibility of mortise and tenon joinery with automated machinery. Modern mass production relies heavily on computer numerical control (CNC) machines and other automated tools that are efficient in producing standardized components. However, traditional mortise and tenon joints are often customized to fit specific structural and aesthetic requirements, with subtle variations that machines struggle to replicate. Although CNC technology can be used to produce basic mortise and tenon joints, the nuanced adjustments needed for high-quality joinery can be challenging to program and execute on a mass scale.

Material limitations and waste reduction. Mass production also tends to emphasize materials and techniques that minimize waste and maximize profit, which can be challenging when working with mortise and tenon joinery. This technique often requires high-quality, solid wood to ensure durability and a secure

⁶⁵ Shanwei Municipal Bureau of Culture, Radio, Television, Tourism and Sports. (n.d.). *Where to go on May Day? Come to the museum to play with mortise and tenon joints.*
https://www.shanwei.gov.cn/swwgljtj/zhengwu/gsjwgk/fwgk/content/post_971148.html

fit between components. However, the high cost of such materials and their potential for waste in mass production processes may discourage manufacturers. The precision required for mortise and tenon joints can lead to a greater likelihood of material waste during assembly, as small errors in cutting or fitting can compromise the strength of the entire joint. In mass production, this risk of material loss may be unacceptable, as it reduces profitability.

Balancing tradition and innovation. Incorporating mortise and tenon joinery into modern designs without losing its traditional essence also poses a challenge. While there is demand for products that showcase cultural heritage and sustainable practices, modern consumers and manufacturers often seek designs that blend tradition with contemporary aesthetics. This dual expectation places pressure on designers to innovate mortise and tenon techniques to align with modern styles and consumer preferences, which can be at odds with the authenticity and historical integrity of the original method. Striking a balance between preserving traditional craftsmanship and meeting modern aesthetic standards requires careful adaptation, often necessitating collaboration between artisans, designers, and engineers.

Cost considerations. Finally, cost remains a significant barrier. The handcraftsmanship associated with mortise and tenon joinery often results in higher production costs, making it difficult for products featuring this technique to compete with mass-produced, low-cost alternatives. In a highly competitive market, where consumers are sensitive to price, the higher expense associated with mortise and tenon joinery can limit its appeal and accessibility, particularly in mainstream markets.

The contemporary application of mortise and tenon face hurdles, such as limited adaptability to mass production and a shrinking pool of craftsmen. The rise of prefabricated materials and automated construction methods further diminishes the perceived utility of traditional joinery. Moreover, economic pressures limit artisans' ability to sustain a living from mortise and tenon craftsmanship, which requires extensive training and hands-on practice. Addressing these issues calls for integrating mortise and tenon into modern design practices and exploring new markets that value heritage and sustainability.

Despite these challenges, there is potential for adaptation through hybrid approaches that combine traditional craftsmanship with modern technology. By exploring options such as digital modeling, CNC machining for basic joint cutting, and modular designs that retain the essence of mortise and tenon, it may be possible

to bring this time-honored technique into the realm of modern production. Overcoming these barriers requires a balanced approach that honors the craft's heritage while adapting it to the practicalities of today's manufacturing landscape.

Recognition of mortise and tenon craft in modern society. As an outstanding representative of traditional Chinese craftsmanship, mortise and tenon craft carries a deep cultural heritage and historical memory. In modern society, mortise and tenon craft is not only regarded as a unique joining technique for construction and furniture, but also given a richer cultural symbolism. With the development of society and the progress of science and technology, the recognition of mortise and tenon craft has gradually changed from the purely practical to the deep excavation of its cultural value and aesthetic characteristics. Modern people in the increasingly fast-paced life, more and more yearning for traditional craftsmanship conveyed by the spirit of craftsmanship and humanistic care, mortise and tenon as a kind of non-nail connection technology, embodies the concept of harmonious coexistence of man and nature, reflecting the ancient wisdom of the Chinese profound and serene. At the same time, the inheritance and innovation of mortise and tenon craftsmanship has also found a new lease of life in contemporary design, and has become a model for modern designers to integrate tradition and modernity. Whether in home design, artwork creation, or cultural heritage activities, mortise and tenon craftsmanship has always been regarded as a precious heritage, inspiring reverence and love for traditional culture. This heightened awareness has not only fuelled the renaissance of mortise and tenon craftsmanship, but has also contributed to its renewed vitality in contemporary society, serving as an important bridge between the past and the future. It is this renewed understanding of mortise and tenon craftsmanship that highlights the value and pursuit of traditional skills in modern society, enabling it to maintain its unique cultural identity and charm in the midst of globalisation.

Challenges to the inheritance of mortise and tenon craftsmanship. As the essence of traditional woodworking techniques, the inheritance of mortise and tenon craft faces many challenges. With the accelerated process of modernisation, the living space of traditional crafts is shrinking, and the learning and practice of mortise and tenon skills are gradually replaced by simplified mechanised production. The break in the transmission of technology has made it difficult to reproduce the delicacy and beauty of this ancient craft. The lack of awareness and interest in traditional culture among the younger generation has led to a shortage of craftsmen, making this art form increasingly isolated in modern society. Changes in market demand have also caused mortise and tenon craft to face the dilemma of lack of adaptability. Consumers' preference for fast and convenient products has

forced traditional craft to give way to fast-moving consumer goods, which not only affects the inheritance of the craft, but also subconsciously weakens the sense of identity of people with traditional culture. At the same time, under the wave of information technology and globalisation, the uniqueness and regionality of traditional craftsmanship has been diluted, and the phenomenon of market-oriented homogenisation is endless, endangering the unique value of mortise and tenon craftsmanship. In the face of such multiple challenges, the inheritance of mortise and tenon craft is in need of new thinking and innovation, and through the fusion of modern design concepts with traditional skills, new ways of living can be found, so that this precious cultural heritage can blossom into a new vitality in contemporary society.

(2) Modern Challenges of Mortise and Tenon Craft

Analysis of the current situation of traditional craftsmanship. As the crystallisation of Chinese wisdom, traditional mortise and tenon craft carries rich cultural connotations and historical inheritance, but in modern society, it is facing unprecedented challenges. The acceleration of industrialisation has led to the rapid occupation of the market by mechanised production, and the standardisation and mass production mode has gradually replaced the handmade mortise and tenon technology, which not only leads to the gradual fading out of the traditional craft, but also makes its unique cultural values and aesthetic concepts subject to impact. The aesthetics of modern consumers tend to be simple and fast, giving rise to a large number of furniture products that are mainly finished quickly, and the complexity and refinement of mortise and tenon craftsmanship have gradually been neglected, and the original deep cultural connotations and craftsmanship charms appear to be more and more scarce. In addition, the number of craftsmen who have inherited the skills has been sharply reduced, and the younger generation is not sufficiently concerned about traditional handicrafts, resulting in this precious cultural heritage facing the crisis of loss. At the same time, the rapid development of science and technology has provided new possibilities for the innovation of traditional crafts, digital design and intelligent manufacturing can promote the regeneration and development of mortise and tenon joinery to a certain extent, but how to organically combine the traditional with the modern is still a problem that needs to be solved. Facing the challenges of modernisation, mortise and tenon craft not only needs to seek breakthroughs in technology, but also to re-examine its own cultural positioning and market demand, in order to seek new paths to adapt to the development of the times, and only in this way can it be revitalised in contemporary society.

Dilemma of mortise and tenon craftsmanship. In the context of today's rapidly developing society, traditional mortise and tenon craftsmanship is facing unprecedented difficulties. On the one hand, the introduction of modern production technology has made standardisation and batch production the new normal in manufacturing, and mechanised assembly lines have replaced the previous production methods that relied on manual skills. Although this shift has improved production efficiency, it has also led to the loss of the essence of traditional mortise and tenon craftsmanship, and it is difficult to inherit and promote the craftsmanship of craftsmen in the cold machinery. On the other hand, the trend of diversification and personalisation of market demand is becoming more and more obvious, and the design requirements of consumers for furniture and other wooden products are constantly rising. Traditional mortise and tenon craftsmanship, with its unique aesthetic value and cultural connotation, still has its irreplaceable position, but in a time when functionality and convenience are becoming the key competitive factors, the complexity of mortise and tenon structure and the continuity of the production time have undoubtedly become a hidden worry for its survival in the market. In the face of these dual challenges, traditional mortise and tenon craftsmanship urgently needs to seek an effective path of innovation and change in order to find a new foothold in the modern design and consumer environment. How to effectively combine this classic technique with modern design concepts, maintaining the unique charm of traditional craftsmanship while meeting the actual needs of the modern market, will be the key to the future development of mortise and tenon craft.

Mortise and tenon joinery, an ancient and subtle wood construction technique, is facing an unprecedented dilemma in the wave of modernisation. Modern production technology, with its efficiency and precision, has swept through almost all areas of manufacturing. The rapid development of automated equipment and CNC technology has made mass production possible, yet this mechanised and standardised mode of production contrasts sharply with the manual finesse and dexterity required for mortise and tenon craft. The intricacies of mortise and tenon and the fine details of the craft are often difficult to replicate in the presence of mechanical equipment, making them clumsy and costly to produce on modern production lines.

Changes in market demand have also put traditional mortise and tenon to the test. Consumers tend to pursue fashionable, fast-changing products, while the production cycle and cost of mortise and tenon furniture is more expensive compared to modern furniture, which makes it less advantageous in terms of price and market share. Diversification of design styles and personalised requirements

continue to rise, the traditional mortise and tenon due to the inherent limitations of the process, in the form of innovation seems to be stretched, unable to respond quickly to the market trend. The diversification of materials and the rise of environmental awareness have forced the mortise and tenon craft to face new constraints in the selection of wood, and the traditional process of relying on specific wood has been forced to adjust, thus raising questions about its sustainability.

This predicament is exacerbated by a breakdown in the transmission of skills. The lack of young craftspeople and the difficulty of learning traditional skills have resulted in fewer and fewer people being able to master mortise and tenon, and the craft has been challenged to pass on and innovate, making it less and less relevant in the modern world. The survival and development of mortise and tenon craft in the modern environment urgently needs to find a new balance between craftsmanship and technology, tradition and innovation, in order to meet the challenges of the times.

Modern Design Needs. In today's society, the diversity and complexity of design needs continue to increase, and traditional mortise and tenon craftsmanship is facing unprecedented challenges. Modern consumers are no longer satisfied with single-function furniture or handicrafts, they are more in pursuit of personalised, environmentally friendly and intelligent product experiences, and this shift in demand has forced practitioners of traditional craftsmanship to engage in profound reflection and innovation. From the selection of materials to the design of structures, traditional mortise and tenon craft can play a unique charm in modern design, but how to integrate it into the modern aesthetic and practical needs has become an urgent task. The wide application of new materials and the introduction of advanced technology provide a wealth of possibilities for the modernisation of mortise and tenon joinery, which can meet the functional needs of modern life while maintaining its cultural value and artistry. Designers need to draw inspiration from traditional techniques and combine them with modern design concepts to create works that are both historically inherited and aesthetically pleasing. At the same time, the market's emphasis on sustainable development has led to the need for mortise and tenon craftsmanship to be green in terms of materials and processes. This process is not only a challenge to traditional craftsmanship, but also a requirement for regeneration and innovation, pushing traditional mortise and tenon craftsmanship to take on a new lease of life in the modern world. In this context, the innovative design of mortise and tenon craft is precisely the construction of that profound and

beautiful bridge between tradition and modernity, becoming a positive response to the design needs of the new era.

Technological and material innovation. The traditional mortise and tenon craft, as an important part of wood-frame construction and furniture making in ancient China, embodies the ancient people's deep understanding of structural mechanics and material properties. However, with the increasing pursuit of functionality, aesthetics and durability in modern society, mortise and tenon craft is facing unprecedented challenges. The limitations of traditional mortise and tenon joinery are becoming more and more apparent as the rapid development of technology has led to the emergence of new materials and processing techniques. The diversification of modern wood choices and the rise of composite materials offer new possibilities for innovation in mortise and tenon craftsmanship. Through the in-depth study of material properties, it is possible to strengthen and optimise the mortise and tenon structure, and improve its adaptability and stability in modern applications. At the same time, the popularity of high-precision CNC machining technology makes the mortise and tenon production process can ensure the beauty of traditional craftsmanship on the basis of achieving higher precision and consistency, thus reducing the impact of human factors on the quality of mortise and tenon. In the face of the diversity of modern design concepts, mortise and tenon craftsmanship also needs to be innovated in design thinking, fusion of modern minimalist style and traditional aesthetics, so as to make it more fashionable and practical. Only in the dual innovation of technology and material, mortise and tenon craft can be renewed vitality, continue to serve as an important carrier of cultural heritage, integrated into the context of modern design. The future development of mortise and tenon is not only about the continuation of the craft itself, but also about the reinvention and sublimation of traditional culture in modern society.

Efficiency: The impact of modern large-scale machine mass production on traditional manual production.

Cost: The complex structure of mortise and tenon joints needs to be completed manually, and the production cost is high.

Inheritance: The decline of the traditional handicraft industry has reduced the number of practitioners, and it is difficult to pass on the craftsmanship and experience passed down from master to apprentice.

As a treasure in traditional Chinese architecture and furniture manufacturing, the mortise and tenon craft has gone through thousands of years of baptism. Now it is in the wave of change in modern society and faces a complex situation of coexistence of challenges and opportunities. The rapid development of social economy and the intensification of globalization have made the industrialized and standardized production mode increasingly dominant in modern architecture and furniture production, while the traditional mortise and tenon craft has gradually lost its competitiveness in the market due to its complexity and time-consuming hand-made production. However, it is in this context that the cultural value and ecological advantages of the mortise and tenon craft have attracted more and more attention. Based on natural materials, it does not require glue or nails to connect, which meets the needs of contemporary society for sustainable development and presents unique green and environmental protection characteristics. At the same time, with the improvement of cultural confidence and the enhancement of awareness of the protection of intangible cultural heritage, the mortise and tenon craft has shown new vitality in the field of cultural inheritance and innovative design. Through the combination of modern scientific and technological means and traditional skills, the mortise and tenon craft has continuously innovated in design and application. The rise of education and training institutions has provided a good platform for inheritance, and the cooperation between professional designers and craftsmen has made the mortise and tenon craft glow with new vitality in modern life. This ancient craft not only plays an important role in modern design, but also becomes an important representative of Chinese traditional culture in global cultural exchanges.

Chapter 3 Innovation Theory and Design Methodology

As the world faces increasing social, environmental, and cultural challenges, the role of design has evolved to encompass not only aesthetic and functional concerns but also broader societal impacts. This chapter explores the theoretical foundations and methodological approaches that shape contemporary design practices, with a particular focus on integrating innovation within traditional craft. By critically examining the relationship between innovation, sustainability, and social responsibility, this chapter provides a framework for understanding how

design can address pressing global issues while preserving cultural heritage. Together, these sections lay the groundwork for a design methodology that promotes innovation not as an isolated act but as a meaningful, responsible, and sustainable practice, deeply rooted in both tradition and forward-thinking principles.

3.1 Meaningful Innovation in Traditional Craft

According to the Innovation of Meaning approach, organizations envision scenarios to support the search for new meaning and to make people fall in love. This concerns a novel vision that redefines the problems worth addressing, proposing a new reason why people use something, a new value proposition, a new vision.

3.1.1 Design-Driven Innovation

(1) The Age of Design is Coming

The phrase “The age of design is coming” reflects an important shift in societal values that accompanies economic growth, as seen in Japan’s post-war period and now increasingly in China. In his book *Designing Design*⁶⁶, Kenya Hara references Konosuke Matsushita’s remark upon returning to Japan from a study tour of Western markets. Observing the evolution of consumer preferences and the role of design in the West, Matsushita, a forward-thinking leader, envisioned a future where design would hold a central place in economic and cultural life.

This statement underscores a milestone: design gains significance when society’s material needs are met, paving the way for an increased demand for aesthetics, functionality, and cultural expression. In Japan, this period marked a rapid rise in product design, merging traditional craftsmanship with industrial production, thereby enhancing quality and meeting large-scale demand.

China today finds itself at a similar turning point. With economic growth ensuring material sufficiency for much of its population, there is now a growing desire for products that not only fulfill functional needs but also satisfy a newfound cultural and aesthetic consciousness. This societal shift suggests that China is entering its own “age of design,” where public demand increasingly aligns with cultural, emotional, and spiritual enrichment. As China’s design industry integrates

⁶⁶ Hara, K., Hohle, M. K., & Yukiko, N. (2021). *Designing design*. Lars Müller Publishers.

with global trends, it will likely follow a trajectory similar to Japan's, positioning design as an essential factor in enhancing both quality of life and cultural identity.

This transition, as Matsushita observed for Japan decades ago, depends on a mature economy that can sustain and cultivate demand for high-quality, thoughtfully designed products—a threshold that China is rapidly approaching.

(2) The Era of "Design-Driven Innovation" is Coming

Design has undergone a paradigm shift from "creating style" to "driving innovation": on the one hand, the role, mission, methods and tools of design are undergoing tremendous changes, and the objects of design have expanded to relationship design, interaction design, service design, system design, organizational design, mechanism design, etc.; on the other hand, design has expanded from a link in the industrial chain and innovation chain to a contributor to the entire system and the entire process, and the era of "design-driven innovation" is coming.

Design-driven innovation, as proposed by Roberto Verganti, emphasizes reinterpreting the meaning of products and processes beyond traditional technological advancements. In the context of mortise and tenon, this approach allows the technique to transcend its historical function, aligning it with contemporary cultural, ecological, and social values. By adopting a design-driven perspective, mortise and tenon can be redefined to resonate with today's sustainability and cultural heritage needs, fostering a new appreciation for this traditional craft.

Design-driven innovation is a strategic approach that emphasizes transforming the meaning and perception of products through design, rather than merely improving functionality or efficiency. This concept, popularized by Roberto Verganti, encourages designers to look beyond conventional problem-solving to consider how a product can create new values, experiences, and cultural relevance. In the context of traditional crafts such as mortise and tenon joinery, design-driven innovation provides a pathway to revitalizing this ancient technique by redefining its role in contemporary design and construction. Design driven innovation, is the radical innovation of product meanings. This innovation doesn't emerge from current user needs, but is a new vision.

Reinterpreting Tradition Through Meaningful Design. Traditional mortise and tenon joinery, while celebrated for its functionality and durability, is often perceived

as a relic of the past. Design-driven innovation seeks to change this perception by highlighting the deeper cultural, ecological, and cultural aesthetic values embedded in the technique. By reinterpreting mortise and tenon joinery in modern design contexts—such as temporary architecture, circular furniture, and cultural creative products—designers can redefine its meaning. This approach enables mortise and tenon to be seen not only as a practical woodworking method but also as a symbol of sustainability, craftsmanship, and cultural heritage.

Creating New Values and Experiences. A core principle of design-driven innovation is the creation of new experiences that resonate with users on an emotional and cultural level. By applying this approach to mortise and tenon joinery, designers can transform it into a medium that offers unique user experiences. For example, a modular furniture piece that uses visible mortise and tenon joints can create a tactile and visual connection to traditional craftsmanship, offering users a tangible link to cultural heritage. Such design innovations allow users to appreciate the simplicity and beauty of mortise and tenon construction, fostering a sense of connection to both history and nature.

Aligning with Contemporary Sustainability Goals. In recent years, sustainability has become a major driver of design innovation. Mortise and tenon joinery naturally aligns with sustainable practices due to its minimal reliance on non-renewable resources like glue and metal fasteners. Through design-driven innovation, this technique can be reimaged to meet modern environmental standards and appeal to eco-conscious consumers. For example, mortise and tenon's disassemble nature lends itself well to circular economy principles, where products are designed for easy repair, reuse, and recycling. By incorporating mortise and tenon joinery into sustainable design frameworks, designers can communicate its ecological benefits, making it a compelling choice for responsible consumers.

Embracing Aesthetic and Cultural Significance. Design-driven innovation also recognizes the importance of aesthetic and cultural factors in product development. Mortise and tenon joinery holds significant cultural value in many regions, particularly in East Asia, where it is associated with heritage and craftsmanship. By integrating mortise and tenon joints into modern designs, designers can celebrate these cultural roots while offering products that fit seamlessly into contemporary aesthetics. For instance, in minimalist or eco-modern architecture, exposed mortise and tenon joints can enhance the visual appeal of a structure, showcasing both the material's natural qualities and the craftsmanship involved. This combination of

aesthetic and cultural appreciation elevates mortise and tenon joinery from a purely functional choice to a design element that enriches the user's experience.

Leveraging Design-Driven Innovation for Market Differentiation. In a competitive market, products that convey unique values and cultural narratives stand out. Mortise and tenon joinery, when applied with a design-driven approach, can differentiate products by adding a layer of authenticity and meaning that mass-produced items often lack. This approach is particularly valuable in the premium market segment, where consumers seek products that tell a story and reflect a commitment to quality and tradition. By using mortise and tenon joinery to convey sustainability, heritage, and craftsmanship, brands can position themselves as champions of cultural preservation and environmental responsibility, appealing to a growing demographic of conscientious consumers.

Encouraging Cross-Disciplinary Innovation. Finally, design-driven innovation promotes cross-disciplinary collaboration, drawing insights from fields such as cultural studies, sustainability science, and industrial design. When applied to mortise and tenon joinery, this approach encourages partnerships between artisans, designers, architects, and engineers, leading to innovative solutions that respect traditional craftsmanship while embracing modern technology. For instance, integrating digital tools like 3D modeling and CNC cutting can streamline the production of mortise and tenon joints, allowing designers to bring this traditional technique to new audiences in scalable, adaptable ways.

In summary, design-driven innovation provides a framework for breathing new life into mortise and tenon joinery by reimagining its cultural, aesthetic, and environmental relevance. By focusing on the meaning and experience behind the craft, this approach enables mortise and tenon joinery to remain a valuable, versatile technique in contemporary design, bridging the gap between ancient tradition and modern sustainability.

3.1.2 Verganti's Theory of Innovation of Meaning

Roberto Verganti's Meaningful Innovation theory represents a shift in how innovation is approached within design and product development. Unlike traditional innovation, which often focuses on technological advancements or incremental functional improvements, meaningful innovation emphasizes the creation of new meanings and emotional connections that resonate deeply with consumers. This form of innovation asks designers to redefine the intrinsic values and purpose of products, aiming to create designs that are not only functional but

also culturally, emotionally, and aesthetically relevant. By connecting with users on a deeper level, meaningful innovation fosters a sense of belonging, authenticity, and resonance, setting products apart in an increasingly fast-paced and competitive market.

Verganti argues that rather than pursuing consumer-driven trends, designers should seek to develop products that challenge existing perceptions and create new cultural meaning. This approach is especially relevant for products rooted in cultural heritage, as it allows for reinterpretation and modernization without compromising authenticity. In the context of mortise and tenon joinery, meaningful innovation provides a framework for redefining this ancient craftsmanship in ways that align with modern values such as sustainability, cultural preservation, and quality-driven consumption.

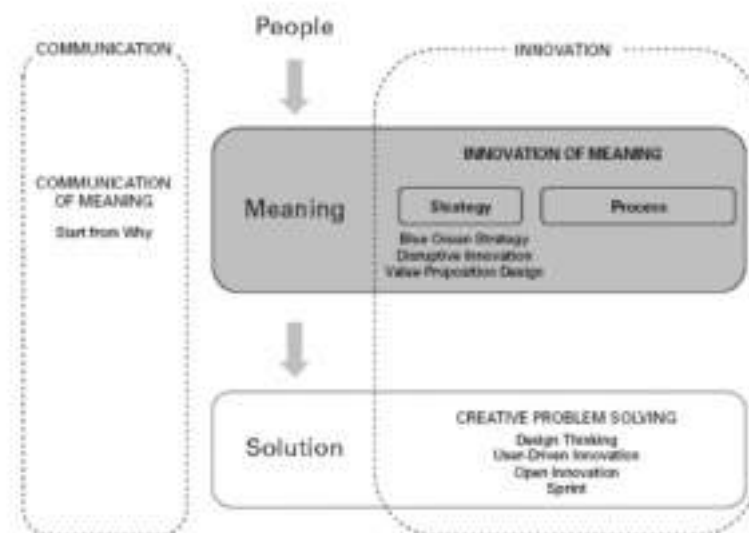


Figure 3.1 Meaningful Innovation⁶⁷

Roberto Verganti’s Theory of Innovation of Meaning posits that true innovation is not merely about improving the technical functionality of a product but about transforming its meaning to create a new, compelling narrative that resonates with users on a cultural and emotional level. According to Verganti, this approach to innovation involves a “design-driven” methodology, where companies and designers reframe how products are perceived, exploring ways to make them more culturally relevant and emotionally impactful. Applying this theory to

⁶⁷ Verganti, R. (2017). *Overcrowded: Designing meaningful products in a world awash with ideas*. The MIT Press.

traditional craftsmanship like mortise and tenon joinery reveals opportunities to redefine its role and significance in contemporary design and sustainable practices.

Redefining Meaning Beyond Functionality. Traditionally, mortise and tenon joinery has been valued for its functionality, durability, and efficiency. However, Verganti's theory encourages looking beyond these functional aspects to consider the deeper, symbolic meaning of the technique. Mortise and tenon joinery, with its roots in ancient cultures, embodies values such as craftsmanship, sustainability, and simplicity. By focusing on these meanings, designers can reposition mortise and tenon joinery as more than a structural method—it can be presented as a cultural symbol, a sustainable alternative to modern construction methods, and a testament to the resilience of traditional knowledge. This redefined meaning enables mortise and tenon to appeal to a contemporary audience that values authenticity, environmental responsibility, and cultural continuity.

Creating a New Narrative for Traditional Techniques. Verganti's theory highlights the importance of developing narratives that resonate with users' evolving values. In the case of mortise and tenon joinery, the narrative could emphasize its alignment with sustainable, minimalist lifestyles and its role in promoting cultural heritage. For instance, framing mortise and tenon as a “green” construction technique that minimizes the need for metal fasteners and adhesives not only highlights its environmental benefits but also appeals to eco-conscious consumers. Similarly, presenting mortise and tenon as a “living heritage” technique that connects modern design with ancient craftsmanship can create an emotional connection with users who value tradition. Through this narrative, mortise and tenon joinery can evolve from a historical technique to a symbol of sustainable, responsible design.

Aligning with Contemporary Cultural Shifts. Verganti's approach to innovation recognizes that meaning evolves alongside cultural shifts. As global concerns about environmental sustainability and resource scarcity increase, consumers are more receptive to products and practices that reflect eco-friendly principles. Mortise and tenon joinery, by its very nature, aligns with these contemporary values as it minimizes waste, uses natural materials, and supports a circular economy by enabling reuse and modular construction. By aligning mortise and tenon joinery with these modern values, designers can enhance its relevance and appeal, ensuring that it remains a vital technique in sustainable design. This alignment represents an evolution in its meaning—from simply a construction technique to a symbol of sustainability and resilience.

Innovation Through Cultural and Emotional Connection. According to Verganti, innovation of meaning is often more impactful when it evokes an emotional response or connection. Mortise and tenon joinery, when presented as a culturally significant and sustainable practice, can resonate emotionally with users who feel connected to heritage crafts or who support environmentally responsible practices. For example, using mortise and tenon joinery in a piece of furniture or a building structure can create a sense of pride and connection to historical craftsmanship, enhancing the user's experience by imbuing the product with cultural value. This emotional engagement can transform how users perceive and interact with the products that incorporate mortise and tenon, elevating the craft's role from purely functional to personally meaningful.

Shaping Future Markets with Innovation of Meaning. Verganti's theory also recognizes that companies and designers can use meaning as a strategic tool to shape markets. By promoting mortise and tenon joinery as part of a broader cultural and environmental movement, designers and businesses can help create demand for products that embody these values. For instance, by positioning mortise and tenon as an eco-conscious choice that supports heritage preservation, brands can appeal to markets that prioritize authenticity, sustainability, and cultural richness. This strategy allows mortise and tenon to compete in a market often dominated by mass-produced, cost-effective alternatives, transforming it from a niche craft to a meaningful component of mainstream sustainable design.

Adapting Traditional Techniques to Modern Aesthetic Preferences. Verganti's innovation theory also involves adapting traditional products to fit modern aesthetics, ensuring their appeal in contemporary contexts. Mortise and tenon joinery can be integrated into minimalist, modern designs that emphasize clean lines, natural materials, and understated elegance—qualities that align with the technique's inherent simplicity and harmony with nature. By aligning the aesthetic appeal of mortise and tenon joinery with current design trends, designers can create a new visual language for this traditional craft, allowing it to gain renewed relevance in modern spaces without compromising its authenticity.

In summary, Verganti's Theory of Innovation of Meaning provides a framework for reimagining mortise and tenon joinery, not as a relic of the past but as a technique that carries significant cultural, environmental, and emotional value. By redefining its meaning and connecting it to contemporary values, designers can ensure that mortise and tenon joinery continues to thrive, appealing to modern audiences who seek both authenticity and sustainability in design.

Verganti's "meaning innovation" theory prioritizes altering the perceived meaning of a product to create a deeper connection with users. For mortise and tenon, this involves reshaping its image from merely a functional joinery technique to a cultural symbol of sustainable and culturally rich design. This study explores how mortise and tenon can convey messages of heritage, longevity, and environmental stewardship, providing users with a sense of historical continuity and sustainable responsibility through culturally embedded design Inside-Out Mindset.

An "inside-out" approach to innovation is central to meaning-driven design, where designers focus on cultural and philosophical values rather than external market trends. Mortise and tenon's cultural significance and its alignment with ecological principles make it an ideal candidate for this approach. By understanding the philosophical underpinnings of this technique, such as harmony with nature and structural integrity, designers can create products that speak to the user's sense of cultural identity and environmental consciousness.

Innovation through a different lens. "If we are blinded by darkness, we are also blinded by light". Paradoxically, Prof Verganti speaking at Oracle Modern Business Experience being in the light and having too many ideas can be as fruitless as being in the dark and having none. The digital era we live in enables us to access creativity; we don't struggle to think of ideas. Ideas are commodities. If we chase everything, we get nothing. The challenge of innovation is finding which ones are meaningful. How do we design meaningful products in a world awash with ideas? The answer lies in the relationship between people, meaning and solutions. People create the meaning (the 'why') which leads to the solution (the 'how'). In a world where ideas are abundant but novel visions are rare, innovation driven by meaning is what makes a difference. If something is meaningful both for the creators and the consumers, business value will follow.⁶⁸

Whether it is a product, service, process or business model, there are two levels of innovation: solution innovation and meaning innovation.

Solution innovation is the use of better ideas to solve an existing problem, a new approach to solving a relevant challenge in the marketplace. A new solution may lead to incremental or even radical improvements, but they all go in the same direction, they are all innovations that are "more of the same".

⁶⁸YouTube. (n.d.-c). YouTube. <https://www.youtube.com/watch?v=WDn3yQKfpqY> Y

Meaningful innovation presents a new reason/value proposition for people to use a product, and takes your interactions with customers to a higher level: the level of love. It focuses on value to people, and if it doesn't have that, people won't love it even if it performs well. Loving someone and anything in life comes from meaning.

Nest Labs designs products to feel "at home," rather than making them overly high-end and fancy. This vision (comfortable rather than programmable, device-dependent rather than device-controlled, simple rather than cumbersome) turns the market's understanding of "meaning" on its head. The vast majority of these features would not be recognised by thermostat manufacturers who want to give users control over the temperature, and some of them even seem quaint (especially the use of a simple rotating interface rather than a touchscreen). When customers saw NestLabs' new concept, they fell in love with it because they found it more meaningful.

The best analogy to describe meaningful innovation is to think of it as a "gift". The NestLabs thermostat is a gift from the Nest Labs innovation team to the consumer. It's not the fulfilment of an explicit need (people don't explicitly ask for it) or the answer to a problem, or something that consumers can design themselves; NestLabs is a surprise, a new possibility that people will find more meaningful.

Mortise and tenon wooden buildings, mortise and tenon wooden furniture is not the same as the mainstream building forms and furniture in today's life, but from the perspective of renewable energy of the material to talk about the mortise and tenon building and furniture, so that mortise and tenon building and furniture to re-occupy a place in the current market, and return to the people's modern life. The cultural connotation of mortise and tenon craft is the essence of traditional Chinese culture, and the domestic attention to traditional culture can make blocks based on mortise and tenon craft become an effective vehicle for spreading traditional Chinese culture.

People's lives are not only focused on finding solutions to established problems, but also on what kind of problems should be solved in a world of uncertain and changing problems. People are constantly searching not only for solutions, but also for meaning.

The author gives an example: I lit a candle in my mother's house in the mountains (solution) because I wanted to light up the room when the power went

out. Lighting up the room was my purpose. 30 years later, my mum put a candle on the dining table because she wanted to create a warm atmosphere to welcome me, and welcome is a new purpose, a new meaning⁶⁹.

The search for meaning in everyday life is a theme for every ordinary person, even though many times we don't realise it. It is integrated into our daily behaviour, not only in the major choices of life, but also in the most ordinary ones. Focusing on meaning rather than solutions is the best way to address the needs of people all over the world, regardless of whether they are rich or not. Because people are looking for meaning wherever they are.

Traditional craftsmanship has played a practical role in the historical development of architecture and furniture, serving as a connection and load-bearing function. With the development of new materials and technologies, new types of joints are gradually replacing the traditional mortise and tenon joinery, which has led to the gradual decline of mortise and tenon joinery and to the loss of craftsmanship during the process of rapid urbanisation. With the setting of the United Nations' sustainable goals and the growing concern for ecology, and the increasing interest in wood-based architecture and furniture, mortise and tenon craftsmanship has received renewed attention and is in need of innovation to solve the contradiction between machine-based mass production and handmade production, in order to return and adapt to the modern way of people's production and life. With China's economic development playing a more and more important role in the world to play an important role in the influence of the world more and more attention and interest in Chinese culture, traditional culture in China has caused a new boom in cultural self-awareness, cultural self-confidence has become the voice of the times. Mortise and tenon craft embodies the concept of the unity of man and nature, and is an important carrier of Chinese culture.

Principles of Solution Innovation vs. Meaningful Innovation

Solution innovation considers innovation as creative problem-solving activity. This means that organisations innovate by first understanding user needs (current customer problems) and then by constructing ideas to better solve those problems.

The solution innovation approach to research implicitly assumes that one of the greatest difficulties is finding superior solutions, so the more creative ideas there

⁶⁹ Verganti, R. (2017). *Overcrowded: Designing meaningful products in a world awash with ideas*. The MIT Press.

are, the better the chances of finding better ways to solve users' problems. These approaches are generated from the outside in, by going out and observing how users use existing products, and then constructing new ideas for products "from an outsider's point of view".

Meaningful innovation is the opposite process: it needs to come from the inside out, not from the outside in, and be based on criticism rather than on constructing ideas.

(3) Innovating from the Inside Out vs. Innovating from the Outside In

For example, Tony started with the idea of creating a thermostat that people would love. For him, the word "people" originally meant him and his family. If I don't love it myself, how can my customers love it? Of course, he then did the usual user analysis, but he didn't start from the user analysis, he started from the heart.

More accurately, he started from his inner discomfort (he hated having to pick from a variety of thermostats). He didn't start with the user, or even take ideas from outsiders, which is exactly the kind of creative problem solving that has been touted for the last 10 years, and what NestLabs' competitors are doing.

Meanings have different properties relative to solutions. They have a whole new way of judging and interpreting good and bad (in the case of NestLabs as an example, the meaning is comfort and simplicity rather than temperature control and perfect programming).

Accordingly, the direction and judgement of meaningful innovation lies in our own vision. Vision is the lens through which we see things and the mind through which we give meaning to our existence in the world. We cannot borrow someone else's glasses, let alone someone else's mind.

Just as one cannot love a gift that we ourselves do not love. A gift is the meeting point between two loves: it is exactly what someone else loves, and we are happy that the person can receive it (i.e., we honestly believe that we can make that person's life better). Creating a meaningful product, like making a gift, is an act of responsibility and delight. If we love the gift, we ourselves will take pleasure in making it.

So, the gift is for someone else, but the act of making it is for ourselves. If we do this, we create meaning. People become aware of the gift before they see it and then they love it.

Critiquing and Constructing Ideas

The second fundamental difference between meaning innovation and solution innovation is the mode of thinking. Creative problem solving builds on the art of constructing ideas; meaning innovation, in contrast, requires the art of criticism. There are two reasons for this.

First, the process of meaning innovation starts from within. Criticism is a way of questioning how we make sense of our environment, prompting us to shake off our egos and shed our meaningless past.

Second, and more importantly, is that criticism causes us to engage in a deeper research quest, to compare our assumptions with those of others, and then to find a new and stronger interpretation.

Unfortunately, criticism is an art that we seldom cultivate with much care. Because criticism is rooted in tension, we need to be cautious. Misplaced criticism only stifles the innovation process and undermines the possibility of generating a superior creative vision.

The world is changing rapidly. Whatever the circumstances, we do not want to deal with a world that can only passively accept its meaning. We want to create meaning, to create something better and something that will make people's lives more meaningful. We want to make gifts for people, and for ourselves. It is only through making that we can pass on the gift; Only through making can we enjoy the ultimate joy of creating meaning. Gifts are meant for people, and the act of making them is meant for us.

This revisiohe theoretical foundation of the study, highlighting the alignment of Verganti's innovation theory with the sustainable and cultural dimensions of mortise and tenon. Each section reinforces the importance of redefining and applying this traditional craft to address contemporary challenges in design.

Applying Meaningful Innovation to Mortise and Tenon Craftsmanship

Mortise and tenon joinery, a centuries-old woodworking technique, is both a technical skill and a cultural symbol of precision, durability, and respect for natural materials. However, its traditional use in construction and furniture-making is at risk of being overshadowed by modern, mass-produced alternatives. By applying meaningful innovation, mortise and tenon craftsmanship can be redefined, emphasizing its cultural value and ecological relevance. This process involves reimagining mortise and tenon joinery not simply as a method of joining wood, but as a design philosophy that embodies values important to today's consumers, such as sustainability, quality, and heritage.

(1) Redefining Mortise and Tenon Through New Meanings

Mortise and Tenon as a Symbol of Sustainability. Meaningful innovation allows mortise and tenon to be reinterpreted as an ideal model for sustainable design. Traditional mortise and tenon joinery is an inherently eco-friendly construction technique that minimizes resource use and reduces waste. In modern contexts, where environmental impact is a critical consideration, mortise and tenon can be presented as an ethical choice. By framing mortise and tenon joinery as a sustainable alternative to conventional joinery methods, designers can appeal to consumers who value eco-friendly practices, helping them connect with the product on an ethical level.

Additionally, the durability and repairability of mortise and tenon structures contribute to a circular economy mindset, where products are designed for longevity rather than disposability. This approach challenges planned obsolescence and promotes the idea that well-made, long-lasting products are inherently more valuable. As consumers grow more conscious of sustainability, mortise and tenon can be positioned as an embodiment of enduring craftsmanship that respects natural resources and opposes waste.

Cultural Heritage and Emotional Connection. Mortise and tenon joinery is deeply embedded in cultural history, particularly in Chinese architectural and furniture design, where it reflects ideals of harmony, simplicity, and balance. Through meaningful innovation, this technique can be repositioned as a cultural artifact that offers consumers a link to tradition and a sense of belonging. By emphasizing its heritage, mortise and tenon products invite users to connect with the past, creating a sense of continuity and emotional connection that mass-produced items cannot offer.

Verganti's concept of meaning innovation supports the reinterpretation of mortise and tenon as more than just a technical skill; it is a storytelling medium that can bring cultural depth and identity into modern living spaces. For example, furniture created with mortise and tenon joinery can be marketed as an investment in cultural preservation, inviting consumers to participate in the legacy of traditional craftsmanship. This connection adds emotional value to products, fostering a sense of pride and awareness in consumers who value cultural heritage.

Minimalism and Aesthetic Simplicity. Meaningful innovation also allows mortise and tenon to be redefined aesthetically. With its clean lines and unadorned joints, mortise and tenon joinery aligns with the minimalist design trend that emphasizes simplicity and functionality. Minimalism resonates with consumers seeking tranquility and order in their environments, making mortise and tenon a natural fit for those who appreciate pared-down aesthetics.

Unlike highly decorative joinery methods, mortise and tenon's beauty lies in its precision and clarity of form, aligning with Verganti's idea of creating new meaning by connecting with the values of today's consumer. In this case, mortise and tenon joinery can be promoted as an aesthetic choice that embodies restraint, quality, and authenticity. This minimalist appeal broadens the craftsmanship's relevance to younger, design-conscious consumers who seek products that reflect their desire for simplicity and intentionality.

(2) Implementing Meaningful Innovation for Mortise and Tenon Craftsmanship

Applying Verganti's meaningful innovation theory to mortise and tenon craftsmanship involves a strategic reorientation that frames mortise and tenon as an artifact of cultural significance, environmental responsibility, and aesthetic intentionality. The following steps outline how meaningful innovation can be practically implemented:

Cultural Rebranding and Storytelling. Rebranding mortise and tenon craftsmanship requires an emphasis on storytelling to convey the cultural and historical value of the technique. By incorporating cultural narratives, designers can create a brand identity around mortise and tenon products that reflects the craftsmanship's origins, philosophical meaning, and unique aesthetic. This approach resonates with consumers who value authenticity and are drawn to products with a story. For example, marketing campaigns and product labels can highlight the philosophy of harmony with nature that mortise and tenon embodies,

drawing parallels between this ancient technique and modern sustainability practices.

Experiential Learning and Consumer Engagement. To further connect consumers with the heritage of mortise and tenon joinery, meaningful innovation can include experiential elements that allow users to engage directly with the craft. Products that incorporate DIY assembly, repair kits, or workshops can give consumers hands-on experiences with mortise and tenon, fostering a sense of respect and appreciation for the skill involved. This experiential approach aligns with Verganti's notion of creating new meaning, as it transforms the consumer's relationship with the product from passive ownership to active involvement, creating a more profound connection.

Designing for Longevity and Emotional Attachment. Products made with mortise and tenon joinery can be positioned as long-term investments, emphasizing durability, repairability, and lasting value. Meaningful innovation in this context involves designing products that consumers will want to keep, repair, and pass down. By encouraging a culture of mindful consumption, mortise and tenon products can cultivate emotional attachment, challenging the short-lived satisfaction associated with disposable consumer goods. This approach fosters a sense of responsibility and care, transforming mortise and tenon joinery into a timeless, cherished element of the user's environment.

Collaborations and Cross-Disciplinary Integration. Finally, meaningful innovation can be supported through collaborations between artisans, designers, and cultural institutions. Partnering with museums, heritage organizations, and educational institutions can reinforce mortise and tenon's cultural significance and extend its reach to broader audiences. Collaborative projects, such as design exhibitions or limited-edition collections, can showcase mortise and tenon in fresh, creative contexts that highlight its versatility. This cross-disciplinary approach reinforces mortise and tenon's relevance, expanding its impact and visibility through meaningful integration into diverse design fields.

Verganti's Meaningful Innovation theory provides a transformative approach for reinterpreting mortise and tenon craftsmanship as a design practice that transcends mere functionality. By applying meaning innovation, mortise and tenon joinery can be redefined as a culturally significant, environmentally responsible, and aesthetically meaningful technique that resonates with today's values. This redefinition enables mortise and tenon to remain relevant in a world that

increasingly values sustainability, authenticity, and cultural connection. Through storytelling, experiential design, and collaborative efforts, mortise and tenon joinery can be preserved and adapted, offering consumers a deeper, more meaningful engagement with design that honors both heritage and modernity. This approach not only ensures the survival of traditional craftsmanship but also sets a precedent for other forms of intangible cultural heritage to thrive in contemporary design.

Meaningful innovation, when applied to mortise and tenon craftsmanship, can take several forms, each contributing to the preservation and enhancement of this traditional woodworking technique. Here are some ways in which meaningful innovation can be applied:

Sustainability and Environmental Responsibility. One meaningful innovation is the use of sustainable materials and the reduction of waste. For example, furniture made from reclaimed or salvaged wood not only adds character but also reduces the demand for new wood, promoting a circular economy. Additionally, the design of furniture can be optimized to minimize waste during the cutting and assembly process, aligning with the principles of the circular economy.

