INDUSTRY AND ACADEMIA KNOWLEDGE AND PERCEPTIONS IMPACTING ADOPTION OF MASS TIMBER

By

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A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

Construction Management – Master of Science

2024

ABSTRACT

The construction industry significantly contributes to global greenhouse gas emissions, underscoring the need for sustainable building materials. Mass timber, an engineered wood product made from laminated lumber- stands out for its environmental benefits and aesthetic appeal. However, research on its adoption particularly in the U.S., is limited. This study addresses this gap by examining the knowledge, perceptions, and adoption factors among academia (students and faculty) and industry professionals in the U.S. construction Industry.

A survey of 440 responses from the AEC community was analyzed using the Kruskal-Wallis test to identify key disparities in knowledge gaps, perceptions, and adoption factors between academia and industry. The findings revealed notable differences in knowledge gaps related to mass timber, emphasizing the need to address the distinct informational needs and perspectives of academia and industry. Additionally, the study uncovers significant variations in perceptions, particularly concerning mass timber performance and safety aspects. These insights highlight the necessity for tailored communication strategies and educational initiatives to bridge perceptual divides.

Key factors influencing the adoption of mass timber were also identified, revealing significant gaps between academia and industry professionals. The study has additionally conducted among-group analyses for students, faculty, and industry professionals considering the AEC community, as well as industry groups based on their levels of experience. These findings provide crucial implications for policymakers, practitioners, and researchers, informing targeted interventions and policy measures to promote the widespread adoption of mass timber in sustainable construction practices.

Overall, this thesis advances our understanding of the dynamics surrounding mass timber adoption in the U.S. construction industry.

ACKNOWLEDGEMENTS

I am deeply grateful to Dr. George Berghorn for his unwavering support and belief in me, which ignited the spark for this exploration. His guidance has been a constant compass, steering me through both academic and personal growth. I owe him a debt of gratitude for his mentorship.

Dr. Matt Syal and Dr. Sandra, my advisory committee members, deserve immense gratitude. Their expertise in navigating the complexities of survey methods made this journey far smoother. Their insights were invaluable.

I'm also thankful to Prof. Emily Huff and Ichchha Thapa for their invaluable guidance in refining the survey, a critical step towards the success of this research.

Special thanks to Prof. Robert Aydukovic for taking my thesis survey forward to groups like ABC Chapters and AGC Michigan. His willingness to champion my research amongst these key industry players was instrumental in reaching a wider audience.

This endeavor wouldn't have been possible without the unwavering support of my incredible partner who always believes in "come what may we'll see it through, EKATRA in all we do" ("EKATRA" means together in my mother tongue, Marathi), my beloved brother Yash, who has always been my biggest cheerleaders. I am especially grateful to both my parents, Vilas Chavan, Veena Chavan, Naresh Bagkar, and Namrata Bagkar for their unwavering belief in me and their constant source of love and understanding. A huge thank you goes to my extended family in the US, my dear best friends Manisha and Ankit, who have been by my side through thick and thin.

Across the miles, my deepest gratitude goes to my amazing best friends in India- Neha, Karan, Pranali, and Lokesh. Your unwavering emotional support has been a constant source of strength, and I am incredibly lucky to have you all in my life.

I dedicate this achievement to the loving memory of my grandfather, Dasharath Chavan, whom I

lost in January 2024. I know he would be immensely proud of this accomplishment. I am also grateful to my grandmother Taramati Chavan for her blessings and her positive attitude throughout life.

The experience and opportunities at Michigan State University's School of Planning Design and Construction have been truly transformative. I am grateful for the lifetime memories and lessons learned during my time here.

This journey has been a profound learning experience. Coming from a background where research was unchartered territory, MSU not only broadened my horizons but also reshaped my perspective on life. I am immensely grateful for the invaluable lessons learned and the personal growth achieved.