Educational and Cultural Preservation. Meaningful innovation can also involve the development of educational tools and programs that teach the art of mortise and tenon craftsmanship. This not only preserves the technique but also fosters a deeper appreciation for traditional craftsmanship. By engaging the next generation in these skills, the knowledge and techniques can be passed down, ensuring the longevity of the craft.

Design for Accessibility and Inclusivity. Designing mortise and tenon furniture that is accessible to a wider audience, including those with disabilities, can be a meaningful innovation. This might involve designing furniture that is modular and can be easily adapted to different needs or incorporating features that make the furniture more accessible, such as adjustable joints or ergonomic designs.

Technological Integration. Meaningful innovation can also involve the integration of technology to enhance the craftsmanship. For example, the use of digital tools for design and prototyping can lead to more efficient and precise mortise and tenon joints. Additionally, the use of 3D printing for jigs and fixtures can make the assembly process faster and more accurate.

Community Engagement and Collaboration. Collaborating with local communities and other artisans can bring new perspectives and skills to the craft. This could involve working with local wood suppliers to source materials that are sustainably harvested or partnering with other craftsmen to create unique pieces that combine different traditional techniques.

Ethical and Sustainable Production Practices. Meaningful innovation in mortise and tenon craftsmanship also involves ensuring that the production process is ethical and sustainable. This includes fair labor practices, ensuring that workers are treated with respect and dignity, and ensuring that the production process is environmentally friendly, minimizing waste and using sustainable materials.

Meaningful innovation in mortise and tenon craftsmanship can take many forms, each contributing to the preservation and enhancement of this traditional technique. By focusing on sustainability, education, accessibility, technological integration, community engagement, and ethical production practices, craftsmen can ensure that their work not only reflects the beauty and skill of traditional craftsmanship but also contributes positively to society and the environment.

This section proposes a new account of the role of the design discipline in the conflict of humanity's relationship with nature. A movement ranging from Italian Radical Design to Dutch Conceptual Design has highlighted both the design discipline's tendency to oppose designing for unbridled consumerism and the transformation of user needs towards dematerialization. While critical theorists have mostly regarded these movements as highly heterodox utopian rebellions, I offer an explanation by appealing to Victor Papanek and contemporary design trends. Papanek viewed design as an object or system as a form of democracy, particularly as a political tool. He has developed a responsible social vision for environmental issues. I apply this dimension to the case of design practice and use it to connect to the work of Richard Neutra and Roberto Verganti on survival through design and design for meaning. In the final section, I argue that a new design paradigm based on Papanek's ideas can guide the sustainability of current environmental issues.

Meaningful Innovation in Mortise and Tenon Design: Cultural Inspiration, Humanistic Care, and Sustainable Development

In contemporary design, there is a shift towards creating products that are not only functional but also fulfill deeper cultural and spiritual needs. This approach is

embodied in Japanese designer Kenya Hara's philosophy, which emphasizes simplicity, depth, and cultural meaning in design, and Roberto Verganti's concept of "meaningful innovation," which seeks to bring new significance to products by addressing users' evolving emotional and cultural aspirations. These principles provide a valuable framework for reinterpreting mortise and tenon joinery in modern contexts, focusing on the sustainable, spiritual, and cultural dimensions that meet the needs of today's public.

This section explores how the cultural philosophy of Japanese design, combined with Verganti's meaningful innovation approach, can inspire new ways of thinking about mortise and tenon joinery. It examines how this ancient technique can be adapted to contemporary furniture and temporary structures that address spiritual, ecological, and cultural needs, thus fostering cultural self-confidence and promoting sustainable development.

Kenya Hara, in his design philosophy and writings, highlights the importance of simplicity, essence, and sensory richness as central to Japanese design. He believes that design should not merely be about functionality but should invite reflection, evoke emotion, and create an immersive experience. This philosophy celebrates minimalism, with a focus on materials, textures, and natural forms that enhance the relationship between the user and the object. Hara's approach to design emphasizes understanding the inherent qualities of materials and honoring their natural beauty and simplicity—principles that resonate strongly with the values embedded in mortise and tenon joinery.

Mortise and tenon, with its unembellished elegance and reliance on the natural properties of wood, aligns perfectly with Hara's design ethos. This joinery method requires minimal intervention and allows the material's texture, grain, and warmth to speak for itself. By emphasizing the material's intrinsic qualities, mortise and tenon joinery achieves a balance between functionality and cultural expression, creating designs that are both practical and spiritually enriching. This harmony resonates with Hara's belief that design should transcend mere utility to inspire a deeper connection between people and their environment.

Roberto Verganti, an innovation theorist, advocates for "meaningful innovation"—a process that goes beyond technological advancements or aesthetic changes to bring deeper meaning to products. Meaningful innovation involves reinterpreting products in ways that fulfill not just practical needs but also the cultural, emotional, and spiritual needs of the contemporary public. Verganti's

approach encourages designers to consider why a product exists and how it can provide new value that resonates with users' evolving desires and values.

Applying Verganti's concept of meaningful innovation to mortise and tenon joinery offers an opportunity to transform this traditional craft into designs that resonate with modern audiences. By infusing mortise and tenon furniture with contemporary cultural significance, designers can create pieces that offer users a sense of connection to heritage, environmental mindfulness, and an appreciation for craftsmanship. For instance, designing mortise and tenon furniture that reflects modern minimalist aesthetics while retaining traditional joinery techniques can meet the need for sustainable and meaningful products in today's fast-paced, consumer-driven society. This fusion of tradition and innovation exemplifies how meaningful innovation can transform a cultural technique into a contemporary art form that fulfills deeper, more lasting needs.

The spiritual and cultural needs of today's public often extend beyond functionality to encompass a desire for authenticity, environmental responsibility, and a sense of identity. Mortise and tenon joinery, as an intangible cultural heritage, is uniquely suited to address these needs. Its design is rooted in tradition, craftsmanship, and sustainability, offering an alternative to mass-produced furniture by emphasizing quality, durability, and connection to cultural roots.

Cultural Self-Confidence and Identity. In a world where globalization often homogenizes cultural expressions, mortise and tenon joinery provides a means of fostering cultural self-confidence. As a design technique that has been passed down for generations, it represents a continuity of cultural values, skills, and aesthetics. By creating furniture and structures that showcase this joinery method, designers can help cultivate a sense of pride and connection to heritage. This cultural self-confidence reinforces the importance of intangible cultural heritage in contemporary life, offering users not just a product, but a piece of history and tradition.

Humanistic Care and Emotional Fulfillment. Mortise and tenon joinery embodies humanistic care through its simplicity, precision, and the thoughtful integration of each component. The act of handcrafting a mortise and tenon joint is itself an expression of dedication and respect, both for the material and for the cultural tradition it represents. This approach to design responds to the public's need for products that are emotionally fulfilling and personally meaningful. Furniture or

structures crafted with mortise and tenon joinery invite users to appreciate the time and skill involved, fostering a sense of connection and respect for the craftsmanship.

Sustainable Development and Ecological Responsibility. Mortise and tenon joinery's green design aligns with the growing demand for sustainable products. The joinery's construction process minimizes environmental impact by reducing the need for synthetic materials and adhesives, and its reliance on wood makes it fully biodegradable and renewable. In this way, mortise and tenon furniture fulfills the public's ecological concerns, aligning with a broader trend towards sustainability and eco-friendly practices in design. The longevity of these structures also promotes sustainable consumption, as they are built to last, reducing the need for replacement and encouraging mindful ownership.

Temporary architecture using mortise and tenon joinery reflects how traditional techniques can be applied to modern construction, offering humanistic care and environmental benefits. This approach involves creating structures that are both ephemeral and impactful, designed to serve a specific purpose or community need while respecting the environment.

Mortise and tenon structures can be easily assembled, disassembled, and repurposed, making them ideal for temporary installations, exhibitions, or emergency shelters. These structures embody the principles of circular design, where materials are reused or reintegrated into new constructions. By designing temporary structures with mortise and tenon, architects and designers can create spaces that provide shelter and comfort while symbolizing respect for nature and community needs.

Moreover, the aesthetics of these temporary structures convey a sense of harmony with the surroundings, often blending seamlessly into natural landscapes. This approach reflects both Japanese and Chinese philosophical values of minimalism, natural integration, and impermanence, connecting the built environment with its ecological and cultural context.

In furniture design, mortise and tenon joinery can be used to create pieces that satisfy both functional requirements and deeper cultural and spiritual needs. Such furniture invites users to connect with their heritage, appreciate craftsmanship, and practice mindful ownership.

For example, creating furniture that combines the elegance of minimalist design with traditional joinery can bring a sense of calm and focus to modern living

spaces. This design serves not just as a functional object but as a reminder of timeless values, encouraging users to engage with their surroundings mindfully. Additionally, these pieces offer a tactile experience, where the natural texture of wood and the visible joinery express a connection to materials and history. The result is a type of furniture that meets contemporary needs for cultural connection, emotional fulfillment, and ecological sustainability.

Embracing Cultural Heritage in Modern Green Design

The philosophy of Kenya Hara's Japanese design culture and Roberto Verganti's meaningful innovation provide a valuable framework for reimagining mortise and tenon joinery in contemporary design. By incorporating principles of cultural continuity, humanistic care, and environmental sustainability, mortise and tenon joinery can meet the spiritual and cultural needs of the modern public. This approach fosters cultural self-confidence by preserving an ancient technique in ways that resonate with today's values and lifestyles.

Mortise and tenon joinery represents more than just a construction technique; it is a powerful expression of human creativity, environmental mindfulness, and cultural pride. Through meaningful innovation, this ancient art can be adapted to create furniture and temporary structures that inspire, comfort, and connect. This design philosophy highlights the importance of merging heritage with contemporary needs, ensuring that intangible cultural heritage remains relevant and impactful in modern society.

In an era where sustainability, authenticity, and cultural identity are increasingly valued, mortise and tenon joinery stands as a model for green design and meaningful innovation. It reminds us that by drawing on our cultural heritage, we can create designs that are not only functional but also rich in history, spirit, and beauty, offering a deeper sense of connection to our world and ourselves.

This thesis will introduce Roberto Verganti's model of meaningful innovation from modern design thinking, and try to explore the use of design as a tool to help the inheritance and innovative development of intangible cultural heritage mortise and tenon craft. The thesis will grasp the trend of the times, deeply explore the cultural connotation and humanistic spirit of mortise and tenon craft, analyse and discuss the method of contemporary innovative design of mortise and tenon craft in combination with case studies, and look forward to the feasible strategies and paths to achieve innovative development.

3.2 Critique of Contemporary Design Practices

Contemporary design practices have increasingly come under scrutiny for their role in promoting unsustainable consumption patterns and prioritizing profit over social and environmental responsibility. Central to this critique are the issues of consumerism and planned obsolescence, which drive overproduction and waste. This section critically examines these problematic practices and their impact on the design industry, beginning with a focus on consumerism and planned obsolescence.

3.2.1 Consumerism and Planned Obsolescence

Consumerism refers to people's consumption and value concepts that consume material wealth and natural resources without scruples and restraint, and regard consumption as the highest goal of life. Consumerism is a kind of value, cultural attitude or lifestyle. Sociologist Yang Kui believes that consumerism is a global cultural ideology and a lifestyle⁷⁰.

Consumerism refers to the ideology that believes that continued and increased consumption activities help the economy. Creating desirability and demand for goods in terms of lifestyle attitudes (more consumption is a good thing) allows capitalism to raise wages and increase consumption. Consumerism is the economic engine of developed countries, giving modern people the social and economic beliefs and collective emotions to purchase and obtain goods.

Planned obsolescence describes the practice of designing products to break down quickly or become obsolete in the short to medium term. The general idea is to encourage sales of new products and upgrades, a practice that has been banned in some countries. However, global material crises are imminent. Global Sustainable Development Report (GSDR) 2023 reported that sustainability transformation is a new normal rather than a goal. This means that a paradigm shift in consumer behavior, manufacturing, construction and design is inevitable. In the near future, recycling will no longer be a choice for those who care about the environment, but a necessity for everyone.

The Environmental Law Institute writes that planned obsolescence "contributes to a culture of wastefulness by perpetuating a 'buy new and buy often'

⁷⁰ <https://wiki.mbalib.com/wiki/消费主义>

mentality and limiting consumer autonomy to keep products longer by hard-wiring a 'self-destruct' button in products".⁷¹

Planned obsolescence leads to an excessive amount of electronic waste as consumers discard their seemingly outdated devices in favor of the latest models. These discarded electronics often end up in landfills or are shipped to developing countries for improper disposal, posing serious health and environmental risks.

This section critiques how consumerism, driven by the pursuit of constant novelty and mass consumption, fundamentally conflicts with sustainable, meaningful design. Consumerism encourage frequent replacements. This practice prioritizes profit maximization over durability and cultural or ecological responsibility.

In contrast, meaningful design, especially as embodied in artisanal craftsmanship, values longevity, cultural heritage, and sustainability. Artisanal methods like mortise and tenon joinery emphasize quality, adaptability, and resource efficiency. These principles directly oppose the ethos of mass production, which often sacrifices these attributes for speed, uniformity, and cost reduction.

Planned obsolescence undermines the possibility of creating deep connections between users and products, reducing them to disposable commodities. This approach diminishes the value of design as a cultural and sustainable endeavor, eroding the traditions and skills that could otherwise inspire innovative solutions for contemporary challenges.

By reorienting design towards cultural preservation and sustainability, this section calls for rejecting consumerist values and adopting practices that harmonize innovation with tradition, fostering a responsible, enduring relationship between people and their material environment.

The Negative Impact of Planned Obsolescence on Sustainable Design

By encouraging frequent replacements and prioritizing short-term profit over long-term value, planned obsolescence fosters a cycle of excessive consumption and waste. This approach not only accelerates resource depletion but also increases

⁷¹ *Smart Tech, Dumb Design: Planned obsolescence and Social Responsibility*. Smart Tech, Dumb Design: Planned Obsolescence and Social Responsibility | Environmental Law Institute. (2017a, October 11). <https://www.eli.org/vibrant-environment-blog/smart-tech-dumb-design-planned-obsolescence-and-social-responsibility>

environmental burdens through heightened production and disposal rates. Products designed to fail or become obsolete undermine efforts to create durable, meaningful, and eco-friendly solutions.

In stark contrast, traditional methods such as mortise and tenon joinery embody the principles of durability and adaptability. Mortise and tenon constructions have withstood centuries of use, exemplifying a design philosophy rooted in longevity and resource efficiency. These methods reflect a sustainable ethos that values materials, minimizes waste, and preserves craftsmanship across generations.

By comparing planned obsolescence with the enduring qualities of mortise and tenon, it becomes evident that the former prioritizes disposability at the expense of environmental and cultural sustainability. Mortise and tenon, on the other hand, aligns with sustainable design by offering a model that integrates cultural heritage with functionality, challenging the wasteful norms perpetuated by consumerism. This comparison highlights the need for a paradigm shift in design practices to favor durability and sustainability over transient convenience.

In contemporary society, consumerism and planned obsolescence are prevalent forces driving product design and manufacturing. Consumerism encourages the continuous acquisition of new products. These practices often conflict with sustainable and culturally rooted design principles, such as those exemplified by mortise and tenon joinery, which prioritize durability, repairability, and resource conservation. Examining the impacts of consumerism and planned obsolescence offers insight into the challenges and opportunities for integrating traditional craftsmanship into modern, responsible design.

The Rise of Disposable Culture. Consumerism has fostered a culture that values novelty, convenience, and low costs, often at the expense of durability and quality. The widespread availability of inexpensive, mass-produced goods encourages frequent product replacement, leading to a “throwaway” mindset that prioritizes immediate gratification over long-term use. This disposable culture undermines the values inherent in traditional techniques like mortise and tenon joinery, which are designed for longevity and minimal environmental impact. By contrast, mortise and tenon joinery promotes sustainable practices by enabling structures and products to last for generations, reducing the need for constant replacement and thereby lessening environmental harm.

Planned Obsolescence vs. Durability of Traditional Crafts. Planned obsolescence directly opposes the principles of traditional craftsmanship, where durability and resilience are key priorities. In mass production, planned obsolescence often takes the form of using lower-quality materials, making repairs difficult, or designing products to become outdated or non-functional within a short time. This approach contrasts sharply with mortise and tenon joinery, which is constructed to be both durable and repairable. In mortise and tenon designs, the parts are made to fit precisely and withstand stress over time, and if needed, individual components can be replaced or adjusted without discarding the entire structure. This approach supports sustainable use of resources, in contrast to planned obsolescence, which generates excess waste and accelerates resource depletion.

Environmental Consequences of Consumerism and Planned Obsolescence. The environmental impact of consumerism and planned obsolescence is profound, contributing significantly to waste, pollution, and resource exhaustion. Fast consumption cycles lead to increased production demands, which in turn drive up greenhouse gas emissions, water usage, and deforestation rates. Planned obsolescence exacerbates this issue by creating products that are quickly discarded, filling landfills with materials that are often non-biodegradable. In contrast, mortise and tenon joinery embodies a sustainable alternative. Its reliance on high-quality, natural materials, and its potential for repair and reuse, make it a model for sustainable production. By valuing longevity and repairability, mortise and tenon joinery minimizes waste and lessens the environmental toll associated with short-lived, disposable products.

Impact on Cultural Heritage and Traditional Crafts. The pervasive nature of consumerism and planned obsolescence also affects the preservation of cultural heritage and traditional crafts. As fast fashion, inexpensive furniture, and low-cost electronics become mainstream, traditional craftsmanship risks being sidelined, with fewer consumers appreciating or investing in long-lasting, culturally significant products. Mortise and tenon joinery, as a time-honored technique, represents a set of skills and values passed down through generations. However, with consumerism favoring mass-produced alternatives, there is a risk that the knowledge and appreciation of such crafts will fade. The shift away from enduring products in favor of transient, low-cost items makes it challenging for traditional craftsmanship to remain relevant in today's market, ultimately threatening the survival of these cultural practices.

Opportunities for Countering Consumerism with Sustainable Craftsmanship. Despite these challenges, the growing awareness of environmental issues and the desire for authenticity offer an opportunity to counteract consumerism and planned obsolescence through sustainable craftsmanship. Mortise and tenon joinery exemplifies principles that align with the shift toward more sustainable and responsible consumption. By promoting products that emphasize durability, heritage, and repairability, designers and artisans can appeal to environmentally conscious consumers seeking alternatives to disposable goods. The longevity of mortise and tenon joinery can serve as a powerful message in advocating for reduced consumption and a return to quality-focused design that respects both cultural heritage and the environment.

Educating Consumers on the Value of Durability and Cultural Heritage. Another approach to counteracting consumerism and planned obsolescence is through education. By raising consumer awareness about the environmental and cultural value of durable, repairable goods, designers and educators can shift consumer attitudes. Highlighting the craftsmanship, sustainability, and historical significance of techniques like mortise and tenon joinery can help consumers recognize the long-term benefits of investing in quality over quantity. Educational initiatives and marketing efforts that emphasize the ecological impact of fast consumption and the benefits of traditional craftsmanship can inspire a shift toward responsible, informed consumer behavior.

In summary, consumerism and planned obsolescence present significant challenges to sustainable design and the preservation of traditional crafts like mortise and tenon joinery. However, by promoting the durability, repairability, and cultural significance of these traditional techniques, there is an opportunity to foster a more responsible approach to consumption that values quality and heritage. By educating consumers and embracing sustainable craftsmanship, the design community can help mitigate the adverse effects of consumerism and planned obsolescence on both the environment and cultural heritage.

3.2.2 Redefining Social and Responsible Design

Through design criticism of consumerism and planned abolitionism, we attempt to evoke designers' thinking about the purpose of design, to redefine the concept of design, and to take the intrinsic meaning of creative products as a modern design thinking, in order to draw out the cultural value of intangible cultural heritage, and to achieve the purpose of intangible cultural heritage mortise and tenon craftsmanship preservation and inheritance.

In an age of rapid consumption, design is often driven by profit maximization and a cycle of constant renewal, encouraging consumers to frequently replace items rather than repair or treasure them. This section critiques the prevalent models of consumerism and planned obsolescence in design, which prioritize short-term trends and profitability at the expense of durability, sustainability, and cultural value. By re-evaluating these prevailing models, this section aims to inspire designers to reflect on the deeper purpose of design and explore ways to incorporate cultural heritage and intrinsic meaning into modern design practices.

Using the example of mortise and tenon craftsmanship as an intangible cultural heritage, this section proposes a shift in design thinking—one that values longevity, cultural continuity, and meaningful innovation over disposability. By reorienting design around these values, designers can contribute to the preservation and inheritance of mortise and tenon joinery, drawing out its cultural significance and sustaining its relevance in contemporary contexts. This section will discuss the limitations of consumerism and planned obsolescence, propose a redefined approach to design, and explore how this approach can ensure the continuity of mortise and tenon craftsmanship.

(1) Design Critique: Consumerism and Planned Obsolescence

Consumerism is a socio-economic system that encourages the acquisition of goods in ever-increasing amounts. This model places a premium on novelty and disposability, often shaping design practices around trends that have a short shelf-life. In consumer-driven markets, products are designed to be replaced frequently, reinforcing a mindset that values acquisition over longevity and superficial trends over enduring quality. The impact of consumerism on design is evident in furniture, fashion, and electronics, where items are often replaced with each new season, disregarding the potential for durability or cultural significance.

In the context of mortise and tenon craftsmanship, consumerism presents a stark contrast to traditional values. Mortise and tenon joinery, with its emphasis on durability, sustainability, and respect for materials, represents an approach to design that values quality and endurance over fleeting trends. The consumerist approach undermines these values by encouraging the rapid production and consumption of furniture and objects, often through industrial methods that do not prioritize craftsmanship or cultural heritage. As a result, the skills and cultural meanings embedded in mortise and tenon craftsmanship are at risk of being lost, overshadowed by mass-produced alternatives that lack depth and authenticity.

Planned Obsolescence: A Design for Disposal. This practice contributes to waste, overconsumption, and environmental degradation. While it supports economic growth by driving continuous sales, it often undermines quality, sustainability, and durability. Products are engineered to become outdated or non-functional quickly, reinforcing a cycle of disposal and replacement that contradicts principles of responsible design.

Mortise and tenon craftsmanship, by contrast, is rooted in an ethos of longevity. Traditional mortise and tenon structures are built to last for generations, a philosophy that is antithetical to planned obsolescence. The practice of creating durable, repairable, and enduring designs aligns with sustainable design principles, which encourage reducing waste and resource consumption. By celebrating the enduring qualities of mortise and tenon, designers can resist the trend of planned obsolescence, creating products that are cherished and valued rather than discarded.

(2) Redefining the Purpose of Design: Toward Cultural Value and Longevity

Designing for Meaning: Beyond Functionality and Profit. To counteract the influence of consumerism and planned obsolescence, designers must rethink the purpose of design. This involves moving beyond a purely functional or profit-oriented approach to consider the intrinsic meaning and cultural value of the products they create. By focusing on meaning, designers can create products that engage users on an emotional and cultural level, encouraging them to form lasting connections with their possessions.

In the case of mortise and tenon craftsmanship, meaning can be drawn from the technique's history, cultural significance, and the values it embodies. Mortise and tenon is more than a joinery technique; it is a tangible expression of craftsmanship, tradition, and respect for natural resources. When incorporated into modern design, it can bring a sense of continuity with the past, offering consumers an opportunity to connect with cultural heritage. Designers who prioritize meaning in their work contribute to a more thoughtful and sustainable form of consumerism, where products are valued for their history and craftsmanship rather than their novelty.

Emphasizing Cultural Value in Design. Intangible cultural heritage, such as mortise and tenon joinery, holds deep cultural value. It represents not only a set of technical skills but also a way of life and a worldview that respects nature, tradition, and longevity. By bringing cultural value into design, designers can create products

that resonate with consumers on a deeper level. This approach allows design to become a medium for cultural education and appreciation, enabling consumers to participate in the preservation of cultural heritage.

When mortise and tenon joinery is used in furniture or architectural design, it brings a cultural narrative into modern living spaces, allowing users to experience the beauty and wisdom of ancient craftsmanship. For example, furniture created with mortise and tenon techniques can serve as a daily reminder of traditional values such as harmony, balance, and resourcefulness. By incorporating cultural value, designers ensure that mortise and tenon craftsmanship remains relevant and meaningful in a world that often prioritizes convenience and disposability over substance and heritage.

Design for Longevity and Preservation. Redefining design to emphasize longevity over disposability aligns with both sustainable practices and cultural preservation. Mortise and tenon craftsmanship inherently supports longevity through its emphasis on strong, durable joints. This natural durability encourages the creation of products that can withstand wear and tear, reducing the need for frequent replacements and contributing to a more sustainable consumption model.

By designing for longevity, designers can promote a sustainable design ethos that values quality over quantity. Products made with mortise and tenon joinery are designed to be repaired, reused, and even passed down through generations, fostering a culture of preservation rather than waste. This approach to design has the potential to transform consumer habits, encouraging individuals to invest in products that are built to last, both physically and culturally.

(3) Achieving Preservation and Inheritance of Mortise and Tenon Craftsmanship through Design

Intangible Cultural Heritage as a Core of Modern Design Thinking. Integrating intangible cultural heritage into modern design thinking allows designers to approach their work with a sense of purpose that goes beyond profit. Mortise and tenon craftsmanship, when viewed as a cultural asset, provides a foundation for creative innovation that respects and celebrates tradition. Designers can explore ways to adapt mortise and tenon techniques for modern applications, preserving the craft while ensuring its relevance in contemporary design.

For instance, reimagining mortise and tenon for modular or portable furniture can meet the functional needs of today's urban lifestyles while maintaining the

cultural essence of the craftsmanship. This approach to design not only preserves traditional skills but also reinforces the cultural self-confidence of societies that value their heritage. When consumers encounter products rooted in cultural heritage, they gain a sense of connection to the past, fostering appreciation and awareness of intangible cultural heritage.

Educational and Experiential Design as Tools for Preservation. Educational and experiential design can play a pivotal role in preserving mortise and tenon craftsmanship. By creating products that encourage hands-on interaction, designers can foster a greater understanding of the craftsmanship's complexity and significance. For example, DIY kits or furniture pieces that require the user to assemble the mortise and tenon joints themselves offer an experiential learning opportunity that promotes respect for the skill and precision required in the craft.

Through these educational products, designers can help consumers appreciate the value of craftsmanship and develop a sense of responsibility toward preserving cultural heritage. This approach aligns with the concept of "learning by doing," where users gain a more profound appreciation for the cultural heritage embedded in mortise and tenon craftsmanship, making it more likely that they will support and advocate for its preservation.

Creating a New Design Paradigm for Intangible Cultural Heritage. By redefining design through the lens of cultural value, sustainability, and longevity, this research proposes a new paradigm for integrating intangible cultural heritage like mortise and tenon into the contemporary design field. This paradigm encourages designers to move beyond conventional design practices, focusing instead on creating products that honor cultural values and contribute to the preservation of traditional skills. This approach not only benefits cultural heritage but also fosters a sustainable and culturally enriching consumption model.

This section has critiqued the influences of consumerism and planned obsolescence on contemporary design, emphasizing the need for a paradigm shift toward meaning, cultural value, and longevity. Mortise and tenon craftsmanship, as an intangible cultural heritage, represents a powerful counterpoint to these trends, embodying principles of durability, sustainability, and cultural depth. By redefining design to focus on these values, designers have the opportunity to create products that transcend mere functionality, connecting consumers with cultural heritage and promoting responsible consumption.

Through this redefined design approach, mortise and tenon craftsmanship can be preserved and inherited by future generations, ensuring its continued relevance and significance. This new paradigm not only enhances the cultural value of design but also aligns with sustainable development goals, offering a way forward for a design field that honors both the past and the future.

As Manzini said, we have seen a fast and deep-reaching transformation of the social and the technical systems. Design, which by its very nature bridges the gap between them, could not avoid being transformed at its roots. Design itself has been (and still is) a fertile ground for social innovation.

The industrial revolution of the 1750s, with its changes in mass production with large machines, led to the separation of design from production as an independent discipline, the central element of which was to change the thousand-year history of design in the service of the powerful and the rich and make design available to the public. In 1851, the Crystal Palace Expo, held in London, England, on the standardization of large machines for mass production of crude and ugly goods, provoked the design community for modern design and mechanized production of a wide range of discussions. The design philosophy of William Morris, the founder of the Arts and Crafts Movement, provides that one cannot distinguish between so-called big art (art) and small art (design). Such a distinction makes small art appear useless, mechanical and irrational and loses its power to reform. On the other hand, by losing the support of small art, great art also loses the value of serving the public and becomes a meaningless appendage, the toy of the rich. His two fundamental design principles: 1. Product design and architectural design serve millions of people, not the businesses of a few. 2. Design work must be a collective rather than an individual activity.

When standardization and mass production became the goal of manufacturing, the standard of internal evaluation of design was no longer "art for art's sake", but "industry for industry's sake". Then the concept of the market was born, and consumer demands and the pursuit of economic interests led to changes in the audience, requirements and purposes of design. Vance Packard, critic of consumerism, exposes the dangers of American capitalism's tendency towards madness.

This discontent with the growing lack of social relevance of design out of greed has led Italian designers to rebel. In the 1960s, a movement ranging from Italian Radical Design to Dutch Conceptual Design highlighted both the design

discipline's tendency to oppose designing for unbridled consumerism. Radical Italian designers believed that designers should have a heavy responsibility to design human products, not just products of economic gain, and that they should use their creativity to the fullest to improve people's quality of life, not just to contribute to the inevitable capital accumulation. Gianni Piretti of UFO is committed to promoting social change through architecture and to "transforming the practice of architecture into an event in itself". Although most critical theorists considered these movements as strong heretical utopian rebellions, they were full of revolutionary ideas and gradually became the starting point for a rethinking of the definition of design, making it more of an incubator for the overthrow of the old paradigm of design. consumerist design and the vision of a new lifestyle.

According to Victor Papanek , in *Design for the Real World* , the most important role of design is not to create commercial value or to compete in terms of packaging and style, but rather to be an element of an appropriate process of social change. He stressed that design should take into serious consideration the use of the planet's limited resources and serve to protect the environment.

The origins of social design lie in Papanek's 1971 book, *Design for the Real World*. In the book, Papanek suggested two major deficiencies in design at that time: one was the designers' neglect of environmental issues and the promotion of consumerism by design; the other was the neglect of the relatively disadvantaged groups. If the former is the designer's concern for environmental sustainability, the latter is the consideration of social justice. Social sustainability, environmental sustainability and cultural sustainability are all included in designers' "social responsibility".

In the context of modern design, social and responsible design principles emphasize creating products, structures, and systems that benefit society, respect cultural heritage, and minimize environmental impact. This approach shifts the focus from profit and efficiency to the well-being of individuals, communities, and the environment. As global challenges such as climate change, cultural homogenization, and resource depletion intensify, redefining social and responsible design becomes crucial. Integrating traditional techniques like mortise and tenon joinery into contemporary design can serve as a powerful model for achieving these goals by embodying values of sustainability, durability, and cultural preservation.

Emphasizing Community-Centric Design. Socially responsible design is community-centric, focusing on creating solutions that directly address the needs

and values of local populations. Traditional craftsmanship, such as mortise and tenon joinery, is inherently rooted in community knowledge and cultural practices. By incorporating this technique into modern design projects, designers can create culturally relevant products and structures that resonate with local identities and histories. For instance, in regions with a rich woodworking heritage, using mortise and tenon joinery in public architecture or furniture design reinforces community identity, providing a sense of pride and continuity. Additionally, involving local artisans in these projects promotes skill transfer and economic growth within the community, making social and responsible design an inclusive, participatory process.

Prioritizing Environmental Sustainability. A fundamental aspect of responsible design is its commitment to sustainability. Mortise and tenon joinery embodies sustainable practices through its minimal reliance on synthetic materials and non-recyclable components. Unlike modern construction methods that often depend on adhesives, screws, or other materials with significant environmental footprints, mortise and tenon relies primarily on natural wood. This glue-free, nail-free construction technique not only reduces waste and toxic emissions but also supports circular design principles by enabling disassembly and reuse. Redefining responsible design to incorporate such environmentally friendly techniques allows designers to address today's ecological challenges while showcasing the resilience of traditional methods.

Encouraging Longevity and Adaptability in Design. One of the core principles of social and responsible design is creating durable and adaptable products that reduce the need for frequent replacement, thereby reducing waste. Mortise and tenon joinery is particularly well-suited to this goal, as it offers a high degree of durability and flexibility. Structures built with this technique can withstand the test of time, as seen in historic buildings and furniture that have endured for centuries. By redefining responsible design to prioritize longevity and adaptability, designers can create products that contribute to a culture of quality over disposability. Additionally, mortise and tenon joinery's modularity allows for easy repairs, adjustments, and disassembly, making it an ideal technique for sustainable, responsible construction that adapts to changing needs.

Incorporating Cultural Preservation into Design. Socially responsible design goes beyond function and sustainability by emphasizing cultural preservation. As global markets continue to promote uniformity, unique cultural practices risk being overlooked or forgotten. Mortise and tenon joinery, as a traditional and culturally

significant technique, represents an opportunity to redefine responsible design by embedding cultural heritage into contemporary practices. By applying this joinery in modern products, designers can create a bridge between past and present, preserving craftsmanship traditions while making them relevant for today's consumers. This approach not only enriches the aesthetic and cultural dimensions of a design but also supports the intangible cultural heritage of communities, offering a meaningful alternative to standardized, mass-produced products.

Promoting Ethical Production and Economic Fairness. Socially responsible design also includes ethical production practices that prioritize fair labor conditions, support local economies, and respect traditional skills. By integrating mortise and tenon joinery into design practices, manufacturers and designers can collaborate with local artisans, promoting fair compensation and enhancing economic opportunities in regions with a strong woodworking heritage. This partnership not only ensures that traditional knowledge is valued but also empowers artisans to sustain their livelihoods in an increasingly competitive market. Redefining responsible design to include ethical production and economic fairness elevates the role of artisans as integral contributors to the design process, reinforcing social responsibility as a foundational design principle.

Encouraging User Connection and Meaningful Engagement. Responsible design emphasizes fostering a deeper, more meaningful connection between users and the products they choose. Products crafted with mortise and tenon joinery can enhance the user's experience by promoting an appreciation for quality craftsmanship, cultural heritage, and environmental responsibility. When users understand the history and care behind a traditionally crafted product, they are more likely to value and maintain it, reducing the tendency toward disposability. Redefining responsible design in this way encourages designers to create products that not only serve functional needs but also resonate with users on a personal and cultural level. This connection can inspire more mindful consumption and a stronger sense of responsibility toward the items one owns.

Shaping the Future of Socially Responsible Design. By redefining social and responsible design to integrate traditional craftsmanship like mortise and tenon joinery, designers and manufacturers can create products that address both contemporary needs and long-term sustainability goals. Mortise and tenon joinery serves as a model for responsible design by offering durability, adaptability, cultural relevance, and environmental benefits. This approach aligns with a broader

movement toward ethical, community-focused design that values quality, heritage, and sustainability over profit-driven, disposable products.

In summary, redefining social and responsible design means moving beyond purely functional objectives to include cultural, environmental, and social considerations. Mortise and tenon joinery embodies these values, offering a pathway to more meaningful, sustainable design that respects both the environment and cultural heritage. By adopting such principles, the design community can lead a shift toward products and structures that not only fulfill practical needs but also enhance cultural continuity and environmental resilience.

3.3 Principles of Sustainable and Social Design

Sustainable and social design principles focus on creating solutions that meet the needs of the present without compromising future generations, while also addressing social equity and responsibility. These approaches aim to reduce environmental impact and promote ethical practices in design, aligning with the evolving demands for sustainability and social justice. This section explores these principles and their significance, beginning with an examination of socially responsible design.

3.3.1 Socially Responsible Design

In light of environmental challenges and cultural loss, there is a need to redefine design to emphasize cultural sustainability and ecological responsibility. This section argues that design should move beyond aesthetics and functionality to include the preservation of cultural practices. Mortise and tenon, with its symbolic and practical resonance, represents a model for this redefined approach to design.

Social design, as opposed to commercial design, prioritizes humanistic and environmental needs over profit. This section outlines how mortise and tenon craftsmanship can support socially responsible design by embodying values of cultural preservation, sustainability, and community engagement. Through the use of this traditional technique, designers can create products that serve societal goals, such as environmental consciousness and cultural continuity.

Sustainable and social design prioritize creating products, environments, and systems that positively impact both society and the planet. Rooted in principles of ecological stewardship, cultural responsibility, and ethical production, these design practices address urgent global issues such as environmental degradation, resource

scarcity, and the loss of cultural heritage. Sustainable and social design principles are based on values that emphasize durability, inclusivity, and the well-being of communities and ecosystems. In the context of traditional craftsmanship, such as mortise and tenon joinery, these principles offer a way to harmonize past techniques with present needs, ensuring that design contributes to a more equitable and sustainable world.

Socially responsible design emphasizes the ethical dimensions of design, focusing on creating products and systems that benefit society. This principle encompasses fair labor practices, community involvement, and the preservation of cultural heritage. Socially responsible design also supports inclusivity, aiming to produce designs that meet diverse social needs and respect local values. By integrating traditional techniques like mortise and tenon joinery, socially responsible design can foster a connection between modern products and cultural identity, empowering communities by preserving and promoting their craftsmanship and heritage. This approach addresses social well-being, cultural continuity, and equity, ensuring that design is accessible, respectful, and aligned with the values of the communities it serves.

The Role of Cultural and Environmental Responsibility. Cultural and environmental responsibility are fundamental to sustainable and social design. Cultural responsibility honors traditional skills and knowledge, safeguarding them for future generations and embedding them within contemporary applications. For example, using mortise and tenon joinery in modern furniture design respects the craft's historical significance while bringing it into modern contexts. Environmental responsibility, on the other hand, involves practices that minimize ecological impact, such as using renewable resources, reducing waste, and designing for longevity. Mortise and tenon joinery embodies this approach by employing natural materials, promoting durability, and facilitating repairability. Together, these values encourage a holistic design approach that respects cultural legacy and environmental health, offering a sustainable alternative to disposable, mass-produced products.

Designing for Durability and Longevity. Sustainable design advocates for the creation of products that endure over time, reducing the need for constant replacement and the waste associated with disposable goods. Designing for durability means choosing high-quality materials and construction techniques that ensure the product's longevity. Mortise and tenon joinery exemplifies this principle with its solid, interlocking joints that withstand wear and time. By promoting durability, sustainable design contributes to a circular economy where products are

valued for their long-term functionality and can be reused, repaired, or repurposed. This shift from short-lived to lasting products reduces resource depletion, minimizes environmental impact, and fosters a mindset of responsible consumption.

Fostering Local Economies and Ethical Production. Sustainable and social design principles also involve supporting local economies and promoting fair, ethical production practices. By working with artisans and local manufacturers, designers can create economic opportunities within communities, helping to sustain traditional crafts and generate fair wages. Mortise and tenon joinery, often practiced by skilled artisans, presents an opportunity to collaborate with local craftspeople, keeping the craft alive and ensuring that the knowledge is passed on. Ethical production also includes transparency in sourcing, fair labor practices, and ensuring safe working conditions, reinforcing a commitment to responsible production that prioritizes people over profit.

Promoting Environmental Stewardship through Material Choices. A core principle of sustainable design is environmental stewardship, which emphasizes choosing materials and production methods that conserve resources and protect ecosystems. Mortise and tenon joinery, with its reliance on natural wood and minimal use of adhesives or fasteners, represents an eco-friendly approach to construction. By selecting renewable materials, reducing toxic outputs, and designing for disassembly and reuse, environmentally responsible design aligns with ecological conservation goals. Sustainable design choices, like using regionally sourced wood and reducing carbon-intensive processing, further reinforce environmental stewardship, allowing designers to contribute positively to global sustainability efforts.

Encouraging Consumer Awareness and Responsible Consumption. Finally, sustainable and social design promote responsible consumption by educating consumers about the environmental and cultural impact of their purchases. When consumers understand the craftsmanship, cultural heritage, and sustainable practices behind a product, they are more likely to value it and maintain it over time. Mortise and tenon joinery, as a traditional craft that emphasizes quality and sustainability, embodies these values, offering consumers a tangible connection to heritage and ecology. Designers can foster responsible consumption by creating products that inspire care, awareness, and appreciation, encouraging a shift away from disposable culture toward a more mindful approach to owning and using products.

In summary, the principles of sustainable and social design provide a framework for creating products and systems that benefit society, honor cultural traditions, and protect the environment. Mortise and tenon joinery embodies these principles, serving as a model for how traditional craftsmanship can inform modern design practices. By integrating these values into their work, designers can help build a more inclusive, resilient, and sustainable future, where products are valued not only for their function but also for their contribution to a healthier, more equitable world.

The role of cultural and environmental responsibility

Cultural and environmental responsibility are essential pillars of socially responsible design, especially in a time of global environmental challenges and cultural homogenization. Designers today have a responsibility not only to create functional and aesthetically pleasing products but also to respect and preserve cultural heritage while minimizing ecological impact. Cultural responsibility honors the traditions, craftsmanship, and heritage that give designs a sense of place and identity. Environmental responsibility, on the other hand, involves practices that reduce waste, conserve resources, and promote sustainability. When combined, these values encourage a holistic approach to design that respects both people and the planet.

Sustainable development is never an isolated goal, but a journey that needs to be persevered for a long time with a humble heart, covering multi-dimensional development such as environmental protection, social responsibility and even cultural heritage.

Preserving Cultural Heritage through Design

Cultural responsibility in design calls for an awareness of and respect for the traditional practices, symbols, and narratives embedded within a given community or society. Traditional techniques like mortise and tenon joinery, for instance, represent centuries-old craftsmanship and cultural knowledge that reflect local identities and values. By incorporating these traditional methods into modern design, designers help preserve and promote cultural heritage, ensuring that these practices remain relevant. This integration fosters cultural continuity, connecting contemporary products to historical narratives and offering consumers a deeper, more meaningful connection to the past. Embracing cultural responsibility also promotes diversity in design, countering the trend of global homogenization by

celebrating the unique aesthetic and functional qualities of different cultural practices.

Encouraging Sustainable Resource Use and Minimizing Waste

Environmental responsibility in design is centered on sustainable resource use, waste reduction, and minimizing the carbon footprint of products. Mortise and tenon joinery is an exemplary model of environmentally responsible design, as it requires no nails, adhesives, or synthetic materials. This technique relies solely on natural materials and interlocking structures, making it both eco-friendly and highly durable. By designing products that use renewable materials, emphasize longevity, and are easy to repair or disassemble, designers can reduce the environmental impact of their creations. In adopting such sustainable practices, environmentally responsible design supports a circular economy, where products and materials are reused and repurposed rather than discarded.

Promoting Quality and Longevity over Disposability

Cultural and environmental responsibility both encourage the creation of products that prioritize quality and longevity over disposability. Many traditional crafts, including mortise and tenon joinery, are designed to withstand the test of time, with structures and furniture that can last for generations. This durability aligns with environmental goals by reducing the need for frequent replacement, thereby conserving resources and minimizing waste. Culturally, the durability and repairability of such designs support a sense of continuity, as these products are valued as heirlooms and symbols of heritage. By focusing on durability and quality, designers contribute to a more sustainable, less wasteful culture of consumption that values meaningful, long-lasting products.

Enabling Cross-Cultural Understanding and Appreciation

Incorporating cultural responsibility into design fosters a greater understanding and appreciation of different traditions and values. When consumers interact with products that reflect cultural heritage, they are exposed to the history, skills, and meanings associated with that culture. Mortise and tenon joinery, for example, not only showcases technical skill but also invites users to appreciate the philosophy of simplicity, balance, and harmony that underpins this craftsmanship. By promoting culturally rich designs, designers can bridge cultural divides, fostering mutual respect and admiration across different communities. This cultural

exchange enriches the global design landscape, helping to create a more inclusive and interconnected world.