To everyone who played a part in shaping this journey, my deepest gratitude. Your support and encouragement have been the wind beneath my wings. I am forever grateful for this transformative experience.

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1 CHAPTER: INTRODUCTION

1.1 BACKGROUND

Over billions of years ago, the journey of life began with the birth of Mother Nature and subsequently, human existence. Alongside human evolution, emerged fundamental needs such as food, clothing, and shelter. Among these, shelter holds paramount importance in ensuring human survival and well-being. Throughout the millennia, humans have continuously strived to meet these essential needs, resulting in the development of various techniques and methods for shelter construction. To date, we boast over billions of dollars construction industry dedicated to ensuring the provision of buildings for shelters, manufacturing, and other essential requirements. This industry underscores the ongoing significance of shelter in human civilization and the vast resources devoted to meeting these basic needs.

In our quest to build shelters, we have employed diverse materials and methodologies. However, this endeavor has not been without its consequences, impacting both human lives and the natural environment. While these efforts have provided us with necessary protection and comfort, they have also exerted both positive and negative effects on the Earth and its ecosystem.

1.1.1 Environmental impact of the construction industry

The development of life and technology on Earth have come along with their very own drawbacks leading to the emission of more than 40% of global greenhouse gas (GHG) emissions. And not just greenhouse gasses but also carbon emissions over large scales (IEA, 2022).

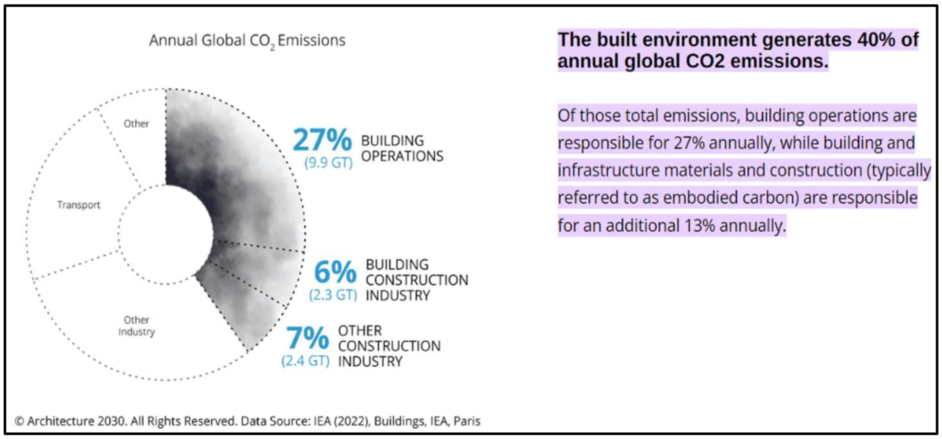


Figure 1.1: Annual Global CO2 Emissions (IEA, 2022)

Fig. 1.1 shows the annual global CO2 emissions due to the built environment (Architecture 2030, 2022). According to research by Bimhow the construction sector solely contributes to 23% of air pollution, 50% of climate change, 40% of drinking water pollution, and 50% of landfill waste (Go Contractor, 2017)

The U.S. Green Building Council (USGBC) also states that the construction industry accounts for 40% of worldwide energy usage, with an estimation that by 2030 emissions from commercial buildings will grow by 1.8% (United States Green Building Council (USGBC), 2018).

Per IEA (2022), just three materials i.e., concrete, steel, and aluminum are responsible for 23% of global emissions. With such statistics and predictions who would not want to make a difference

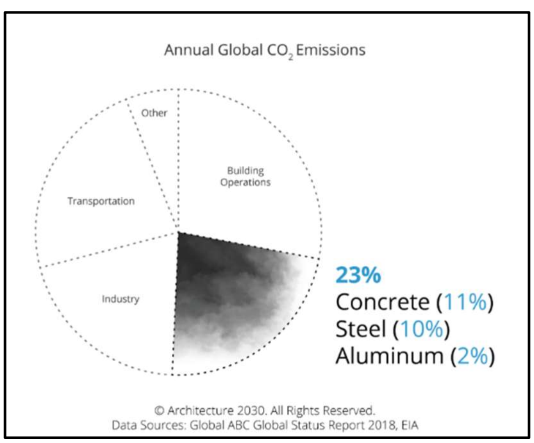


Figure 1.2: Annual Global CO2 Emissions (IEA, 2018)

and make the world a better place again?