Responding to Contemporary Environmental Challenges

As environmental challenges such as climate change, deforestation, and pollution become more urgent, designers are increasingly called upon to adopt practices that minimize ecological impact. Environmental responsibility in design includes choosing renewable materials, reducing reliance on non-biodegradable components, and designing for a product life cycle that supports repair, reuse, and recycling. Mortise and tenon joinery's emphasis on natural materials and repairability aligns seamlessly with these goals, making it a valuable model for environmentally conscious design. By creating products that are eco-friendly and designed for minimal waste, designers can play a crucial role in supporting environmental sustainability and reducing the ecological footprint of the design industry.

Integrating Cultural and Environmental Responsibility in Modern Design

Cultural and environmental responsibility are complementary, as both seek to preserve essential resources—be they cultural knowledge or natural materials—for future generations. By integrating these principles into design, practitioners can create products that honor tradition while advancing sustainability. For instance, modern furniture crafted using mortise and tenon joinery combines environmental sustainability with cultural significance, offering consumers a choice that respects both heritage and nature. This approach represents a balanced design philosophy that values resource conservation and cultural preservation, aligning with contemporary goals for sustainable development.

Inspiring Mindful Consumption and Social Awareness

Products designed with cultural and environmental responsibility in mind encourage consumers to make mindful choices, valuing products that are not only functional but also meaningful and sustainable. This shift can lead to a more socially and environmentally aware consumer culture, where people actively seek out products that reflect their values and support a sustainable future. By educating consumers on the cultural significance and ecological benefits of their products, designers can help foster a culture of responsible consumption that values quality, heritage, and environmental health.

In summary, cultural and environmental responsibility play a crucial role in shaping a design approach that is ethical, sustainable, and culturally resonant. Traditional techniques like mortise and tenon joinery embody these values, providing a model for designers seeking to balance heritage with sustainability. By embracing cultural and environmental responsibility, designers can contribute to a more inclusive, sustainable, and meaningful design practice that respects both cultural legacy and ecological health.

In an era marked by rapid industrialization and environmental challenges, cultural and environmental responsibility has become essential in the design field. Cultural responsibility refers to the obligation of designers to preserve and respect the heritage, values, and traditions embedded within cultural artifacts and practices. This aspect of responsibility emphasizes an appreciation for the historical and symbolic significance of traditional craftsmanship, such as the mortise and tenon joinery, which carries centuries of accumulated knowledge, aesthetic principles, and cultural identity. Recognizing this responsibility, designers can help protect and elevate cultural heritage by integrating these traditional elements into contemporary applications, promoting awareness and appreciation across diverse contexts.

Environmental responsibility, on the other hand, calls for sustainable practices that minimize environmental impact and prioritize resource efficiency. As the construction and design industries are significant contributors to environmental degradation, there is a growing need for solutions that reduce waste, conserve resources, and emphasize durability and adaptability. Traditional mortise and tenon joinery offers a model for environmentally responsible design, as its glue-free, nail-free construction method aligns naturally with principles of sustainability. This approach allows for ease of disassembly and reuse, reduces reliance on synthetic adhesives, and enhances the longevity and adaptability of structures. By adopting mortise and tenon techniques in modern design, architects and designers can reduce the ecological footprint of their projects and foster a more circular economy.

Together, cultural and environmental responsibility foster a holistic approach to design that values both heritage and sustainability. For mortise and tenon craftsmanship, this dual responsibility enables the technique to evolve within contemporary frameworks while preserving its historical essence and adapting to the needs of today's world. This research advocates for a design paradigm that goes beyond functionality, emphasizing the preservation of cultural identity and ecological integrity. By embedding cultural and environmental responsibility into the foundation of design practices, the craft of mortise and tenon can be revitalized

and protected, serving as a model for a sustainable and culturally aware design future.

Tim Brown, president and CEO of IDEO, defined it this way: “Design Thinking is a human-centered approach to innovation that draws on the tools of the designer to integrate the needs of people, the possibilities of technology and the requirements for business success”.

3.3.2 The Role of the Responsible Designer

This section concludes by emphasizing the role of the designer as a steward of cultural heritage and sustainability. Designers have a responsibility to respect and preserve traditional craftsmanship while adapting it for modern contexts. By integrating mortise and tenon into sustainable and meaningful designs, designers can contribute to cultural preservation and promote a broader understanding of design as a tool for positive social impact .

Creating meaningful products, like making gifts, is an act of responsibility and pleasure. Responsibility because, through the gift, we have a chance to create a more meaningful world. It's the way we contribute to people's lives.⁷²

Manzini clearly states that design for social innovation is not a new discipline: it is simply one of the ways in which contemporary design is appearing. Therefore, what it requires is not so much a specific set of skills and methods as a new culture, a new way of looking at the world and at what design can do with and for people living in it.

Design disciplines sometimes seem to operate through paradigms, methodologies, tools and norms that presuppose an idea of "normality", an implicit crisis, a status quo that limits designers at least they are aware of it.

⁷² Verganti, R. (2017). *Overcrowded: Designing meaningful products in a world awash with ideas*. The MIT Press.

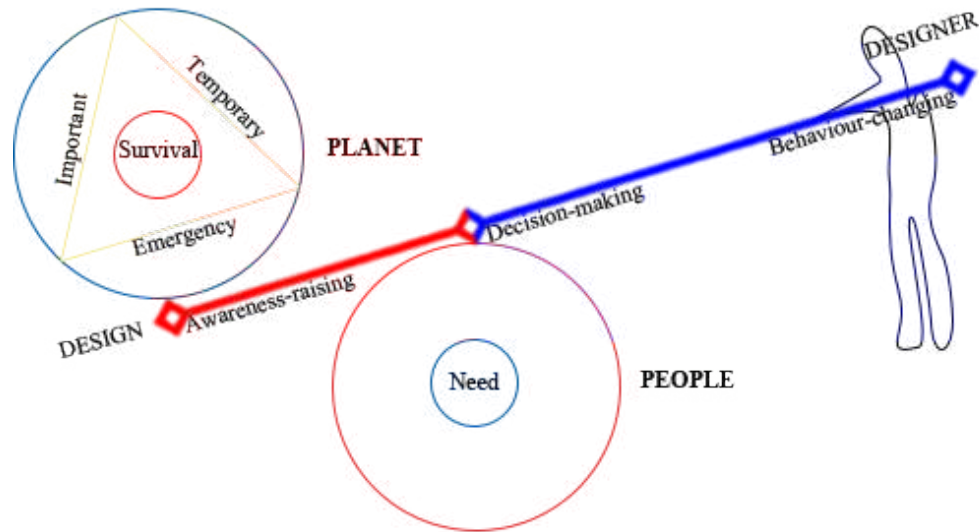


Figure 3.2 The Role of the Responsible Designer(Drawings by author)

The illustration depicting a lever-like structure with “DESIGN” and “PLANET” on one side and “PEOPLE” on the other, accompanied by concepts such as “Survival,” “Need,” “Decision-making,” and “Awareness-raising,” visually encapsulates the concept of design-driven innovation as a lever for social change. Here is unpack this visual metaphor in detail.

Design as a Lever for Change: The great scientist, Archimedes, made his famous statement, "Give me a place on which to stand, and I will move the earth." The diagram highlights “DESIGN” as a fundamental fulcrum or pivot point, suggesting that design can act as a powerful lever. This is akin to the idea that “with the right fulcrum, one can lift the world,” implying that design has the potential to shift societal behaviors, awareness, and decision-making.

Empowering Role of Design in Addressing Needs: The “PEOPLE” side of the diagram includes the term “Need,” signifying that the primary drive of design should be to fulfill human needs. Design-driven innovation does not merely create products but addresses fundamental human requirements, which could range from basic survival (e.g., in emergencies) to more sustainable, long-term changes.

- **Awareness-raising:** Located near “DESIGN,” this element suggests that one role of design is to elevate awareness around critical issues (such as environmental sustainability). By raising awareness, design can help shape public perception and understanding of important challenges facing society.

- Decision-making: This element bridges the two spheres (“PLANET” and “PEOPLE”), emphasizing that design’s impact is not passive but involves active choices that guide human actions and societal outcomes.

- Behavioral-changing: This indicating that designers play a key role in influencing or modifying behavior. Designers are tasked with creating solutions that encourage positive changes in how people interact with each other and the environment.

Design for Planetary and Human Welfare: The elements “PLANET” and “Survival” emphasize the role of design in ensuring the well-being of both the environment and society. The inclusion of terms like “Emergency” and “Important” in the “Survival” area stresses that design must respond to urgent global issues, such as climate crises or social inequities.

Connecting People, Planet, and Designers: The illustration suggests an interconnected system where the designer’s role is to mediate between human needs and planetary welfare. This conceptual structure implies that true innovation in design considers both human-centered and planet-centered values, advocating for sustainable and responsible practices.

In essence, the image reflects an advanced approach to design-driven innovation, where design is more than aesthetics; it becomes a strategic tool to address, influence, and resolve societal and ecological needs. It underscores the empowering role of design in fostering awareness, guiding decisions, and shaping behaviors, which altogether contributes to meaningful social change.

“We don't expect things to change if we continue to do them the same way as always. The crisis is the best thing that can happen to people and entire countries, because it is precisely the crisis that brings progress. Creativity is born from anxiety, as the day is born from the dark night. It is in crisis that inventiveness is born, that discoveries and great strategies are born... Without crisis there are no challenges, without challenges life is routine, a slow agony. Without crisis there are no merits. It is in crisis that the best of each of us emerges because without crisis any wind is a caress. Overcoming the crisis means creating movement; adapting to it means exalting conformism. The only threatening crisis is the tragedy of not being willing to fight to overcome it.” --Albert Einstein

Chapter 4 Innovation Design Applications of Mortise and Tenon Craftsmanship

This chapter explores international and domestic applications of mortise and tenon joinery based on three main criteria: adaptability, examining how the technique has been modified with modern materials or for current needs; structural integrity, which assesses durability and resilience; and cultural symbolism, evaluating the integration of local heritage. By following these criteria consistently, this analysis underscores the versatility of mortise and tenon across diverse cultural contexts.

4.1 Temporary and Modular Architecture

Temporary and modular architecture has gained increasing relevance in response to the need for flexible, efficient, and sustainable building solutions. Whether addressing the demands of disaster relief, rapid urbanization, or the evolving preferences for adaptable living spaces, these structures offer unique benefits in terms of mobility, resource efficiency, and reusability. This section explores the innovative applications of mortise and tenon craftsmanship in the design of mobile and emergency structures, highlighting their potential in temporary and modular architectural solutions.

4.1.1 Application in Mobile and Emergency Structures

(1) Origins of Architecture and Primitive Building Forms

Architecture, in its earliest forms, arose from a fundamental human need: to seek shelter from the elements and protect against external threats. Primitive structures were simple, utilitarian, and designed to provide safety, warmth, and a degree of permanence in the face of uncertain and often harsh environments. As societies evolved, so too did their building techniques, with architecture gradually encompassing symbolic, aesthetic, and social functions. However, at its core, architecture has always been a response to humanity's basic needs for protection, security, and stability. In contemporary design, this fundamental nature of architecture is being re-evaluated, particularly in the context of humanitarian and humanistic building approaches.

Primitive building forms were a direct response to the environment and to survival needs. Early shelters, often constructed with materials readily available in the surrounding landscape, were crafted to shield inhabitants from harsh weather conditions, such as cold, wind, and rain, as well as from wild animals or other external threats. Caves, huts made from branches and leaves, and dwellings composed of animal skins or mud were among the earliest examples of human-made shelters, each tailored to the specific conditions and available resources of the environment.

These structures reflected a profound understanding of natural materials and a high degree of adaptability. For instance, in forested regions, early humans used timber and branches, binding them together to create robust and insulated shelters. In arid climates, mud and clay were the preferred materials, as they provided insulation against intense heat. This ingenuity in building served as a basic yet effective means of survival, illustrating the deeply rooted connection between humans and their environment. At this stage, architecture was purely functional, with the primary purpose of providing refuge and safety.

Beyond protection from the elements, architecture also emerged as a means of defense against external threats from other groups or animals. Fortified structures, such as walls and enclosures, evolved to safeguard communities and resources. These defensive structures can be seen as some of the earliest examples of architectural adaptation, where form and function were specifically tailored to meet the dual needs of shelter and security.

As societies became more complex, so did their architectural forms. Defensive structures evolved from simple enclosures to more elaborate fortifications, such as walls with watchtowers, gates, and barriers. These early forms of architecture not only protected people but also symbolized a growing sense of community and the need to safeguard shared spaces and values. This protective function of architecture endures today, especially in the realm of humanitarian design, where buildings are designed to offer shelter and security for vulnerable populations.

In contemporary architecture, there is a renewed focus on creating structures that reflect the fundamental, humanistic purposes of shelter and protection. Humanitarian architecture, specifically, emphasizes designs that prioritize human needs and dignity, especially in times of crisis. The aim is to provide secure, dignified, and comforting spaces for individuals and communities affected by conflict, displacement, or natural disasters.

Humanitarian and humanistic buildings, such as emergency shelters for refugees and temporary housing for disaster survivors, are designed to be quickly deployable, adaptable, and protective. This approach reaffirms architecture's core purpose—providing shelter and security while fostering a sense of stability and dignity. Architects working in humanitarian contexts often draw on materials and construction methods that are sustainable, affordable, and locally sourced, which allow for rapid assembly and disassembly, thus adapting to the often urgent and temporary nature of these needs.

With the rise of urbanization, particularly in the 20th century, architecture became increasingly focused on verticality and density. High-rise buildings emerged as a solution to the growing demand for residential and commercial space in cities, particularly as urban populations expanded. These skyscrapers symbolized progress and technological achievement, catering to economic demands and maximizing land use efficiency. While high-rise buildings are remarkable feats of engineering and serve important functions in densely populated areas, their focus on space efficiency, economy, and corporate or residential needs often distances them from the core essence of architecture as shelter and sanctuary.

Many high-rise buildings are designed with a primary emphasis on functionality, efficiency, and aesthetics, rather than human-centered values. This trend has led to criticism that urban architecture has strayed from its essential purpose, prioritizing economic and functional considerations over human well-being and environmental harmony. In the modern cityscape, these towering structures, while visually impressive, can often feel detached from the lives of their inhabitants, offering limited opportunities for meaningful human interaction or connection with nature.

In recent years, there has been a growing movement within the field of architecture that advocates for a return to the fundamental principles of shelter and human well-being. This approach encourages architects to look beyond mere function and aesthetics, embracing design principles that center around comfort, community, and environmental stewardship. The humanitarian and humanistic aspects of architecture are gaining importance, particularly in light of global challenges such as climate change, natural disasters, and large-scale displacement. These challenges demand a re-evaluation of architectural practices, focusing on sustainable, adaptable, and resilient building forms.

One way contemporary architecture can return to its roots is through the use of modular, demountable, and prefabricated structures that offer flexibility, sustainability, and ease of assembly. For example, designs that incorporate traditional construction techniques, like mortise and tenon joinery, provide structures that are both durable and easily dismantled for reuse. These techniques not only honor traditional craftsmanship but also provide practical solutions for temporary and emergency shelters, aligning with the humanistic goals of protecting and uplifting communities in need.

Moreover, the modern focus on sustainable building materials—such as bamboo, recycled paper, and other low-impact resources—echoes the primitive architectural practice of using local materials that harmonize with the environment. Architects like Shigeru Ban, who have pioneered the use of recyclable materials in emergency shelters, exemplify this approach, demonstrating that architecture can once again become a tool for protection and human support in its most essential form. Ban’s innovative use of cardboard tubes, for example, shows how low-cost, eco-friendly materials can provide effective shelter, offering protection from both environmental elements and the psychological distress often associated with displacement.

The origins of architecture, grounded in the primal need for shelter and protection, continue to offer valuable insights for contemporary design. As urbanization has driven architecture toward high-rise, high-density structures, the field risks losing sight of its foundational purpose. However, the current trends in humanitarian architecture and sustainable building practices signal a return to architecture’s essence. By focusing on human-centered, adaptable, and ecologically sound designs, architects today can address the pressing needs of both urban and vulnerable populations.

Moving forward, the integration of traditional joinery techniques, modular construction, and environmentally friendly materials will be essential in creating spaces that are not only functional but also humane and protective. This reorientation of architecture toward its original goals—providing shelter, security, and a sense of belonging—underscores a timeless truth: at its core, architecture is a manifestation of humanity’s enduring need to create spaces that nurture and protect.

(2) Mobile Architecture

Yona Friedman's "mobile architecture" is a result of his personal experience as a refugee and homeless person, despite being perennially labelled as utopian.

We find Friedman's influence in many areas, and his concept of Mobile Architecture in the 1950s had an impact on the emergence of Archigram in the UK in the 1960s. The concept of Mobile Architecture, which he proposed in the 1950s, had an impact on the "Archigram" that emerged in Britain in the 1960s. This influence even spread to Japan in the East, which is known as "Metabolism" in the history of architecture.

The so-called "Metabolism" idea is to regard the city and architecture as a dynamic process, and advocate the introduction of the time factor, because the "Metabolism" regarded the architecture and the city as an organic matter, and it has "metabolism" and "cycle". "Metabolism" sees architecture and the city as an organic matter, with "metabolism" and "circulation". This doctrine is a challenge to the modernist style that influenced architecture all over the world in the twentieth century, which led to the great transformation of modernism.

Published in 1958, Friedman had three requirements for a "mobile building": 1/ to be in contact with the ground in a very small area; 2/ to be able to be dismantled and moved; and 3/ to be able to be modified according to the requirements of the occupants.

Spatial City Project shows. The Spatial City is a unit that can be repeated ad infinitum. All of the structural elements connected to the individual user, such as walls, floor slabs, and partitions, are radically mobile, and the architecture deliberately avoids committing itself to any particular style or pattern of use. Versatile and free as Friedman's composition is, however, it is contained by a superior order, on which it relies: the wide grid of pillars and slabs on which it stands. Friedman called this grid the "spatial infrastructure," and designed it for collective use. The user's determination was to play as important a role in it as the architect's: "Mobile architecture looks for techniques which don't impose a preconceived plan. . . . It is the user who makes the project with a potential 'designer's participation.'" The design of Friedman's ideal city is only perfected in its use.

The concept of mobile architecture was Friedman's contribution to the tenth International Congress of Modern Architecture (CIAM) in Dubrovnik in 1956. It was during this session of the congress that modernism was famously called into

question as an outdated, static scheme inappropriate for new global realities. Friedman's concept highlighted the relationship between social dynamics and architecture in the proto-postmodern world, and suggested to architects how they could include that relationship in their thinking about the future.

Yona Friedman's concept of "mobile architecture" emerged in response to modern architectural trends in the mid-20th century, which were marked by increasing urbanization and the dominance of high-rise buildings. Friedman's ideas challenged these trends by proposing a flexible, user-centered approach to architecture that prioritized the needs and agency of the individual. His personal experiences as a refugee and periods of homelessness profoundly shaped his vision, leading him to develop designs that focused on adaptability, accessibility, and freedom of movement. This approach, while often labeled as utopian, was intended to empower people, particularly those in transient or vulnerable situations, by giving them control over their living environments.

Friedman's "mobile architecture" was based on the idea that buildings should be as adaptable and movable as the people they serve. He proposed that structures be designed as modular systems that could be easily assembled, disassembled, and rearranged according to the users' changing needs. This approach was revolutionary in its departure from the rigid, permanent structures dominating the urban landscape. Instead of static high-rises, Friedman envisioned cities composed of modular, prefabricated elements that could be transported, reconfigured, or even dismantled entirely as necessary. His concepts emphasized a high degree of user involvement in the creation and adaptation of their living spaces, which he believed was crucial for fostering a sense of autonomy and human dignity.



Figure 4.1 Yona Friedman's Concept of "Mobile Architecture"⁷³

Friedman's mobile architecture concept also aligned with humanistic principles in design, reflecting his belief that architecture should serve not just functional needs, but also emotional and psychological ones. His work laid the foundation for later explorations of modular and demountable construction methods, including the use of mortise and tenon joinery in temporary buildings. Mortise and tenon, a traditional joinery method known for its simplicity and strength, embodies these human-centered values by providing a means of construction that is both durable and adaptable. Mortise and tenon joints can be assembled and dismantled without damage to the components, making them an ideal choice for temporary and emergency buildings where flexibility and speed are essential.

In connecting Friedman's mobile architecture with mortise and tenon construction, we can see an architectural trajectory that places value on responsiveness to human needs, adaptability to various circumstances, and sustainability. Friedman's concepts resonate today in the context of prefabricated, dismantlable structures used in emergency housing, particularly post-disaster shelter and temporary buildings. This convergence of Friedman's philosophy with traditional, easily assembled construction methods like mortise and tenon reflects a continued commitment in architectural design to address both practical needs and the deeper, humanistic concerns of those it serves.

(3) From Yona Friedman's Mobile Architecture to Shigeru Ban's Emergency Shelters for Humanitarian Relief

The concept of architecture as a mobile, adaptable structure serving immediate human needs is a significant theme in modern architectural thought, rooted in the fundamental purpose of providing shelter. This idea was notably advanced by Yona Friedman in the 1960s, who argued for "mobile architecture" that could adapt to the changing needs and constraints of urban life, empowering people to construct their own environments. Decades later, architect Shigeru Ban would echo these ideas in his designs for temporary shelters, bringing innovative, low-cost, and ecologically sustainable solutions to communities affected by natural disasters. Friedman's theoretical foundations of mobile architecture paved the way for Ban's hands-on, humanitarian approach to post-disaster shelters, underscoring a shared commitment to architecture that addresses basic human needs in times of crisis.

⁷³ <https://www.archdaily.com/912823/a-selection-of-the-most-representative-drawings-by-yona-friedman>

Yona Friedman, an influential architect and urban planner, envisioned a type of architecture that would respond directly to human needs by prioritizing flexibility, adaptability, and user agency. His concept of “mobile architecture” was inspired by his experiences as a refugee, which made him acutely aware of the essential need for shelter that could quickly adapt to changes. Friedman critiqued the rigid, high-rise architecture that dominated urban landscapes, which he felt was out of touch with humanistic concerns. Instead, he proposed modular, demountable structures that individuals could assemble and adapt themselves. This architectural model, while often deemed “utopian,” was firmly rooted in Friedman’s belief in empowering people to construct environments that suited their lives and needs.

Friedman’s mobile architecture approach emphasized temporary structures that could be assembled, disassembled, and reconfigured as needed. This emphasis on flexibility aligns closely with primitive origins of architecture, where shelters were designed to protect people from environmental threats and provide basic security. Friedman’s vision laid important conceptual groundwork for an architecture that prioritizes adaptability, resonating with the needs of refugees, disaster victims, and others in transient or emergency situations.

Shigeru Ban, a Japanese architect and humanitarian, brought the principles of mobile, adaptable architecture to life in the context of disaster relief. His commitment to providing shelter for those in crisis situations has led to numerous innovative designs that respond to the urgent needs of displaced communities around the world. Ban’s work builds on the foundational ideas of adaptability and human-centered design set forth by Friedman but is distinguished by his hands-on approach and dedication to humanitarian causes. Ban first began working with temporary, lightweight materials in the 1990s and has since become renowned for his use of unconventional, recyclable materials such as cardboard tubes, paper, and bamboo. These materials not only meet the structural requirements for temporary shelters but also reflect an ecologically sound approach long before sustainability became a widespread concern.

Ban’s use of cardboard tubes as a primary building material exemplifies his innovative approach to emergency shelters. These tubes, made from recycled paper, are lightweight, cost-effective, and environmentally friendly, making them ideal for rapid deployment in disaster-stricken areas. First used in the aftermath of the Rwandan refugee crisis in 1994, Ban’s cardboard tube structures provided a practical, low-cost solution that could be quickly assembled by untrained individuals, much like Friedman’s concept of mobile architecture. Over the years,

Ban's cardboard architecture has been deployed in various disaster sites, including the 1995 Great Hanshin Earthquake in Japan, the 2008 Sichuan Earthquake in China, and the 2010 Haiti Earthquake. His shelters are designed to meet the immediate needs of displaced populations, offering safety, comfort, and a sense of dignity through thoughtful, user-centered design.

Both Friedman's and Ban's approaches highlight a fundamental principle in architecture: the need to center design on humanistic care. Friedman's theoretical model encouraged individuals to actively shape their environments, and Ban's shelters extend this empowerment by enabling people in crisis to participate in the construction and adaptation of their own spaces. This user-centered approach is a response to the psycho-emotional needs of those affected by disaster. Ban's shelters, while temporary, are carefully crafted to provide more than basic protection. His designs offer privacy, comfort, and even aesthetic appeal, recognizing that even temporary homes should be dignified and humane spaces.

Ban's architectural philosophy reflects his belief that architects should play a role in addressing social challenges. Upon winning the Pritzker Prize in 2014, Ban affirmed his commitment to using architecture as a tool for humanitarian relief, stating that he wanted to continue creating buildings that "make people happy." His work demonstrates that even in temporary structures, beauty and comfort can coexist with functionality. Ban's shelters are examples of how architecture can contribute to psychological and emotional healing by providing victims of disaster with spaces that feel safe, familiar, and respectful.

Ban's use of sustainable materials such as cardboard tubes and bamboo is a significant advancement in the field of emergency shelter design. Long before sustainability became a priority in architecture, Ban recognized the need for materials that were both low-impact and recyclable. His approach aligns closely with the modern push for environmentally responsible design, emphasizing that architecture should minimize ecological footprints, even in temporary applications. Ban's structures are not only effective in their immediate context but also contribute to long-term sustainability by using materials that are renewable and biodegradable.

Through Ban's shelters, the architectural community has witnessed the value of combining traditional, low-tech solutions with innovative materials and methods. In several instances, Ban has integrated local materials and building techniques, allowing communities to contribute resources and knowledge to the construction process. This collaborative approach strengthens community ties, fosters resilience,

and encourages self-sufficiency, as communities actively participate in the rebuilding process.

The principles advanced by Friedman and Ban point toward an evolving paradigm in temporary architecture—one that prioritizes adaptability, humanistic care, and sustainability. As architects explore further innovations in disaster-relief structures, there is increasing interest in combining mobile, prefabricated designs with traditional construction techniques such as mortise and tenon joinery. This traditional joinery method, known for its strength and ease of assembly without nails or adhesives, aligns with Ban’s principles by offering a sustainable and dismantlable solution for temporary buildings. Mortise and tenon could be adapted for prefabricated modular shelters that are both robust and easily demountable, meeting the needs of emergency housing with flexibility and respect for cultural craftsmanship.

Friedman’s and Ban’s ideas thus come full circle, as the field of architecture seeks to blend high-tech innovation with the time-tested practices of traditional construction. This convergence of mobile architecture, sustainable materials, and traditional joinery represents a model for temporary buildings that address immediate physical needs while fostering psychological resilience and community cohesion. Through their work, both Friedman and Ban have shown that architecture can—and should—serve as a source of comfort and stability in times of profound crisis.

4.1.2 Digital Fabrication Techniques for Mortise and Tenon



Figure 4.2 CNC Technology⁷⁴

Digital Continuum Between Design and Manufacture.

The integration of digital technologies in design and manufacturing has created a seamless continuum, bridging the gap between conceptualization and production. As Giulio Barazzetta notes, “Digital continuum between design and manufacture, achieved with CAD/CAM technologies, numerical control, and prototyping, creates a synthesis between design and construction, in line with the tradition of the close relationship between design and craftsmanship.”⁷⁵ This synergy between digital tools and traditional craftsmanship has revolutionized fabrication processes, enabling precision, efficiency, and innovation.

CNC Machining Process (Computer Numerical Control)

CNC machining is a cornerstone of modern digital fabrication. It falls under the umbrella of subtractive manufacturing, where material is removed from a solid block, bar, or rod of plastic, metal, or other materials through cutting, boring, drilling, and grinding. CNC processes are typically automated, driven by computer systems that translate virtual models from CAD (Computer-Aided Design) software into precise toolpaths. These toolpaths guide the cutting tool through the material, creating complex geometries with minimal human intervention.

⁷⁴ *Technique (EN)*. Veneer House. (n.d.). <https://www.veneerhouse.com/technique-en>

⁷⁵ Barazzetta, G. (2015). *Digital takes command: Orizzonti di Progettazione e Produzione Digitale = design horizons and digital fabrication*. Rubbettino.

Key Features of CNC Machining:

- **Precision and Automation:** CNC machines follow coded instructions to execute tasks such as motion control, tool changes, and spindle operation, ensuring high accuracy and repeatability.
- **Versatility:** CNC milling and routing are widely used in architecture and design, offering scalability and efficiency for both small-scale and large-scale projects.
- **Complexity and Flexibility:** The ability to work in non-cubic spaces and integrate various tools (end-effectors) allows CNC machines to perform highly specific and complex tasks.

As Gilles Retsin explains, “We combine the scalability and efficiency of modular and prefabricated architecture with the complexity and versatility of the digital.”⁷⁶ This statement highlights the transformative potential of digital fabrication in merging traditional modular construction methods with advanced computational design.

Additive Manufacturing (3D Printing)

In contrast to subtractive methods, additive manufacturing builds objects layer by layer, adding material until the final part is complete. Like CNC machining, 3D printing relies on CAD models for design input. However, the preparation of models for 3D printing is largely automated, using slicer software to generate instructions for the printer. This process simplifies setup and reduces production time, making additive manufacturing an accessible and efficient alternative for prototyping and small-scale production.

Advantages of Additive Manufacturing:

- **Material Efficiency:** By adding material only where needed, 3D printing minimizes waste.
- **Design Freedom:** Complex geometries that are difficult or impossible to achieve with traditional methods can be easily produced.

⁷⁶ Retsin, G. (2020). DISCRETE TIMBER ASSEMBLY. In *UCL Press eBooks* (pp. 264–271). <https://doi.org/10.2307/j.ctv13xpsvw.38>

- **Rapid Prototyping:** The ability to quickly produce prototypes accelerates the design iteration process.



Figure 2.12 3D Printed Urban Cabin⁷⁷

Robotic Fabrication

Robotic fabrication represents the next frontier in digital manufacturing. Robots equipped with specialized end-effectors can perform highly complex and precise tasks, offering unparalleled flexibility. Unlike traditional CNC machines, which are constrained by the size and position of the tool bed, robotic arms can operate in non-cubic spaces and adapt to various materials and geometries. This flexibility makes robotic fabrication ideal for custom and large-scale projects, such as modular architecture and bespoke furniture.

(1) Integration of mortise and tenon construction with digital fabrication

Modern CNC machining technology. Development of CNC machining technology. The development of CNC machining technology has given new life and vitality to the production of traditional mortise and tenon structure. In the past, the mortise and tenon process relied on the experience of craftsmen and manual operation, the cumbersome production process is not only time-consuming and labour-intensive, but also susceptible to the influence of human factors, resulting in the finished product is difficult to guarantee the accuracy and consistency. Nowadays, the introduction of CNC technology breaks this limitation, through the precise control of computer programs, the design drawings into efficient processing instructions, so that the cutting and milling of mortise and tenon to achieve automation and standardisation. This process not only improves the production efficiency, but also ensures the cooperation between the various components of the

⁷⁷ Cardenas, D., Rojas, C., Villa, V., & Mena, F. (2016, October 20). ArchDaily. https://www.archdaily.com/country/the-netherlands/page/42?ad_content=category&ad_medium=highlighted&ad_name=flyout

mortise and tenon structure, which in turn improves the stability and durability of the overall structure.

With the continuous progress of CNC technology, the improvement in machining precision, speed and flexibility, the design of mortise and tenon structure has become more and more diversified. The shape and size of traditional mortise and tenon can be innovated according to modern design concepts, bringing more possibilities. The extensive use of CNC engraving machines, laser cutting machines and other equipment makes it easy to realise complex mortise and tenon forms, and even detailed engraving on the edges of the material, adding decorative and artistic qualities to the product. At the same time, the programmed nature of CNC technology makes mass production possible, which not only meets the market demand for personalised products, but also reduces production costs and promotes the inheritance and innovation of mortise and tenon techniques.

In this process, CNC machining technology is not only a technological innovation of traditional craftsmanship, but also a profound reflection and reshaping of mortise and tenon culture. It has given birth to a new design concept that integrates tradition and modernity, making the ancient craft of mortise and tenon shine in the new era.

Application of CNC machining technology in mortise and tenon structure. The introduction of CNC machining technology has revolutionised the production of traditional mortise and tenon joinery, significantly improving production efficiency and machining accuracy. Through computer-controlled CNC machines, designers and craftsmen are able to carry out accurate 3D modelling in a virtual environment, and then generate high-fidelity machining paths. This technology not only shortens the design and production time, but also makes it possible to realise complex mortise and tenon structures, breaking the limitations of traditional manual machining in terms of process complexity and precision. CNC machining technology can ensure the diversity of mortise and tenon joints, while achieving efficient mass production, to meet the needs of the modern market for personalisation and rapid response. During the machining process, advanced sensors and feedback systems ensure real-time monitoring and adjustment, so that each mortise and tenon joint meets the preset dimensions and tolerances. This technology not only greatly improves the repeatability and consistency of mortise and tenon construction, but also opens up new creative possibilities for designers, allowing them to explore the possibilities of non-linear and heterogeneous material combinations. The practical use of CNC technology is no longer a simple copy of

traditional craftsmanship, but a deep fusion of traditional wisdom and modern technology, which promotes the diversified development of mortise and tenon construction in modern life, making it more in line with the current dual pursuit of function and aesthetics. This innovative design supported by technology not only continues the traditional cultural connotation of mortise and tenon, but also gives it a new life in the context of modern craftsmanship.

The use of biodegradable materials in mortise and tenon joints. In the current global advocacy of sustainable development, the introduction of biodegradable materials into the design of mortise and tenon joints is undoubtedly an innovative practice in line with the trend of the times. These materials not only have the excellent characteristics of traditional wood, but also show great advantages in environmental protection. By optimising the design of mortise-and-tenon joints, biodegradable materials can compete with traditional wood in terms of load-bearing capacity, durability and aesthetics, and even perform better in some aspects. For example, bio-based plastics and modified wood composites, as biodegradable materials, are able to guarantee the robustness of mortise and tenon joints with their unique physical properties and good processability. Such materials can decompose quickly in the natural environment, reducing the burden on the ecology and meeting the urgent needs of modern society for environmental protection. At the same time, the nailless design of mortise and tenon joints is also a good match with the use of biodegradable materials, which not only preserves the cultural heritage of traditional craftsmanship, but also realises the double innovation of function and form through the introduction of new materials. The application of biodegradable materials is not only a useful supplement to traditional craftsmanship, but also a profound reflection and exploration of the lifestyle of modern people. In the pursuit of aesthetics and practicality at the same time, the environmental protection concept carried by mortise and tenon structure and the goal of sustainable development are intertwined and fused, together constituting a beautiful picture of the synergistic development of new crafts and materials.

Application of digital design technology. Digital design technology plays an indispensable role in the innovative design of mortise and tenon structures. With the development of digital tools such as computer-aided design (CAD), 3D modelling and virtual reality (VR), designers are able to carry out accurate conception and expression at the initial stage, which greatly improves the design efficiency and accuracy. Digital technology not only enables the visualisation of complex mortise and tenon structures, but also simulates the performance of different materials and joints, allowing designers to visualise the physical and

mechanical properties of mortise and tenon structures during the design process. The digital transformation of this process not only reduces the possibility of design errors, but also provides designers with more room for innovation. On this basis, the introduction of parametric design allows designers to automatically generate a variety of mortise and tenon joints by adjusting the parameters, further expanding the scope of application of the traditional mortise and tenon structure. With the help of big data analysis and artificial intelligence technology, designers can extract experience from historical data, predict the performance of different structures in practical applications, and then optimise the design scheme. The application of digital technology also promotes the integration of mortise and tenon construction into modern materials. The combination of traditional wood and new high-performance materials not only improves the aesthetics of mortise and tenon construction, but also enhances its functionality and durability. This cross-border design thinking and technological integration has given mortise and tenon construction new vitality, making it more diversified and innovative in the contemporary design field.

Selection and application of advanced materials. The selection and application of advanced materials play a crucial role in the innovative design of modern mortise and tenon construction. Although wood, on which the traditional mortise and tenon process relies, has historically demonstrated unrivalled resilience and beauty, in today's rapidly changing society, a single material limits its adaptability and functionality. As technology advances, emerging materials such as composites, engineered plastics, and metal alloys offer unprecedented possibilities for mortise and tenon design. Lightweight, high-strength materials such as carbon fibre and glass fibre, with their excellent physical properties, can significantly increase the load-bearing capacity and durability of structures while retaining the traditional aesthetics of mortise and tenon. By combining the properties of different materials, designers are able to create innovative works of art that combine aesthetics and functionality within the mortise and tenon structure. The introduction of modern technology, such as 3D printing and laser cutting, allows for breakthroughs in the precision and efficiency of complex mortise and tenon joints, encouraging designers to explore more possible forms and structures in the creative process. The diversity of materials and the flexibility of the process complement each other, and together they are driving the modernisation of traditional mortise and tenon craftsmanship. In this process, designers are not only pursuing a balance between function and aesthetics, but also establishing a new dialogue between inheritance and innovation, giving mortise and tenon construction a deeper cultural connotation and contemporary value. With the unique properties of advanced materials, mortise

and tenon construction can not only adapt to the needs of modern society, but also reshape the definition and application of traditional crafts in the context of globalisation.

The rapid development of digital manufacturing technology provides unprecedented opportunities and possibilities for innovation in mortise and tenon construction. Digital manufacturing technology not only covers traditional means such as computer-aided design (CAD) and computer numerical control (CNC) machining, but also introduces new processes such as additive manufacturing, laser cutting and 3D printing, which make mortise and tenon construction show unprecedented flexibility and accuracy in the design and production process. With the help of digital manufacturing technology, designers can carry out comprehensive simulation and optimisation of mortise and tenon structure in the virtual environment to form more complex and diversified connection forms, thus breaking the design bottlenecks that used to be caused by the limitations of the process. The high degree of automation and intelligence of digital manufacturing makes the combination of traditional craftsmanship and modern technology smoother, and every detail of the design process can be verified in advance through precise calculations and modelling to ensure that the performance and aesthetics of the final product. At the same time, digital manufacturing technology has also given mortise and tenon construction a stronger ability to personalise and customise, and consumer demand can be directly translated into specific design solutions through the digital platform, further promoting the diversity and innovation of furniture and other products in the market. Through the re-examination of mortise-and-tenon joinery and the integration of digital technology, traditional craftsmanship has not only been able to revitalise new vitality, but also demonstrated its unique cultural value and artistic charm in modern design.

Laser cutting technology. The uniqueness of mortise and tenon construction lies in the fact that it does not rely on external connectors to achieve a tight fit between the parts, and the combination of this feature with laser cutting technology opens up a whole new range of possibilities in contemporary design. Laser cutting technology, with its high precision and efficiency, allows the production of mortise and tenon joints in a more refined and personalised way. In traditional craftsmanship, mortise and tenon production often relies on the experience and skill of the craftsman, but in the context of digital manufacturing, laser cutting offers a way to generate accurate drawings through computer-aided design, which in turn enables standardised and personalised mortise and tenon construction. Designers can use computer software to create designs according to different needs and

aesthetics, and the laser cutting machine can quickly convert these designs into actual material forms, ensuring that each mortise and tenon has an optimal fit. This combination not only improves precision, but also allows designers to incorporate more innovative elements into the mortise and tenon structure, thus giving new life to traditional techniques. With the help of laser cutting, the shape of mortise and tenon structure can be more complex and varied, and designers can retain the traditional craft aesthetics while cleverly combining modern aesthetics with practical functions to create new furniture or devices that are both beautiful and practical. The application of laser cutting technology not only makes the traditional mortise and tenon structure break through the limitations in design, but also gives it a new context and value in modern life.

Analysis of CNC machining process. The introduction of CNC machining process provides strong technical support for the modernisation and transformation of traditional mortise and tenon joints. Through high-precision computer numerical control machine tools, the production of mortise and tenon joints can not only achieve stricter tolerances in shape and size, but also realise the processing of complex geometric shapes, which is often difficult to achieve in manual operation. The use of digital manufacturing technology allows designers to give full play to their creativity when conceptualising mortise and tenon joints and to come up with more innovative and varied design solutions, which can be quickly transformed into actual products through the implementation of CNC technology. This efficient manufacturing process not only significantly improves the processing efficiency of the workpiece, but also effectively reduces material waste and production costs, reflecting the perfect combination of economic efficiency and environmental protection concepts. Through precise programme control and real-time machining feedback, the CNC machining process enables every detail of the mortise and tenon structure to be rigorously inspected and adjusted to ensure its superior performance in terms of functionality and aesthetics. Digital manufacturing technology not only gives new vitality to the traditional mortise and tenon structure, but also promotes the innovation and development of this ancient craft in the field of contemporary design in the fusion of technology and art, providing a solid foundation for its wide application in modern furniture, architecture and other fields. The combination of mortise and tenon and digital manufacturing is like a bridge between tradition and modernity, setting up a dialogue between craftsmanship and technology, and giving traditional skills a new connotation of the times.

Exploration of 3D Printing Technology. As the essence of traditional woodworking techniques, the unique connection of mortise and tenon structure has

been increasingly valued in contemporary design. With the rapid development of 3D printing technology, the combination of the two opens up new frontiers for innovative design. 3D printing technology, with its precise modelling and complex structural building capabilities, enables the realisation of mortise and tenon construction that is no longer restricted by the limitations of traditional manual processes. Through digital modelling, designers have the freedom to explore a wide range of mortise and tenon forms, creating more diverse and complex joints. Unlike the traditional mortise and tenon process, 3D printing allows for the incorporation of multiple materials into the same piece, and even achieves different combinations of hardness and flexibility, giving mortise and tenon construction a whole new functional and aesthetic experience. This combination not only enhances the practicality of mortise and tenon construction, but also presents an unprecedented modern sense of visual appearance. 3D printing's layers make the details of mortise and tenon structure more abundant, increasing the layering and artistry of the design work. At the same time, the introduction of digital manufacturing technology also provides greater efficiency and flexibility in the production of mortise and tenon structures, allowing designers to quickly iterate their designs in a short period of time to respond to changes in market demand. Overall, the integration of mortise and tenon construction and 3D printing technology not only inherits the essence of traditional craftsmanship, but also gives new life in the field of modern design, and becomes an important force to promote innovation in furniture and architectural design.

according to Yona Friedman, “a new, profitable relationship between social and technical innovation” [29], p. 21

This subsection explores the adaptation of mortise and tenon joinery to temporary and mobile structures through innovative approaches, focusing on the veneer system developed by Hiroto Kobayashi. By integrating traditional craftsmanship with modern digital technologies, Ruggiero’s work highlights the versatility and relevance of mortise and tenon construction in addressing contemporary architectural needs, such as post-disaster emergency shelters and mobile buildings.

(1) Innovative Use of Mortise and Tenon in Veneer Systems

The veneer system represents a modern reinterpretation of mortise and tenon joinery, combining the craft’s structural stability and simplicity with the precision

of digital fabrication techniques. Kobayashi's system employs thin, lightweight veneers joined with mortise and tenon joints to create modular components that are:

- **Easy to Assemble and Disassemble:** Veneer-based mortise and tenon joints enable rapid construction without the need for complex tools, making them ideal for temporary structures.

- **Lightweight and Portable:** The use of veneers reduces the weight of components, enhancing mobility and facilitating transport to remote or disaster-affected areas.

- **Sustainable:** By leveraging renewable materials like wood veneers and reducing reliance on non-recyclable components, the system aligns with sustainable design principles.

Integration of Digital Technologies. Digital tools play a pivotal role in Ruggiero's adaptation of mortise and tenon for temporary architecture. Techniques such as computer-aided design (CAD) and computer numerical control (CNC) machining allow for:

- **Precision Engineering:** Digital fabrication ensures high accuracy in producing mortise and tenon joints, reducing errors and material waste.