As a result, more sustainable building techniques are required to be adopted on an urgent basis which will minimize the construction's negative effects on the environment while still satisfying modern society's demands.

1.1.2 Advantages and Environmental Benefits of Wood Construction

"Wood" is a highly "versatile" resource because it can be utilized in various forms, and for a wide range of purposes. It is renewable, recyclable, locally available, sustainable biodegradable also has quite a lower energy, water, and carbon life cycle footprint than other products. Basically, it's the ultimate "green" product (Forests, 2023). But when wood is considered as a building material, people are cautious of two prominent factors: deforestation and structural limitations of wood (HKS, 2022). Considering deforestation, the United States has about 750 million acres of forestland to date, and since the 1940's the forest growth in states has been observed to continuously exceed its harvest (Martinez, 2015). Hence, an ample amount of wood is available to be used as a building material. Also, wood is a renewable resource and if harvested responsibly - the flow of wood can be maintained (Ramage M. H.-W., 2017).

In the context of construction materials, wood has historically been perceived as structurally limited, often deemed insufficient for supporting structures beyond a certain height. Concerns related to fire susceptibility, water infiltration, and wood decay have contributed to a preference for alternatives such as concrete and steel, believed to offer greater strength and stability. However, this perception is not always aligned with reality, as concrete and steel can entail significant misconceptions and substantial financial investments. In contrast, wood, despite harboring some environmental concerns, presents a more favorable carbon footprint compared to steel or concrete (Wood Products & Carbon, 2023).