- **Customization and Modularity:** The flexibility of digital design enables the creation of modular structures that can be tailored to specific needs, such as emergency shelters or mobile housing units.

Applications in Post-Earthquake Emergency Architecture. Ruggiero's veneer system has been applied in post-earthquake scenarios, demonstrating its potential to address urgent shelter needs. Key features of these structures include:

- **Rapid Deployment:** The simplicity of mortise and tenon connections allows for quick assembly in disaster zones, reducing response time.

- **Structural Stability:** Mortise and tenon joints offer durability and resistance to environmental stresses, ensuring the safety and longevity of temporary shelters.

- **Cultural Sensitivity:** By incorporating traditional craftsmanship into modern solutions, Ruggiero's designs promote cultural continuity and respect for local heritage, even in emergency contexts.

Contribution to Temporary and Mobile Architecture. Ruggiero's work exemplifies how mortise and tenon joinery can be reimaged for contemporary challenges. The veneer system bridges the gap between traditional methods and modern requirements, offering a model for sustainable, adaptable, and aesthetically pleasing temporary architecture. By leveraging digital technology and modular design, this approach demonstrates how ancient techniques can inspire innovative solutions for mobile and emergency structures in the 21st century.

People-Centered Design and Resilience in Mortise and Tenon Structures

The people-centered nature of mortise and tenon structures is evident not only in their ability to safeguard lives during natural disasters, such as earthquakes, but also in their role in empowering affected individuals to rebuild quickly and effectively. This reflects the resilience of humanity in the face of adversity. The veneer system based on mortise and tenon joinery is designed for ease of assembly, requiring no specialized technical skills. This accessibility allows disaster survivors to actively participate in the reconstruction process, fostering a sense of agency. This empowerment significantly alleviates the feelings of helplessness often experienced during such crises, improving mental health and overall happiness.

Structural Safety in Earthquakes. The phrase "walls collapse, but the house does not" captures the fundamental advantage of mortise and tenon structures in earthquakes. The self-locking mechanism of mortise and tenon joints ensures that even if individual walls or components fail, the overall structure remains stable, safeguarding lives. This resilience is due to the unique design of mortise and tenon connections, which are composed of two interlocking pieces rather than a single rigid component. This design offers greater flexibility and elasticity, enabling the structure to absorb and dissipate external forces such as seismic shocks. Furthermore, the joints adapt to natural thermal expansion and contraction, enhancing long-term structural stability.

Comparison to Other Construction Methods. While stone buildings may appear more durable at first glance, their rigidity often makes them less effective in withstanding seismic forces. In contrast, wooden buildings constructed with mortise and tenon joinery demonstrate a superior ability to cushion and distribute seismic impacts. This characteristic makes them exceptionally reliable in protecting human lives during earthquakes, one of the most severe natural disasters. The ultimate measure of a structure's resilience lies in its capacity to preserve life under uncertain

and extreme conditions—a criterion that mortise and tenon construction meets admirably.

The Essence of People-Centered Thinking. The ability of mortise and tenon structures to safeguard lives, enable rapid reconstruction, and empower communities embodies a deeply human-centered philosophy. This design approach prioritizes both physical safety and psychological well-being, showcasing resilience and adaptability in the face of natural disasters. By combining traditional craftsmanship with modern needs, mortise and tenon joinery demonstrates its enduring relevance as a model of people-centered and disaster-resilient design.

In temporary architecture, mortise and tenon’s modular design supports sustainability by enabling disassembly and reuse, reducing waste, and minimizing the need for synthetic adhesives. Similarly, in cultural products, mortise and tenon joinery becomes an educational tool, symbolizing heritage and the enduring significance of traditional craftsmanship. Both applications highlight the technique’s adaptability to modern eco-conscious and heritage-preserving demands.

Temporary and Mobile Architecture: The Role of Mortise and Tenon Joinery

The architectural field is experiencing a shift toward flexible, temporary, and mobile structures that address the need for adaptable spaces in a world of constant change. Temporary and mobile architecture is utilized in numerous contexts, from disaster relief and emergency shelters to pop-up markets, exhibitions, and remote workspaces. In these applications, architectural solutions must be versatile, easy to assemble and disassemble, and environmentally sustainable. Mortise and tenon joinery—a traditional construction technique known for its interlocking system that requires no nails or adhesives—offers a viable solution to these modern demands. With its structural adaptability, environmental benefits, ease of assembly, and resilience, mortise and tenon is well-suited for the demands of temporary and mobile architecture.

This chapter explores how mortise and tenon joinery can be applied to temporary and mobile architecture, highlighting the environmental benefits, assembly efficiency, and durability of this time-tested technique in meeting contemporary architectural challenges.

1. Structural Adaptability of Mortise and Tenon for Temporary Architecture

Modular Design and Flexibility. Mortise and tenon joinery inherently supports modular design, making it ideal for temporary and mobile structures that need to adapt to different spatial and functional requirements. In mortise and tenon construction, individual components are joined without permanent fasteners, allowing parts to be easily connected, removed, or reconfigured. This modularity enables the creation of flexible spaces that can be reassembled in various configurations, adapting to the specific needs of each application.

For example, a temporary exhibition pavilion built with mortise and tenon joinery could be designed to adjust its layout based on the type of event or display. Components such as walls, partitions, and roof beams can be assembled and rearranged as needed, providing adaptable spatial arrangements. This flexibility is essential in temporary and mobile architecture, where the purpose and context of the structure may change frequently. Mortise and tenon's modular adaptability, therefore, meets the dynamic needs of temporary architecture while minimizing the need for new materials or permanent alterations.

Ease of Assembly and Disassembly. Mortise and tenon joinery simplifies the construction process by eliminating the need for nails, screws, or adhesives. Instead, wooden components interlock precisely through tenons (protruding elements) that fit into corresponding mortises (recessed slots). This system allows structures to be assembled and disassembled efficiently, requiring minimal tools or specialized skills, which is particularly advantageous in mobile and temporary architecture.

For structures that need to be deployed quickly, such as in emergency or disaster relief scenarios, mortise and tenon joinery offers a straightforward assembly process. With prefabricated components, such structures can be erected rapidly without relying on power tools or heavy machinery, making it easier to establish temporary shelters in remote or resource-limited areas. Additionally, the simplicity of mortise and tenon construction reduces labor costs and assembly time, making it a practical choice for projects with tight budgets and timelines.

Structural Integrity and Load-Bearing Capabilities. While mortise and tenon joinery is known for its simplicity, it also offers remarkable structural strength, with joints designed to withstand tension and compression forces effectively. This resilience makes mortise and tenon joinery suitable for constructing load-bearing frameworks, even in temporary or mobile applications. The interlocking design of the joints distributes weight evenly across the structure, providing stability and durability without the need for additional hardware.

For instance, in mobile structures exposed to varying environmental conditions—such as strong winds, rain, or snow—the structural integrity of mortise and tenon can provide stability and safety. The joinery’s capacity to withstand stress and maintain alignment over time makes it a reliable choice for structures that may need to be transported, erected, and dismantled multiple times. This resilience reduces the risk of structural failure, ensuring that the integrity of temporary architecture is preserved, even under challenging conditions.

Sustainable Resource Use and Material Efficiency. Mortise and tenon joinery aligns with sustainable design principles by using wood as its primary material and eliminating the need for metal fasteners or chemical adhesives. This reliance on natural materials minimizes the environmental impact of construction, as wood is a renewable and biodegradable resource. Additionally, the efficient use of wood in mortise and tenon construction reduces waste, as components are often custom-designed to interlock precisely, making use of every piece of material.

For temporary architecture, which is frequently assembled, disassembled, and relocated, the use of wood provides further ecological benefits. Unlike conventional building materials that may degrade or lose effectiveness when reused, wood maintains its structural integrity when reassembled, allowing mortise and tenon structures to be repurposed multiple times. This reusability reduces the demand for new materials, contributing to a more sustainable construction cycle that aligns with circular economy principles.

Low Environmental Impact and Minimal Waste Generation. Temporary structures, by nature, often result in waste due to short lifespans and frequent relocation. Mortise and tenon’s sustainable attributes help mitigate these impacts by providing structures that can be dismantled without damage, enabling components to be reused in future projects. As the joinery requires no adhesives or nails, there is minimal waste generation during both construction and deconstruction, ensuring that temporary structures leave behind little to no environmental footprint.

In contrast to temporary architecture constructed with concrete, steel, or synthetic materials that may require significant energy and resources for disposal or recycling, mortise and tenon joinery allows materials to return to the natural environment if no longer needed. Biodegradable materials and the low-impact nature of the construction process further support the environmental viability of mortise and tenon for temporary and mobile applications.

Transportability and Adaptation to Different Environments. Mobile architecture must be resilient enough to withstand transport, relocation, and variable environmental conditions. Mortise and tenon joinery facilitates this mobility, as it allows structures to be easily disassembled and reassembled without compromising the integrity of the joints or materials. Each component can be transported separately, making it possible to relocate structures across diverse terrains or remote locations without the need for heavy equipment.

For instance, a mobile shelter or temporary pavilion constructed with mortise and tenon joinery can be disassembled into compact components, transported to a new site, and reassembled quickly. This adaptability is crucial for applications in remote or rural settings where transportation infrastructure may be limited, as well as in urban areas where compact, modular designs allow structures to be easily moved and reconfigured as needed.

Resistance to Environmental Stressors. Mortise and tenon joinery's interlocking construction provides resilience against environmental stressors such as wind, rain, and temperature fluctuations. The inherent strength of the joinery minimizes movement and shifting, which can occur in structures that rely on fasteners like nails or screws. The durability of the joinery design ensures that temporary and mobile structures can remain stable and safe, even when exposed to challenging conditions.

In regions prone to earthquakes or high winds, the flexibility and strength of mortise and tenon joinery offer an added layer of safety. The natural wood materials, coupled with the secure fit of each joint, enable these structures to absorb and dissipate energy from environmental forces, reducing the risk of structural damage. This resilience supports the use of mortise and tenon joinery in diverse climates, making it suitable for temporary and mobile structures in locations with varying environmental demands.

Ease of Maintenance and Repairability. One of the key benefits of mortise and tenon joinery is its ease of repair, an essential quality for temporary and mobile structures that may face frequent wear and tear. Unlike modern fasteners, which can degrade or become loose over time, mortise and tenon joints are designed to maintain their integrity with minimal maintenance. Should any component become damaged, it can be replaced individually without compromising the overall structure.

This ease of repair not only prolongs the life of temporary structures but also reduces maintenance costs and resource use. By minimizing the need for replacements or extensive repairs, mortise and tenon joinery contributes to a more sustainable and resilient architectural approach, particularly suited for structures that are regularly relocated or reassembled.

Mortise and tenon joinery offers a compelling alternative for temporary and mobile architecture, addressing modern demands for adaptability, sustainability, and resilience. Through its modular design, ease of assembly and disassembly, and environmental benefits, mortise and tenon meets the unique needs of temporary structures in a way that aligns with both functional and ecological considerations. The joinery's ability to withstand environmental stressors, support sustainable material use, and promote reuse and repair makes it an ideal choice for projects that prioritize durability and low environmental impact.

As the architectural industry increasingly turns toward flexible and eco-friendly design solutions, mortise and tenon craftsmanship stands out as a traditional technique with contemporary relevance. Its adaptability for temporary and mobile structures underscores the value of heritage practices in addressing modern challenges, providing a model for architecture that is both mindful of the past and responsive to the future.

4.1.3 Veneer System in Construction

(1) Mortise and tenon construction in modern architecture

Revival of traditional mortise and tenon in modern architecture. As a representative of the excellent traditional craftsmanship of the Chinese nation, the uniqueness and cultural connotation of traditional mortise and tenon construction has shown new vitality in modern architectural design. In the wave of globalisation and modernisation, many architects have begun to re-examine this ancient technique and seek to combine it with modern design concepts. The revival of the traditional mortise and tenon joint, which reflects not only the craftsman's deep understanding of and respect for the material, but also his clever grasp of the relationship between space and structure, is now not only limited to the pursuit of aesthetics, but also an exploration of the sustainability, flexibility, and humanisation of modern architecture in some modern buildings. With its unique way of joining, the traditional mortise and tenon is able to achieve seamless integration between different materials, reducing the reliance on metal connectors and thus reducing the overall energy consumption of the building. The introduction of mortise and tenon

construction into the designs of modern architects is not only a tribute to traditional craftsmanship, but also a profound reflection on the harmonious co-existence between nature and the man-made environment. Through the modern interpretation of mortise and tenon construction, it shows an elegant and dynamic beauty of form in architectural façade, internal space separation and furniture design, which not only preserves the essence of traditional techniques, but also integrates the simplicity and practicality of modern design, embodying a kind of dialogue and fusion that transcends time and space. This revival is not only a respect and inheritance of traditional culture, but also a re-exploration of modern design philosophy in a historical context, providing new perspectives and inspiration for future architectural development.

Application of mortise and tenon joints in modern architectural design. As a traditional structural design concept, mortise-and-tenon joints show a unique potential for innovative application in modern architecture. Its unique connection not only emphasises the close integration between materials, but also provides a flexible spatial layout and a unique aesthetic performance for the building. In contemporary architectural design, the use of mortise and tenon joints is not only limited to wood, but also extends to a variety of materials such as steel, concrete, etc., forming a diversified structural form, which not only strengthens the stability of the structure, but also allows the integration of traditional craftsmanship and modern technology. The construction characteristics of mortise and tenon joints provide architects with a richer means of spatial expression, resulting in a more harmonious relationship between the building and its environment. Through the modern interpretation of mortise and tenon, architects are able to realise more free and creative spatial forms, breaking the monotony of traditional architectural geometries, and giving buildings more vivid visual effects and cultural connotations. In some modern architectural cases, the application of mortise and tenon joints is not only reflected in the functionality of the structure, but also becomes an important element in the design of the building facade, enhancing the cultural symbols and artistic value of the building. The combination of modern material technology and traditional craftsmanship has given new life to mortise and tenon joints, making them an indispensable part of contemporary architectural design, promoting the innovation and development of architectural design, and conveying a profound reflection on history and modernity, tradition and future. The innovative application of mortise and tenon joints in modern architecture reflects the designer's search for the essence of architecture and the inheritance of cultural roots, which is both a tribute to traditional craftsmanship and an exploration of future architectural forms.

Innovative interpretation of mortise and tenon structure in modern architecture. The innovative interpretation of mortise and tenon construction in modern architecture not only carries the essence of traditional craftsmanship, but also brings out a new vitality in the context of contemporary design. Through in-depth study and application of mortise and tenon construction, architects have explored the perfect balance between structure and aesthetics while pursuing spatial fluidity and functional diversity. In modern architecture, the nail-less nature of mortise and tenon joints allows for a more flexible connection between components, greatly improves the seismic capacity and adaptability of the structure, and promotes the concept of sustainable architecture. With its simple yet elegant form, mortise and tenon construction is not only a means of material construction, but also a carrier of spatial narrative. The innovative application of mortise and tenon, such as modern wood frame buildings, reflects the concept of harmonious symbiosis between man and nature, and has become a model of eco-architecture. At the same time, cross-border design thinking has also injected new vitality into mortise and tenon construction, and the cross-border cooperation between architects and artists has allowed this traditional craft to make unprecedented attempts in materials, colours and shapes, showing a rich expressive power. This innovative interpretation is not only a respect and continuation of traditional skills, but also a profound interpretation of modern design concepts, highlighting the fusion of cultural accumulation and innovation. In future architectural practice, mortise and tenon structure will continue to serve as an important design language, promoting the development of architectural art to a higher realm, and inspiring people to pursue new possibilities in the process of exploring the intersection of history and modernity.

Structural advantages of mortise and tenon structure in modern architecture. The structural advantages of mortise and tenon structure in modern architecture are not only embodied in its unique connection method, but also in its profound influence on the stability and spatial beauty of the building. As a traditional connection method, mortise and tenon can effectively enhance the overall stability of the building by virtue of its excellent load dispersing ability. In load-bearing structures, mortise and tenon joints are precisely matched and embedded with each other to achieve uniform force transmission and reduce deformation and damage caused by external forces. This metal-free connection design reduces the self-weight of the building and avoids corrosion and fatigue of metal materials in long-time use, which makes the building more stable in the test of time and improves the safety of use.

In the shaping of spatial aesthetics, mortise and tenon structure, with its simple and rhythmic appearance, has become a major highlight in modern architectural design. Through the texture and colour of natural wood, mortise and tenon construction not only embodies the ecological concept of architecture, making the building integrated with the natural environment, but also gives the space a warm and harmonious atmosphere. The visual expressiveness of mortise and tenon makes every connection an important part of the architectural language, conveying an aesthetics that intertwines heritage and innovation. In modern design, mortise and tenon is not only a symbol of function, but also a carrier of culture and beauty, showing the unique charm and value of traditional craftsmanship in contemporary architectural context. Whether in the creation of living space or the conception of public buildings, the stability and beauty of mortise and tenon structure undoubtedly opens up broader possibilities for modern architectural design.

(2) Veneer System in Construction

The article by Ruggiero et al., *Digital Innovation for the Post-Earthquake*, investigates the application of traditional mortise and tenon joinery within digitally



fabricated, demountable prefabricated building systems designed for emergency response and community care. Mortise and tenon, an ancient woodworking technique known for its stability and simplicity, is reinterpreted in this research to serve as a versatile and humane approach to creating temporary buildings that address the psychological and emotional needs of post-disaster communities. This section explores key themes from Ruggiero et al.'s study, including the use of mortise and tenon for temporary shelters, digital fabrication's role in emergency shelter construction, and the humanistic aspects of post-disaster architecture.

Figure 4.3 Veneer System for the Post-Earthquake⁷⁸

Mortise and Tenon for Temporary Structures. Mortise and tenon joinery, typically employed in traditional architecture, provides an effective and adaptable method for creating temporary structures. Ruggiero et al. emphasize that mortise and tenon's tool-free assembly process allows for quick deployment, making it well-suited for emergency situations where rapid construction is critical. By adapting this joinery method to demountable prefabricated systems, the study underscores mortise and tenon's suitability for environments that require both stability and flexibility. The research highlights that using traditional joinery within a contemporary context offers both functional and cultural value, as it allows communities to build shelters that are more attuned to local aesthetics and construction practices, fostering a sense of familiarity in uncertain times.

Digital Fabrication and Demountable Prefabricated Systems. Digital fabrication plays a central role in Ruggiero et al.'s approach, allowing for the precise production of mortise and tenon joints in prefabricated components. This process facilitates the creation of modular parts that can be assembled and disassembled with minimal tools and training, essential for emergency response scenarios. Digital fabrication ensures consistency and accuracy, allowing mortise and tenon structures to be produced quickly and at scale. By combining traditional joinery with digital manufacturing techniques, the study illustrates how digital innovation can modernize and expand the applications of mortise and tenon joinery, making it viable for temporary structures that can be easily transported and erected in post-earthquake regions.

Temporary Buildings and Emergency Shelters. Temporary buildings, specifically designed for post-earthquake scenarios, require careful consideration of not only structural stability but also the psycho-emotional needs of affected communities. Ruggiero et al. argue that mortise and tenon joinery provides a structurally sound foundation that can withstand repeated assembly and disassembly without degrading, making it ideal for temporary structures used in fluctuating and resource-scarce environments. The design principles outlined in their study align with the necessity for emergency shelters to be robust yet easy to assemble, emphasizing safety and durability as key features. Furthermore, the prefabricated nature of the mortise and tenon-based system allows for flexible

⁷⁸ Ruggiero, R., Kobayashi, H., Cognoli, R., & Kaito, S. (2021). Digital Innovation for the post-earthquake "second emergency phase" (SEP). research experience in central Italy. *International Journal of Disaster Risk Reduction*, 61, 102293. <https://doi.org/10.1016/j.ijdr.2021.102293>

spatial arrangements, accommodating different shelter layouts that can adapt to varying site constraints and community needs.

Humanistic Care and Psycho-Emotional Needs in Temporary Shelter Design. A unique aspect of Ruggiero et al.'s approach is the integration of humanistic care within the design of temporary shelters. The study recognizes that post-disaster architecture must consider the psychological and emotional well-being of individuals and communities. By utilizing a familiar and culturally resonant construction technique like mortise and tenon, the shelter design promotes community cohesion and provides a comforting environment for those who have experienced trauma. The simplicity and warmth of wood, coupled with mortise and tenon's traditional craftsmanship, create spaces that feel more personal and humane compared to conventional, sterile shelter designs. This approach aligns with recent trends in disaster recovery architecture that prioritize the psycho-emotional needs of residents, acknowledging that a sense of security, identity, and comfort is essential for effective recovery.

Community Cohesion and Cultural Resonance. Ruggiero et al. highlight the importance of culturally resonant architecture in fostering community cohesion during recovery. The use of mortise and tenon joinery, a technique with deep historical and cultural significance, encourages community engagement and collective participation in the construction process. This not only helps speed up the building process but also creates a shared experience that can strengthen bonds within the community. The demountable prefabricated system is designed to involve community members, allowing them to actively contribute to their environment and fostering a sense of ownership and empowerment. This approach addresses not only the structural needs of post-earthquake communities but also their social and emotional recovery.

Ruggiero et al.'s study demonstrates the potential of combining digital fabrication with traditional mortise and tenon joinery to create post-earthquake temporary shelters that prioritize humanistic care. The use of mortise and tenon in demountable prefabricated systems enables rapid, tool-free assembly and disassembly, making it ideal for emergency contexts. The human-centered approach in Ruggiero et al.'s work exemplifies how architecture can support the psychological and emotional needs of disaster survivors by fostering community cohesion and providing culturally resonant spaces. This integration of traditional craftsmanship with modern fabrication techniques offers a sustainable, resilient, and compassionate solution for post-disaster shelter design.



Figure 4.4 Japanese Veneer House Project⁷⁹

Temporary architecture design based on mortise and tenon detachable features involves the use of traditional Chinese joinery techniques to create structures that are easily assembled and disassembled. This approach offers several advantages, including flexibility, sustainability, and the ability to create temporary spaces for events, exhibitions, and other purposes. Here's how the design process might unfold:

Conceptualization: The design begins with a conceptual idea that aligns with the temporary nature of the architecture. This could be a temporary exhibition space, a pop-up restaurant, or a portable shelter.

Design Development: The design is developed using the mortise and tenon joinery technique, which allows for the creation of modular components that can be easily assembled and disassembled. The design process involves detailed planning

⁷⁹ *Introduction (EN)*. Veneer House. (n.d.). <https://www.veneerhouse.com/>

of the components' dimensions, shapes, and the types of mortise and tenon connections required.

Material Selection: Materials that are durable, lightweight, and easy to work with mortise and tenon joinery are selected. This could include hardwoods, softwoods, or engineered wood products that are suitable for the specific design requirements.

Construction: The construction process involves the precise cutting of the components to ensure that the mortise and tenon connections fit together perfectly. The use of traditional tools and techniques ensures that the final structure is both strong and aesthetically pleasing.

Assembly and Disassembly: The temporary architecture is assembled and disassembled using the mortise and tenon joinery. This process is designed to be quick and easy, allowing for the rapid deployment and removal of the structure as needed.

Testing and Evaluation: The structure is tested to ensure that it meets the required safety and durability standards. Feedback from users and experts is collected to evaluate the design and make any necessary adjustments.

Implementation: The temporary architecture is implemented at the designated location, providing a unique and sustainable solution for temporary spaces.

By leveraging the detachable features of mortise and tenon joinery, temporary architecture can be designed with flexibility and sustainability in mind. This approach not only preserves the traditional craftsmanship of the mortise and tenon technique but also contributes to the development of innovative and sustainable architectural solutions.

4.2 Circular Design in Furniture

Circular design in furniture emphasizes the importance of sustainability by extending product lifecycles, minimizing waste, and promoting resource efficiency. In the context of mortise and tenon craftsmanship, this approach is particularly relevant as it aligns with traditional techniques that prioritize durability and material conservation. This section delves into the principles of sustainable development and how they inform circular furniture design, highlighting the integration of ecological and cultural considerations into modern design practices.

4.2.1 Principles of Sustainable Development

The 2030 Agenda is a transformative agenda for “People, Planet, Prosperity, Peace and Partnership” that offers a paradigm shift from the traditional development model. It offers a transformative vision of sustainable development, centered on people and planet, based on human rights and sensitive to gender issues, which goes far beyond the narrow vision of the United Nations Millennium Development Goals.

Despite global calls for change in response to the warming climate and energy crisis, the world is still facing a clear crisis of economic, social and environmental problems in relation to the Sustainable Development Goals. With the date of 2030 upon us, we are still not doing enough and the blueprint for the future of sustainable development remains uncertain and elusive.

The United Nations Sustainable Development Goals (SDGs), established in 2015, set an ambitious agenda to address some of the most pressing global issues, such as poverty, inequality, climate change, and environmental degradation, with a target completion date of 2030. However, as the 2023 Sustainable Development Report reveals, global progress on these 17 SDGs has faced significant challenges, with many targets still unmet due to factors such as economic instability, geopolitical tensions, and the enduring impacts of the COVID-19 pandemic. Despite these obstacles, the report emphasizes that the global community is moving toward embedding sustainable development as a foundational norm. This shift represents an essential pivot where sustainable practices are increasingly expected, advocated for, and integrated across economic, social, and environmental domains. This chapter contextualizes the SDGs as they relate to the growing focus on the circular economy and circular design, which offer essential frameworks for achieving a more sustainable and resilient future.

(1) Progress and Challenges in Achieving the SDGs by 2023

The 2023 Sustainable Development Report reflects both advancements and ongoing difficulties in the pursuit of the SDGs:

- **Poverty and Inequality:** Despite efforts to reduce poverty (SDG 1) and inequality (SDG 10), economic disparities persist, exacerbated by inflation, rising global debt, and uneven economic recovery after the pandemic. While some regions have made strides, a large portion of the global population remains vulnerable, with

limited access to basic necessities, social services, and opportunities for upward mobility.

- **Climate Action and Environmental Concerns:** The goals related to climate action (SDG 13), life below water (SDG 14), and life on land (SDG 15) are perhaps the most critical, as environmental degradation and biodiversity loss continue to threaten ecosystems and human health. In 2023, the increasing frequency of extreme weather events highlights the urgent need for robust climate adaptation and mitigation strategies, which are yet to be fully realized on a global scale.

- **Healthcare and Well-being:** Good health and well-being (SDG 3) remain a global priority, especially as many countries continue to recover from the pandemic's long-term effects. Healthcare systems in various regions are stretched, especially in low-income areas, and mental health concerns are rising globally. Addressing these issues is essential to achieving broader societal resilience and equity.

- **Responsible Production and Consumption:** The report underscores the urgency of transitioning to more sustainable production and consumption patterns (SDG 12). This involves minimizing waste, reducing resource consumption, and advancing sustainable business practices across sectors, highlighting the importance of circular economy principles in the future of sustainable development.

The 2023 report's insights reveal that, while these challenges are substantial, they are driving a shift in priorities across governments, industries, and societies worldwide. The global push toward sustainable practices has created momentum for embedding the SDGs as core principles guiding policy, economic models, and daily life.

(2) The Emergence of Sustainable Development as the New Norm

Despite unmet targets, the trend of the times is increasingly clear: sustainable development is not just an ideal but is becoming a standard against which global progress and prosperity are measured. The normalization of sustainable practices reflects a widespread understanding that long-term prosperity depends on a balanced relationship between human activity and the natural environment. Key drivers in this shift include:

- **Governmental and Corporate Policy Shifts:** Policies aimed at reducing carbon emissions, improving resource efficiency, and ensuring social equity are

becoming standard practice. Governments are setting more ambitious climate goals, investing in renewable energy, and supporting sustainable infrastructure. Businesses, likewise, are increasingly held accountable for their environmental and social impacts through Environmental, Social, and Governance (ESG) frameworks, which encourage companies to align their operations with SDG-related goals.

- **Rising Consumer and Civic Demand:** Public awareness of sustainability issues has grown significantly, with consumers, activists, and civil society demanding more responsible practices from corporations and governments. This demand for change has led to a rise in sustainable products, ethical business practices, and grassroots initiatives that support social and environmental causes.

- **Technological Innovation and Sustainable Solutions:** Technology is playing a transformative role in advancing sustainable development. Innovations in clean energy, waste management, and green building design are contributing to more resource-efficient and eco-friendly industries. Technology is also integral to data collection and transparency, allowing stakeholders to track progress on the SDGs and adjust strategies in real-time.

This global shift toward sustainable development as a guiding norm represents a meaningful response to contemporary environmental, social, and economic challenges. The aim is not just to achieve the SDGs as discrete targets but to create a world where sustainable development principles are deeply ingrained in systems, policies, and cultures, fostering a resilient future for all.

(3) Circular Economy and Circular Design as Pathways to Sustainable Development

The emergence of the circular economy model is among the most promising developments within the sustainable development landscape. Unlike the traditional “take-make-dispose” model, which has led to widespread resource depletion and waste, the circular economy is designed to minimize waste, optimize resource use, and create systems where materials are reused, remanufactured, and recycled. Circular economy principles directly support several SDGs, particularly those related to responsible consumption and production (SDG 12), climate action (SDG 13), and life on land (SDG 15).

Circular Design is an essential aspect of the circular economy, as it promotes creating products with extended life cycles, minimal environmental impact, and adaptability for reuse or repurposing. Circular design emphasizes eco-friendly

materials, modularity, and product longevity, aligning with sustainable production goals by reducing the ecological footprint of products and infrastructure.

(4) The Role of Circular Economy and Circular Design in Making SDGs the New Normal

By adopting circular economy and circular design principles, organizations and communities can play a significant role in realizing the SDGs. These approaches embody a systemic shift toward regenerative, resilient, and inclusive growth that aligns with the UN's sustainability agenda. Key ways in which circular economy principles contribute to making sustainable development the new normal include:

- **Reducing Resource Dependency:** The circular economy encourages the efficient use of materials and energy, which can mitigate resource scarcity and reduce pressure on natural ecosystems. This aligns with the SDGs' vision of sustainable production and consumption and contributes to the long-term availability of resources essential for economic stability.

- **Minimizing Waste and Pollution:** Circular design reduces waste generation by designing products and systems that can be reused, recycled, or safely biodegraded. Reducing waste is central to achieving SDG 12 and plays a critical role in addressing environmental pollution, supporting cleaner air, water, and land.

- **Fostering Economic Resilience and Innovation:** The shift to circular economic models promotes innovation in materials science, product design, and supply chain management. It fosters economic resilience by creating new business opportunities and diversifying revenue streams, contributing to a more robust and adaptable economy that is better equipped to withstand global disruptions.

- **Encouraging Social Responsibility and Community Involvement:** The circular economy supports sustainable development by promoting inclusive practices that consider the well-being of workers and communities. Community-led recycling initiatives, sustainable product design workshops, and shared economy practices empower people to participate in sustainability efforts, reinforcing SDG 11's vision of sustainable, inclusive cities and communities.

(5) Sustainable Development and Circular Economy as Intertwined Goals

While the 2023 Sustainable Development Report acknowledges that progress on the SDGs has been uneven, it also highlights the rise of sustainable development as a widely accepted standard. In this evolving context, the circular economy and circular design have emerged as essential frameworks for achieving and sustaining progress on the SDGs. These models represent an integrated approach to sustainability that not only addresses current needs but also builds a foundation for future generations to live within environmental limits.

By prioritizing regenerative practices, reducing waste, and promoting responsible resource use, the circular economy and circular design hold the potential to normalize sustainable development practices across all sectors. This shift suggests a future where sustainable development is no longer an aspiration but a global standard, influencing policies, economic systems, and everyday behavior. As societies continue to adopt and embed the principles of the circular economy, the SDGs can become not only achievable but sustainable norms, guiding humanity toward a more equitable, resilient, and environmentally conscious world.

4.2.2 Circular Economy in Furniture Design

Boulding introduced the concept of the "spaceship economy" in his work "Earth as a Spaceship."⁸⁰ He described a future closed economy as an "astronaut economy," where the Earth functions like an isolated spaceship with limited resource supply and pollution purification capacities. In this cyclical ecosystem, materials are continuously reproduced by consuming energy, and humanity must adapt to thrive within these constraints. In his seminal article "The Economics of the Coming Spaceship Earth,"⁸¹ Boulding emphasized the epistemological and philosophical necessity of recognizing the Earth's finite resources and production capacity. He argued for the establishment of a circular production system on our limited and relatively closed planet. This system would replace the traditional growth-oriented economy with a reserve-oriented one, shift from a consumption-driven model to a recuperation-based economy, and transition from a production-focused economy to a welfare-oriented one.

In our current linear economy, we extract materials from the Earth, manufacture products, and ultimately discard them as waste. This take-make-waste model is unsustainable. In contrast, a circular economy aims to eliminate waste from the outset by transforming every aspect of this system: how we manage

⁸⁰ *Earth as a Space Ship*, www.economia.unam.mx/cedrus/descargas/Boulding-EARTH AS A SPACE SHIP 1965.pdf. Accessed 9 June 2024.

⁸¹ Boulding, Kenneth E. *The Economics of the Coming Spaceship Earth*. S.n., 1993.

resources, produce and use goods, and handle materials at the end of their life cycle. By doing so, we can create a thriving circular economy that operates within the planet's ecological limits, benefiting both people and the environment. The circular economy represents a shift from a throwaway culture to one where waste is eradicated, resources are continuously circulated, and natural systems are regenerated.

At its core, the circular economy is a sustainable system that keeps materials in use through processes such as maintenance, reuse, refurbishment, remanufacturing, recycling, and composting. This ensures that materials never become waste. By decoupling economic activity from the consumption of finite resources and transitioning to renewable energy and materials, the circular economy tackles global challenges like climate change, biodiversity loss, waste, and pollution. It offers a resilient framework that not only regenerates natural ecosystems but also generates value for businesses, individuals, and the environment, providing a comprehensive solution to the urgent issues of our time.

The circular economy is guided by three key principles, driven by design:

- Eliminate waste and pollution.
- Circulate products and materials at their highest value.
- Regenerate natural systems.

This model of production and consumption emphasizes sharing, leasing, reusing, repairing, refurbishing, and recycling materials and products to extend their life cycles.⁸² Circular design plays a critical role in this system, focusing on creating durable, reusable, repairable, and recyclable products that generate zero waste. Designers consider every stage of a product's life cycle, ensuring sustainability from production to disposal. By adopting a design-thinking approach, they explore innovative ways to create sustainable, resilient, and long-lasting value within the circular economy. This empowers designers to reimagine and redesign the world around us, fostering a future where economic activity aligns with ecological balance.⁸³

⁸² *Circular economy: Definition, importance and benefits: Topics: European parliament.* Topics | European Parliament. (n.d.). <https://www.europarl.europa.eu/topics/en/article/20151201STO05603/circular-economy-definition-importance-and-benefits>

⁸³ YouTube. (n.d.). YouTube. <https://www.youtube.com/watch?v=yAvkM7B7BBs&t=2s>

(1) Green Design Concept in Mortise and Tenon based on Sustainable Development Goals and Circular Economy

The concept of green design has garnered significant attention in recent years, driven by the global push for sustainable development and the principles of the circular economy. Integrating these principles with traditional crafts like the mortise and tenon joint technique presents unique opportunities for environmentally friendly design solutions. Mortise and tenon, an ancient joinery technique known for its durability and resource efficiency, aligns naturally with the values of green design and the circular economy. This section examines how the mortise and tenon technique contributes to sustainable development by minimizing waste, extending product lifecycles, and promoting the use of renewable materials in construction and furniture design.

The concept of green design has gained significant attention in recent years, largely influenced by the global imperative for sustainable development and the adoption of circular economy principles. The integration of these principles into traditional crafts, such as the mortise and tenon joint technique, offers unique opportunities for environmentally friendly design. Mortise and tenon, an ancient joinery technique dating back thousands of years, is renowned for its durability and resource efficiency, aligning naturally with green design and circular economy values. This chapter explores how mortise and tenon techniques can contribute to sustainable development by minimizing waste, extending product lifecycles, and promoting renewable material usage within the construction and furniture industries.

The United Nations Sustainable Development Goals (SDGs) provide a framework for addressing environmental, social, and economic issues worldwide. Specifically, SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) are relevant to green design in construction and manufacturing, as they advocate for sustainable materials, energy efficiency, and waste reduction. Mortise and tenon joinery aligns with these goals by offering a sustainable alternative to synthetic or metal fasteners, which often require significant energy in their production and disposal. Moreover, mortise and tenon structures enable the creation of modular, repairable, and recyclable furniture and buildings, contributing to a reduction in the demand for new raw materials.

The circular economy model emphasizes maintaining products, materials, and resources in use for as long as possible. Unlike the linear economy, which operates

on a “take-make-dispose” model, the circular economy encourages durability, repairability, and recyclability. Mortise and tenon joinery techniques are ideal for the circular economy because they create robust, long-lasting structures that can be disassembled and reused or recycled without damaging the material. For example, wooden furniture with mortise and tenon joints can be disassembled for repair or repurposing, thereby extending its lifecycle and reducing the need for virgin resources.

Additionally, mortise and tenon joinery supports material efficiency by minimizing the need for nails, screws, or other fasteners that complicate the recycling process. This design approach enhances the reusability of materials at the end of their lifecycle, allowing them to be reclaimed or repurposed in line with circular economy principles.

Resource efficiency is a cornerstone of both green design and circular economy. Mortise and tenon joinery optimizes resource use in several ways:

- **Minimization of Material Use:** The design itself requires minimal material, reducing waste compared to other joint techniques that rely on metal fasteners.
- **Enhanced Durability:** Mortise and tenon joints are highly durable, reducing the need for replacement and maintenance over time, which translates to a lower demand for materials.

Waste Reduction in Manufacturing: Unlike some modern joinery techniques that generate waste from additional components, mortise and tenon joints use a single material (usually wood), simplifying production and waste management.

Furthermore, this technique encourages the use of renewable materials, as it is traditionally applied to wood—a renewable and biodegradable resource. When sourced responsibly, wood offers a low environmental impact compared to other construction materials, thereby supporting sustainable production and consumption patterns.

A key feature of green design is product longevity, which ensures that resources embedded within a product are maximally utilized over time. Mortise and tenon joinery, by virtue of its stability and strength, enables the creation of long-lasting structures that fulfill this objective. This technique has been widely applied in traditional architecture and furniture, where resilience against wear and environmental conditions is essential. In terms of sustainability, the durability of

mortise and tenon joints translates to fewer replacements, repairs, and resource demands over the product's lifespan, supporting the broader objectives of the circular economy.

Sustainable green design emphasizes the use of renewable materials to reduce environmental impact. Wood, as the primary material in mortise and tenon joinery, is a sustainable resource when harvested responsibly. Using wood from certified forests contributes to carbon sequestration, biodiversity preservation, and forest health. Furthermore, wood has a lower embodied energy compared to metals or plastics commonly used in other joint types, reducing the environmental footprint of products and buildings using mortise and tenon techniques.

Integrating wood with mortise and tenon joinery also facilitates closed-loop production systems, as the resulting products are fully biodegradable or recyclable, contributing to a more sustainable materials cycle. Through the use of renewable materials, mortise and tenon joinery not only reduces the demand for non-renewable resources but also supports the global shift towards eco-friendly design practices.

Cultural and Heritage Value. Beyond environmental benefits, mortise and tenon joinery has cultural and heritage value, especially in regions where traditional crafts are integral to cultural identity. Incorporating this joinery method in modern green design can promote heritage preservation and encourage sustainable development within local communities. The preservation and adaptation of traditional mortise and tenon techniques contribute to cultural continuity while aligning with modern sustainability goals, fostering a sense of place and responsibility towards local resources.

Mortise and tenon joinery exemplifies a sustainable, resilient, and resource-efficient approach to construction and furniture design, aligning closely with the SDGs and circular economy principles. By reducing waste, promoting material efficiency, and supporting product longevity, mortise and tenon techniques provide an ecologically responsible alternative in design and manufacturing sectors. This integration of traditional craftsmanship with modern sustainability frameworks not only advances environmental objectives but also contributes to cultural preservation and heritage.

(2) Circular Economy vs. Linear Economy: Theoretical Basis for Green Circular Furniture Design with Mortise and Tenon

The transition from a linear to a circular economy represents a fundamental shift in how resources are valued, used, and reused. In the traditional linear economy, the production cycle follows a “take-make-dispose” model, where raw materials are extracted, transformed into products, and ultimately discarded after use. This model has dominated industrial production since the onset of the Industrial Revolution, driving economic growth but also leading to unsustainable levels of waste, pollution, and resource depletion. As environmental concerns grow, it has become evident that the linear model is unsustainable for the long term. In contrast, the circular economy offers a regenerative framework, wherein resources are cycled back into production processes, minimizing waste and promoting sustainable, eco-friendly practices.

The circular economy is increasingly being adopted as the foundation for sustainable industries, particularly in fields like green furniture design, which benefits from the efficiency and longevity of traditional mortise and tenon joinery. This section examines the theoretical underpinnings of the circular economy as a basis for green furniture design, exploring how mortise and tenon construction methods align with circular principles by enhancing repairability, reusability, and durability.



Figure 4.4 Circular Economy⁸⁴

The Linear Economy: Characteristics and Limitations. The linear economy is rooted in a one-way flow of resources. This approach is characterized by:

⁸⁴ Design and the circular economy. (n.d.). <https://www.ellenmacarthurfoundation.org/topics/circular-design/overview>

- **Resource Extraction:** Raw materials are mined or harvested, often depleting finite natural resources.

- **Production and Consumption:** Materials are processed, manufactured into products, and distributed to consumers with limited focus on the longevity of the item.

- **Disposal and Waste:** At the end of a product's life cycle, it is disposed of, typically in landfills or incinerators, resulting in waste and environmental pollution.

This linear approach has numerous environmental and economic drawbacks. It relies on a constant influx of raw materials, creates massive amounts of waste, and generates pollution that negatively impacts ecosystems and public health. In furniture design, a linear approach often means producing low-cost, mass-manufactured items with short lifespans that contribute significantly to landfill waste. This model is incompatible with the goals of sustainable development, as it fails to consider resource scarcity, environmental impacts, and the potential for resource recovery.

In contrast to the linear model, the circular economy follows a “closed-loop” system where materials and products are continuously cycled through various stages of use, repair, refurbishment, and recycling. Key principles of the circular economy include:

- **Design for Longevity:** Products are designed to last, often through high-quality materials and construction methods that allow for easy repair and maintenance.

- **Resource Efficiency:** By minimizing material use, optimizing energy inputs, and selecting sustainable materials, the circular economy reduces resource dependency and environmental impacts.

- **Reuse and Recycling:** Products and materials are returned to the production cycle after use, either as refurbished items or as raw materials for new products, creating minimal waste.

The circular economy emphasizes durability, adaptability, and waste reduction, which is particularly relevant in green furniture design. By designing furniture for long-term use, repairability, and modularity, the circular economy model offers a sustainable alternative that aligns with contemporary environmental goals.

Furniture design within the circular economy framework leverages materials and construction techniques that promote longevity, minimize waste, and support resource recovery. This approach to furniture design is characterized by several circular strategies:

- **Design for Disassembly:** Furniture is created with joints and components that allow for easy assembly, disassembly, and reconfiguration. This makes the furniture modular and adaptable to different spaces and uses over time.

- **Material Selection:** Sustainable materials, such as certified wood or recycled content, are chosen to reduce the environmental impact. For instance, furniture designed with responsibly sourced wood and natural finishes avoids the use of harmful chemicals and synthetic components.

- **Repair and Refurbishment:** Circular furniture design prioritizes repairability, enabling users to replace worn parts rather than discard the entire item. This not only extends the lifespan of the furniture but also fosters a sense of value and attachment to the product.

Mortise and tenon joinery, a traditional woodworking technique, aligns naturally with the principles of the circular economy. This joinery method, which involves interlocking a tenon (a protruding piece of wood) into a mortise (a corresponding hole or slot), is durable, stable, and requires no adhesives or metal fasteners. The simplicity and effectiveness of mortise and tenon make it an ideal choice for circular furniture design. Some specific advantages include:

Durability and Longevity: Mortise and tenon joints are known for their strength and longevity. Furniture constructed with these joints can endure decades of use, even withstanding regular disassembly and reassembly. This durability ensures that the furniture can remain in use for extended periods, reducing the need for replacement and minimizing resource consumption.

Ease of Disassembly and Repair: Mortise and tenon joinery allows for easy disassembly without damaging the wood or the joints, making it easier to repair or refurbish individual components. Unlike modern fasteners or adhesives, which can be difficult to replace or remove, mortise and tenon joints are inherently modular and support circular design principles by simplifying the maintenance process.

Sustainable Material Compatibility: Mortise and tenon construction works well with sustainable materials like solid wood, allowing for furniture that is fully

biodegradable or recyclable at the end of its life cycle. This choice aligns with the circular economy's emphasis on eco-friendly material use and minimal waste generation.

The circular economy's focus on extending product life, reducing waste, and maximizing resource efficiency aligns seamlessly with mortise and tenon joinery's inherent qualities. By utilizing this traditional technique within a circular design framework, furniture makers can create products that meet both ecological and functional needs, embodying sustainable values through tangible design practices. Mortise and tenon joinery also reinforces the humanistic aspect of sustainable furniture design by encouraging craftsmanship, attachment to quality products, and care for the environment.

In green circular furniture design, the mortise and tenon method serves as a theoretical and practical foundation for products that align with the SDGs, specifically those focused on responsible production (SDG 12), climate action (SDG 13), and sustainable cities and communities (SDG 11). Furniture designed with mortise and tenon is not only a sustainable choice but also a durable investment in functional and eco-friendly living spaces. This approach illustrates how traditional techniques can meet modern sustainability demands, blending circular economy principles with enduring craftsmanship to create furniture that is both aesthetically and environmentally sound.

By basing furniture design on circular economy principles and mortise and tenon joinery, designers and manufacturers can create products that support a sustainable lifestyle, reduce environmental impacts, and foster a culture of mindful consumption. This alignment of traditional methods with circular objectives highlights the potential of circular design to not only improve product sustainability but also to shape a future where sustainability is integrated as the standard in everyday life.

The MacArthur Foundation, one of the main promoters of the circular model, defines it as "an alternative that seeks to redefine what growth is, with benefits for society as a whole and, especially, for the environment". It is based on several principles, but one of them emphasizes the importance of reducing pollution levels and waste by design. This is where the concept of circular design comes in.⁸⁵

⁸⁵ Iberdrola. (2021, April 22). *Circular design: How to rethink the creative process and commit to Sustainability*. <https://www.iberdrola.com/social-commitment/circular-design>

The best theory for green design and circular design in the context of mortise and tenon reassemblable furniture would be the Circular Economy (CE) model. The Circular Economy is a design principle that aims to eliminate waste and the continual use of resources. It focuses on designing out waste and designing products and services that are safe, affordable, and resource-efficient.

(3) Circular Economy applied to mortise and tenon reassemblable furniture:

Design for Reuse: The mortise and tenon joinery system is inherently modular, allowing for easy disassembly and reuse of components. This design approach supports the circular economy by enabling furniture to be disassembled at the end of its life, and its components can be reused or recycled.

Design for Repair: The reassemblable nature of the furniture encourages repair over replacement. When parts wear out or break, they can be easily replaced without discarding the entire piece. This reduces waste and extends the life of the furniture.

Use of Sustainable Materials: The choice of materials should prioritize sustainability. This means selecting materials that are renewable, locally sourced, and have a low environmental impact. For example, using wood from sustainably managed forests or bamboo, which is a fast-growing and highly sustainable material.

Minimal Waste: The design should aim to minimize waste during the manufacturing process. This can be achieved through efficient use of materials, avoiding excess material during the joinery process, and ensuring that all parts can be used in the final product.

Educate and Engage: Educating consumers about the benefits of circular design and engaging them in the repair and maintenance of their furniture can foster a culture of sustainability. This can also encourage the sharing of furniture and components, further extending their lifespan.

Innovation and Collaboration: Collaboration between designers, manufacturers, and users can lead to innovative solutions that further enhance the circular design of mortise and tenon reassemble



Figure 4.5 Reassemble Furniture⁸⁶

(4) Green Circular Furniture Design with Mortise and Tenon: Aligning with Circular Design, Circular Economy, and the Sustainable Development Goals (SDGs)

Green circular furniture design utilizing mortise and tenon joinery represents a sustainable, culturally rich approach to furniture production that aligns with the principles of circular design, the circular economy, and the United Nations Sustainable Development Goals (SDGs). Mortise and tenon joinery, an ancient construction technique that interconnects wooden pieces without adhesives or metal fasteners, embodies durability, reparability, and sustainability—core tenets of the circular economy. This method stands in stark contrast to the disposable culture often associated with modern, mass-produced furniture, offering a viable pathway to achieving several key SDGs.

Mortise and Tenon in Circular Design and the Circular Economy

Circular design emphasizes extending product life cycles, reducing waste, and promoting resource efficiency, aligning closely with the circular economy's objective to "close the loop" by reusing, repairing, and recycling materials. Mortise and tenon joinery, renowned for its strength and longevity, integrates seamlessly

⁸⁶ *Han's Woodworking Journey: Xinbei*. Facebook. (n.d.). <https://www.facebook.com/hansjoinery/>

into this framework. Its design allows furniture to be disassembled, repaired, and reconfigured without damaging the materials, thereby extending the product's lifespan and enabling the repurposing of components for new designs. This approach minimizes resource consumption and waste, fostering a more sustainable production model.

In green circular furniture design, mortise and tenon joinery enhances circularity by:

- **Extending Product Lifespan:** The durability of high-quality joints ensures that furniture can last for decades, reducing the need for frequent replacements and supporting the circular economy.
- **Facilitating Repairability and Maintenance:** The joinery's design allows for easy disassembly and reassembly, enabling users to replace parts and perform maintenance without compromising structural integrity.
- **Promoting Material Efficiency:** Mortise and tenon joinery typically relies on natural wood without additional fasteners, adhesives, or synthetic materials, making the furniture fully recyclable and biodegradable at the end of its life cycle.

Alignment with Sustainable Development Goals (SDGs)

Mortise and tenon furniture design supports several SDGs, including:

- **SDG 12: Responsible Consumption and Production:** By creating products designed for longevity and repair, this approach aligns with responsible production practices that minimize waste and promote sustainable consumption.
- **SDG 13: Climate Action:** The reduced reliance on synthetic materials, adhesives, and frequent replacements lowers the carbon footprint associated with production, transportation, and waste, contributing to climate mitigation efforts.
- **SDG 11: Sustainable Cities and Communities:** By encouraging the use of sustainable and locally sourced materials, as well as designs that honor cultural heritage, this approach supports sustainable urban development, making cities more resource-efficient and environmentally friendly.

Counter-Example: Mortise and Tenon in IKEA Furniture

While some IKEA furniture incorporates mortise and tenon-like joints to achieve a clean, functional design, this application often falls short of the true principles of mortise and tenon joinery. IKEA's version is typically designed for low-cost production and easy assembly, with pieces intended for single-use rather than long-term durability. Unlike traditional mortise and tenon joints, which are engineered for multiple assemblies and disassemblies, IKEA's constructions often rely on dowels and cams that are not designed for longevity or repair. As a result, these pieces are less durable and not easily repairable, contributing to a cycle of disposability rather than circularity.

While IKEA's approach offers affordability and convenience, it lacks the durability, repairability, and respect for material longevity that define genuine mortise and tenon joinery. This superficial adoption of sustainable design elements exemplifies a linear production model disguised as circularity, where the values and practices of the circular economy are not fully realized.

4.2.3 Neo-Chinese Furniture

(1) Neo-Chinese Furniture: A Fusion of Tradition and Modernity

Neo-Chinese furniture is a defining expression of the Neo-Chinese style, seamlessly blending traditional Chinese aesthetics with contemporary functionality and sustainability. Rooted in the timeless craftsmanship of mortise and tenon joinery, this furniture style embodies two core principles of Neo-Chinese design: first, it reinterprets the cultural significance of traditional Chinese design for modern contexts, and second, it adapts this understanding to align with contemporary Chinese cultural values and lifestyles. The result is a respectful yet innovative homage to traditional craftsmanship, producing sustainable designs that resonate with the principles of green design.

Cultural Continuity in Neo-Chinese Style

The Neo-Chinese style is deeply rooted in the cultural heritage of Chinese design, transcending mere aesthetics to reflect a nuanced understanding of traditional philosophy and craftsmanship. Drawing inspiration from iconic elements of Ming and Qing dynasty furniture—such as clean lines, balanced proportions, and harmonious spatial arrangements—Neo-Chinese furniture reinterprets these historical forms with modern sensibilities. Rather than replicating the past, it reimagines traditional elements to create pieces that meet today's aesthetic and functional demands.

This fusion of past and present offers a sophisticated interpretation of cultural identity, utilizing materials, forms, and techniques that hold meaning for modern users. The focus on cultural continuity is not limited to preserving traditional forms; it also involves adapting and evolving them to reflect contemporary social values and sustainable practices.

Mortise and Tenon Joinery: A Pillar of Green Design

Mortise and tenon joinery, a hallmark of traditional Chinese woodworking, serves as the structural foundation of Neo-Chinese furniture. This ancient technique, which joins wood pieces without nails or adhesives, embodies durability, repairability, and environmental responsibility. Neo-Chinese designers embrace mortise and tenon not only for its historical and cultural significance but also for its alignment with green design principles. By employing this method, they create furniture that is resilient, easy to maintain, and conducive to a circular, waste-minimizing approach.

The sustainability benefits of mortise and tenon joinery are multifaceted:

- **Durability and Longevity:** The joints are designed for strength and stability, enabling furniture to last for decades or even centuries with minimal maintenance. This longevity reduces the need for replacement, conserving resources and minimizing waste.
- **Repairability and Adaptability:** The construction allows for easy disassembly and reassembly, simplifying repairs and part replacements. This extends the furniture's lifespan and encourages users to view each piece as a lasting investment rather than a disposable item.
- **Eco-friendly Materials:** Traditional joinery is often paired with natural materials like solid wood, which are biodegradable and have a lower environmental impact than synthetic alternatives. Many Neo-Chinese designers also prioritize responsibly sourced wood and natural finishes, further aligning with sustainable practices.

Neo-Chinese Furniture: A Modern Green Design Solution

Belini noted on "*Corriere della Sera*", "Today, we are considering the concept of disposal at the end of a product's life. But if a piece of furniture is well-crafted,

using solid materials of excellent quality, we can be confident that it will never be discarded and will last a lifetime. Longevity is the ultimate eco-brand for furniture.”

This emphasis on durability and quality highlights the importance of designing furniture with a long life cycle. By prioritizing robust materials and meticulous craftsmanship, furniture can transcend trends and temporary uses, becoming enduring pieces that resist the throwaway culture. In this way, longevity not only reduces waste but also serves as a hallmark of sustainable design, ensuring that furniture remains functional and cherished for generations.

Neo-Chinese furniture exemplifies green design by prioritizing sustainability, minimalism, and a profound respect for natural resources. The use of mortise and tenon joinery reflects an eco-conscious mindset, treating furniture as an enduring cultural artifact rather than a disposable commodity. This approach is particularly relevant in today’s context, where environmental awareness and sustainable consumption are increasingly valued.

To cater to contemporary consumers, Neo-Chinese furniture blends traditional forms with modern elements. Designers often incorporate minimalist lines, modular components, or multifunctional features, appealing to modern tastes while retaining the elegance and craftsmanship of traditional Chinese furniture. This balance not only preserves cultural heritage but also ensures that the pieces remain relevant and appreciated in today’s design landscape, adding cultural value to sustainable practices.

Circular Design in Neo-Chinese Furniture

The principles of Neo-Chinese furniture align closely with the concept of circular design, promoting products that are built to last, repaired, and reused. Mortise and tenon joinery supports this circular approach, as the absence of synthetic adhesives or fasteners makes the furniture fully recyclable at the end of its lifecycle. Furthermore, the emphasis on quality craftsmanship and timeless design discourages the throwaway mentality often associated with mass-produced furniture.

By merging traditional techniques with modern aesthetics, Neo-Chinese furniture becomes a model of circularity, where each piece is valued not only for its function but also as a representation of cultural heritage and sustainable design. This approach demonstrates how green design can be both practical and culturally

resonant, creating spaces that reflect a harmonious relationship with nature, history, and contemporary living.

Neo-Chinese furniture, built on the foundation of mortise and tenon joinery, represents a sustainable design approach that honors both environmental responsibility and cultural heritage. By reinterpreting traditional Chinese aesthetics through a modern lens, this style bridges the past and present, offering a green design model that is durable, repairable, and aligned with circular economy principles. As a response to the growing demand for sustainable living, Neo-Chinese furniture stands as a thoughtful blend of tradition and innovation, making it a meaningful and eco-conscious choice in today's design landscape.

(1) Innovative performance of mortise and tenon structure in furniture design

Integration of craft heritage and innovation. In modern furniture design, mortise and tenon structure, as the essence of traditional craftsmanship, shows unique charm and value. Its unique connection not only reflects the ancient craftsmen's deep understanding of material properties, but also carries rich cultural connotations and craft aesthetics. On the basis of inheriting this traditional technique, modern designers have revitalised the mortise and tenon structure through innovative use of materials and reinterpretation of design concepts. Designers have cleverly combined mortise and tenon construction with modern materials such as composite wood, metal and new environmentally friendly materials to create furniture that has a traditional flavour and meets the demands of modern life. Functionality and aesthetics of the furniture are united in this process, and the hidden craftsmanship of mortise and tenon and the simplicity of the form realise a minimalist style of design, which is aptly integrated into the contemporary aesthetic pursuit of space. At the same time of inheritance, designers also continue to explore the extensibility of mortise and tenon structure, through innovative forms and structural combinations, giving new ways of expression to traditional craftsmanship, enriching the language of furniture design. Such innovations not only make furniture more flexible and versatile in function, but also allow the cultural value of mortise and tenon to be further disseminated and recognised in contemporary design. Through this clever fusion, mortise and tenon structure not only reproduces the historical sense of gravity, but also finds a new position in modern life, and becomes a model for the intersection of traditional craftsmanship and modern design.

Combination of material and form. As an important part of traditional craftsmanship, mortise and tenon construction, with its unique connection method, shows unrivalled innovative potential in contemporary furniture design. The combination of material and form provides a wealth of possibilities for the modern application of mortise and tenon construction and promotes the diversified development of furniture design. Modern designers have explored the properties of different materials and the harmony of mortise and tenon construction to create new furniture that is both aesthetically pleasing and functional. The alternating use of wood, metal, glass and synthetic materials extends the use of mortise and tenon construction beyond traditional wooden furniture into a wider range of design areas. The texture of the material and the geometry of the mortise and tenon are intertwined to form a work of visual impact and tactile pleasure. With the advancement of technology and the introduction of new processes such as 3D printing, designers are able to realise even more complex mortise and tenon constructions, giving them unprecedented flexibility and innovation in form. This shift in design thinking not only enriches the expression of mortise and tenon structure, but also redefines the experience and aesthetic value of furniture. The deep understanding and skilful use of materials has given mortise and tenon construction a new vitality in contemporary furniture design, and has become an important way for designers to explore sustainable development and cultural heritage. By combining traditional craftsmanship with modern materials, mortise and tenon construction not only preserves the weight of history, but also inspires unlimited possibilities for contemporary design, pushing furniture design towards greater innovation and diversity.

Balance between functionality and aesthetics. As the essence of traditional Chinese craftsmanship, mortise-and-tenon joinery is a unique way of connecting components that not only achieves a solid combination between them functionally, but also demonstrates the ultimate rhythm and harmony aesthetically. In contemporary furniture design, designers skilfully incorporate mortise and tenon joinery into their work, demonstrating the perfect balance between functionality and aesthetics. By reinterpreting the mortise and tenon form, designers have not only preserved the essence of traditional craftsmanship, but also deconstructed and restructured it for the times, creating furniture with a modern sensibility. This balance between the beauty of the mortise and tenon form and its practicality ensures the structural stability and durability of the furniture, while enhancing the overall visual aesthetics of the piece through its simple yet expressive lines. Each mortise and tenon joint of the furniture conveys the designer's deep understanding of space and respect for the nature of the material. Through precise craftsmanship,

the meticulous treatment of the mortise and tenon form makes the furniture visually light and layered, as if telling the intimate relationship between people and objects. Such design is not only the pursuit of function, but also an exploration of the aesthetics of life. The innovative use of mortise and tenon structure makes the furniture not only limited to the realisation of a single function, but also carries cultural significance and artistic value, which makes each piece of work a work of art that can be passed on, showing the infinite possibilities of traditional craftsmanship in modern design.

Digital production and mortise and tenon construction. The rise of digital production has provided unprecedented opportunities for innovation in mortise and tenon construction. The traditional mortise and tenon craft has survived for millennia due to its subtle joinery, however, in contemporary design, digital technology has allowed the craft to take on a new lease of life. Computer-aided design (CAD) software allows designers to accurately simulate and optimise the details of mortise and tenon construction, and this high degree of visualisation and adjustability makes the design process more efficient and creative. Digital production also introduces advanced manufacturing techniques such as laser cutting and CNC machining, which enable the realisation of complex mortise and tenon constructions, breaking the technological boundaries of traditional handmade production. Designers are not only able to freely explore different combinations of materials to create richer visual effects, but also to create individual and diverse products through parametric design. The precision and consistency of digital production gives mortise and tenon construction a higher degree of repeatability and executability, allowing it to gradually break away from the limitations of traditional craftsmanship in modern furniture design, and to meet the market's demand for both functionality and aesthetics. Through the redefinition and application of mortise and tenon structure, modern design not only inherits the cultural connotation of this traditional craft, but also shows new innovative thinking in the choice of materials, processes and structural forms, highlighting the infinite possibilities and vitality of furniture design in the digital era.

(2) Exploration of Mortise and Tenon Craftsmanship Design from the Perspective of Sustainability

Utilisation of Renewable Resources. The use of renewable resources plays a crucial role in the innovative design of mortise and tenon craft, and by advocating the use of these resources, the sustainable development of traditional craft can be effectively promoted. In modern society, wood, as the main material of mortise and

tenon craft, often faces the crisis of resource depletion due to excessive cutting. The introduction of renewable resources, however, not only provides an environmentally friendly source of materials for mortise and tenon construction, but also breathes new life into traditional crafts. For example, the use of bamboo, beech wood, and composite materials processed from renewable forests can effectively reduce dependence on natural resources and lower the ecological footprint. Through scientific management and rational harvesting, these resources can not only be sustainably utilised, but also demonstrate their unique aesthetic value and structural advantages in the design of mortise and tenon joinery. At the same time, the use of renewable resources can inspire designers to explore more material combinations and process innovations, resulting in new forms of mortise and tenon joinery with a sense of the times, which not only passes on the essence of traditional craftsmanship, but also demonstrates a deep understanding and practice of the concept of sustainable development. In short, making full use of renewable resources not only protects the ecological environment, but also reinvents and sublimates traditional craftsmanship, opening up a wide range of possibilities for the future development of mortise and tenon craftsmanship. Through such exploration and practice, mortise and tenon craft will surely shine on the road of sustainable development.

Selection of environmentally friendly materials. Nowadays, when sustainable development is getting more and more attention, the selection of environmentally friendly materials has become an indispensable part of mortise and tenon craft design. Traditional mortise and tenon craft is favoured for its natural and simple characteristics, and its harmonious symbiotic relationship with the environment is an important reflection of modern design concepts. Eco-friendly materials not only reduce the burden on the ecosystem during the process of use, but also show respect for natural resources in the source and treatment of materials. Recycled wood, for example, not only reduces the impact of deforestation on the forest ecosystem, but also gives the work a unique sense of history and cultural depth. Bio-based plastics, as another cutting-edge material, are made from renewable plant material, which allows them to better integrate into the natural environment after use and reduces the risk of plastic pollution. By choosing these eco-friendly materials, designers can not only visually create humanistic aesthetics, but also convey a sense of reverence and appreciation for nature in the clever combination of form and structure. The mortise and tenon design incorporating these eco-friendly materials not only reflects the inheritance and innovation of traditional skills, but also demonstrates the deep thinking about the sustainable development in the future. In this process, designers' choices are not only about the aesthetics and functionality of their work,

but also about our interdependence with the natural environment, thus pushing the entire design field towards a more eco-responsible direction. Through this exploration, mortise and tenon joinery will not only be revitalised in modern design, but will also become an important expression of the growing emphasis on sustainability.

Biodegradable materials. In the context of sustainable development, the selection of biodegradable materials has injected new vigour into the design of mortise and tenon craftsmanship. As a kind of material that can be decomposed by microorganisms in nature, this kind of material is not only in line with the concept of ecological and environmental protection, but also can realise the diversity and innovativeness of design while protecting resources. By introducing biodegradable materials such as bio-based plastics and natural fibre composites, the flexibility of mortise and tenon construction can be enhanced, thus adapting to the dual goals of modern design needs and environmental protection. These materials are not only comparable to traditional wood in terms of physical properties, but their unique biological properties also provide designers with a broader creative space, making mortise and tenon craft not only limited to the traditional use of wood, but also expanding to a richer range of materials. When choosing materials, designers should take into account their life cycle, and strive to use and dispose of them without burdening the environment, so as to realise lasting eco-efficiency. The application of biodegradable materials not only enhances the sustainability of mortise and tenon craft, but also encourages designers to inject more reverence and responsibility for nature into their conception and practice, and this innovative concept will certainly promote the regeneration and development of traditional crafts. With the help of biodegradable materials, mortise and tenon craft has been redefined in modern design, becoming a model of fusion of traditional wisdom and modern technology, and demonstrating the infinite possibilities of sustainable development.

Resource recycling. As a traditional way of joining, the design concept of mortise and tenon is rich in cultural connotation and craft wisdom. In the context of sustainable development, the recycling of resources in mortise and tenon design is becoming more and more important. By reusing traditional materials such as wood, mortise and tenon construction can effectively reduce resource consumption and environmental burden. On the one hand, wood, as a renewable resource, can be used in mortise and tenon craftsmanship to maximise the use of the material's properties through precise cutting and splicing, and to reduce the production of waste materials. On the other hand, the no-glue, no-nail joints advocated by mortise

and tenon joinery are precisely in line with the concept of resource recycling, which builds up the material's detachability and reusability, and offers the possibility of subsequent continuation of the product's life cycle. In design practice, the use of reprocessed waste wood or other renewable materials not only demonstrates the designer's commitment to environmental responsibility, but also enhances the cultural value and uniqueness of the product to a certain extent. Through this idea of resource recycling, mortise and tenon design can not only effectively promote the implementation of the concept of sustainable development, but also build a bridge between tradition and modernity, prompting traditional craftsmanship to revitalise and energise in the emerging sustainable society. Through in-depth exploration and innovation of mortise and tenon joinery, designers are able to contribute their wisdom to the building of a more harmonious ecological environment, thus promoting the sustainable development of society. This kind of design is not only an inheritance of traditional skills, but also a profound reflection and reshaping of future lifestyles.

Eco-material selection considerations. Under the framework of sustainable development, the selection of eco-materials becomes the core issue of mortise and tenon design. In the face of the increasingly serious global environmental problems, the modern transformation of traditional craftsmanship not only needs to retain its cultural essence, but also needs to incorporate the concept of ecology. Eco-materials, as a combination of biodegradable and renewable options, can effectively reduce the consumption of natural resources and environmental burden of industrial production. The use of eco-friendly materials such as bamboo, recycled wood and bio-based composites not only shows respect for the environment, but also provides a wide design space for flexibility and aesthetics in mortise and tenon construction. Bamboo, with its high strength and lightweight characteristics, ensures structural stability while displaying a natural and rustic aesthetic, fully meeting the dual needs of modern consumers for environmental protection and aesthetics. The use of recycled wood reflects the recycling of resources, which not only reduces the pressure of timber harvesting on the ecological environment, but also preserves the cultural memory of wood, which coincides with the spiritual core of mortise and tenon craftsmanship. Bio-based composite materials open up a new design vision, with their excellent physical properties and ecological properties, providing more possibilities for the innovation of mortise and tenon structure. At the same time, the selection of eco-materials should take into account the environmental impact of the production process, and pursue the sustainability of the whole life cycle, to ensure that from the acquisition of raw materials, to the use of the product and even its final disposal, harmony can be sought in the ecological balance. Through the careful

selection of eco-materials, mortise and tenon joinery can not only be revitalised in contemporary design, but also take up the dual mission of heritage and innovation in the wave of sustainable development.

Optimisation of mortise and tenon structure. The optimisation of mortise and tenon structure is not only an inevitable requirement for the inheritance of traditional craftsmanship, but also a key way to achieve the goal of eco-friendly design. In the design process of mortise and tenon structure, through the scientific and reasonable adjustment of the shape and size of each mortise and tenon, it can effectively improve the stability of the connection and bearing capacity, and reduce the waste of materials. Using the natural fibre properties of wood, combined with modern computer-aided design technology, more accurate mortise and tenon fit can be achieved, with minimal material use to achieve the best structural performance. This optimisation not only preserves the aesthetic value of mortise and tenon craftsmanship, but also achieves a balance between harmony and aesthetics in the structure, reflecting the wisdom and philosophy of design.

In an eco-friendly context, the optimisation of mortise and tenon construction can also be combined with the use of renewable materials, choosing timber from sustainably managed forests to further enhance the environmental friendliness of the materials. The functionality and detachability of the mortise and tenon structure allows the finished furniture to be easily dismantled and reused or recycled at the end of its life, extending its life cycle and reducing the consumption of resources. In the detailed design, the characteristics of natural biological materials are used, and their adaptability and durability in different environments are taken into account, so that the mortise and tenon structure not only maintains the traditional flavour of craftsmanship, but also shows a new form of eco-philosophy under the guidance of modern environmental design concepts. This fundamental structural optimisation is not only a respect for traditional craftsmanship, but also an active exploration of sustainable lifestyles for the future.

Recycling design scheme. The design concept of mortise and tenon joinery, as a traditional Chinese building and furniture connection technology, can be recycled to achieve more far-reaching ecological and environmental values in modern society. The structural characteristics of mortise and tenon make it naturally advantageous in disassembling and reassembling, and it can be flexibly converted into different usage scenarios without compromising the performance of the materials. This design not only extends the service life of the object, but also provides the possibility of efficient use of resources. The combination of recyclable

eco-materials and mortise-and-tenon design creates a complete recycling system that takes into account the entire life cycle of the product at the beginning of the design process, and aims to continue to serve the environment and the society after the product is retired from the market. Through the innovative design of mortise and tenon structure and its adaptability in different environments, it can effectively reduce the waste of resources and realise the reuse of materials. For example, the use of bamboo and recycled wood to create dismantlable furniture, connected by mortise and tenon joints rather than chemical adhesives, ensures that the product can be recycled after use and avoids the environmental burden caused by adhesives. This design concept not only echoes the core idea of eco-design, but is also a modern interpretation of traditional craftsmanship. The recycling design of mortise and tenon joinery is a fusion of traditional wisdom and modern eco-concepts, demonstrating the cultural heritage and at the same time pointing out the direction of future sustainable development, highlighting the important role of design in promoting the construction of an eco-civilisation.

Energy saving and emission reduction measures. The implementation of energy saving and emission reduction measures is crucial in the eco-friendly exploration of mortise and tenon craft design. Choosing green materials is the primary path to achieving sustainable design, and advances in modern technology have made renewable resources and natural materials the preferred choice for designers. Bamboo, recycled wood and bio-based composites, for example, not only have excellent physical properties, but can also significantly reduce energy consumption and carbon footprint during the production process. By choosing the right materials, we can effectively reduce the emission of pollutants during the production process and realise a truly eco-friendly concept. Recycling is another important measure in mortise and tenon design. Designers should take into account the reuse potential of materials during the creative process, and encourage the disassembly, restructuring and reprocessing of old materials to give them a new life. The uniqueness of mortise and tenon construction lies in its detachability, which facilitates repair and reuse at a later stage, reduces the waste of resources and enhances the life cycle of furniture and buildings. By transforming waste materials into new design elements, it demonstrates both innovation in design and respect for and appreciation of resources. This design concept not only promotes the development of ecological civilisation, but also injects new vitality into the modern transformation of traditional craftsmanship. In this process, the combination of the wisdom of mortise and tenon craftsmanship and modern environmental awareness will provide a strong support and practical model for future sustainable development.

(2) Neo-Chinese Furniture

In the context of sustainable furniture design, this case study examines a contemporary furniture line created with mortise and tenon joinery. As environmental awareness grows, many designers are turning to traditional craftsmanship to create eco-friendly, durable, and aesthetic furniture pieces. This case was selected to show how mortise and tenon's core attributes—strength, beauty, and sustainability—are well-suited for modern green design.

The furniture pieces in this line used mortise and tenon joinery exclusively, avoiding nails and synthetic adhesives, which can off-gas or harm the environment. The design allowed for easy disassembly and repair, extending the product's life cycle and reducing waste. The designers adapted traditional techniques to accommodate modern tools and materials, using computer-aided design (CAD) to ensure precision in each joint and creating a seamless assembly process that retained the aesthetic appeal of visible joinery.

Insights Gained and Implications for Innovative Design. This case highlights mortise and tenon's versatility and relevance in sustainable design. By combining traditional craftsmanship with modern technology, the designers created furniture that meets today's environmental standards without compromising on aesthetics. This example suggests a pathway for integrating digital tools with traditional joinery, offering a model for producing high-quality, eco-friendly furniture that appeals to contemporary consumers seeking sustainable options.

Each case follows a clear structure: Context introduces relevance, Application provides specific details of mortise and tenon's role, and Insights connect findings to broader design implications. This structured approach guides readers smoothly from one case to the next, helping them understand each case's unique contributions and overarching relevance to the thesis's goals.

Circular design furniture based on mortise and tenon joinery is a sustainable approach to furniture design that emphasizes the use of circular shapes and the traditional Chinese mortise and tenon joinery technique. This design philosophy is rooted in the principles of circular economy, which aims to minimize waste and make the most of resources. Here's how circular design furniture can be conceptualized and implemented using mortise and tenon joinery:

Material Selection: The selection of materials is crucial in circular design. Materials that are durable, recyclable, and have a low environmental impact are

preferred. Hardwoods, softwoods, and engineered wood products that are certified as sustainable are often used.

Design Principles: The design principles of circular furniture are centered around minimizing waste, using materials efficiently, and designing for disassembly. This means that the furniture is designed to be easily dismantled for repair, reuse, or recycling.

Mortise and Tenon Joinery: The traditional mortise and tenon joinery technique is used to create strong, durable connections between the circular components of the furniture. This technique allows for precise alignment and tight joints, which are essential for the structural integrity of circular furniture.

Circular Shapes: Circular shapes are used to minimize waste and maximize material use. This includes using round legs, circular tables, and other circular forms. The use of circular shapes also allows for a more dynamic and visually appealing design.

Sustainability: The use of circular design and mortise and tenon joinery is a sustainable approach to furniture design. This approach reduces waste, uses materials efficiently, and promotes the reuse and recycling of materials.

Ease of Assembly and Disassembly: The furniture is designed to be easily assembled and disassembled using the mortise and tenon joinery technique. This makes it easier to transport, store, and recycle the furniture when it is no longer needed.

Aesthetic Appeal: The circular shapes and the traditional mortise and tenon joinery technique create a unique aesthetic that is both modern and timeless. This aesthetic appeal makes the furniture both functional and beautiful.

By combining the principles of circular economy with the traditional mortise and tenon joinery technique, circular design furniture can be both sustainable and aesthetically appealing. This approach not only preserves the traditional craftsmanship of the mortise and tenon technique but also contributes to the development of innovative and sustainable furniture designs.

Neo-Chinese furniture, a contemporary movement in furniture design, exemplifies how traditional craftsmanship can be innovatively adapted to fit the principles of circular design and sustainable development. This movement

celebrates traditional mortise and tenon joinery techniques, integrating them with modern aesthetics and functional requirements. By combining the heritage of craftsmanship with contemporary design sensibilities, Neo-Chinese Furniture creates pieces that are not only visually appealing but also embody the durability and repairability that align with circular economy principles.

An example of this innovation is evident in modern reinterpretations of the Ming-style chair. Lv Yongzhong is seeking inspiration between the traditional and the modern, striving to achieve the best combination of oriental aesthetics and modern ergonomics in contemporary Chinese furniture design. Lv use mortise and tenon joinery to create minimalist yet robust structures, preserving the visual elegance and structural integrity of the traditional design while meeting contemporary standards of comfort and adaptability. The use of high-quality, locally sourced wood also enhances sustainability by reducing the environmental impact of transportation and promoting the use of renewable resources.

The Neo-Chinese Furniture approach highlights the possibility of merging craftsmanship heritage with sustainable innovation. By designing for durability and encouraging a connection to cultural values, this movement advances a holistic vision of sustainability that includes not only environmental and economic factors but also social and cultural resilience.



Figure 4.6 Neo-Chinese Furniture⁸⁷

The integration of mortise and tenon joinery in green circular furniture design represents a model for sustainability that aligns with both the circular economy and the SDGs. By prioritizing longevity, reparability, and cultural heritage, this approach offers a counterpoint to the disposable culture of mass-produced furniture, creating a more sustainable, responsible, and meaningful approach to furniture design. In contrast to the linear practices seen in mass-market applications, such as IKEA's adaptation of mortise and tenon, Neo-Chinese Furniture showcases how traditional joinery can authentically support sustainable principles and contribute to a lasting, circular design ethos.

The circular economy theory, which emphasizes the concept of sustainability and the reduction of waste, can be applied to the design of wooden furniture with mortise and tenon structures. This approach not only promotes the reuse of materials but also enhances the longevity and durability of the furniture. Here's how the circular economy theory can guide the design of wooden furniture:

Reduce Waste: The circular economy theory encourages the reduction of waste at every stage of the product's lifecycle. In the design of wooden furniture, this can be achieved by optimizing the use of materials. For example, the mortise and tenon structure allows for the efficient use of wood, minimizing waste during the cutting and assembly process. This approach aligns with the circular economy's goal of reducing the environmental impact of furniture production.

Reuse and Recycle: The circular economy theory promotes the reuse of materials and components. In the context of wooden furniture, this can be achieved by designing furniture that can be disassembled and reused. The mortise and tenon structure, with its interlocking joints, can be easily disassembled, making it easier to recycle the wood. This approach not only reduces waste but also extends the life of the furniture.

Design for Longevity: The circular economy theory encourages the design of products that are durable and long-lasting. The mortise and tenon structure is known for its strength and durability, making it an ideal choice for furniture that is designed

⁸⁷ BANMOO – New Chinese style, original, solid wood furniture, high-end furniture. (n.d.-a). <https://banmoo.cn/en/>

to last. By designing furniture that is built to last, manufacturers can reduce the need for frequent replacements, which reduces waste and promotes sustainability.

Design for Modularity: The circular economy theory encourages the design of products that are modular and can be easily customized. The mortise and tenon structure can be used to create modular furniture that can be easily customized to meet the needs of different users. This approach not only promotes sustainability but also allows for greater flexibility in design.

Design for Ease of Assembly and Disassembly: The circular economy theory encourages the design of products that are easy to assemble and disassemble. The mortise and tenon structure can be designed to be easy to assemble and disassemble, making it easier to recycle the furniture when it reaches the end of its lifecycle. This approach not only promotes sustainability but also reduces the environmental impact of furniture production.

The circular economy theory can guide the design of wooden furniture with mortise and tenon structures in several ways. By optimizing the use of materials, promoting the reuse of components, designing for longevity, modularity, and ease of assembly and disassembly, the circular economy theory can help to reduce the environmental impact of furniture production. This approach not only promotes sustainability but also enhances the durability and longevity of the furniture.

Mortise and Tenon Joinery: A Foundation for Green Design. Mortise and tenon joinery, a hallmark of traditional Chinese woodworking, serves as a structural foundation for Neo-Chinese furniture. This ancient construction technique, which involves joining pieces of wood without nails or adhesives, embodies durability, repairability, and environmental responsibility. Neo-Chinese furniture designers embrace mortise and tenon not only for its historical and cultural significance but also for its alignment with green design principles. By choosing this joinery method, Neo-Chinese furniture makers create pieces that are resilient, easy to maintain, and conducive to a circular, waste-minimizing approach.

The use of mortise and tenon in Neo-Chinese furniture offers several sustainability benefits:

- **Durability and Longevity:** Mortise and tenon joints are designed for strength and stability, enabling furniture to last for decades, if not centuries, with minimal maintenance. This longevity reduces the need for replacement, minimizing resource consumption and waste over time.

- **Repairability and Adaptability:** The construction method allows for easy disassembly and reassembly, making repairs and part replacements simple. This repairability extends the life of the furniture and encourages users to view each piece as a lasting investment rather than a disposable item.

- **Eco-friendly Materials:** Traditional mortise and tenon joinery is often paired with natural materials like solid wood, which are biodegradable and have a lower environmental impact than synthetic or composite materials. This approach aligns with sustainable sourcing practices, as many Neo-Chinese furniture designers prioritize responsibly harvested wood and natural finishes.

Neo-Chinese Furniture as a Response to Modern Green Design Needs. Neo-Chinese furniture exemplifies green design by prioritizing sustainability, minimalism, and a deep respect for natural resources. The integration of mortise and tenon joinery in these pieces reflects an eco-conscious mindset, one that sees furniture not as a disposable commodity but as an enduring cultural artifact. This is particularly relevant in a modern context, where environmental awareness and sustainable consumption are increasingly valued.

Neo-Chinese furniture caters to the aesthetic and functional needs of contemporary consumers by blending traditional forms with modern elements. For instance, designers may incorporate minimalist lines, modular components, or multifunctional features that appeal to modern tastes while retaining the elegance and craftsmanship of traditional Chinese furniture. By doing so, Neo-Chinese furniture not only preserves cultural heritage but also creates pieces that are relevant to and appreciated by today's consumers, adding cultural value to sustainable practices.

Neo-Chinese Furniture and Circular Design. The principles behind Neo-Chinese furniture align with the circular design concept by promoting products that are meant to last, be repaired, and be reused. Mortise and tenon joinery supports this circular approach, as the lack of synthetic adhesives or fasteners makes the furniture both reusable and fully recyclable at the end of its lifecycle. Additionally, Neo-Chinese furniture's emphasis on quality craftsmanship and timeless design discourages the throwaway mentality associated with modern mass-produced furniture.

By merging traditional craftsmanship with modern aesthetics, Neo-Chinese furniture becomes an exemplar of circularity, where each piece is valued not only

for its function but also as a representation of cultural heritage and sustainable design. Through this approach, Neo-Chinese furniture offers a model for how green design can be both practical and culturally resonant, creating spaces that reflect a balanced relationship with nature, history, and contemporary living.

Neo-Chinese furniture, built on the foundation of mortise and tenon joinery, exemplifies a sustainable approach to design that respects both the environment and cultural heritage. By reinterpreting traditional Chinese aesthetics through a modern lens, this furniture style provides a bridge between past and present, offering a green design model that is durable, repairable, and aligned with circular economy principles. As a response to the current era's call for sustainable living, Neo-Chinese furniture presents a thoughtful blend of tradition and innovation, making it a meaningful and eco-friendly choice in today's design landscape.

4.3 Cultural and Creative Product Design

The twenty-first century is a new century, and the Chinese people are increasingly aware of the important role of culture in the process of China's modernisation. In today's world, where economy and culture are intertwined, where communication technologies and productivity are increasingly developed, and where the trend of globalisation is having a profound impact, cultural development has departed from its original pattern and has begun to integrate with the economy, thus becoming products and commodities in an increasingly competitive market. At the same time, the sale and promotion of cultural products in the international market is a clear testimony to the political and economic competitiveness of a region or country. The more popular a cultural product becomes in the marketplace, the greater the social impact it has, and culture not only promotes economic development, but also moves culture itself from the elite to the masses, from the bookstore to reality.⁸⁸

4.3.1 Cultural Confidence and Heritage

Liang Sicheng, a master architect, once said: 'The arrogance and inferiority of peoples stem from ignorance of their own history and culture. Ignorance inevitably leads to blindness, and blindness, in turn, closes people's eyes and ears to their own history, thus breeding further ignorance. Therefore, it is only through a profound

⁸⁸ Wang Zhenjun. *Creative Central Plains--Research on Cultural Industry Innovation in Henan* [M]. Zhengzhou: Elephant Publishing House, 2007.9.

understanding of the nation's past that one can stand on a more objective footing and develop a deep sense of national self-respect and self-improvement.’⁸⁹

In 1990, Fei Xiaotong put forward the ideal vision of ‘Every form of beauty has its uniqueness. Precious is to appreciate other forms of beauty with openness. If beauty represents itself with diversity and integrity, the world will be blessed with harmony and unity’.⁹⁰ Points out the direction for the development and coexistence of world cultures. In 1997, Fei Xiaotong first put forward the concept of ‘cultural self-awareness’.

Cultural self-consciousness means that people living in a certain culture have ‘self-knowledge’ of their culture, understanding its origin, formation process, characteristics and tendency of its development, without any meaning of ‘cultural reversion’, not reversion, and at the same time not advocating ‘total westernisation’ or ‘adherence to tradition’. It is not to revert, and at the same time does not advocate ‘total westernisation’ or ‘adherence to tradition’. The purpose of self-knowledge is to enhance the ability to be autonomous in cultural transformation, and to gain the ability to adapt to the environment.

Cultural confidence is a concept rooted in an individual or community’s deep awareness and pride in their cultural heritage. It involves recognizing the intrinsic value and significance of one’s own culture and using that recognition as a foundation for building a confident and innovative society. For intangible cultural heritage, such as mortise and tenon craftsmanship, cultural confidence plays a crucial role in its preservation, promotion, and modernization.

The relationship between cultural awareness and cultural confidence is direct and mutually reinforcing. Cultural awareness is the process by which individuals and societies become conscious of their cultural heritage, traditions, and values. This awareness often begins with education—learning about the origins, history, and significance of cultural practices such as mortise and tenon joinery. Through this process, people can appreciate the unique aspects of their heritage, recognizing the skills, knowledge, and creativity embedded in traditional crafts.

When people gain cultural awareness, they begin to see the value of their heritage not only in historical terms but also in how it shapes their present identity. In the context of intangible cultural heritage like mortise and tenon craftsmanship,

⁸⁹ Liang, S., & Fairbank, W. (2005). *Chinese architecture: A pictorial history*. Dover Publications.

⁹⁰ Fei & Fang. *Globalization and cultural self-awareness*[M]. Beijing: Foreign Language Teaching and Research Press, 2013.

understanding its role in architecture, furniture, and artistic expression fosters a deeper connection to this tradition. This connection creates a sense of pride and belonging, which is foundational to cultural confidence.

Cultural confidence extends beyond awareness to include a belief in the worth of one's culture and its relevance to the present and future. For intangible cultural heritage, like mortise and tenon craftsmanship, cultural confidence manifests in the willingness to preserve, protect, and integrate these traditions into modern life. As a form of architectural and artistic expression, mortise and tenon represents not just an ancient building technique but a deep-rooted cultural philosophy—one that emphasizes sustainability, craftsmanship, and harmony with nature.

When societies are confident in their cultural heritage, they are more likely to innovate within that tradition, applying it to contemporary contexts while ensuring its values and principles are not lost. This confidence encourages the modernization of traditional crafts without compromising their essence. For example, mortise and tenon techniques can be adapted for modern furniture design or sustainable construction projects, which in turn reinforces the relevance and continued viability of these cultural practices.