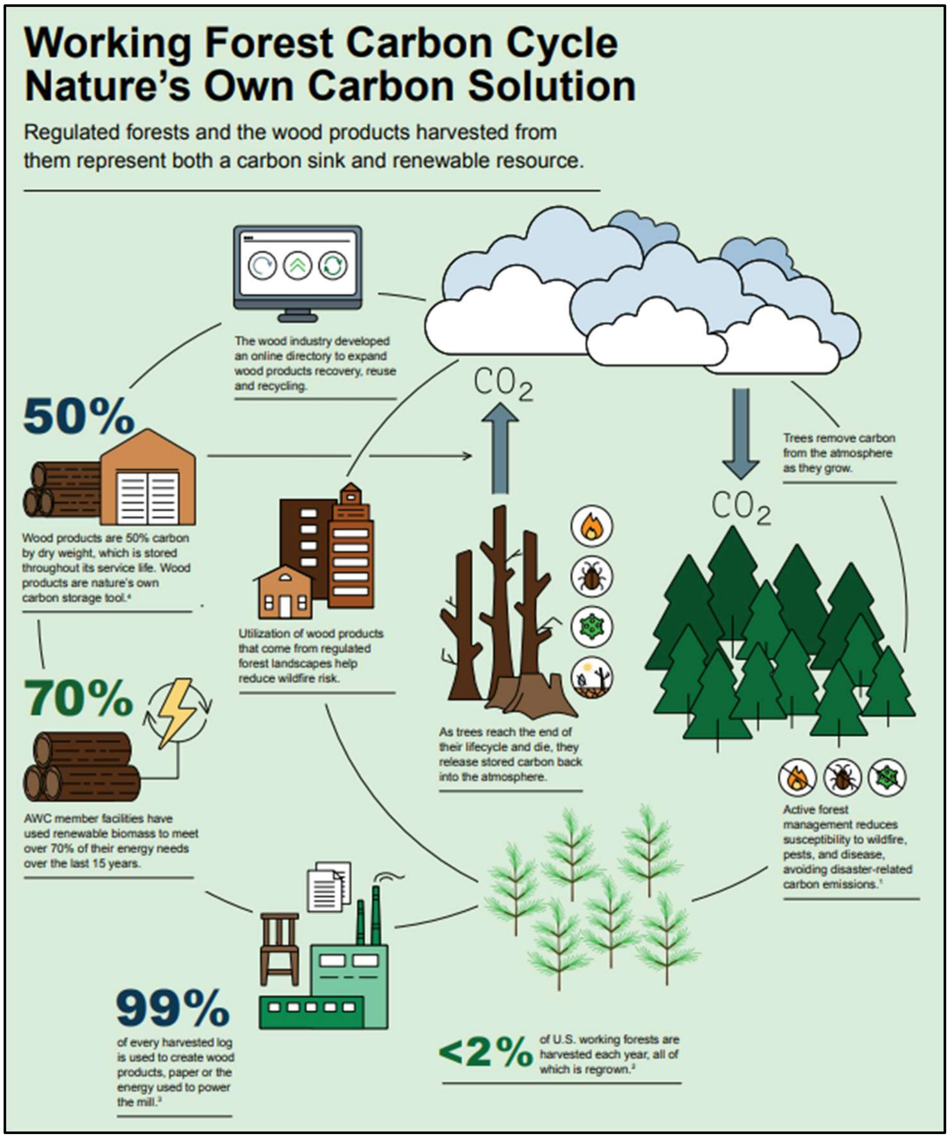


Figure 1.3: The Forest Carbon Cycle (American Wood Council, 2022)

Fig. 1.3 from the American Wood Council data, best explains how wood is the best building material, and it absorbs carbon dioxide during the process of photosynthesis and later converts that into carbon. Above 50% of the weight of the tree is carbon and when this is used as lumber for the building material, the carbon is stored back in the building till the life of the building. Hence, Nature has its own carbon solution (American Wood Council, 2022).

1.1.3 Mass Timber and its Environmental Benefits

According to Roberts (2020), mass timber, often described as "Wood, but like Legos", emerged as a popular building material in Europe in the early 1980s. While this concept is relatively new to the US construction industry, it has gained prominence due to its potential to revolutionize the building sector. Mass timber offers sustainable alternatives to traditional building materials, presenting various environmental benefits and advantages (Roberts, 2020).

Mass Timber is an engineered wood product produced using softwood trees, coniferous such as spruce, pine, fir, larch, hemlock, southern yellow pine, etc. which are either nailed or glued together. It consists of large solid lumber panels that can be used as walls, roofs, and floor slabs (Lehmann & Hamilton, 2011). These engineered mass timber products are as follows:

- Cross-Laminated Timber (CLT)
- Glued Laminated Timber (Glulam)
- Laminated Veneer Lumber (LVL)
- Nail-Laminated Timber (NLT)
- Dowel-Laminated Timber (DLT)
- Other Structural Composite Lumber (SCL) (Laguarda & Espinoza, 2014).