Intangible cultural heritage like mortise and tenon craftsmanship is a wellspring of cultural confidence because it embodies the historical wisdom, skills, and creativity of a society. By preserving and promoting ICH, societies reinforce their identity and cultural resilience in the face of globalization and homogenization. Mortise and tenon, with its centuries-old tradition, can serve as a symbol of cultural continuity, reflecting a society's capacity to maintain and innovate its heritage in new ways.

As communities engage with intangible cultural heritage, they affirm the value of their cultural identity. For example, through educational programs or workshops focused on traditional craftsmanship, younger generations gain firsthand experience of the skill, patience, and creativity involved in the practice of mortise and tenon joinery. This tangible interaction with heritage builds cultural confidence, enabling individuals to see their culture as not only historically significant but also as something that has a place in modern design, art, and architecture.

Cultural confidence fosters innovation by providing a secure foundation from which to explore new possibilities. Designers who are rooted in their cultural heritage, for instance, are better equipped to create culturally relevant and

meaningful products. When applied to mortise and tenon craftsmanship, this confidence can lead to the exploration of modern applications, such as using the technique in modular furniture systems, sustainable housing, or creative product design. Innovation within the framework of cultural heritage enhances the visibility and importance of the craft, making it more relevant and accessible to global audiences.

Through innovation, cultural confidence can be both preserved and expanded. By embracing new materials, design principles, and market demands, mortise and tenon craftsmanship can be reintegrated into the fabric of contemporary life. This integration not only ensures the survival of traditional crafts but also strengthens a society's confidence in its ability to maintain its cultural heritage while embracing modernity.

On a broader societal level, cultural confidence contributes to cultural sustainability. When people believe in the value of their cultural practices, they are more likely to engage in efforts to preserve, protect, and promote these traditions. For mortise and tenon craftsmanship, this can lead to a range of initiatives, from setting up cultural workshops and exhibitions to incorporating traditional

Moreover, cultural confidence enables societies to resist the cultural erosion that often accompanies rapid modernization. It allows communities to approach global challenges, such as environmental sustainability, through the lens of their own cultural wisdom. Mortise and tenon, as a technique that emphasizes material efficiency, durability, and craftsmanship, aligns well with modern sustainable design goals, making it a powerful tool for societies that are confident in their cultural identity and its relevance to current global challenges.

Cultural confidence is a vital element in the preservation and revitalization of intangible cultural heritage like mortise and tenon craftsmanship. By fostering cultural awareness and pride, societies can ensure that traditional practices continue to thrive in modern contexts, serving as sources of innovation, sustainability, and cultural identity. In the case of mortise and tenon, cultural confidence not only preserves a historical craft but also redefines its role in contemporary design, creating a bridge between the past and the future.

4.3.2 Learning-by-Doing and Experiential Design

"Learning-by-doing" is a teaching method that involves students in hands-on activities to learn a skill or concept. This method is particularly effective for

teaching traditional crafts like mortise and tenon joinery, which is a type of woodworking joinery that uses a mortise and a tenon to join two pieces of wood.

(1) Applying Learning-by-Doing in Mortise-and-Tenon Design

The concept of “learning-by-doing” offers a powerful approach to understanding and preserving the principles of mortise-and-tenon craftsmanship. By engaging directly in hands-on assembly, learners not only gain practical skills but also connect with the deep cultural roots and values that define traditional Chinese craftsmanship. This experiential learning approach provides a tangible way to appreciate the nuances of mortise and tenon, allowing participants to internalize the values of patience, precision, and respect for natural materials that are central to the craft. Through learning-by-doing, mortise-and-tenon design becomes accessible and relevant, offering a dynamic means of cultural transmission and sustainable design practice.

This section explores how learning-by-doing can enhance understanding of mortise-and-tenon joinery, foster cultural awareness, and encourage innovation in both traditional and contemporary design contexts.

Learning-by-doing in the context of mortise-and-tenon joinery provides an immersive experience, where learners develop both technical skills and a deep appreciation for the craftsmanship involved. Unlike passive observation, hands-on learning allows individuals to explore the assembly process firsthand, gaining insight into the structural integrity and visual harmony that mortise-and-tenon joints create. By physically handling each component, aligning joints, and understanding the importance of precision, learners gain an authentic understanding of the craft’s requirements and its underlying principles.

This hands-on approach helps to demystify traditional joinery methods, making mortise and tenon accessible to all skill levels. As learners experience the satisfaction of assembling stable, interlocking joints without nails or adhesives, they come to appreciate the ingenuity and simplicity of the design. This tactile experience reinforces essential lessons about spatial awareness, joint alignment, and the balanced relationship between form and function—key concepts that are difficult to convey solely through theory.

Learning-by-doing also fosters a connection to traditional culture, allowing participants to engage deeply with the philosophies and values that mortise-and-tenon joinery embodies. Assembling these joints requires patience, precision, and a

respect for materials, mirroring the virtues valued in traditional Chinese culture. Through hands-on assembly, learners are invited to view mortise and tenon as more than a structural technique; it is a means of experiencing Chinese philosophy in action, where harmony, balance, and simplicity are paramount.

This approach to learning encourages self-discovery as participants internalize these cultural values and apply them in real-time. By interacting directly with wood and joining methods, learners gain a sense of continuity with generations of artisans who practiced this craft before them. They are able to experience the craftsmanship as a bridge to cultural heritage, inspiring cultural self-awareness and confidence as they actively engage with a living tradition.

Hands-on assembly in mortise-and-tenon joinery promotes critical thinking, problem-solving, and creativity, as participants learn how to align, fit, and balance each joint precisely. Encountering real-life challenges—such as aligning joints, ensuring a snug fit, or adjusting for wood’s natural variations—teaches adaptability and fosters a sense of accomplishment. These problem-solving opportunities make the learning process dynamic and engaging, encouraging participants to think critically and develop solutions within the constraints of traditional techniques.

Furthermore, learning-by-doing encourages creativity as learners explore new configurations and applications for mortise and tenon. This creative exploration supports a modern reinterpretation of traditional craftsmanship, inspiring participants to adapt the joinery to contemporary design contexts. By experimenting with different layouts, modular configurations, and even mixed materials, learners are empowered to innovate within the tradition, merging old techniques with new ideas in cultural and creative design.

Learning-by-doing in mortise-and-tenon joinery aligns well with sustainable design principles. This hands-on approach highlights the durability and eco-friendliness of mortise-and-tenon construction, as learners see how it eliminates the need for synthetic fasteners, adhesives, or disposable components. By experiencing firsthand the stability of well-crafted joints, participants gain a better understanding of how sustainable, natural materials can meet structural needs without environmental compromise.

Through this approach, learners become advocates for sustainable design practices. By handling renewable materials like wood, they witness how craftsmanship can extend product life cycles, reduce waste, and support a circular

economy. In this way, learning-by-doing becomes not only a method for cultural preservation but also a means of embedding sustainable practices into design education, encouraging participants to prioritize environmental responsibility in their future work.

Learning-by-doing instills a deep respect for craftsmanship and encourages a mindset of lifelong learning. The hands-on engagement with mortise-and-tenon design reinforces the value of skill, dedication, and meticulous attention to detail. As participants witness the gradual refinement of their abilities, they develop an appreciation for the patience and effort that skilled artisans dedicate to their craft, fostering respect for craftsmanship as a whole.

This respect can inspire participants to pursue further learning in traditional joinery or explore other areas of Chinese craftsmanship, contributing to cultural continuity and heritage preservation. Through this process, learning-by-doing empowers individuals to view traditional craftsmanship as a living practice that is relevant, adaptable, and enriching in both personal and professional contexts.

The Lasting Impact of Learning-by-Doing in Mortise-and-Tenon Design

Learning-by-doing is a powerful approach for understanding and appreciating mortise-and-tenon craftsmanship. Through hands-on assembly, participants gain practical skills, engage with traditional cultural values, and develop sustainable design principles, all while fostering a mindset of creativity, problem-solving, and respect for craftsmanship. This immersive approach transforms the abstract principles of mortise and tenon into a tangible experience, where learning becomes an act of cultural and personal connection.

As a result, learning-by-doing not only preserves the knowledge of mortise-and-tenon joinery but also inspires individuals to carry its principles into their own creative work. This approach to education embodies the spirit of cultural self-awareness and confidence, offering a pathway to a more sustainable, innovative, and culturally enriched future. Through active engagement with traditional craftsmanship, learners contribute to a legacy of mortise and tenon that is as relevant and impactful today as it was in centuries past.

(2) Transforming Luban Lock into Cultural and Creative Products

The traditional Lu Ban lock, an ingenious interlocking wooden puzzle, is a powerful example of ancient Chinese craftsmanship that embodies the wisdom of

mortise and tenon joinery. This deceptively simple yet intricate lock serves as a gateway to understanding the values, techniques, and philosophies that underpin traditional Chinese woodworking. Inspired by the Lu Ban lock, designers and educators are transforming mortise and tenon into accessible cultural and creative products that invite public engagement through hands-on assembly. These products encourage learning by doing and offer an experiential approach to understanding and appreciating intangible cultural heritage.

This subsection explores how mortise and tenon joinery, adapted into cultural and creative products, facilitates public engagement, strengthens cultural confidence, and contributes to the protection and inheritance of intangible cultural heritage. By making traditional craftsmanship accessible and interactive, mortise and tenon building products inspired by the Lu Ban lock connect people with their cultural roots, fostering awareness and pride in heritage.

The Lu Ban lock is a classic example of traditional Chinese mortise and tenon joinery. This wooden puzzle requires careful alignment and precision to disassemble and reassemble, relying on the interlocking of parts rather than nails or glue. The Lu Ban lock exemplifies the technical ingenuity, patience, and harmony of traditional Chinese craftsmanship. It has long been used as a way to test skill, patience, and problem-solving abilities, symbolizing a philosophical approach to work that values both practicality and beauty.

The Lu Ban lock serves as an excellent foundation for developing cultural and creative products because it distills the essence of mortise and tenon craftsmanship into a form that is both functional and engaging. Inspired by the Lu Ban lock, modern mortise and tenon-based products leverage this ancient wisdom to connect people with Chinese culture through interactive design, encouraging them to experience the craftsmanship firsthand.



Figure 4.7 Luban Lock⁹¹

Inspired by the Lu Ban lock, cultural and creative products based on mortise and tenon joinery have emerged as a bridge between traditional craftsmanship and modern-day design. These products vary from decorative models and puzzles to functional items like modular furniture, toys, and even small architectural models. Each piece offers users an opportunity to engage with mortise and tenon techniques through hands-on assembly, allowing them to experience the cultural significance of the technique in a tangible, memorable way.

For example, mortise and tenon puzzle blocks or miniature architectural models enable users to assemble complex structures by interlocking parts. In doing so, they encounter the logic of traditional Chinese joinery and its emphasis on harmony and balance. These cultural and creative products allow the public to see, touch, and understand mortise and tenon's structural principles and design elegance, transforming learning into an experiential process that connects individuals with heritage on a personal level.

Through these products, the Lu Ban lock concept is adapted and expanded to reach a broader audience, enabling more people to access and appreciate Chinese craftsmanship in their everyday lives. This hands-on approach serves as both an educational and cultural tool, deepening awareness and understanding of traditional Chinese joinery and its philosophical roots.

⁹¹ Lightning Review | From the Luban Lock to the exquisite "Shandong Handmade". (n.d.). <https://sdxw.iqilu.com/share/YS0yMS0xNTE0MDgxMA==.html>

The concept of learning by doing is central to the effectiveness of mortise and tenon cultural and creative products. When users engage with these products, they are actively involved in the assembly process, experiencing the structural logic and craftsmanship of mortise and tenon firsthand. This experiential design approach transforms the learning process from passive observation to active engagement, allowing users to develop practical skills while gaining insight into Chinese culture and heritage.

Through learning by doing, users encounter the precision and patience required for traditional joinery. This approach fosters problem-solving skills, spatial awareness, and an appreciation for the craftsmanship needed to create stable and harmonious structures. As users manipulate each piece to fit, align, and interlock, they experience the values of dedication, respect for materials, and balance that are central to Chinese craftsmanship. This hands-on involvement not only enhances skill development but also provides a profound, culturally immersive experience that brings mortise and tenon craftsmanship to life.

Learning by doing also allows participants to connect personally with the craft, as they experience a sense of accomplishment from completing their own structures. This sense of achievement reinforces cultural confidence, as individuals recognize the value and ingenuity of traditional Chinese craftsmanship.

Mortise and tenon-based cultural and creative products play a vital role in raising public awareness of Chinese cultural heritage. By inviting people to actively engage with traditional craftsmanship, these products make cultural learning accessible and enjoyable. Unlike passive observation, assembling mortise and tenon structures offers a meaningful connection to traditional culture, inspiring pride and appreciation for the cultural wisdom embodied in each joint and connection.

These products reinforce cultural confidence by showcasing the adaptability and relevance of Chinese craftsmanship in modern design contexts. As individuals experience the elegance and ingenuity of mortise and tenon firsthand, they come to understand the timeless value of traditional techniques and recognize them as an integral part of their cultural identity. The hands-on assembly of these products cultivates a sense of cultural pride and confidence, affirming that traditional Chinese craftsmanship is not only worthy of preservation but also relevant and valuable in contemporary life.

Mortise and tenon joinery is an example of intangible cultural heritage that encompasses both technical skill and cultural knowledge. By creating mortise and tenon cultural products, designers contribute to the protection and inheritance of this heritage. Each product serves as a learning tool, allowing users to practice and understand the craft in a manner that honors its original philosophy and techniques. In this way, mortise and tenon products help to preserve and transmit cultural knowledge, ensuring that future generations appreciate and continue to practice these skills.

These products also help to adapt mortise and tenon to new generations, ensuring that traditional joinery techniques are not lost but transformed and reinterpreted in ways that are relevant to modern lifestyles. This process of cultural inheritance demonstrates that mortise and tenon joinery is a living tradition, one that can continue to evolve and inspire as it passes from one generation to the next.

Furthermore, by making mortise and tenon accessible to a global audience, these cultural products contribute to cross-cultural exchange, where Chinese craftsmanship can be shared and appreciated worldwide. This international exposure not only strengthens cultural confidence but also broadens the reach of Chinese cultural heritage, allowing it to find new expressions in a global context.

Mortise and Tenon Cultural Products as a Legacy of Cultural Confidence

Inspired by the Lu Ban lock, mortise and tenon cultural and creative products serve as a powerful medium for cultural education, awareness, and inheritance. Through hands-on assembly and experiential design, these products offer an engaging way to understand and appreciate traditional Chinese craftsmanship, emphasizing the values of patience, balance, and interconnectedness. By raising cultural awareness and confidence, mortise and tenon products play a significant role in protecting and transmitting intangible cultural heritage, ensuring that the wisdom of Chinese joinery continues to thrive.

As a legacy of cultural confidence, these products exemplify how traditional craftsmanship can be adapted to contemporary design in ways that celebrate and honor Chinese heritage. Mortise and tenon cultural products invite users to experience the depth and beauty of Chinese craftsmanship firsthand, fostering a sense of pride and respect for a cultural legacy that transcends time. Through these interactive designs, mortise and tenon craftsmanship becomes accessible to all, preserving its relevance and importance for future generations.

(3) Design for Hands-on Cultural Education

Hands-on cultural education plays a crucial role in preserving and promoting traditional crafts, such as mortise and tenon joinery, while also cultivating an appreciation for cultural heritage among new generations. By designing educational programs and spaces that incorporate this ancient technique, educators can engage students in experiential learning, making the history, skill, and significance of mortise and tenon joinery accessible and relevant. This approach not only teaches technical skills but also fosters a deeper understanding of cultural values and sustainable design principles.

To effectively teach mortise and tenon joinery, it is essential to create environments where students can actively engage with the craft. Learning studios, workshops, and maker spaces equipped with traditional woodworking tools provide students with an authentic experience of the materials, processes, and skills involved in creating mortise and tenon joints. By working directly with wood and learning the steps of cutting, shaping, and fitting joints, students develop a hands-on understanding of craftsmanship, material properties, and structural design. This immersive approach enhances their ability to grasp both the technical and aesthetic dimensions of the craft.

In these settings, instructors can guide students through the history of mortise and tenon joinery, including its evolution, regional variations, and cultural significance. Understanding the context in which this technique developed helps students appreciate the ingenuity and resourcefulness of earlier artisans, as well as the values embedded in the craft, such as sustainability, durability, and simplicity. Through this experiential learning, students are encouraged to view mortise and tenon joinery not just as a technique, but as an expression of cultural identity and a model for eco-conscious design.

Incorporating digital design tools alongside traditional woodworking practices can enhance hands-on learning while bridging the gap between past and present. Digital modeling, 3D printing, and computer numerical control (CNC) technology allow students to visualize mortise and tenon joints in a virtual space, experiment with variations, and understand the structural mechanics before crafting the joints manually. This integration of traditional and digital methods enables a multifaceted learning experience, where students appreciate both the ancient techniques and modern applications of mortise and tenon joinery.

Digital tools also make it possible to document and share student work, creating a digital archive that records learning progress and allows for the study of craftsmanship over time. By blending traditional craft education with contemporary technology, educators encourage students to explore how mortise and tenon joinery can be applied innovatively in sustainable, modern design. This cross-disciplinary approach broadens the potential for cultural education and helps students understand how traditional skills can adapt to new contexts and challenges.

Hands-on education in mortise and tenon joinery not only teaches practical skills but also instills a sense of responsibility toward cultural preservation and sustainable practices. Working with natural materials and learning to build durable, reusable structures fosters an appreciation for resource efficiency and minimal waste. These values are especially relevant in today's context, as students recognize the environmental benefits of traditional, non-invasive construction techniques that require fewer resources and reduce ecological impact.

By designing for hands-on cultural education, mortise and tenon joinery can be taught in a way that emphasizes its relevance to sustainable design principles, encouraging students to think critically about material use, longevity, and adaptability. This approach also strengthens cultural connections by helping students engage with the heritage of their communities or explore the craftsmanship traditions of other cultures. Hands-on experience with mortise and tenon joinery serves as a powerful reminder that traditional techniques are not only relevant but also essential to fostering a sustainable and culturally rich design future.

In summary, hands-on cultural education through mortise and tenon joinery promotes technical skill development, cultural understanding, and sustainable design awareness. By merging traditional practices with modern educational tools, this approach offers a holistic and impactful learning experience, connecting students to the values and techniques that define this enduring craft.

4.3.3 Case Studies in Cultural and Creative Product Design

According to the definition given by the United Nations Educational, Scientific and Cultural Organization (UNESCO), cultural and creative design indicates “a product of modern society that shows cultural resources in the form of creativity, and it is also a product formed after materializing the concept of spiritual level, which requires designers to find the cultural concepts contained in tangible and intangible culture, form a draft through planning and design, and then transform

it into products with creative and practical value in contemporary life, which itself is a commodity with high added value".⁹²

Ezio Manzini⁹³ mentioned that design is both a process of problem solving and a process of meaning construction. Design is not just about providing a useful object, but about providing a lifestyle that represents an era, a culture and a nation. Roberto Verganti⁹⁴ proposes the paradigm of Innovation of Meaning by quoting the mantra "Forging Meaning, Building Identity," which can be used as a shared methodology for survival in a pluralistic era of complexity and uncertainty.

Beyond sustainability, mortise and tenon joinery embodies cultural heritage, reflecting the deep respect for material efficiency and craftsmanship in East Asian cultures. This connection to cultural values enriches its modern applications, making each use of the technique a continuation of a centuries-old legacy.

In the field of cultural and creative product design, there is a growing emphasis on engaging consumers with heritage crafts in ways that foster cultural education and personal interaction. Mortise and tenon joinery, as a significant element of intangible cultural heritage, embodies the values of durability, precision, and respect for natural resources. Its history and technical sophistication offer rich educational potential, enabling users to engage with traditional craftsmanship principles. This chapter explores how mortise and tenon joinery can be integrated into cultural and creative products that emphasize experiential learning, such as DIY furniture kits, educational toys, and interactive craft projects. By enabling users to assemble and engage with traditional joinery techniques firsthand, these products contribute to a broader understanding of cultural heritage while fostering a hands-on appreciation for craftsmanship.

The rise of DIY culture has created new opportunities for individuals to engage with product design directly, encouraging a sense of ownership and personalization. DIY furniture kits featuring mortise and tenon joinery allow users to participate in the construction process, experiencing the precision and satisfaction associated with traditional craftsmanship. By focusing on assembly without the need for adhesives,

⁹² Chu, D., Dong, F., Wu, W., & Wang, X. (2023). Applying generative art to cultural and creative product design to construct human-product relationship. *IASDR 2023: Life-Changing Design*. <https://doi.org/10.21606/iasdr.2023.180>

⁹³ Manzini, E. (2015). *Design, when everybody designs*. <https://doi.org/10.7551/mitpress/9873.001.0001>

⁹⁴ Verganti, R. (2009). *Design Driven Innovation: Changing the rules of competition by radically innovating what things mean*. <https://ci.nii.ac.jp/ncid/BA90815694>

screws, or nails, these kits provide an introduction to the integrity and complexity of mortise and tenon joinery.

The hands-on nature of DIY kits appeals to consumers who value experiential learning, allowing them to understand the principles of joinery and the patience required for precise assembly. This approach is particularly effective in conveying the historical significance of mortise and tenon, as users actively participate in a process that reflects centuries of woodworking tradition.

When designing DIY furniture kits that incorporate mortise and tenon joinery, it is essential to balance accessibility with authenticity. Furniture components should be pre-cut to precise specifications, enabling users to focus on the assembly without requiring advanced woodworking skills. Designers may include instructional materials, such as illustrated manuals or video tutorials, that guide users through the assembly process while explaining the cultural background of mortise and tenon.

Another consideration is the choice of materials. Using sustainable wood varieties reinforces the traditional values of mortise and tenon joinery, while modular designs allow users to customize the furniture according to their preferences. For example, a DIY table kit could allow users to experiment with different types of mortise and tenon joints, such as through-tenon or blind-tenon, each offering a unique aesthetic and structural quality. This flexibility not only enhances the educational aspect but also deepens the user's connection to the craftsmanship by allowing for personalization.

DIY mortise and tenon furniture kits are powerful tools for cultural education. By engaging users in a construction process that embodies historical values of simplicity, precision, and durability, these kits foster a personal understanding of mortise and tenon's cultural significance. Moreover, the assembly process itself serves as a form of experiential learning, where users gain insight into the patience, skill, and dedication that traditional joinery requires.

Through DIY kits, consumers gain a new appreciation for traditional craftsmanship, often developing a more sustainable mindset as they come to value durability and quality. The educational experience encourages users to see mortise and tenon joinery not only as a functional technique but as an art form and cultural heritage that deserves preservation and respect.

Educational toys that incorporate mortise and tenon joinery offer children and adults alike the opportunity to learn about structural integrity, precision, and spatial reasoning. By allowing users to assemble small-scale structures, these toys introduce the principles of mortise and tenon in an accessible and playful manner. As users experiment with interlocking pieces, they gain a foundational understanding of how joinery works, fostering both critical thinking and problem-solving skills.

Educational toys that integrate mortise and tenon principles can range from simple wooden blocks that teach basic interlocking concepts to more complex kits that allow users to construct small structures, such as bridges, houses, or temples. These toys are effective in introducing traditional joinery in a way that is engaging, allowing users to explore craftsmanship in a hands-on, interactive context that promotes learning by doing.

The design of mortise and tenon educational toys must account for age-appropriateness and user skill level. For younger children, simplified interlocking blocks with larger, rounded tenons and mortises can introduce basic joinery concepts safely. As users grow in skill, more complex kits can be introduced, allowing them to create small architectural models that require increased precision.

Educational toys can also incorporate storytelling elements to enrich the user experience. For example, a toy kit based on traditional Chinese architecture could come with a storybook explaining the historical significance of mortise and tenon joinery in ancient temples and palaces. This narrative dimension allows users to connect their hands-on activities with the cultural heritage of the technique, making the learning experience both enjoyable and meaningful.

Educational toys featuring mortise and tenon joinery serve as powerful tools for raising cultural awareness. By introducing users to a craft that embodies values of resilience, patience, and harmony with nature, these toys encourage a deeper understanding of craftsmanship and cultural heritage. They foster curiosity about the origins of joinery techniques and inspire users to appreciate the wisdom embedded in traditional woodworking methods.

The hands-on interaction with mortise and tenon principles provides a tactile learning experience, helping users internalize the structural and cultural significance of the technique. This approach supports a more comprehensive

understanding of craftsmanship and heritage, nurturing an early appreciation for cultural diversity and sustainability through play.

Interactive cultural products go beyond passive appreciation by allowing users to actively engage with mortise and tenon joinery in a way that emphasizes cultural connection. These experiences can include workshops, online interactive modules, or augmented reality (AR) applications that allow users to explore the technique virtually. By immersing users in the process, these products offer a meaningful connection to the craftsmanship, allowing participants to appreciate the skill and complexity involved.

In-person workshops provide an especially valuable experience, enabling users to work with artisans to create small furniture pieces or decorative items using mortise and tenon techniques. These events often include a historical and cultural introduction, where participants learn about the technique's origins and philosophical significance, creating a holistic cultural experience that combines learning with hands-on creation.

Digital platforms, such as interactive apps or AR modules, can offer immersive educational experiences that make mortise and tenon joinery accessible to a wider audience. In an AR application, for example, users could visualize mortise and tenon joints in 3D, rotating and examining the components to understand how they interlock. This technology enables users to engage with the joinery in a virtual environment, providing a realistic yet accessible introduction to traditional woodworking techniques.

These digital tools can be used in combination with physical products, such as DIY kits, to enhance the educational experience. For example, an app that accompanies a DIY furniture kit could provide step-by-step AR guidance, showing users how each joint fits together while offering historical information about mortise and tenon's cultural significance. By integrating physical and digital elements, these interactive products enhance the user's engagement, merging craftsmanship with modern technology to foster cultural education.

Partnering with artisans for product development adds an element of authenticity to cultural and creative product design. Collaborations with master craftsmen can ensure that mortise and tenon products are both technically accurate and culturally respectful, reinforcing the educational integrity of the experience.

These partnerships can extend to collaborative product design, workshops, or online courses where artisans teach traditional techniques directly to users.

Through partnerships with artisans, cultural products gain credibility, offering consumers an authentic and immersive experience. Such collaborations not only enhance the user's experience but also support the transmission of skills to future generations, helping to preserve mortise and tenon craftsmanship by making it accessible and relevant to modern audiences.

Mortise and tenon joinery, as a technique steeped in history and cultural meaning, offers rich possibilities for cultural and creative product design. By incorporating mortise and tenon into DIY furniture kits, educational toys, and interactive experiences, designers can engage users in a process of discovery and appreciation for traditional craftsmanship. These products serve as vehicles for cultural education, enabling users to experience mortise and tenon firsthand while gaining insight into the values of patience, precision, and sustainability embedded in the technique.

Through hands-on learning, storytelling, and digital augmentation, mortise and tenon-based cultural products encourage users to explore the legacy of this heritage craftsmanship. These experiences foster a deeper connection to cultural heritage, bridging the gap between tradition and contemporary relevance. By transforming traditional joinery into accessible, interactive products, this approach ensures that mortise and tenon joinery remains a vibrant and meaningful part of modern design, promoting cultural awareness, environmental responsibility, and an appreciation for enduring craftsmanship.

(1) Enhancing Cultural Identity and Learning

The preservation and promotion of mortise and tenon joinery can play a significant role in strengthening cultural identity and fostering learning. As a centuries-old craft, this woodworking technique embodies a wealth of cultural values, traditional knowledge, and technical skills that contribute to a sense of continuity and connection with the past. By integrating mortise and tenon joinery into modern design and educational practices, contemporary designers and educators can reinforce cultural identity, inspire creativity, and provide valuable hands-on learning experiences.

Mortise and tenon joinery is not just a technical method; it represents a symbolic connection to heritage, reflecting values of resourcefulness, resilience,

and craftsmanship. By promoting this traditional technique in architecture, furniture, and creative product design, cultural identity is celebrated and made visible in daily life. Structures and objects crafted using mortise and tenon joinery resonate with history and tradition, offering a tangible link to the cultural origins of woodworking. This integration fosters a sense of pride and continuity, particularly in communities that have practiced and refined these techniques over generations.

Incorporating mortise and tenon joinery into public and cultural spaces—such as museums, educational institutions, and heritage sites—also serves as a reminder of cultural resilience and adaptability. By using this joinery method in visible, functional ways, designers can highlight cultural distinctiveness while bridging the past with the present. For instance, the presence of mortise and tenon elements in a public building not only reinforces cultural identity but also invites conversations about sustainable, non-invasive construction methods that align with contemporary environmental values.

The study and practice of mortise and tenon joinery offer unique educational opportunities, engaging learners in a hands-on, experiential approach to craftsmanship. Through workshops, apprenticeships, and design programs, students can explore the historical context, technical principles, and practical applications of this technique. Learning to create mortise and tenon joints cultivates a range of skills, including spatial awareness, precision, patience, and problem-solving—qualities essential to both traditional craftsmanship and modern design.

Furthermore, mortise and tenon joinery provides a rich context for interdisciplinary learning, connecting history, culture, mathematics, and design. Students gain insight into traditional measurement systems, geometric relationships, and structural integrity as they construct interlocking joints. Educational programs centered on mortise and tenon joinery encourage learners to appreciate the aesthetic and functional qualities of woodworking, while also promoting the values of sustainability and minimalism inherent in the technique.

The inclusion of mortise and tenon joinery in educational settings also encourages innovation and cross-cultural exchange. As students and designers experiment with adapting this technique to modern materials and digital design tools, they contribute to its evolution and relevance in contemporary design. This ongoing innovation reflects how traditional crafts can adapt to new contexts, merging cultural heritage with modernity. In multicultural educational environments, mortise and tenon joinery can serve as a foundation for dialogue

about shared techniques and adaptations across cultures, fostering a global appreciation for traditional craftsmanship.

By enhancing cultural identity and facilitating immersive learning experiences, mortise and tenon joinery provides a meaningful, hands-on approach to education that goes beyond technical skills. It serves as a reminder of cultural heritage, inspires creativity, and promotes sustainable values, offering a model for integrating traditional techniques into contemporary design education and practice.

(1) Cultural Self-Awareness and Cultural Confidence in the Context of Mortise and Tenon Craftsmanship

In today's globalized and rapidly evolving world, cultural self-awareness and cultural confidence are essential for preserving and promoting a society's unique identity and heritage. These concepts are particularly significant for China, a nation with a rich history of material culture, artistic expression, and philosophical traditions that have shaped its identity over millennia. The ancient craft of mortise and tenon joinery—an emblem of Chinese ingenuity, beauty, and harmonious craftsmanship—embodies the values and wisdom of Chinese civilization. Mortise and tenon joinery represents a unique intersection of form, function, and philosophy that encapsulates a profound respect for nature, a commitment to quality, and the spirit of creation that lies at the heart of Chinese culture.

This section explores how mortise and tenon craftsmanship exemplifies China's cultural self-awareness and confidence, demonstrating how traditional craftsmanship continues to resonate in the modern era as a testament to Chinese civilization's material beauty, ingenuity, and philosophy of harmony between heaven and humanity.

Cultural self-awareness is the recognition and understanding of one's cultural heritage, values, and practices. In China, self-awareness of cultural heritage involves a deep appreciation for the traditions, artistic expressions, and philosophical insights that define Chinese civilization. Mortise and tenon joinery, with its millennia-old history, is one of the many embodiments of this heritage, serving as a symbol of material beauty, craftsmanship ingenuity, and the harmony of human and nature that underpins traditional Chinese culture.

Mortise and tenon joinery is far more than a construction technique; it is a cultural artifact that reflects the essence of Chinese design principles and the worldview of ancient Chinese craftsmen. These artisans believed that the beauty of

an object lay not only in its appearance but in its structural integrity, balance, and the invisible connections that held it together. The mortise and tenon joint achieves this through precise craftsmanship and a meticulous understanding of wood's natural properties, representing a harmony between human skill and natural materials. By embracing mortise and tenon joinery, modern Chinese society reaffirms its cultural self-awareness, honoring the values of sustainability, quality, and harmony that are central to Chinese identity.

Cultural confidence refers to the pride, assurance, and creativity with which a society upholds its cultural traditions in a modern context. For China, cultural confidence involves not only preserving traditional craftsmanship but also adapting and innovating it for contemporary use, allowing it to remain relevant and meaningful in the present day. Mortise and tenon joinery exemplifies this approach, as it is increasingly incorporated into modern design, architecture, and furniture, merging traditional aesthetics with modern functionality.

In recent years, the resurgence of interest in mortise and tenon joinery reflects a broader movement of cultural confidence in China. By embracing this craftsmanship tradition in contemporary design, China demonstrates pride in its heritage and affirms the timelessness of its cultural values. This confidence is evident in the Neo-Chinese furniture movement, which combines mortise and tenon craftsmanship with minimalist, modern aesthetics. Through such innovations, Chinese designers demonstrate that traditional craftsmanship techniques are not relics of the past but dynamic, living traditions that continue to evolve.

Cultural confidence in mortise and tenon joinery also extends beyond aesthetics. It affirms that Chinese craftsmanship can contribute to global sustainability efforts by emphasizing natural materials, repairability, and longevity. This approach contrasts sharply with the throwaway culture of mass-produced, disposable goods, presenting Chinese craftsmanship as a solution to modern environmental and social challenges. By confidently promoting mortise and tenon as both a cultural and a sustainable practice, China positions itself as a leader in values-based design and production.

The philosophy of harmony between heaven and humanity is a fundamental principle in Chinese thought, especially within Confucian, Daoist, and Buddhist traditions. This concept underscores the importance of balance, unity, and respect for the natural world, principles that are deeply embedded in mortise and tenon craftsmanship. Traditional Chinese artisans believed that their work should align

with natural principles rather than dominate them. This respect for natural materials is evident in mortise and tenon joinery, where the unique qualities of wood are honored and enhanced rather than altered through synthetic means.

Mortise and tenon joinery reflects a harmonious relationship between humans and nature. By using wood's natural characteristics—its grain, strength, and flexibility—Chinese craftsmen created structures that were not only functional but also spiritually resonant, symbolizing a balance between human intent and natural law. Each mortise and tenon joint is a manifestation of this philosophy, showcasing how human skill and wisdom can work within the framework of nature, rather than in opposition to it. This philosophy of harmony remains highly relevant in today's sustainability-driven world, where the need to respect and preserve natural resources is more urgent than ever.

Mortise and tenon joinery is an example of China's craftsmanship wisdom—a wisdom that values quality over quantity, process over speed, and subtle beauty over superficial ornamentation. Traditional craftsmen saw their work as a spiritual endeavor, where the act of creating was a means to connect with the natural world and express cultural values. This dedication to quality and process is a vital lesson for contemporary society, which often prioritizes efficiency and convenience over depth and meaning.

In today's world, mortise and tenon craftsmanship provides a pathway to reconnect with these deeper values. As Chinese society embraces this ancient craft with renewed interest, it finds in mortise and tenon an example of how to live thoughtfully and sustainably. By emphasizing quality, durability, and aesthetic harmony, mortise and tenon furniture aligns with the global push for sustainable and meaningful consumption, proving that traditional practices can offer innovative solutions to modern issues.

With cultural self-awareness and confidence, China is not only preserving but also promoting mortise and tenon craftsmanship as part of a shared global heritage. By highlighting this craftsmanship in international design exhibitions, educational programs, and sustainable building initiatives, China is sharing the values and techniques of mortise and tenon with the world. In doing so, it enriches global culture with an example of sustainable, thoughtful craftsmanship that transcends national borders.

As the world grapples with environmental challenges and cultural homogenization, mortise and tenon joinery stands as a testament to the enduring value of regional craftsmanship, respect for nature, and cultural heritage. By sharing this craft internationally, China contributes to a global dialogue on sustainability, creativity, and cultural diversity, reinforcing the idea that ancient wisdom can guide us toward a more balanced and resilient future.

Embracing Mortise and Tenon as a Symbol of Cultural Identity and Modern Relevance

The mortise and tenon craft is more than a symbol of Chinese material beauty and skill; it is a vehicle for cultural self-awareness and confidence that resonates in today's world. Through this craft, China expresses its unique identity, values, and aspirations, reminding itself and the world of the importance of craftsmanship, harmony, and respect for nature. Mortise and tenon joinery embodies a timeless wisdom that aligns perfectly with contemporary needs for sustainability, cultural preservation, and global cooperation.

By embracing mortise and tenon with cultural self-awareness and confidence, China upholds the values of its civilization while paving the way for future innovation. This approach not only preserves the beauty and spirit of Chinese culture but also invites the world to participate in a shared vision of sustainable, culturally rich, and harmonious living. In a world where rapid change often challenges cultural heritage, mortise and tenon joinery stands as a powerful reminder of the enduring wisdom found in traditional craftsmanship and the lasting impact of cultural confidence.

(2) Promoting Cultural Confidence through Contemporary Integration of Mortise and Tenon

In a globalized world where trends often overshadow tradition, promoting cultural confidence has become essential for the preservation and appreciation of heritage crafts. Cultural confidence empowers individuals and communities to take pride in their cultural heritage, fostering a sense of identity and continuity that bridges past and present. Mortise and tenon joinery, an ancient technique known for its precision, durability, and symbolic resonance, holds immense potential as a medium for cultivating cultural confidence. By creatively integrating mortise and tenon joinery into contemporary design practices, designers can celebrate this traditional craftsmanship while making it relevant to modern aesthetics and

sustainable design principles. This chapter explores how mortise and tenon joinery can inspire cultural confidence through its innovative applications in furniture, architecture, and product design, raising awareness of cultural heritage and demonstrating the timelessness of traditional craftsmanship.

Cultural confidence refers to the pride and self-assurance that individuals and societies feel in their cultural heritage. It involves an active appreciation and understanding of traditional values, practices, and aesthetics, fostering a sense of identity that resists homogenization. Cultural confidence is especially important in contemporary society, where rapid technological and social changes can sometimes result in a disconnect from heritage. When traditional crafts like mortise and tenon joinery are integrated into modern designs, they become symbols of cultural resilience, reflecting values such as patience, quality, and respect for materials.

As a design practice deeply rooted in craftsmanship and cultural philosophy, mortise and tenon joinery embodies principles of harmony, sustainability, and simplicity. By reinterpreting these values in contemporary contexts, designers can highlight the unique characteristics of this traditional technique, emphasizing its relevance and cultural significance. This integration not only elevates mortise and tenon craftsmanship as a respected art form but also encourages a broader audience to connect with, appreciate, and take pride in cultural heritage.

Mortise and tenon joinery is more than a woodworking method; it is a cultural narrative that tells the story of ancient craftsmanship, ingenuity, and respect for nature. When this technique is featured in contemporary designs, it brings a sense of cultural depth that enriches the product's meaning. For example, mortise and tenon structures in furniture or architectural designs serve as visual and functional reminders of the past, making cultural heritage a visible and valued component of modern living spaces.

By positioning mortise and tenon as both a functional and cultural element in modern design, designers can create products that resonate with users on an emotional level. The knowledge that a piece of furniture or a structure was made using a technique with centuries of history fosters a sense of connection and appreciation. This awareness, in turn, instills cultural confidence, as users recognize and celebrate the craftsmanship embedded in their everyday surroundings.

One of the most accessible and impactful ways to promote cultural confidence through mortise and tenon joinery is in furniture design. By combining traditional

joinery techniques with minimalist aesthetics, designers can create pieces that appeal to modern sensibilities while preserving the essence of mortise and tenon craftsmanship. For example, a minimalist table or chair that uses exposed mortise and tenon joints highlights both the structural integrity and cultural significance of the joinery, demonstrating that traditional techniques can coexist harmoniously with contemporary aesthetics.

This fusion of minimalism and traditional craftsmanship appeals to consumers who value simplicity, authenticity, and quality. Each piece becomes a cultural artifact, subtly educating users about the value of craftsmanship. By integrating mortise and tenon joinery into modern furniture design, designers contribute to a renewed appreciation for heritage craftsmanship, fostering cultural confidence among consumers who take pride in owning products that reflect cultural integrity and artisanal skill.

Mortise and tenon joinery has traditionally been used in architecture to create stable, resilient structures. Contemporary architects can incorporate mortise and tenon principles into modern building designs, using exposed joinery to showcase the strength and simplicity of traditional construction methods. For example, mortise and tenon beams can be featured in open-framed structures or pavilions, where the craftsmanship of the joints is highlighted as both a design feature and a structural element.

Architectural designs that embrace mortise and tenon joinery contribute to cultural confidence by reinforcing the idea that traditional techniques are not outdated but are enduring solutions that meet modern architectural demands. These structures demonstrate that ancient methods of construction remain relevant, adaptable, and visually impactful, embodying a harmonious blend of tradition and innovation. Through these applications, mortise and tenon joinery serves as a bridge between past and present, inspiring pride in cultural heritage and encouraging a deeper appreciation for craftsmanship among both architects and the public.

Another effective approach to fostering cultural confidence through mortise and tenon is the development of cultural creative products and DIY kits that encourage hands-on interaction with the technique. DIY furniture kits, educational toys, and interactive learning tools that incorporate mortise and tenon joinery allow users to engage directly with traditional craftsmanship, promoting experiential learning and a tangible connection to heritage.

These products enable users to assemble mortise and tenon structures themselves, fostering an understanding of the care and precision involved in traditional joinery. By engaging with the craft on a personal level, users gain a new appreciation for the technique and the culture it represents. DIY kits, in particular, empower individuals to participate in cultural preservation by bringing mortise and tenon joinery into their own homes, instilling a sense of pride and accomplishment in creating something rooted in heritage.

Public education initiatives and interactive exhibitions are valuable tools for raising awareness about mortise and tenon craftsmanship and its cultural significance. Museums, galleries, and cultural institutions can host exhibitions that showcase mortise and tenon joinery, providing historical context and demonstrating how the technique has evolved over time. Interactive displays that allow visitors to touch, assemble, or observe mortise and tenon joints in action make the experience engaging and memorable, encouraging visitors to appreciate the intricacies of traditional craftsmanship.

Educational programs that include live demonstrations, artisan workshops, or virtual reality experiences can further enhance public understanding. By making mortise and tenon craftsmanship accessible and interactive, these initiatives foster a deeper appreciation for cultural heritage and inspire pride in a craft that reflects cultural values of patience, resourcefulness, and respect for materials.

Digital platforms and social media offer powerful tools for promoting cultural confidence in mortise and tenon craftsmanship. By sharing videos, tutorials, and stories about the technique, designers, artisans, and cultural organizations can reach a global audience, raising awareness of mortise and tenon's history, process, and cultural significance. Virtual workshops, 3D visualizations, and augmented reality applications that allow users to explore mortise and tenon joinery in a digital format can make the craft accessible to a wider audience, particularly younger generations.

Digital engagement provides a platform for storytelling, where artisans can share the philosophy and values embedded in mortise and tenon craftsmanship. This exposure not only preserves the craft's cultural identity but also empowers audiences worldwide to take pride in heritage crafts, fostering cultural confidence by showcasing the craft's adaptability and beauty.

Collaborative design projects that integrate mortise and tenon joinery with other cultural aesthetics can promote cultural confidence by illustrating how

traditional techniques transcend borders. Partnerships between artisans from different cultural backgrounds can result in products that combine diverse styles and skills, creating innovative designs that celebrate craftsmanship as a universal language. For instance, a cross-cultural furniture collection that incorporates both mortise and tenon and Japanese or Scandinavian woodworking techniques could reflect a harmonious blend of global design traditions.

These collaborative projects illustrate the universality of craftsmanship and the adaptability of traditional techniques, showing that mortise and tenon joinery is not only a symbol of cultural heritage but also a versatile tool for global design. By fostering cultural exchange, these collaborations build cultural confidence, empowering communities to share their heritage while embracing new influences.

Mortise and tenon joinery, with its deep cultural roots and structural integrity, offers a powerful medium for promoting cultural confidence through contemporary design. By creatively integrating this traditional technique into modern furniture, architecture, and cultural products, designers can celebrate mortise and tenon as a meaningful and enduring craft that enriches modern aesthetics. Each product or structure that features mortise and tenon joinery serves as a testament to the resilience and relevance of heritage crafts, inspiring pride in cultural identity and encouraging a renewed appreciation for craftsmanship.

Through hands-on learning tools, public exhibitions, and digital engagement, mortise and tenon craftsmanship becomes accessible to a broader audience, fostering a sense of cultural continuity and pride. In today's fast-paced world, where tradition is often overshadowed by convenience, promoting cultural confidence through crafts like mortise and tenon helps preserve and honor the wisdom of the past, ensuring that heritage remains an integral part of contemporary design and everyday life.

(3) Mortise and Tenon Block Design for Cultural and Creative Education

Building on the principles of cultural self-awareness and confidence, the use of mortise and tenon joinery in block-based cultural and creative design serves as a powerful educational tool. Mortise and tenon blocks, designed as modular components that can be assembled by hand, offer a unique and interactive way to learn about traditional craftsmanship and Chinese cultural values. This hands-on approach allows participants to gain an appreciation for the principles of mortise

and tenon, while also fostering creativity, problem-solving, and an understanding of sustainable design.

In this section, we explore how mortise and tenon blocks can be used as a medium for cultural education, offering experiential learning that highlights the value of craftsmanship and traditional Chinese culture. By engaging directly with these blocks, individuals of all ages can develop a deeper connection to the principles of mortise and tenon, fostering respect for traditional culture and encouraging innovation in design.

Manzini argues that in a resilient society, cultural diversity and creativity must flourish. Indeed, cultural diversity and creativity must be an integral part of any scenarios of resilient societies.

Mortise and tenon blocks serve as an accessible introduction to traditional Chinese joinery, enabling users to experience the principles of this ancient craft through hands-on assembly. These blocks, typically designed as interlocking pieces that mimic actual mortise and tenon joints, are crafted to be user-friendly and suitable for educational purposes. The modular design allows users to experiment with assembling and disassembling structures, providing a tangible understanding of how mortise and tenon joints work to create stability and flexibility without the need for fasteners or adhesives.

As educational tools, mortise and tenon blocks bridge the gap between theory and practice, offering students and enthusiasts a way to engage actively with traditional craftsmanship. By manipulating these blocks, learners develop a practical understanding of structural design, spatial awareness, and the precise craftsmanship required in traditional Chinese woodworking. This hands-on experience not only makes learning enjoyable but also reinforces the principles of patience, precision, and harmony central to mortise and tenon craftsmanship.

Hands-on assembly of mortise and tenon blocks immerses participants in traditional Chinese culture, where values such as harmony, balance, and respect for nature are fundamental. Each block represents a piece of Chinese heritage, allowing users to experience how ancient artisans created stable, elegant structures that reflected broader cultural ideals. Through assembly, users internalize the philosophy of harmony between man and nature, as they learn to appreciate the functional and aesthetic qualities of wood as a natural material.

This practical approach to cultural education goes beyond passive observation, offering a dynamic, embodied way to learn. Assembling mortise and tenon blocks can be both a meditative and collaborative activity, where participants work with others or individually to create stable structures. This approach nurtures a connection to the traditional mindset of Chinese artisans, whose work was not only about function but also about creating a harmonious relationship with their materials and environment.

Furthermore, the hands-on experience encourages users to learn through trial and error, fostering an understanding of craftsmanship that extends beyond theoretical knowledge. Participants become familiar with the principles of balance, joint alignment, and the relationship between different structural components, which are all central to mortise and tenon construction. This experiential learning strengthens cultural self-awareness, as participants gain insight into the wisdom and patience that defined traditional craftsmanship.

Mortise and tenon blocks provide a versatile medium for creative expression, allowing users to explore various forms and configurations beyond traditional furniture and architecture. By engaging with these blocks, individuals are encouraged to experiment with unique designs, merging traditional craftsmanship principles with contemporary innovation. This creative freedom transforms mortise and tenon from a historical technique into a flexible tool for modern cultural and creative design.

The modular nature of mortise and tenon blocks enables users to test and modify their designs, encouraging problem-solving and critical thinking. Designers and educators can incorporate these blocks into cultural and creative programs to inspire new ideas, blending traditional joinery with modern aesthetics. This adaptability fosters a sense of cultural confidence, as it demonstrates that traditional craftsmanship can evolve and inspire innovation without losing its essence.

For instance, contemporary designers have used mortise and tenon blocks to create modular toys, decorative items, and even architectural models that reflect both cultural heritage and modern design sensibilities. By providing users with a toolkit that blends cultural tradition and creative freedom, mortise and tenon block design encourages individuals to become cultural innovators, reinterpreting traditional forms in new and imaginative ways.

In addition to fostering cultural appreciation and creativity, mortise and tenon blocks align with the principles of sustainable and circular design. By promoting repairable, reusable, and modular components, mortise and tenon blocks encourage a circular approach to design that values durability and minimizes waste. This aligns closely with sustainable development goals and circular economy principles, as the blocks are typically made from natural wood and can be reassembled, recycled, or repurposed without significant environmental impact.

Mortise and tenon blocks thus embody the essence of green design, demonstrating that sustainable practices are intrinsic to traditional craftsmanship. Each block is crafted with care and intended for long-term use, reflecting an eco-conscious approach that is inherently aligned with the values of circular design. In educational settings, these blocks serve as a powerful example of how traditional practices can contribute to modern sustainability efforts, teaching users the importance of mindful material use and product longevity.

Mortise and tenon block design provides a platform for building cultural confidence, allowing users to experience, appreciate, and innovate upon traditional Chinese craftsmanship. By engaging directly with these blocks, participants can internalize the value of Chinese heritage and recognize the timelessness of its design principles. This hands-on connection fosters pride in traditional culture and encourages participants to view their heritage as a source of inspiration and creativity.

In the context of modern design, mortise and tenon blocks symbolize a resilient cultural identity that can adapt to contemporary needs without losing its authenticity. This approach to cultural confidence demonstrates that traditional values and techniques remain relevant, adaptable, and valuable in a globalized world. As participants explore new ways to use mortise and tenon blocks, they contribute to the evolution of cultural heritage, reinforcing the belief that traditional craftsmanship has a vital role in the future of design.

Mortise and tenon block design represents an effective way to teach and experience traditional Chinese craftsmanship, offering a hands-on approach to cultural education that fosters self-awareness, creativity, and sustainability. Through these blocks, participants learn to appreciate the artistry, wisdom, and philosophy of traditional Chinese joinery, gaining insights into the values of harmony, balance, and respect for nature that underpin this ancient craft.

By engaging with mortise and tenon blocks, individuals not only learn technical skills but also develop a deeper understanding of their cultural heritage and its relevance to contemporary challenges. This fusion of traditional craftsmanship and modern creativity supports the development of a sustainable, culturally aware society that values both innovation and heritage. Mortise and tenon blocks, therefore, stand as a powerful educational tool and a cultural legacy, bridging the past with the future in a way that promotes cultural self-awareness, confidence, and a commitment to sustainable design.

In recent years, mortise and tenon building blocks have emerged as an innovative form of cultural and creative design, drawing inspiration from traditional Chinese craftsmanship, particularly the ancient Lu Ban locks. These blocks honor the structural ingenuity of mortise and tenon joinery, reinterpreting it as an educational and cultural experience akin to building with LEGO but with a distinctly Chinese cultural identity. The Lu Ban lock, a complex interlocking puzzle traditionally used to test skill and patience, serves as a prototype for this design concept, embodying the ancient wisdom of Chinese artisans and offering users an opportunity to engage deeply with traditional craftsmanship.

This section explores how mortise and tenon building blocks capture the cultural and educational spirit of Chinese craftsmanship, distinguishing them from LEGO by emphasizing the values of cultural identity, cultural self-awareness, and cultural confidence. Through examples like Wang Zhenhua's model of the Hall of Prayer for Good Harvests in the Temple of Heaven, we examine how these blocks serve as a vehicle for cultural awakening and appreciation for the intricacies of Chinese joinery and architectural philosophy.

The Lu Ban lock, named after the legendary Chinese carpenter and inventor Lu Ban, is a traditional wooden puzzle that relies on mortise and tenon joinery principles to hold itself together without glue or nails. The complexity of the Lu Ban lock requires precise alignment of interlocking pieces, symbolizing the craftsmanship, patience, and wisdom inherent in traditional Chinese woodworking. As a cultural artifact, the Lu Ban lock represents the harmony of structure, beauty, and functionality that defines Chinese craftsmanship.

Luban lock is actually a toy involving solid geometry knowledge. Through geometric segmentation, it can form a variety of locking methods. The exhibition of classical mathematical toys witnessed the long-standing civilization of ancient China and also delivered knowledge and fun to modern people.

The mortise and tenon structure contains rich Chinese traditional cultural elements, showing the wisdom and talent of the Chinese nation. Today, Luban lock and cultural and creative product designs based on Luban lock have become special handicrafts loved by the world. They are not only popular in overseas markets, but also an important carrier for Chinese culture to "go out".

Luban Lock Cultural and Creative Product Design Based on Mortise and Tenon Joinery is a concept that combines traditional Chinese craftsmanship with modern design principles to create unique and innovative products. Luban Lock is a traditional Chinese lock mechanism that is similar to the mortise and tenon joinery technique, which is used to create strong, durable connections between components. This concept is based on the principles of cultural and creative product design, which emphasizes the use of traditional craftsmanship and cultural elements to create new and innovative products.

Using the Lu Ban lock as a prototype for mortise and tenon building blocks highlights the cultural wisdom behind each connection. Unlike LEGO bricks, which focus on the ability to stack and connect for structural creativity, mortise and tenon blocks require careful consideration of each joint, teaching users the art of balance, precision, and interconnectedness. This focus on the craftsmanship of connection forms the basis for mortise and tenon building blocks as an educational tool and as a means of appreciating Chinese heritage.

Mortise and tenon building blocks, inspired by the Lu Ban lock, allow users to engage directly with Chinese craftsmanship traditions in a hands-on way. Each block represents not only a physical component of a larger structure but also a piece of cultural heritage that embodies the philosophical values of Chinese civilization. This approach to building emphasizes the value of precision and interconnectedness over rapid assembly, reinforcing a mindset of appreciation for quality and the wisdom of traditional design.

In this context, building with mortise and tenon blocks fosters a sense of cultural identity and pride. For example, Wang Zhenhua's mortise and tenon model of the Hall of Prayer for Good Harvests—a remarkable piece of architecture in Beijing's Temple of Heaven—captures the structural and aesthetic beauty of Chinese architecture using traditional joinery. As users construct this model, they engage not only with the technical aspects of building but also with the symbolism and history embodied in the Temple of Heaven. The experience provides a means

of connecting with Chinese culture in a way that is both intellectually and emotionally resonant, reinforcing cultural self-awareness and confidence.

LEGO and mortise and tenon building blocks share the goal of encouraging creativity and exploration, yet their intentions and cultural implications differ significantly. LEGO is primarily designed to shape children's dreams of creation and fulfillment, offering limitless possibilities for imaginative play. The blocks are easily connected and disconnected, allowing for endless reconfiguration. In this sense, LEGO emphasizes creativity, play, and the joy of building without a deep focus on the structural relationships or cultural meanings of each connection.

In contrast, mortise and tenon building blocks are rooted in the philosophy of appreciating connection as a means of understanding cultural heritage. The focus on precise, interlocking joints requires users to slow down, consider each piece carefully, and appreciate the structural logic that holds the model together. This mindful approach reflects traditional Chinese values of patience, harmony, and respect for natural materials, emphasizing cultural education rather than simple entertainment. Mortise and tenon building blocks thus teach not only building skills but also cultural values and an appreciation for the intricate wisdom of Chinese craftsmanship.

The experience of assembling mortise and tenon blocks fosters a sense of cultural awakening, as users discover the depth and beauty of Chinese craftsmanship firsthand. Unlike passive observation, building with these blocks immerses users in the technical and aesthetic principles that Chinese artisans have developed over centuries. This experience creates a sense of cultural self-awareness, as individuals recognize the unique qualities of Chinese design and the intellectual heritage that it represents.

Cultural awakening through hands-on assembly is a powerful way to inspire pride and confidence in Chinese identity. By understanding and replicating traditional techniques, users connect with their heritage in a way that is both meaningful and personally enriching. This process of cultural engagement goes beyond mere recognition; it fosters an appreciation for the depth of knowledge, skill, and philosophy that underpins traditional Chinese craftsmanship. The blocks thus become a medium for rediscovering and celebrating cultural heritage, instilling cultural confidence in the participants.

Mortise and tenon building blocks do not only preserve cultural heritage; they also serve as a platform for contemporary innovation. By applying traditional joinery techniques to modern cultural and creative products, designers can reinterpret mortise and tenon craftsmanship for today's audiences. This innovation reinforces cultural confidence, as it demonstrates that traditional Chinese techniques remain relevant and adaptable in a modern context.

For instance, designers have introduced modular furniture, decorative items, and educational toys based on mortise and tenon principles. These contemporary applications of traditional craftsmanship allow individuals to experience the functional beauty of mortise and tenon joinery in their daily lives, reinforcing pride in Chinese cultural heritage while promoting sustainability. Mortise and tenon building blocks, therefore, play a dual role as both a tool for cultural education and a source of creative inspiration, demonstrating that ancient techniques can evolve and contribute meaningfully to contemporary design.

Mortise and Tenon Building Blocks as a Cultural Legacy

Mortise and tenon building blocks inspired by the Lu Ban lock represent a unique approach to cultural and creative design that emphasizes cultural self-awareness, appreciation for craftsmanship, and the enduring wisdom of Chinese heritage. Unlike LEGO, which prioritizes imaginative freedom, mortise and tenon blocks teach the art of connection, patience, and cultural understanding. They serve as a means of cultural awakening, helping users to connect with the craftsmanship, values, and intellectual heritage that define traditional Chinese joinery.

Through hands-on assembly, mortise and tenon building blocks inspire pride in Chinese identity and a sense of cultural confidence, bridging the gap between past and present. By promoting this interactive form of cultural education, mortise and tenon building blocks not only preserve but also reimagine Chinese craftsmanship for future generations, offering a model of sustainability, ingenuity, and respect for tradition in the realm of cultural and creative design.

(4) The National Tide in Lu Ban Lock Toys

In recent years, a renewed interest in traditional Chinese craftsmanship and cultural heritage has emerged as a growing trend known as the “national tide” (国潮). This movement reflects a broader trend of cultural consciousness and cultural self-confidence in China, driven by the desire to reconnect with indigenous

knowledge systems, artistic heritage, and craftsmanship traditions. Cultural consciousness emphasizes an awareness and appreciation of one's heritage, while cultural self-confidence asserts the value and distinctiveness of these traditions in a globalized world. Together, these principles empower a society to honor and sustain its identity through creative adaptations and innovative expressions.

With its deep historical roots and functional elegance, mortise and tenon joinery has become a symbol of China's cultural and artistic heritage, representing both technical ingenuity and aesthetic simplicity. As Chinese society continues to celebrate its craftsmanship heritage, mortise and tenon structures, particularly through Lu Ban lock puzzles and educational toys, have become popular cultural artifacts. They offer not only a way to engage with history but also a medium through which individuals can learn through hands-on experience, gaining a deeper understanding of Chinese woodworking and engineering practices.

The national tide movement has created significant opportunities for cultural and creative industries to incorporate traditional Chinese elements into contemporary designs. This trend emphasizes cultural symbols, craftsmanship, and techniques that resonate with younger generations, fostering a renewed appreciation for Chinese aesthetics. As consumers increasingly seek products that express cultural pride, mortise and tenon joinery—particularly in the form of Lu Ban lock toys—presents an ideal medium to embody this cultural consciousness.

The popularity of Lu Ban locks showcases the value of hands-on cultural products that offer intellectual engagement and cultural enrichment. These toys invite users to interact with traditional craftsmanship techniques, serving as an educational bridge to the wisdom embedded in mortise and tenon structures. They demonstrate how learning by doing can be an effective approach to cultural education, where participants gain knowledge about structural stability, interlocking designs, and the enduring relevance of ancient techniques through play.

The design of Lu Ban lock mortise and tenon toys is grounded in principles of both cultural heritage and cognitive learning. Unlike other forms of entertainment, these puzzles encourage users to engage with the material on multiple levels, both physically and intellectually. Through the process of assembling mortise and tenon structures, users learn the intricacies of interlocking components, which is a core aspect of traditional Chinese joinery.

The educational purpose of Lu Ban locks aligns with the concept of “learning by doing” . As users handle, explore, and fit the various pieces together, they gain practical insights into the engineering principles behind the design. This approach offers a dual experience: it teaches structural mechanics and problem-solving skills while also imparting an appreciation for traditional Chinese craftsmanship. By engaging with the puzzle in a tactile, hands-on manner, users develop an understanding of mortise and tenon techniques as more than just a historical curiosity, but as a sophisticated system of joinery that has stood the test of time.

(5) Showcasing Craftsmanship and Cultural Spirit through Model Blocks

One notable example of cultural consciousness in mortise and tenon model design comes from Wang Zhenhua’s work on model blocks inspired by iconic Chinese structures such as the Prayer Hall and the Zhaozhou Bridge. These models are meticulously designed to replicate traditional architecture, providing a miniature yet accurate representation of the craftsmanship that went into creating these historical monuments.

From a child who loved to play with shavings, to giving up restoration of ancient buildings due to fear of heights, to studying in technical schools, to failing to start his own business twice, Wang Zhenhua, an old man from Shanghai, was determined to find the dream of his youth when he was 60 years old. Before and after 5 years, after more than 100,000 procedures, the production of 7108 parts, without glue, without numbering, will not be deformed, to restore the Temple of Heaven Prayer Hall with full mortise and tenon structure, and won the 2016 World Handicrafts and Industry Expo and Intangible Cultural Heritage Achievement Exhibition ‘National Craftsman Cup’ Gold Medal. A small carving knife polished for 3 years, working 10 hours a day, the thinnest dovetail groove of only 1.5 mm, 7000 times the mortise and tenon connection, so that people see this hidden in the residential building ‘contemporary Luban’ of the superb skills, but also let people deeply feel a kind of artisanal spirit. After reproducing the Temple of Prayer for the Year of the Dragon, he is now working on his second work, the Zhaozhou Bridge, followed by a large meeting place, the Yellow Crane Tower and other ancient Chinese architectural restoration ideas.

Prayer Hall Model Blocks: The Prayer Hall model uses mortise and tenon blocks to recreate the architectural details of traditional Chinese temples. The model encourages users to carefully assemble each block, experiencing firsthand the complexity and stability that mortise and tenon joints provide. Through this process,

participants gain a deeper understanding of traditional Chinese religious architecture and its reliance on timber framing without the use of nails or adhesives. The assembly process becomes a learning experience in itself, illustrating the design principles that enable these structures to endure.

“I did this work for five years, done four times, when I was doing it is impossible to do things, people say I'm a bit of a fool, I really become a fool, I decided to do things I can not back, many things are back, do half of the back on the failure, a year off four days without a penny of income, I did the third generation, I did the third generation, I really feel that I have hope. I a little five millimetre tenon out, the third generation has been four years, he did a good job of the third generation, it is already very good, every make a prayer hall at least a year, the third generation of the prayer hall, in the eyes of outsiders enough to shock, but Wang Zhenhua always feel that it is not right to do the fourth generation, he fell into a tangle, no one to support of the problem of time, all day long walk outside, I want to insist on, to make a fine product, to let the People's eyes light up the feeling. Eighty-six years when I went to mapping, often see students in the drawing of sketches, a few hours down I turned and looked at the visual is not the same, it is not the same effect, this then gave me a vigilant thought, but I did the third generation I remembered this thing, I want to look up effect I do not want to overlook the effect, I said it must be changed.” When in front of the Temple of Heaven to look at the Hall of Prayer is to look up, and hands-on production is the whole overlooking, this difference in perspective, so that Wang Zhenhua spent another year and a half of time. A total of seven thousand one hundred and eight parts, seventy-four large parts, the smallest part of the width of only two millimetres, will not be deformed, without glue, without numbering, this than the original proportion of eighty-one times smaller, so that Wang Zhenhua most satisfied with the Hall of Prayer, and finally in the fifth year of the start of the success of the work. This work was completed on the 30th of October, 15 years ago, at 8:00 p.m. I finished assembling it, and after I went up, I was amazed, and I felt that the effect of looking up had come out a little bit, and I climbed up to the highest point to look

at it again, and I looked at it from all angles, and I saw it at 12:00 p.m., and I was very happy to see it.



Figure 4.8 Prayer Hall Model Blocks⁹⁵

Zhaozhou Bridge Model Blocks: The Zhaozhou Bridge, a renowned ancient Chinese stone bridge, is an engineering marvel that dates back to the Sui Dynasty. Wang Zhenhua's model of this bridge utilizes mortise and tenon-inspired blocks to represent the bridge's structural innovations. Assembling the bridge model provides a lesson in historical Chinese engineering, showing how precise alignment and interlocking components can create a strong and resilient structure. Through hands-on interaction with the model, users appreciate the ingenuity that enabled the bridge

⁹⁵ Minhang craftsmen create the first 162 times miniature "Qinian Hall" full mortise and tenon toy to be launched soon_ The Paper. _The Paper. (n.d.). https://www.thepaper.cn/newsDetail_forward_7564894

to withstand natural forces, reflecting the wisdom and practicality of ancient Chinese engineering.

Zhaozhou Bridge, with a history of more than 1,400 years, uses mortise and tenon structure to produce an arch, which is very different from the way the Prayer Hall was created, Wang Zhenhua designated it as his second work, which is another new beginning for him, which actually means that “when I go to survey and map it, I don't go to survey and map it with a very blank mind, for example, for the Zhaozhou Bridge I've already called up all the drawings by Liang Sicheng from 1933 on the Internet, but why do I still have to go to Mapping it, first of all to reflect, it prototype and Liang's between there is no error, the second if you do not see the scene you can not see the beauty of this reflection, the third how many turns he has, how many bricks he has how many bricks I have, if I only do the bridge is certainly not beautiful, the beauty of it in the reflection.” After the field mapping. Isolated for five years, after more than half a million procedures, more than 20,000 hours of lonely dead, 60,000 kilometres round trip in the stars, the next decade and two decades, Wang Zhenhua want to make more ancient architecture miniature reproduction, self-conceited, but not conceited inside, is the craftsman is even more tenacious people. Wang Zhenhua wrote the Chinese mortise and tenon joints of the former and the latter. Full of curiosity about the world, unwilling to wake up in the young dream. Unconvinced of defeat, he searches for the value of existence according to the rhythm of his heart. He carries the essence of tradition in his heart, and the flavour of the Orient in his tools.



Figure 4.9 Zhaozhou Bridge Block⁹⁶

The “learning by doing” approach used in Lu Ban lock toys and Wang Zhenhua’s models highlights the educational potential of engaging directly with cultural heritage through practical, hands-on activities. This experiential approach

⁹⁶ He concentrated the "most beautiful corner" of the Forbidden City and perfectly reproduced it with every detail. Xuexi Qiangguo - Content has been offline. (n.d.). https://article.xuexi.cn/articles/index.html?art_id=16641097374717140263&t=1680773866710&showmenu=false&study_style_id=feeds_default&source=share&to_audit_timestamp=2023-04-06+16%3A03%3A08&share_to=wx_single&item_id=16641097374717140263&ref_read_id=2d707afa-61ce-4ad5-a3a6-b6db0aaee554_1737190645310

promotes active learning, allowing users to understand complex structural principles that would otherwise be difficult to convey through passive observation alone. Assembling these models requires concentration, patience, and critical thinking, as users must understand the spatial relationships between each piece to complete the structure.

This hands-on learning experience not only teaches mechanical principles but also immerses users in the spirit of craftsmanship. By replicating traditional joinery methods and encouraging active participation, these models convey the dedication, patience, and attention to detail that are integral to Chinese craftsmanship. This interaction fosters a sense of accomplishment and pride, as users complete a tangible representation of Chinese architectural wisdom, echoing the cultural self-confidence that drives the national tide movement.

The cultural and creative designs of mortise and tenon toys and model blocks underscore the Chinese spirit of craftsmanship. Each model is a tribute to the artisans who historically developed and perfected these techniques, emphasizing durability, precision, and harmony with nature. This craftsmanship culture is rooted in a respect for natural materials, efficient use of resources, and the pursuit of functional beauty. By engaging users in the meticulous assembly process, these toys and models emphasize the values that define traditional Chinese craftsmanship.

Moreover, these cultural products serve as ambassadors of Chinese cultural heritage, particularly in a globalized world where cultural identity can be easily diluted. By showcasing these traditional joinery techniques in modern, accessible formats, products like Lu Ban lock toys and mortise and tenon models contribute to cultural continuity and education. They inspire a new generation to appreciate and preserve the cultural legacy of craftsmanship, ensuring that the wisdom of traditional Chinese engineering and joinery remains vibrant and relevant.

The national tide movement has created a fertile ground for cultural education through creative design, particularly with traditional crafts like mortise and tenon joinery. Through culturally conscious products like Lu Ban locks and architectural models, people can interact with and appreciate the depth of Chinese craftsmanship. Wang Zhenhua's model blocks of the Prayer Hall and Zhaozhou Bridge exemplify this approach, using "learning by doing" to connect users with traditional engineering principles and cultural wisdom. This hands-on engagement fosters cultural consciousness and self-confidence, highlighting the value of China's rich heritage and inspiring pride in traditional craftsmanship.

In a world increasingly dominated by digital interactions, these tactile, culturally significant products underscore the importance of physical engagement with heritage and tradition. They serve as a bridge between past and present, teaching not only technical skills but also the values embedded in traditional Chinese craftsmanship, thereby cultivating a new generation that values and perpetuates this cultural spirit.

Chapter 5 Innovation Development Strategies of Mortise and Tenon Craftsmanship

The final chapter describes strategies for the preservation and innovation of the intangible cultural heritage of mortise and tenon, considering that protection presupposes preservation, concluding that innovative design is one of the most important driving forces for preservation and development, and that design education and mortise and tenon carpentry workshops can be combined as a way of passing on the craft, as well as an industry-university-research model where design works in partnership with other partners to work together on the innovation of the intangible cultural heritage of traditional crafts.

5.1 Digital Preservation and Craftsmanship Inheritance

In the digital age, the preservation of traditional craftsmanship has expanded beyond physical artifacts and oral transmission, incorporating advanced technologies to safeguard and revitalize cultural heritage. Digital preservation offers new avenues to document, share, and study craftsmanship, ensuring its continuity for future generations. From virtual platforms to 3D modeling, these tools not only archive the techniques but also enhance accessibility and foster innovation. This section delves into how digital technologies are reshaping the ways traditional crafts, like mortise and tenon joinery, are preserved and inherited in modern contexts.

5.1.1 Digital Craft Museums and 3D Modeling

As digital technology advances, virtual platforms like digital museums and 3D modeling have become essential tools for the preservation, documentation, and dissemination of cultural heritage. Digital museums allow for the virtual exhibition of cultural artifacts, making them accessible to a global audience. This accessibility not only preserves the knowledge of traditional craftsmanship but also invites cross-cultural engagement and understanding. For mortise and tenon joinery—a craft deeply rooted in Chinese history—digital museums can effectively showcase the artistry and technical expertise involved in its construction, offering viewers an in-depth look at its cultural significance.

In conjunction with digital museums, 3D modeling provides a practical and versatile tool for preserving the structural details of mortise and tenon craftsmanship. High-resolution 3D scans capture intricate details of various joinery techniques, preserving both the aesthetic and functional aspects of this ancient craft. 3D modeling can also facilitate detailed analysis, enabling designers, researchers, and students to examine the technical aspects of joinery methods in a virtual environment. The digitization process ensures that even as physical artifacts may degrade or remain inaccessible, their digital counterparts can be studied, replicated, or even modified within a design context.

Furthermore, 3D modeling supports the education and transfer of craftsmanship knowledge to future generations. With accurate 3D models, artisans and educators can provide immersive training experiences, allowing learners to interact with digital representations of joinery in ways that are otherwise difficult to achieve in traditional settings. This virtual exploration fosters both preservation and innovation by allowing new interpretations of mortise and tenon techniques in modern design applications. By merging traditional craftsmanship with cutting-edge technology, digital museums and 3D modeling create a bridge between cultural heritage and contemporary design, ensuring the survival and evolution of mortise and tenon joinery within the context of sustainable and innovative design.

The theoretical basis and significance of establishing a digital museum of mortise and tenon craft products can be explored from the following aspects:

Theoretical basis:

- **Digital technology:** Using digital technology, such as 3D scanning, 3D printing and virtual reality (VR), mortise and tenon craft products can be accurately reproduced and displayed.
- **Cultural heritage protection:** As an important part of Chinese traditional culture, digital museums can help protect and inherit this cultural heritage.
- **Education and research:** Digital museums can serve as education and research platforms, providing scholars and students with opportunities to gain in-depth understanding of mortise and tenon crafts.

Significance:

- **Cultural heritage preservation:** Through digitization, mortise and tenon craft products can be preserved for a long time and better protected without being restricted by physical space.

- **Dissemination of knowledge:** Digital museums can break geographical restrictions and allow more people to access through the Internet, thereby increasing the popularity and influence of mortise and tenon crafts.

- **Innovation and development:** Digital museums can promote the innovation and development of mortise and tenon crafts, and stimulate the public's interest and creativity in traditional crafts through virtual displays and interactive experiences.

- **Education and training:** Digital museums can serve as education and training tools to help people understand the history, technology and artistic value of mortise and tenon crafts and cultivate a new generation of craftsmen.

- **Cultural exchange:** Digital museums can become a platform for cultural exchange, showcasing the unique charm of mortise and tenon craftsmanship and promoting understanding and respect between different cultures.

In short, the establishment of a digital museum for mortise and tenon craft products will not only help protect and inherit this cultural heritage, but also promote its innovation and development, while providing new avenues for education and cultural exchange.

Application of digital design technology. In today's era of rapid technological development, digital design technology is not only a cutting-edge tool for industrial design, but also an important driving force to promote the innovation of traditional crafts. As a traditional Chinese carpentry craft, the unique connection and cultural connotation of mortise and tenon joinery urgently needs to be combined with modern design concepts to achieve more efficient and precise innovative designs. The application of digital design technology enables designers to simulate, analyse and optimise the mortise and tenon structure in three-dimensional space, fully exploring its potential aesthetics and functionality. Through computer-aided design (CAD) and 3D modelling, designers are able to anticipate the strength and stability of mortise and tenon joints and the ease of assembly at the design stage, thus reducing the cost of trial and error and improving design efficiency.

At the same time, digital technology offers the possibility of standardisation and modularisation of mortise and tenon craftsmanship, which not only helps to

achieve mass production, but also maintains the uniqueness and complexity of traditional craftsmanship. With the support of Virtual Reality (VR) and Augmented Reality (AR) technologies, designers can gain a deeper understanding of the structural relationship and spatial expression of mortise and tenon through immersive experiences, and then incorporate more innovative elements into the design process. The introduction of digital design technology not only makes the design process more intuitive and flexible, but also provides a new perspective on the cultural heritage and modern transformation of mortise and tenon craftsmanship. In the future, with the continuous progress of technology and the expansion of application fields, digital design will certainly bring a broader development space for the innovative design of mortise and tenon craft, and help its revival and reinvention in contemporary design.

5.1.2 University-Industry Partnerships

The integration of practical skills training with academic learning has long been a goal of vocational education, aiming to bridge the gap between theoretical knowledge and real-world application. This section explores the evolution of dual-track education, starting from the influential Bauhaus School's model in Germany, which emphasized a close collaboration with industry, to modern implementations in China, particularly through Tianjin Vocational University's Xin Quansheng Carpentry Workshop and the international outreach of Luban Workshops. These institutions have become vital in cultivating the next generation of craftsmen and innovators, preserving traditional techniques like mortise and tenon joinery while adapting them to modern industrial needs.

Tianjin Vocational University (TVU) has implemented a unique approach to vocational education that aligns with China's emphasis on preserving cultural heritage. One of TVU's most notable initiatives is the Xin Quansheng Carpentry Workshop, named in honor of a renowned craftsman who contributed significantly to preserving and promoting traditional Chinese carpentry. The workshop serves as a training ground for students to learn about intangible culture heritage mortise and tenon craftsmanship, a technique that has been an integral part of Chinese architecture and furniture for centuries.

Through a structured curriculum that combines classroom learning and practical workshops, students at the Xin Quansheng Carpentry Workshop are exposed to both the artistry and the cultural significance of mortise and tenon joinery. This experience allows them to appreciate the intricate skills required for the craft and the historical context that has shaped it. By adapting traditional

methods for contemporary applications, TVU not only preserves these ancient techniques but also provides students with valuable skills that are applicable in modern carpentry and construction industries.

The workshop also emphasizes an experiential learning approach, where students work directly under master craftsmen, including those recognized as intangible cultural heritage bearers. This mentorship ensures the transfer of knowledge from generation to generation, blending traditional wisdom with modern vocational education techniques. Additionally, this program cultivates a sense of pride and responsibility among students, encouraging them to contribute to cultural preservation while acquiring skills for their future careers.



Figure 5.1 Xin Quansheng Woodworking Workshop (Photographed by the author)

The Xin Quansheng Carpentry Workshop at Tianjin Vocational University (TVU) serves as a vital platform for inheriting and innovating traditional mortise and tenon craftsmanship. This workshop integrates traditional woodworking skills with a modern educational approach inspired by the dual-track model of the Bauhaus School, where students learn through both theoretical coursework and hands-on practice. Such a model aligns with China's goals of preserving cultural heritage while equipping students with practical skills that meet contemporary industry demands.

Heritage Transmission through Experiential Learning. The Xin Quansheng Carpentry Workshop provides students with an immersive experience that connects them to traditional woodworking techniques. Through direct mentorship under master craftsmen, including recognized heritage bearers, students gain an in-depth understanding of mortise and tenon joinery—a cornerstone of Chinese architectural and furniture design. This hands-on mentorship ensures a faithful transfer of skills, as students learn intricate joint designs and their cultural significance from seasoned experts.

Cultural Preservation and Modern Applications. By combining traditional craftsmanship with modern applications, the workshop not only preserves the cultural essence of mortise-and-tenon jointing, but also explores ways to make it relevant to the modern environment. For example, students experiment with transforming mortise and tenon construction into sustainable furniture and modular design solutions, utilising the durability and eco-efficiency of the technique to meet today's demand for environmentally friendly products.

Combines Academic Learning with Practical Training. Xin Quansheng Workshop combines academic learning with practical training. This approach prepares students to transition seamlessly between conceptual design and practical craftsmanship, fostering adaptability and skill in both traditional and modern carpentry. Students are not only trained as craftsmen but as designers capable of infusing traditional techniques with innovative perspectives.

A Model for Intangible Cultural Heritage Education. The Xin Quansheng Carpentry Workshop exemplifies a successful intangible cultural heritage educational model that preserves cultural knowledge while equipping students with career-ready skills. By teaching mortise and tenon craftsmanship within a structured vocational program, TVU empowers students to become future custodians of this

cultural heritage, bridging the gap between past traditions and future innovations in carpentry and design.

This approach not only ensures the continuity of mortise and tenon joinery but also enhances its relevance in a rapidly evolving design landscape, preparing graduates to sustain this traditional art form while adapting it to contemporary needs.

5.2 Integration of Traditional and Contemporary Design

The integration of traditional craftsmanship with contemporary design practices is an essential approach to preserving cultural heritage while addressing modern needs. By blending time-honored techniques, such as mortise and tenon joinery, with innovative design principles, new possibilities emerge for both artisans and designers. This section examines the transition from professional craft to broader social applications, exploring how traditional skills are being adapted for contemporary use in various fields, including product design, architecture, and social innovation.

5.2.1 From Professional Craft to Social Applications

In the current educational landscape, design programs in many colleges and universities often focus narrowly on specialized, professional skills. This approach emphasizes technical proficiency and aesthetic development within specific design fields—graphic, industrial, interior, or product design. However, by concentrating predominantly on industry-standard techniques and discipline-specific knowledge, these programs can sometimes overlook the broader social and cultural roles that design can play. True to its purpose, design has the potential not only to serve commercial industries but also to address complex social challenges, connect deeply with people’s everyday lives, and create meaningful change. This chapter advocates for a paradigm shift in design education, encouraging institutions to move beyond strictly professionalized curricula and adopt a social design approach. By integrating design with community needs and emphasizing its potential to promote positive societal change, colleges can prepare designers who are capable of engaging with pressing social issues and contributing to the well-being of society at large.

(1) The Narrowness of Professionalized Design Education

Many college-level design programs are structured to equip students with skills that are directly applicable in professional contexts. These programs often

follow a formulaic approach, providing students with technical training in areas like digital rendering, software proficiency, and formal design principles. While this approach develops proficiency in technical and aesthetic skills, it often narrows students' understanding of design to commercial applications, emphasizing industry expectations over the broader potential of design as a societal tool.

Courses in professional design programs may also be centered around individual achievement and portfolio development, which are essential for entering the job market but insufficient for fostering a broader perspective on how design can serve communities or address social issues. Consequently, students may graduate with a limited view of the impact of their work, seeing themselves as service providers for corporate or commercial clients rather than as contributors to society.

The focus on professionalism in design education can sometimes detach students from the realities of the world around them. In many cases, design assignments are simulated exercises with hypothetical clients, abstract scenarios, and idealized problems. This approach, while useful for honing skills, often overlooks the messy, complex nature of real-world issues, where solutions need to account for social, cultural, and economic factors. Without exposure to these complexities, students may miss the opportunity to see design as a means to address challenges like sustainability, social justice, and community health.

As a result, students may develop a narrow view of their role as designers, primarily focused on aesthetics and functionality within predefined industry frameworks. In reality, design has the potential to be an influential agent for social good, capable of bridging gaps between diverse stakeholders, addressing inequalities, and contributing to environmental responsibility. This broader, socially-oriented role of design remains underemphasized in traditional professional design education.

(2) Design as a Social Tool: Connecting Education to Society

Design gains true value when it is integrated into the lives of people, addressing real needs, enhancing well-being, and improving the quality of daily life. To make design education relevant, it must be “landed” in a way that connects students with the communities and individuals they are designing for. This requires shifting the focus from theoretical, skill-based exercises to projects that actively engage with real-world problems, particularly those faced by underserved or

marginalized communities. For example, students might work on projects that address accessibility, urban living conditions, or environmental sustainability in partnership with local communities or non-profit organizations.

When design education includes direct engagement with community issues, students gain an understanding of design as a responsive, interactive process that adapts to the needs and voices of the people it serves. Such an approach helps students develop empathy, cultural sensitivity, and adaptability—qualities that are essential for socially oriented designers. By connecting design education to everyday life, colleges can prepare students to approach their work as an integrated and socially meaningful practice.

Social design emphasizes the use of design thinking to solve societal issues, from healthcare access and environmental sustainability to educational equity and urban livability. Unlike professional design, which is often client-oriented and product-focused, social design considers the needs of society as a whole, seeking to improve the collective quality of life. Social design projects may focus on creating affordable housing solutions, designing educational tools for underprivileged communities, or developing public awareness campaigns on issues such as mental health or climate change.

This approach not only expands the role of design but also reframes the designer's purpose. In a social design framework, the designer is not simply a creator of visual or functional products but an agent of change, capable of using their skills to address significant societal challenges. By introducing students to social design early in their education, institutions can inspire a sense of responsibility and purpose, positioning design as a field that is not only relevant but essential for societal progress.

(3) Integrating Social Design into College Education

To foster a more socially oriented approach, design education curricula should integrate social design principles across courses and projects. This may involve developing interdisciplinary courses that bring together design students with those in sociology, psychology, environmental studies, and public policy. Interdisciplinary projects encourage students to collaborate with peers from different fields, allowing them to consider diverse perspectives and gain insights into complex social dynamics.

Curricula can also include courses on ethical and sustainable design, community engagement, and human-centered design. These courses help students understand the broader impact of their work, teaching them how to consider environmental, social, and economic implications in their designs. Service-learning projects, where students work directly with local communities to co-create solutions for social challenges, are another valuable way to integrate social design into the curriculum. Through these initiatives, students learn that design is not merely about producing attractive or functional objects but about creating meaningful, transformative experiences for people.

Collaboration with industry and community organizations is essential for exposing students to the practical applications of social design. By partnering with non-profit organizations, local governments, and businesses that are committed to social responsibility, colleges can create opportunities for students to engage in projects with real social impact. For example, a partnership with a non-profit focused on affordable housing could allow students to develop innovative solutions for sustainable, low-cost housing, while a collaboration with a healthcare organization could involve designing accessible health education materials for underserved communities.

These collaborations not only give students hands-on experience but also expose them to the real-world complexities and ethical considerations involved in social design. Working alongside community members and industry professionals, students learn to address design challenges in a way that respects the voices and values of the communities they serve. This experience builds their capacity to become socially conscious designers who understand the importance of inclusivity, accessibility, and community-centered design.

To fully realize the potential of social design, educational institutions must also foster a culture of design activism, encouraging students to see themselves as change-makers who can use their skills to advocate for positive social change. This involves creating an environment where students are empowered to address issues they are passionate about and are provided with the resources and mentorship to pursue socially driven projects. Guest lectures from social designers, field trips to community-based design studios, and workshops on design for social impact can help cultivate a mindset of activism within the student body.

By promoting a culture of design activism, colleges can inspire students to think beyond conventional design roles and consider how they can contribute to the

public good. This perspective motivates students to view design as a powerful tool for addressing injustices, improving quality of life, and fostering sustainable communities. Encouraging design activism within academic institutions also positions colleges as leaders in the movement toward socially responsible design, setting a standard for other educational programs to follow.

The narrow focus on professional skills in current design education limits the potential of designers to engage with society and drive meaningful change. By shifting from professional to social design, colleges can prepare students to approach design as a socially conscious practice, rooted in empathy, cultural awareness, and a commitment to societal well-being. Integrating social design into education fosters cultural confidence, enabling students to view their skills not just as tools for career success but as catalysts for positive transformation.

Through curriculum reform, industry and community partnerships, and a culture of design activism, educational institutions can help students develop a broader understanding of the role of design. In this expanded view, design moves beyond aesthetics and functionality to become a force for social improvement, allowing designers to make meaningful contributions to the lives of individuals and communities. Embracing social design in education ultimately empowers a new generation of designers who are prepared not only to succeed professionally but also to create a lasting impact on society.

5.2.2 Transitioning from Commercial to Socially Responsible Design

In recent decades, the field of design has undergone a profound shift, moving away from purely commercial goals toward a more responsible, socially aware approach. While traditional commercial design focuses on profitability, mass appeal, and rapid production, responsible design emphasizes ethical considerations, sustainability, cultural preservation, and community well-being. This shift reflects a growing awareness of the environmental, social, and cultural impacts of design, pushing designers to create products, services, and systems that contribute positively to society and the planet.

In this section, we explore the characteristics of responsible design, the factors driving this shift, and how this approach transforms both the design process and its outcomes. Through case studies and examples, we examine how responsible design not only meets functional needs but also aligns with broader values, addressing the urgent challenges of today's world.

(1) Characteristics of Commercial Design: Profit-Driven and Market-Oriented

Commercial design, which has dominated the industry for much of the 20th and early 21st centuries, is typically characterized by its focus on marketability, consumer demand, and cost-efficiency. This approach often emphasizes high-volume production, standardized materials, and aesthetic trends that appeal to the widest possible audience. The primary goal of commercial design is to maximize profit, often by creating products that encourage quick turnover and repeat purchases.

While commercial design has contributed to economic growth and innovation, its downsides are becoming increasingly apparent. This profit-driven focus has led to the widespread adoption of planned obsolescence, disposable goods, and unsustainable practices that contribute to environmental degradation, waste, and a lack of cultural diversity in design. As consumers and communities become more aware of these issues, there is a growing demand for design approaches that consider long-term impacts and prioritize responsibility over profitability.