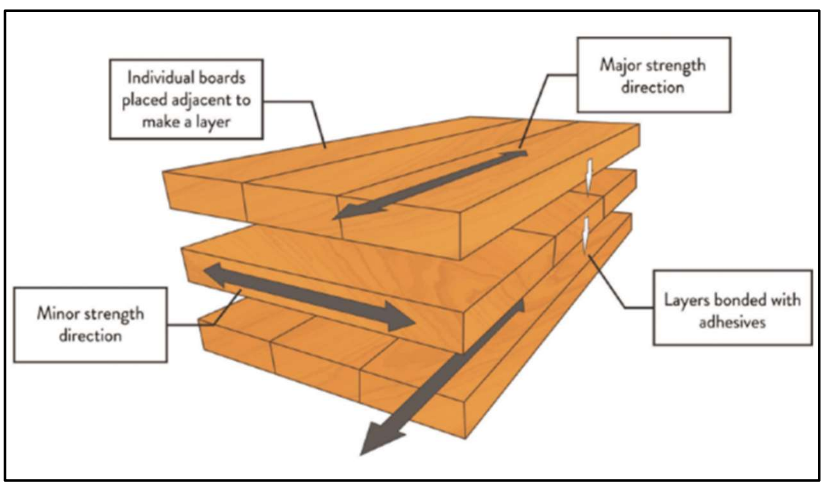


Figure 1.4: Cross-Laminated Timber Configuration (Ebrary.net, n.d.)

CLT is made of 1-1.6 inches thick engineered lumber that is glued together alternating 90 degrees (Laguarda & Espinoza, 2014). This formation used for CLT is proven to achieve improved rigidity, stability, and mechanical properties in two directions (Evans, 2013).

One of the earliest instances of mass timber can be traced back to the 1990s in Austria. Since then, it has been introduced to both the North American and Australian markets (Mallo & Espinoza, 2018). Presented in Table 1.1 are the top 10 Tallest Mass Timber Buildings in the World (Tallest Mass Timber Buildings, 2022).

RANK	NAME	CITY	COUNTRY	HEIGHT (M)	FLOOR COUNT	STRUCTURAL TYPE	FUNCTION	STATUS	YEAR
1	Ascent	Miwaukee	United States	86.6	25	Tamber Concrete Hybrid	Residential	Under Construction	2022
2	Mystimet	Brunsunddal	Norway	85.4	18	All Timber	Mixed Use	Completed	2019
3	Home	Vienne	Austria	84.0	24	Timber Concerte Hybrid	Mixed-Use	Completed	2020
4	Hour	Amsterdam	Netherlands	73.0	22	Timber Concrete Hybrid	Residential	Under Construction	2022
5	Sara Kunushus	Skelletted	Sweden	72.8	20	Tember Steel Hybrid	MiseOUse	Completed	2021
6	De Karel Doorman	Rotterdam	Netherlands	70.5	22	Timber Concrete Steel Hybrid	Mixed-Use	Completed	2012
7	55 Southbank	Melbourne	Australia	69.7	19	Timber Concrete Steel Hybrid	MiseG Use	Completed	2020
8	Wellington	Melbourne	Australia	65.0	15	Tember Concrete Hybrid	Office	Under Construction	2023
8	Roots Tower	Hamburg	Germany	65.0	19	Timber Concerte Hybrid	Residential	Under Construction	2023
10	Koomet	Gothenburg	Sweden	60.0	15	Timber Concerner Hybrid	Mixec Use	Under Construction	2022
10	Abro	Risch Rothour	Switzerland	60.0	15	Timber Concern Hybrid	MoerC Use	Completed	2019

Table 1.1: Top 10 tallest M.T buildings in the world

According to (Caulfield, 2020), the mass timber building sector is anticipated to experience a twofold increase every two years until 2034. By that time, the construction industry is projected to sequester more carbon than it releases.

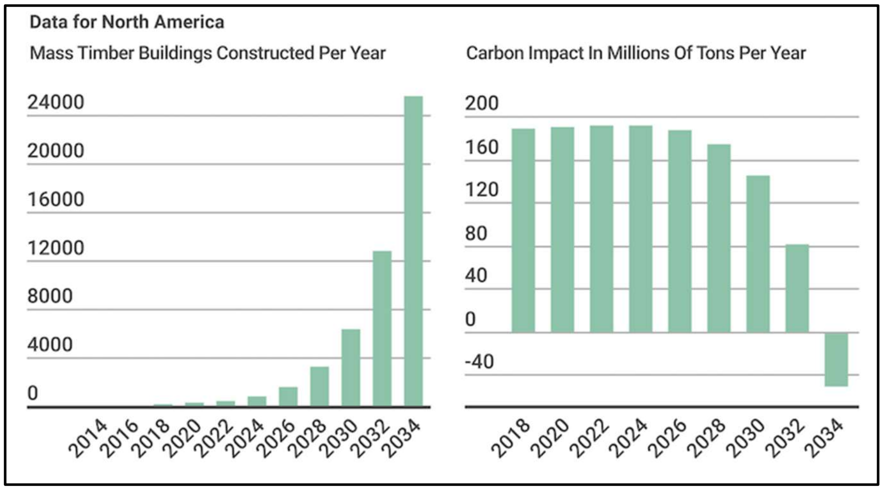


Figure 1.5: MT Construction/ Year and Carbon Impact/ Year

Mass timber is becoming more and more popular as a sustainable substitute for conventional construction materials like concrete and steel as a result of a growing trend toward sustainable building techniques in recent years. Analysts predict that by 2034, there will be new demand for 12.9 million board feet of lumber that would require nearly 77 million acres of new forestland. Hence, the mass timber is expected to expand dramatically over the next few years. (Caulfield, 2020)

One of the key benefits of mass timber is that it has a lower carbon footprint than traditional building materials. This is because mass timber manufacturing uses less energy than the manufacture of concrete and steel (Laguarda Mallo & Espinoza, 2015). Moreover, mass timber is produced using wood that has been harvested responsibly, making it a resource that may be regenerated over time.

Another benefit of mass timber is that it produces less waste than traditional building materials. This is due to the mass timber production method being extremely efficient. Mass timber may also be readily recycled or repurposed at the end of its existence, minimizing its impact on the environment even further (Azeez, 2022).

Mass timber stands out among various construction materials due to its recognized attributes such as strength, durability, environmental advantages, and aesthetic appeal. Additionally, compared to traditional materials, mass timber construction is characterized by potentially faster, quieter, and less disruptive progress (Laguarda Mallo & Espinoza, 2015). The adoption of mass timber in the US construction market has progressed gradually, despite its numerous perceived benefits. Various factors may contribute to this gradual adoption, and an exploration of these factors would be valuable.

1.1.4 Current Development of Mass Timber Construction

One of the most notable examples of mass timber construction is the Ascent MKE, in Milwaukee, Wisconsin which is currently the tallest building in both the United States and the world. It is 25 Stories off the ground and 284.1 feet tall comprising retail spaces, amenities, and 259 luxury apartment units. It is also predicted to hold roughly 7,200 metric tons of CO2 within (Biro, 2023). There are a few other examples as well such as Mjostarnet, Brumunddal in Norway which is 280 Feet tall - one of the tallest mass timber buildings in Europe. Also, HoHo Wien, Vienna in Austria, which is 275.6 feet tall, Haut in Amsterdam which is 240 feet and 21 stories residential building which is also one of the tallest buildings in the Netherlands, etc. (Tallest Mass Timber Buildings, 2022).

Figure 1.6: Ascent MKE, Milwaukee, WI. (KAA Design Group, Nairn Olker)

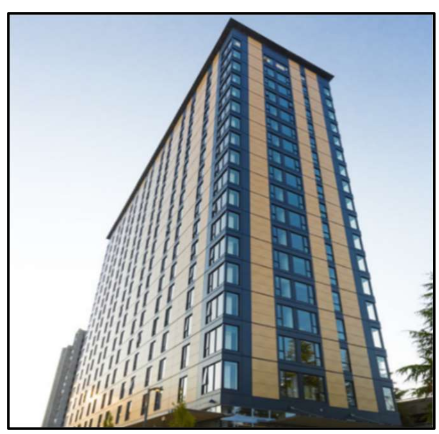


Figure 1.7: Brooks Common Tallwood House

Another good example of mass timber is the Brock Commons Tallwood House, 174 feet tall, located in Vancouver, Canada which is also a part of the University of British Columbia's Point Grey Campus. This is an 18-story student housing building that provides housing facilities to 400 students. It provides a practical example of mass timber construction for the future generation of architects, engineers, and builders, and it may excite students and make them curious to learn more about it (Biro, 2023).