(2) Characteristics of Responsible Design: Ethics, Sustainability, and Cultural Relevance

In contrast to commercial design, responsible design is rooted in ethical values, aiming to balance aesthetic and functional appeal with environmental and social responsibility. Key characteristics of responsible design include:

- **Sustainability:** Responsible design considers the entire lifecycle of a product, from materials sourcing and production to usage and disposal. Sustainable materials, energy-efficient processes, and designs that encourage longevity and repairability are prioritized, minimizing the ecological footprint.

- **Social Impact:** Responsible design is often community-oriented, taking into account the needs, values, and well-being of those it serves. Designers consider the social implications of their work, from fair labor practices in production to ensuring accessibility and inclusivity in product use.

- **Cultural Sensitivity and Preservation:** Rather than imposing a homogenized or globalized aesthetic, responsible design respects and incorporates local traditions, materials, and craftsmanship. This approach honors cultural diversity and helps to preserve intangible cultural heritage, ensuring that design reflects and strengthens local identity.

- **Transparency and Accountability:** Responsible design practices promote transparency in materials sourcing, production methods, and pricing. This openness fosters trust with consumers and demonstrates a commitment to ethical and responsible business practices.

These values form the foundation of responsible design, making it a powerful tool for addressing global issues such as climate change, resource scarcity, and social inequality. By focusing on long-term benefits over short-term gains, responsible design seeks to create lasting value for society and future generations.

(3) Drivers of the Shift from Commercial to Responsible Design

The shift from commercial to responsible design is driven by several factors, including:

- **Environmental Awareness:** As climate change and resource depletion become increasingly urgent, designers are recognizing the role of design in shaping consumption patterns and reducing waste. This awareness has led to a rise in sustainable design practices, as designers seek to minimize ecological harm and support a circular economy.

- **Consumer Demand for Ethical Products:** Modern consumers are more informed and discerning, often choosing products that align with their values of sustainability, ethical sourcing, and social impact. This demand has put pressure on designers and brands to adopt responsible practices and to be transparent about their materials, labor practices, and environmental impacts.

- **Cultural and Community Resilience:** As globalization accelerates, there is a growing recognition of the need to preserve cultural heritage and foster local resilience. Responsible design emphasizes the value of cultural diversity in design, incorporating traditional techniques, materials, and aesthetics into modern products to honor and preserve cultural identity.

- **Regulatory Changes and Industry Standards:** Governments and industry bodies are increasingly implementing regulations that encourage sustainable practices, such as limits on carbon emissions, restrictions on hazardous materials, and incentives for recycling and waste reduction. These regulations support the shift toward responsible design by encouraging compliance with higher standards of environmental and social responsibility.

Together, these drivers are reshaping the design landscape, encouraging designers to consider not just the market appeal of their work, but its broader implications for society and the environment.

(4) Transformative Impact of Responsible Design

The shift toward responsible design has transformed the design process itself, encouraging more thoughtful, intentional approaches to creating products and systems. Key changes include:

- **Lifecycle Thinking:** Responsible designers take a holistic view of their products' lifecycles, considering the environmental impact from the sourcing of raw materials through to the product's end of life. This shift has led to the growth of eco-design principles, such as using biodegradable or recyclable materials and designing for disassembly.

- **Co-creation and Community Engagement:** Responsible design often involves direct engagement with the communities it serves, prioritizing local needs and perspectives. This collaborative approach not only produces more relevant and meaningful designs but also empowers communities to take ownership of design solutions, ensuring they are sustainable and culturally appropriate.

- **Emphasis on Craftsmanship and Quality:** Responsible design values quality and longevity over mass production, often incorporating artisanal techniques and durable materials. This approach not only supports sustainability but also enhances the aesthetic and emotional value of products, encouraging consumers to cherish and maintain them rather than replace them frequently.

- **Innovation in Sustainable Technologies and Materials:** The focus on responsibility has driven innovation in sustainable materials, such as bio-based plastics, recycled textiles, and low-impact finishes. Responsible designers are increasingly adopting these new technologies to reduce their environmental impact while maintaining functionality and beauty.

(5) Examples of Responsible Design Inspired by Traditional Craftsmanship

In recent years, many designers have drawn inspiration from traditional craftsmanship techniques to create products that are both responsible and culturally resonant. For example, the use of mortise and tenon joinery in contemporary furniture design reflects a return to sustainable, durable construction methods that

prioritize repairability and minimize waste. Unlike commercial furniture that often relies on disposable components, mortise and tenon furniture honors the principles of durability and respect for natural materials, embodying responsible design.

Another example is the development of cultural and creative products based on traditional crafts like the Lu Ban lock in Chinese design. These products go beyond commercial objectives by preserving cultural heritage, fostering cultural awareness, and engaging consumers in hands-on learning. By transforming traditional joinery techniques into accessible, interactive products, designers are creating a sense of connection with cultural heritage, encouraging consumers to value craftsmanship and tradition.

(6) Challenges and Future Directions in Responsible Design

The shift to responsible design is not without challenges. Economic pressures, resource limitations, and the demand for low-cost products can make it difficult to prioritize responsibility over profitability. Additionally, achieving a balance between tradition and innovation requires sensitivity and adaptability, as designers work to create products that honor cultural heritage while meeting contemporary needs.

However, as awareness grows and consumer preferences continue to shift, the future of design increasingly lies in responsible practices. The next generation of designers has the potential to further integrate sustainable materials, engage communities, and celebrate cultural heritage, advancing responsible design as a norm rather than a niche practice.

(7) Responsible Design as a New Standard

The shift from commercial to responsible design marks an important evolution in the field of design, highlighting the need to create products and systems that serve society, protect the environment, and celebrate cultural diversity. Responsible design redefines success not as market dominance but as meaningful contribution, encouraging designers to make a positive impact through sustainable practices, ethical engagement, and respect for heritage.

As responsible design continues to grow, it has the potential to reshape industries, influence consumer behavior, and contribute to a more sustainable and culturally enriched world. This shift calls on designers to not only create products

but to craft experiences and systems that inspire awareness, confidence, and pride in our shared cultural and ecological legacy.

5.2.3 Transitioning from Local to Integrated Design

Although rooted in Chinese heritage, mortise and tenon techniques can be adapted for a global audience. Integrating local craftsmanship with modern, international design principles can create a hybrid style that resonates globally while retaining cultural authenticity. This section explores strategies for collaborating with international designers, merging mortise and tenon with diverse aesthetics, and adapting it for various cultural contexts, thus ensuring that the craft remains relevant and appreciated worldwide.

Manzini mentioned that various design experts, from both the problem-solving and the sense-making sides, are converging in a central area of the map to develop projects at a local or regional scale. They are aiming at regenerating “the local” by creating a new ecology of places: an ecosystem in which local culture and production are able to live and regenerate in a balanced relationship between local and global.

(1) Understanding Local vs. Integrated Design

Local design emphasizes the characteristics, materials, techniques, and aesthetics specific to a particular region. This approach respects and preserves cultural heritage, making it particularly valuable in promoting cultural identity and continuity. For example, Japanese wood joinery, Moroccan tile work, or Scandinavian minimalism are all expressions of local design that reflect their unique cultural histories and values.

While local design preserves the specificity of cultural practices, it can sometimes be limited by a narrower perspective. When designers focus exclusively on their regional context, they may miss opportunities to innovate through external influences, collaborative methodologies, or advancements from other fields. In today’s interconnected world, adopting an integrated approach can broaden the potential of local design, making it adaptable to global issues while still preserving its unique identity.

Integrated design expands beyond the local context by incorporating interdisciplinary knowledge, cross-cultural perspectives, and collaborative innovation. This approach involves designing solutions that are responsive to

multiple contexts, merging local materials and techniques with global insights and contemporary technologies. For instance, combining traditional wood joinery with modern sustainable materials can yield furniture that respects heritage while meeting contemporary standards for environmental responsibility. Integrated design embraces cultural diversity, adapts to different environments, and leverages collective expertise to solve complex problems on both local and global scales.

In the transition to integrated design, regional elements remain crucial but are considered within a broader context. By collaborating with experts from different fields and cultural backgrounds, designers can create solutions that are richer, more innovative, and better suited to address universal challenges, such as resource scarcity, environmental impact, and inclusivity.

(2) Benefits of Transitioning to Integrated Design

Integrated design brings together diverse viewpoints, methodologies, and creative practices, leading to greater innovation. By working with designers, artisans, and experts from different cultural and disciplinary backgrounds, local designers can explore new approaches, materials, and techniques that may not have been accessible within a strictly local framework. For example, incorporating digital fabrication technologies into traditional woodworking practices, such as mortise and tenon joinery, can enhance precision and scalability, making it easier to apply heritage crafts to contemporary design projects.

Cross-cultural collaboration encourages the exchange of ideas and techniques that can lead to unique solutions tailored to modern needs. Through integrated design, traditional methods are not replaced but enriched, allowing them to evolve in ways that are respectful of heritage while meeting global standards for functionality, aesthetics, and sustainability.

Integrated design allows designers to tackle global challenges—such as climate change, resource management, and social inequality—by applying local knowledge and resources. For instance, designers can combine indigenous materials with sustainable design principles, creating products that are eco-friendly, culturally resonant, and locally sourced. By integrating local materials and techniques with global best practices, designers contribute to sustainable development while preserving and celebrating regional identities.

This approach ensures that design solutions are not only practical but also sensitive to local environmental and cultural conditions. In places where resources

are limited, integrating local and global insights allows designers to create solutions that are both effective and sustainable, reducing the ecological footprint of the design and ensuring cultural relevance.

Integrated design emphasizes inclusivity by valuing the diversity of cultural perspectives and design traditions. In a globalized world, consumers increasingly seek products that reflect cultural diversity and have meaningful, multi-layered narratives. Integrated design responds to this demand by creating products that merge different cultural influences, fostering a sense of connection and respect among people from varied backgrounds.

When designers embrace integrated design, they promote cultural exchange and mutual learning. A project that combines, for instance, Japanese and Scandinavian minimalist aesthetics not only celebrates both traditions but also creates a space for dialogue and appreciation between cultures. Integrated design bridges cultural gaps, offering consumers and creators alike products that are enriched by a plurality of influences and respectful of the cultural stories they carry.

(3) Strategies for Transitioning to Integrated Design

To transition to integrated design, designers must actively seek collaboration with experts from various fields, such as sustainability, digital technology, and anthropology, as well as with designers and artisans from different cultural backgrounds. These collaborations provide insights that enrich the design process, offering new perspectives on materials, forms, and applications. For example, a collaboration between a traditional furniture artisan and a materials scientist might lead to innovative uses of sustainable materials that retain cultural integrity while enhancing durability and functionality.

Design studios and educational institutions can facilitate these collaborations by establishing programs and initiatives that connect students and professionals from different disciplines and regions. By fostering environments that prioritize teamwork and the sharing of knowledge, institutions can promote a mindset that values the contributions of diverse perspectives in the design process.

Technology plays a key role in integrated design, especially when it comes to scaling traditional techniques and making them accessible to global markets. Designers can use digital tools, such as 3D modeling and computer-aided design (CAD), to create precise replicas of traditional joinery techniques, for example, allowing them to be reproduced in different contexts without compromising their

authenticity. Furthermore, digital fabrication tools like CNC machines and 3D printers can be used to apply heritage techniques in new ways, enhancing accessibility while respecting the craftsmanship behind the original methods.

However, the use of technology must be balanced with respect for traditional methods. Rather than replacing the artisanal skills involved in local crafts, technology should support and extend these skills, preserving their cultural value while adapting them to contemporary design needs. This approach ensures that tradition and technology coexist harmoniously, allowing integrated design to honor the past while embracing the future.

Integrated design requires solutions that can adapt to different cultural and environmental contexts. Designers must develop products that are sensitive to the unique needs and preferences of diverse communities, creating designs that are flexible and responsive to different settings. For example, a furniture collection that uses mortise and tenon joinery might be designed in modular units, allowing users to customize the layout and configuration based on available space or cultural preferences.

Creating adaptable solutions also involves listening to the needs and feedback of local communities, especially when working in contexts that are unfamiliar to the designer. Engaging with local artisans, community leaders, and consumers ensures that design solutions are relevant and respectful, addressing local priorities while maintaining global applicability. This adaptability is central to integrated design, allowing products and projects to be scaled or modified based on regional demands and preferences.

(4) Case Studies in Integrated Design

A project that integrates traditional joinery techniques, such as Japanese mortise and tenon, with modular design principles exemplifies the potential of integrated design. By creating modular furniture pieces that can be assembled and reconfigured without tools or adhesives, designers can appeal to modern consumers seeking flexibility, while honoring traditional craftsmanship. This approach combines the cultural depth of local techniques with the adaptability of modular design, resulting in products that are versatile, sustainable, and culturally significant.

Many global design initiatives bring artisans from different countries together to work on collaborative projects, often focused on sustainable development and cultural exchange. For example, design studios and non-profit organizations may

initiate partnerships between artisans in Latin America and designers in Europe, producing collections that merge indigenous textile techniques with contemporary fashion. These collaborations not only enrich design through cross-cultural influence but also create economic opportunities for artisans, preserving heritage skills within a sustainable business model.

Such projects demonstrate the potential of integrated design to foster cultural pride and generate income for local communities, while also appealing to consumers who value authentic, ethically produced products.

The transition from local to integrated design marks a crucial evolution in how designers approach and apply their craft. By incorporating global perspectives, interdisciplinary insights, and advanced technologies, integrated design enables local traditions to thrive within a broader context, addressing universal challenges such as sustainability, inclusivity, and resource conservation. This approach enriches design, fostering innovation and cultural exchange while preserving the unique attributes of local practices.

Integrated design does not dilute the cultural essence of local craftsmanship; rather, it enhances and amplifies it, allowing traditional techniques to remain relevant in a rapidly changing world. Through thoughtful collaboration, respect for tradition, and adaptability, integrated design empowers designers to create solutions that are both meaningful and modern, bridging the gap between local heritage and global influence in ways that honor the past while shaping the future.

5.3 Living Inheritance and Modern Adaptation

Preserving traditional craftsmanship, such as mortise and tenon joinery, is not merely about maintaining historical practices but also about ensuring their relevance in contemporary society. Living inheritance refers to the ongoing transmission of these traditional skills across generations, while modern adaptation reflects the innovative processes that allow these crafts to evolve and meet current demands. Traditional crafts can find renewed vitality by combining respect for cultural heritage with modern design, education, and technological advancements. This subsection section explores how these two dynamics—inheritance and adaptation—can coexist and thrive in the context of contemporary innovation and collaboration.

5.3.1 Research-University-Industry Collaboration Model

In recent years, the preservation and modernization of traditional crafts, such as mortise and tenon joinery, have increasingly relied on collaboration between industry and education. These partnerships bridge the gap between traditional artisanship and modern industry demands, fostering environments that support skill development, innovation, and cultural continuity. The Research-University-Industry (RUI) model serves as a foundational framework for such collaborations, integrating resources from academia, industry, and research institutions to create a holistic approach to sustainable craft innovation. This section examines the RUI model's role in revitalizing traditional craftsmanship, fostering sustainable design, and addressing modern skill requirements.

(1) The RUI Model: A Collaborative Framework

The RUI model facilitates collaboration between academic institutions, industry leaders, and research organizations to advance knowledge, skills, and technological innovation. This model is particularly well-suited for traditional crafts like mortise and tenon joinery, where preserving heritage practices is as important as adapting to contemporary design needs. Universities and research centers contribute academic insights and technological advancements, while industry partners provide practical applications, funding, and market insights. Together, these entities ensure that traditional craftsmanship evolves to meet modern demands without losing its cultural value.

A core benefit of the RUI model is its role in skill development and knowledge transfer. In the context of mortise and tenon craftsmanship, the model enables students, artisans, and industry professionals to interact and learn from one another, promoting an exchange of knowledge that supports both preservation and innovation. Universities involved in RUI partnerships often develop specialized curricula that incorporate mortise and tenon techniques, emphasizing both the cultural significance and technical aspects of the craft. Additionally, workshops and training programs led by master artisans provide hands-on experience, ensuring that traditional skills are effectively transmitted to new generations of designers and craftsmen.

The RUI model also supports sustainable innovation in traditional crafts by integrating research into eco-friendly materials, digital tools, and design strategies. Research institutions within the RUI partnership explore sustainable materials, such as certified hardwoods or engineered bamboo, that are compatible with mortise and

tenon joinery, helping to modernize the craft without compromising its sustainability. Industry partners bring insights into market trends and consumer demands, enabling craftspeople and students to align their work with contemporary expectations for sustainable, high-quality products.

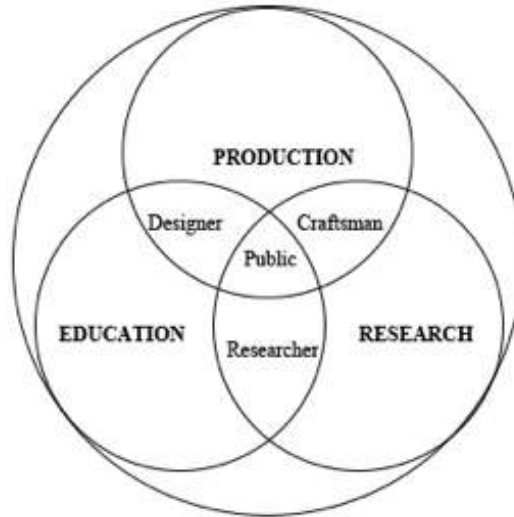


Figure 5.2 Research-University-Industry (RUI) Model (Drawings by author)

(2) The RUI Model: A Venn Diagram of Collaboration

The diagram is a Venn diagram that visualizes the interconnected roles of production, education, and research within the Research-University-Industry (RUI) collaboration model. At the intersection of these three circles lies the public, representing the ultimate beneficiary and central focus of this collaborative approach.

The Three Primary Circles and Their Roles

- **Production:** This circle represents the industry or craftsman aspect of the model. It focuses on practical applications, including manufacturing and craftsmanship, driven by real-world requirements and market demand. The goal is to create functional, desirable, and market-ready products. In the context of mortise and tenon joinery, this involves artisans or production facilities manufacturing traditional or modernized furniture using these techniques.

- **Education:** This circle encompasses schools, universities, and other educational institutions. It emphasizes training, nurturing design skills, and passing on cultural knowledge and craftsmanship techniques to future generations. Designers play a key role here, bridging the gap between traditional craft

knowledge and contemporary design education. Students learn both theoretical and hands-on skills needed for practical application.

- **Research:** Led by researchers, this circle focuses on expanding knowledge, investigating new materials, techniques, and applications. Research drives innovation, enabling crafts to evolve by adapting to modern requirements for sustainability, technology integration, and usability. For mortise and tenon joinery, research might explore how to apply this technique in contemporary, modular furniture or align it with sustainable design principles.

Manzini argue that design schools as agent of change. Design schools, with their PhDs and doctoral programs, of course, but also with the tremendous potential of all their students' enthusiasm and their teachers' experience, could be very meaningful nodes in these design research networks, and in the resulting open programs. At the same time the existence and viability of these networks and programs are the conditions that can make this possibility real. In fact, without them the potentialities of design schools would most probably remain only potential. Or better, the energy and capabilities that schools express would be wasted. However, if they use well the network possibilities, design schools become a real social resource. They can generate original ideas and interact with local communities to trigger new initiatives or support ongoing ones while adopting a design research approach (as a matter of fact, it is not by chance that in many of the proposed examples, design schools played an important role in promoting and sustaining them, and reflecting on them in order to generate new design knowledge).

Donald Norman challenges the premises and practices of the design profession. In the past, designers operated on the belief that talent and a willingness to jump into problems with both feet gave them an edge in solving problems. Norman writes⁹⁷:

In the early days of industrial design, the work was primarily focused upon physical products. Today, however, designers work on organizational structure and social problems, on interaction, service, and experience design. Many problems involve complex social and political issues. As a result, designers have become applied behavioral scientists, but they are woefully undereducated for the task. Designers often fail to understand the complexity of the issues and the depth of knowledge already known. They claim that fresh eyes can produce novel solutions,

⁹⁷ Norman, Donald. (2011). Wir brauchen neue Designer! Why Design Education Must Change. form: The Making of Design. 92-95.

but then they wonder why these solutions are seldom implemented, or if implemented, why they fail. Fresh eyes can indeed produce insightful results, but the eyes must also be educated and knowledgeable. Designers often lack the requisite understanding. Design schools do not train students about these complex issues, about the interlocking complexities of human and social behavior, about the behavioral sciences, technology, and business. There is little or no training in science, the scientific method, and experimental design.

Design schools may work as independent design research agencies, meaning design agencies that can operate with a high degree of freedom: the freedom to decide with whom to work (i.e., with which communities, associations, companies, and institutions) and which kind of project to develop (i.e., where and how to improve the enabling ecosystems). And, most importantly, they can do so feeding the open-design research program, and more general social conversations, with precious unconventional, critical, alternative views.

The Overlapping Regions and Collaborative Roles

The areas where two circles overlap highlight the synergies that arise from collaboration between these sectors:

- **Designer (Education + Production):** Designers connect education and production by translating theoretical knowledge into market-ready products. They innovate within the parameters set by both the market and traditional techniques, modernizing crafts while respecting heritage.

- **Craftsman (Production + Research):** Craftsmen benefit from research advancements to enhance production. By engaging with research, they can adopt new materials or techniques that make their craft more efficient, sustainable, or adaptable to current demands. For example, craftsmen working with mortise and tenon joinery might streamline techniques or adapt traditional designs for modern applications.

- **Researcher (Education + Research):** Researchers link educational knowledge with research efforts, often at academic institutions. They study the cultural, historical, and material aspects of traditional crafts, generating insights that support both education and innovation. For mortise and tenon joinery, researchers might investigate the cultural significance of techniques or test the performance of different materials and designs.

The Center Intersection – Public

The public sits at the center of this model, benefiting from the collaborative efforts of production, education, and research. This central positioning signifies that the ultimate goal of the RUI model is to serve the public by preserving cultural heritage, improving product quality, and promoting sustainable practices. Through this collaboration, the public gains access to high-quality, culturally significant, and sustainably produced products, along with educational resources that keep traditional crafts alive and relevant.

The RUI model illustrates how industry-academia-research collaboration functions as a holistic system that:

- Preserves and modernizes traditional crafts through production, guided by educational knowledge and research.
- Empowers designers, craftsmen, and researchers to work together, each contributing unique expertise to strengthen the craft sector.
- Ensures that traditional crafts like mortise and tenon joinery meet modern market demands without losing their cultural and historical significance.

This model promotes a balanced approach where production, education, and research converge to create an ecosystem that nurtures traditional crafts while innovating for contemporary relevance, benefiting society at large.

(3) The Role of Partnerships in Cultural Preservation

Partnerships play a crucial role in sustaining, revitalizing, and disseminating traditional practices such as mortise and tenon joinery. Collaborative efforts between institutions, governments, local communities, and educational organizations provide the resources, knowledge, and networks necessary to keep cultural craftsmanship alive. These partnerships not only support the documentation and protection of traditional skills but also create pathways for adapting and applying these practices in contemporary design contexts.

Academic Institutions: Research and Innovation

Academic institutions are instrumental in cultural preservation through research, documentation, and innovation. By collaborating with artisans and local

craftspeople, universities and research institutions document traditional techniques and develop educational resources to ensure these skills are transferred to new generations. Advanced technologies like 3D scanning and digital modeling enable accurate documentation and virtual preservation, ensuring that knowledge of the craft remains accessible even as physical examples age or become limited.

Government and Cultural Heritage Organizations: Funding and Awareness

Government and cultural heritage organizations provide funding, regulatory support, and public engagement initiatives. Partnerships with government bodies can lead to policies and funding programs that support craftsmen and craftswomen, allowing them to continue practicing and teaching their craft. Cultural heritage organizations contribute by establishing public exhibitions, workshops, and training programs that increase awareness and appreciation of traditional crafts like mortise and tenon joinery.

Private-Sector Partnerships: Commercial Platforms

Private-sector partnerships provide commercial platforms for traditional crafts, helping artisans and designers market products that feature mortise and tenon joinery. Collaborations with design studios and companies encourage the incorporation of traditional techniques in modern applications, expanding the reach and impact of cultural craftsmanship. Through these collaborations, traditional joinery methods can be adapted for eco-conscious products, modular furniture, and sustainable architecture, making them relevant and accessible to contemporary consumers.

By fostering a network of support that spans educational, governmental, and private sectors, partnerships ensure that mortise and tenon craftsmanship remains a living tradition. These alliances bridge the gap between cultural preservation and modern innovation, ensuring that this ancient craft is not only protected but also adapted to the needs of today's world. Together, these collaborative efforts emphasize the importance of cultural heritage within a sustainable design framework, demonstrating how traditional techniques can contribute to environmentally and culturally responsible design.

(4) Case Study: Zhengzhou University of Light Industry (ZZULI)

Zhengzhou University of Light Industry (ZZULI) has emerged as a leader in integrating intangible cultural heritage (ICH) into education, research, and industry

collaboration. Through its Intangible Cultural Heritage Research Center and the China Intangible Cultural Heritage Inheritors Training Program, ZZULI has developed an innovative industry-university-research model that advances the preservation, transformation, and marketability of traditional crafts. This case study highlights ZZULI's efforts in building a platform for ICH, fostering talent training, and promoting sustainable innovation through collaboration.

(a) Building a Platform for ICH: The “Leaning Against the Mountain to Make Things” Brand

ZZULI's collaboration with the Henan Provincial Department of Culture and Tourism has resulted in the creation of the “Leaning Against the Mountain to Make Things” brand, which debuted at the Eighth China Intangible Cultural Heritage Fair. This initiative showcases the integration of traditional craftsmanship and modern design, demonstrating how the university's industry-university-research model fosters creativity while honoring cultural heritage.

The brand was developed through joint research, design, and training between the university and traditional artisans. Students worked alongside skilled ICH bearers to learn techniques in crafts such as clay sculpture, embroidery, and woodblock printing, gaining hands-on experience in creating culturally meaningful products. This approach not only provided a platform for artisans to share their knowledge but also enabled students to develop practical design and production skills rooted in their cultural heritage.

The project exemplifies ZZULI's commitment to the principle of “seeing people, seeing things, seeing life” (见人、见物、见生活), which emphasizes the human connection, cultural value, and everyday relevance of intangible cultural heritage. By adapting traditional crafts for modern consumption, the initiative enriches the lives of both artisans and consumers.

(b) Education and Talent Training in Traditional Handicrafts

ZZULI's School of Art and Design integrates ICH into its curriculum, offering a unique educational experience that combines artistic and technical knowledge with cultural preservation. Since 2016, the university has trained over 800 participants through its China Intangible Cultural Heritage Inheritors Training Program, which emphasizes “strengthening the foundation, broadening horizons, and increasing knowledge.”

Students in these programs learn about design principles as well as the cultural significance and historical context of traditional crafts. The curriculum covers eight key categories of traditional crafts, including:

- **Paper-cutting:** The intricate art of creating patterns and images from paper, symbolizing aspects of Chinese folklore and history.
- **Woodblock printing:** A centuries-old technique used for artwork and religious texts.
- **Clay sculpture:** A three-dimensional art form depicting mythological and folk figures.
- **Weaving and embroidery:** Textile crafts that express regional identity through patterns, textures, and colors.
- **Ceramics:** The ancient art of crafting pottery, deeply rooted in Chinese culture.

Workshops and hands-on training complement the curriculum, providing students with a strong technical foundation while fostering an appreciation for the cultural and economic potential of traditional crafts. The programs encourage a spirit of “adhering to the right and innovation” (守正创新), inspiring students to preserve traditional techniques while exploring innovative design possibilities.

(c) Industry-University-Research Synergy for ICH Innovation

ZZULI’s industry-university-research model fosters collaboration between academic research, cultural preservation, and commercial application. This approach promotes ICH innovation in three key ways:

- **Research and Development:** Faculty and students at the Intangible Cultural Heritage Research Center collaborate on projects that explore new methods of adapting traditional crafts for modern applications. This research examines materials, techniques, and aesthetics, ensuring that traditional crafts are incorporated into contemporary design while preserving their cultural integrity.

- **Training and Skill Transfer:** The hands-on training model enables students to learn directly from master artisans. Since 2016, ZZULI has organized 19 ICH research and training sessions for 876 trainees, many of whom have become

recognized masters in their craft. The program has produced 35 Henan Provincial Masters of Arts and Crafts, 46 representative bearers of ICH, and 28 senior arts and crafts masters, reflecting the effectiveness of the university's mentorship model.

- **Brand Development and Market Integration:** ZZULI supports the development of ICH brands through partnerships with over 20 artisan workshops. The university provides branding assistance, product development, and market analysis, helping artisans build sustainable businesses. These efforts have nurtured 48 ICH brands, highlighting traditional crafts adapted for modern markets.

These initiatives align with ZZULI's goal of transforming ICH resources into cultural and economic assets, stimulating sustainable growth in local economies while preserving cultural heritage.

(d) Promoting ICH Brands for a New Era

ZZULI's commitment to brand building and innovation reflects a broader trend of bringing traditional crafts into modern contexts. Through collaborations with artisan workshops, the university facilitates knowledge exchange, resource sharing, and brand co-development. By showcasing traditional crafts as high-quality, culturally resonant products, these partnerships enable ICH brands to thrive in the contemporary marketplace.

Notable achievements include:

- **Master Artisans and Brand Success:** Over 35 alumni from ZZULI's training program have achieved the title of Henan Provincial Master of Arts and Crafts, enhancing their credibility and market potential. Many have leveraged their skills to create successful brands, contributing to the vitality of local cultural economies.

- **Collaborative Brand Creation:** ZZULI's partnerships with ICH workshops help artisans build brand identities and market their products, providing visibility and access to broader audiences.

- **Revitalization of Rural Economies:** By transforming traditional crafts into viable sources of income, ZZULI has played a role in poverty alleviation, empowering communities to achieve sustainable development through cultural heritage.



Figure 5.3 ZZULI Industry-University-Research Achievements Exhibition⁹⁸

The industry-university-research model at Zhengzhou University of Light Industry exemplifies a sustainable approach to preserving and innovating intangible cultural heritage. By integrating education, research, and industry collaboration, ZZULI has developed a dynamic system that produces skilled artisans, innovative products, and viable brands. This model not only preserves the essence of traditional crafts but also enhances their economic value, bringing them into contemporary life in meaningful ways.

Through initiatives like the Intangible Cultural Heritage Research Center, the “Leaning Against the Mountain to Make Things” brand, and the China Intangible Cultural Heritage Inheritors Training Program, ZZULI has created a blueprint for other institutions to follow. By empowering artisans, fostering creativity, and connecting tradition with modern needs, ZZULI has contributed to a new era of ICH innovation, where cultural pride and economic sustainability go hand in hand.

5.3.2 Luban Workshop

The Luban Workshop initiative represents a key strategy in China’s efforts to enhance its global educational and cultural influence. By sharing technical and vocational expertise with the world, the program combines traditional craftsmanship with cutting-edge technology and international collaboration. Established in multiple countries across Africa, Asia, and Europe, Luban

⁹⁸ Thumbs up! ZZULI’s intangible cultural heritage makes a wonderful appearance! . WeChat public platform. (n.d.). <https://mp.weixin.qq.com/s/4vnjydp03V20MRbvXUMd1w>

Workshops serve as hubs for skill development, cultural exchange, and the promotion of Chinese intangible cultural heritage.

Global Reach and Educational Framework

Luban Workshops offer vocational training in fields such as carpentry, engineering, and information technology, emphasizing hands-on skills and technical knowledge. These workshops are designed to elevate vocational standards globally while fostering mutual understanding through international cooperation. A distinguishing feature of the program is its integration of traditional Chinese crafts, such as mortise and tenon joinery, into its curriculum. Students from diverse backgrounds gain insight into the history and cultural significance of these techniques, enhancing their appreciation of cultural diversity and equipping them with specialized skills valued in global industries.

Integration of Tradition and Modernity

The Luban Workshop initiative builds on the legacy of vocational education models like the Bauhaus School and the Xin Quansheng Carpentry Workshop. While the Bauhaus emphasized industrial collaboration and the Xin Quansheng Workshop integrated cultural preservation, Luban Workshops take this a step further by making Chinese craftsmanship accessible on an international scale. The program emphasizes a dual-track system where students engage in both theoretical learning and practical experience, fostering adaptability, innovation, and technical proficiency. This approach ensures that cultural heritage remains relevant and functional in contemporary settings, creating opportunities for students to contribute meaningfully to their professions and communities.

Educational Exchange and Skill Transmission

- **Hands-on Learning:** Central to the Luban Workshop is the combination of hands-on training with academic instruction. This dual approach provides students and artisans with a holistic understanding of mortise and tenon craftsmanship, enabling them to physically engage with materials and appreciate the precision and cultural significance of each joint.

- **Cross-Cultural Collaboration:** Luban Workshops partner with educational institutions and craft organizations worldwide, facilitating cross-cultural knowledge exchange. This international collaboration allows students to learn mortise and tenon joinery while promoting a global appreciation for Chinese

craftsmanship. It also encourages reinterpretations of the technique that resonate with diverse cultural aesthetics.

Technological Integration for Modern Relevance

- **Digital Design Tools:** The workshops incorporate modern technologies such as CAD (Computer-Aided Design) and CNC (Computer Numerical Control) systems. These tools enable students to visualize and test mortise and tenon structures digitally before creating physical prototypes, enhancing accuracy and fostering innovation.

- **Sustainable and Modular Design Applications:** By leveraging digital tools, Luban Workshops encourage the application of mortise and tenon joinery in sustainable design practices, such as modular furniture and eco-friendly architecture. This approach aligns with global interest in environmentally responsible craftsmanship and highlights the adaptability of traditional joinery for contemporary needs.

Promoting Mortise and Tenon as International Cultural Heritage

- **Cultural and Creative Products:** Inspired by traditional elements like the Lu Ban lock, the workshops develop cultural and creative products that embody the essence of mortise and tenon craftsmanship. These products—ranging from educational models to functional design items—connect global audiences to the cultural heritage of Chinese joinery, reinforcing cultural pride and introducing the craft in engaging, accessible ways.

- **Global Network for Cultural Preservation:** By establishing workshops in various countries, the Luban initiative creates a platform for ongoing cultural exchange. This network supports the preservation and evolution of mortise and tenon craftsmanship, transforming it into a living heritage with global relevance and adaptability for future generations.

Technological Integration and Modernization

A unique aspect of the Luban Workshop model is its emphasis on merging traditional craftsmanship with modern technology. Students are introduced to CAD software, 3D printing, and CNC technology, which allow them to experiment with variations of mortise and tenon joinery that align with modern aesthetics and production techniques. This integration fosters innovation and positions mortise

and tenon as both a respected heritage skill and a viable design solution for contemporary markets.

Fostering Cross-Cultural and Global Knowledge Exchange

Luban Workshops facilitate cross-cultural knowledge exchange by collaborating with educational institutions and craft organizations globally. Through partnerships with universities and vocational institutions, the workshops introduce mortise and tenon joinery to international students and professionals, promoting appreciation for Chinese craftsmanship worldwide. This global reach allows the joinery technique to gain new meanings and applications, as students reinterpret it in ways that reflect their own cultural aesthetics.

Ensuring Cultural Continuity and Heritage Preservation

Industry-education collaborations like the Luban Workshops play a vital role in ensuring the continuity of cultural heritage. By institutionalizing traditional crafts within formal education and partnering with industry, these collaborations provide a platform for preserving and promoting mortise and tenon joinery. Academic institutions lend credibility to traditional crafts, enabling the documentation, study, and standardization of techniques for future generations. Industry involvement provides a practical dimension, helping students understand how traditional joinery can be applied in contemporary design fields.

Promoting Sustainable Craft Practices

The Luban Workshop initiative advances sustainable craft practices by exploring environmentally friendly materials, efficient production methods, and waste reduction techniques. Research institutions within the RUI model investigate materials and design solutions that align with sustainable development goals, while industry partners provide insights into consumer preferences. This approach ensures that mortise and tenon craftsmanship remains compatible with modern environmental standards, appealing to consumers who prioritize ethical and sustainable consumption.

Enhancing Employment Opportunities and Economic Development

The Luban Workshop model contributes to economic development by equipping students with specialized skills valued in the design and construction industries. Graduates trained in mortise and tenon joinery can pursue careers in

custom furniture, sustainable architecture, and cultural creative products. By aligning traditional craftsmanship with modern market demands, the workshops support economic sustainability while preserving cultural heritage.

The Luban Workshop initiative exemplifies a powerful pathway for preserving and modernizing traditional crafts like mortise and tenon joinery. Through international collaboration, technological integration, and a dual-track educational framework, the program ensures that cultural heritage remains relevant, adaptable, and accessible in a rapidly changing world. By promoting cultural continuity, sustainability, and innovation, Luban Workshops set a precedent for how traditional craftsmanship can thrive within modern industry, enriching design fields with a legacy of quality, resilience, and cultural depth.

Chapter 6 Conclusion

The conclusion summarizes the main findings and contributions of the research. It emphasizes the role of mortise and tenon craftsmanship as both a sustainable design practice and a cultural heritage asset. The thesis underscores the potential of innovative design to preserve, adapt, and modernize traditional craftsmanship to meet contemporary ecological, cultural, and consumer needs. Future research suggestions include exploring digital tools for interactive learning of mortise and tenon, and the continued development of circular economy strategies within craftsmanship-based industries.

The thesis applies the theory of meaningful innovation and the design methodology of social design to the innovative design practice of mortise and tenon crafts, and discusses the design-driven preservation and inheritance development of intangible cultural heritage.

Based on the theoretical research results of many scholars on the protection and inheritance of intangible cultural heritage, this study analyzes the protection and inheritance problems faced by the mortise and tenon craft of intangible cultural heritage from the perspective of design. The main problem is the contradiction between large-scale machine mass production and handicraft production methods. It is proposed that the key to solving the protection and inheritance problems of the mortise and tenon craft of intangible cultural heritage lies in the innovative design of the meaning of the mortise and tenon craft, so as to seek a balance and symbiosis between adapting to digital production methods and traditional handicraft production.

From the perspective of innovative design of meaning, with the intervention of design in the protection and inheritance of intangible cultural heritage as a clue, through digital wooden building design, detachable furniture design, museum cultural and creative design and other means, the mortise and tenon craft is expected to realize the contemporary production mode and life aesthetic needs, so that it can re-enter the lives of contemporary people. Through the modernization and commercialization of the mortise and tenon craft, the practical application value and the inheritance of its technical knowledge are realized, so as to promote the

contemporary inheritance and innovative development of the mortise and tenon craft of intangible cultural heritage.

6.1 Summary of Findings

The findings of this study emphasize that mortise and tenon craftsmanship, though ancient, possesses inherent qualities that align well with modern design principles. This research highlights the versatility of mortise and tenon in its adaptation to multiple domains: temporary architecture, circular furniture design, and cultural creative products. Each of these applications demonstrates mortise and tenon’s potential to provide innovative, sustainable, and culturally rich alternatives to modern, mass-produced construction methods.

- **Temporary Architecture:** The application of mortise and tenon in temporary and mobile architecture reveals its potential to create flexible, modular, and easily assembled structures. These qualities offer valuable contributions to sustainable design, particularly in scenarios requiring rapid deployment and reusability, such as exhibitions or emergency housing.

- **Circular Furniture Design:** Mortise and tenon’s inherent reparability and lack of synthetic adhesives make it well-suited for circular economy principles, allowing furniture to be disassembled, reused, and reconfigured. This aspect appeals to contemporary consumers who value sustainable and repairable products.

- **Cultural and Creative Product Design:** The study’s exploration of cultural creative products, such as Luban locks, illustrates how mortise and tenon can be incorporated into educational and experiential products. These designs serve as tools for cultural education, strengthening cultural identity and fostering appreciation for traditional craftsmanship.

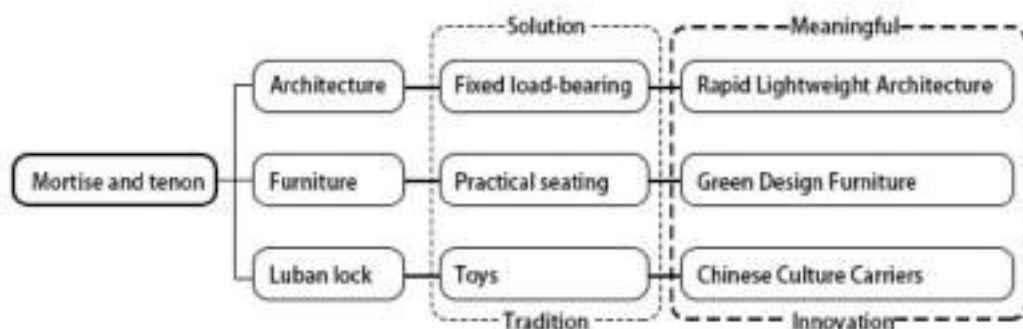


Figure 6.1 The Meaning-Driven Innovation Paradigm for Mortise and Tenon Craftsmanship (Illustration by author)

Mortise and tenon based on the meaning of innovation in social design methods embodied in: temporary building human-centred on humanistic care and based on veneer system traditional and digital technology fusion embracing the relationship between the big machine production mode processing; sustainable development goals in the context of the recycling of furniture of the unity of mankind in moderation and with the new Chinese furniture aesthetic aesthetics of the current aesthetic fusion of dismantling and installation to facilitate the transport of the fast pace of the pursuit of a convenient way of life; cultural creativity The cultural confidence of the design. They reflect social sustainability, environmental sustainability and cultural sustainability respectively.

6.2 Implications for Sustainable Craftsmanship and Design

The conclusions drawn from this research highlight the potential of mortise and tenon to contribute significantly to sustainable design. Mortise and tenon's reliance on natural materials and low-environmental-impact construction methods demonstrates a model of ecological responsibility and long-term durability that contrasts sharply with disposable, industrially produced alternatives. Furthermore, this technique aligns with the circular economy by promoting reparability and minimizing resource waste.

On a cultural level, mortise and tenon's integration into contemporary design fosters cultural confidence, allowing designers to draw on traditional practices while addressing the humanistic and environmental demands of modern society. By combining tradition with innovation, mortise and tenon serves as a bridge between past and present, offering a design philosophy that is at once respectful of heritage and forward-looking.

6.3 Limitations and Future Research Directions

While this study provides a comprehensive exploration of mortise and tenon's potential applications in modern design, it is not without limitations. First, the practical implementation of mortise and tenon in large-scale production environments poses challenges due to the skill and precision required for traditional joinery. Further research into digital modeling and CNC machining could offer solutions, making mortise and tenon more accessible to contemporary manufacturers.

Additionally, this study has focused primarily on the philosophical and cultural underpinnings of mortise and tenon in Chinese design contexts. Future research

could explore comparative studies with joinery techniques in other cultures, examining how mortise and tenon can be integrated into global design practices and adapted to meet diverse aesthetic and functional requirements.

Future research could explore CNC-driven joinery for precision in modern applications, as well as partnerships with digital heritage platforms to document and disseminate mortise and tenon techniques globally, preserving this intangible heritage digitally for generations.

Final Reflections

In conclusion, this research has demonstrated that the mortise and tenon technique, rooted in sustainable and culturally significant principles, holds untapped potential for modern design. By revitalizing this traditional craft through innovative applications and aligning it with the values of social design, mortise and tenon can serve as a meaningful alternative to conventional manufacturing processes. This thesis invites designers and scholars to continue exploring the intersections of traditional craftsmanship and contemporary design, ensuring that mortise and tenon remains a living and evolving cultural heritage in the 21st century.

This research has systematically explored the innovative design of the traditional mortise and tenon craft as a means of preserving and adapting this heritage within a modern context. Throughout the thesis, the mortise and tenon technique has been approached not simply as a mechanical solution for joining materials, but as a profound cultural asset that embodies Chinese philosophical principles, sustainable practices, and aesthetic values. The study has applied Roberto Verganti's concept of meaning-driven innovation to contextualize mortise and tenon in contemporary design, addressing the evolving needs for humanistic care, ecological sustainability, and cultural continuity.

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