As per Fig. 1.8 (WoodWorks, 2024), a total of 2,115 mass timber projects are built or are underway in 50 states comprising either multifamily, commercial, or institutional projects.

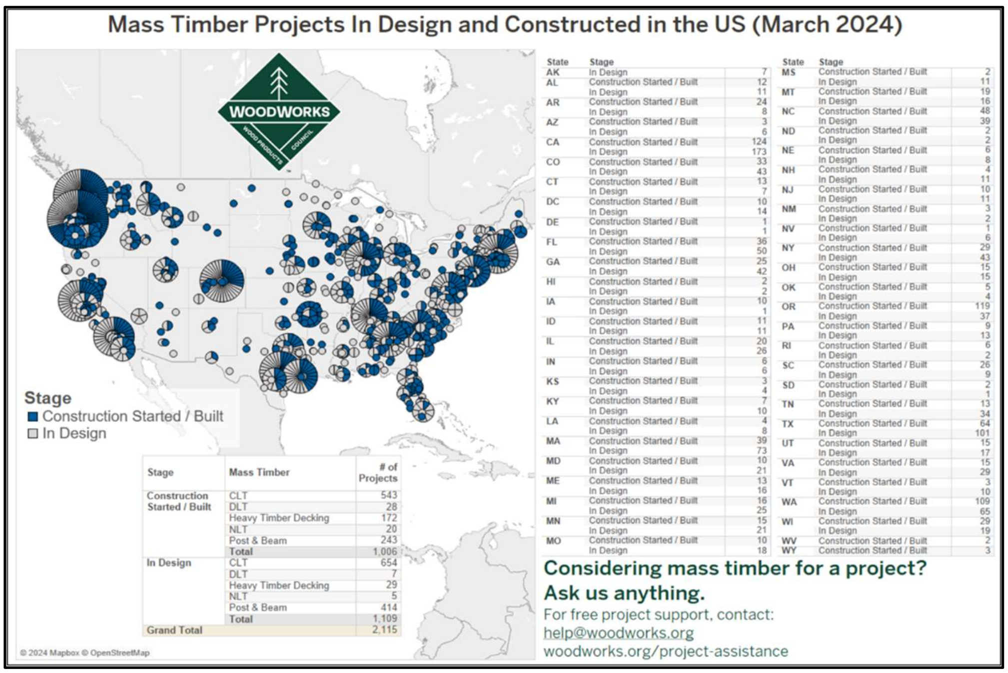


Figure 1.8: Mass Timber Projects in the US
(The WoodWorks Innovation Network WIN, 2024)

In tandem with the growing prevalence of mass timber projects, the regulatory landscape governing mass timber buildings has undergone progressive changes. Beginning with the 2015 International Building Code (IBC), subsequent modifications occurred in 2018, and further updates took place in 2021. Looking ahead, there are anticipated changes slated for the 2024 IBC edition. These evolutionary adjustments are designed to enhance the acceptance and integration of mass timber construction methods by addressing safety considerations and aligning with established building standards (Codes, 2021).

While the evolution of construction types has been ongoing, the introduction of three novel construction types represents a respectively unprecedented development in building codes. These new types, closely associated with traditional heavy timber construction, include Type IV-A for buildings where structural elements are entirely shielded with noncombustible protection, Type IV-B for buildings with structural elements predominantly safeguarded with noncombustible protection, and Type IV-C for buildings where most structural elements remain unprotected (Codes, 2021). Even in Type IV-C, noncombustible protection is mandated for concealed spaced, shaft walls, and the exterior surface of outside walls. Under these classifications:

- Type IV-A typically encompasses buildings where structural elements are fully shielded with noncombustible protection, suitable for various applications such as office and residential structures (Codes, 2021).
- Type IV-B is commonly found in structures where structural elements are mostly protected with noncombustible materials, catering to a range of uses including commercial and institutional buildings (Codes, 2021).
- Type IV-C applies to buildings with a significant portion of structural elements left unprotected and is often employed in industrial or warehouse structures (Codes, 2021).
- Type IV- HT (Heavy Timber) construction is a type of construction in which the exterior walls are of non-combustible material and the interior building elements are of solid wood, laminated heavy timber, or structural composite lumber, without concealed spaces or with concealed spaces (Codes, 2021).

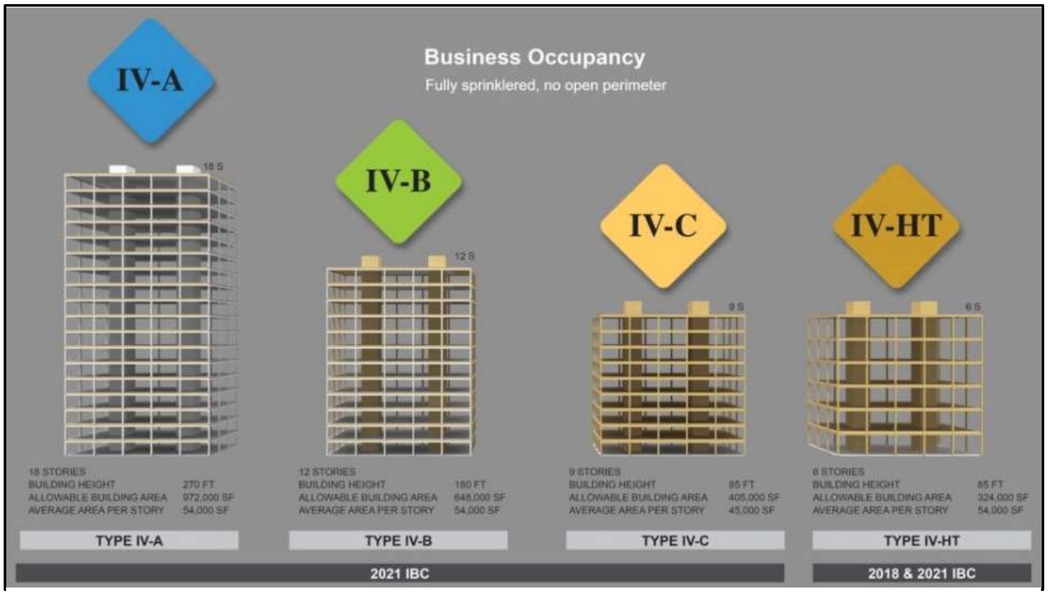


Figure 1.9: Representative Building (Showalter, 2020)

These code modifications reflect the increasing acceptance and acknowledgment of mass timber as a practical construction material and advise producers to boost output.

1.2 RESEARCH NEEDS

As advancements continue to unfold across various sectors, the construction industry has consistently explored and integrated novel materials and techniques. Despite this trend, mass timber, a relatively recent introduction to the US construction market, has been undergoing a gradual acceptance process. This adoption pace is notably slower compared to that observed in European countries, a discrepancy attributed to the need for a thorough analysis of the materials' market potential (Shafayet & Ingrid, 2020). Consequently, this study is poised to play a significant role in advancing the promotion of mass timber.

Multiple factors may contribute to the sluggish adoption rate of mass timber. These factors include insufficient knowledge, cost implications, adherence to building codes and regulations, educational gaps, and prevailing attitudes and perceptions toward the material (Lupien, 2018). Moreover, the limited availability of resources and information regarding the market potential of cross-laminated timber (CLT) poses a challenge. This scarcity hinders entrepreneurs and early adopters from securing financing for the development of mass timber in the US (Laguarda & Espinoza, 2014). Consequently, there is a compelling need to thoroughly investigate and address the barriers and challenges hindering the adoption of mass timber within the US construction industry.

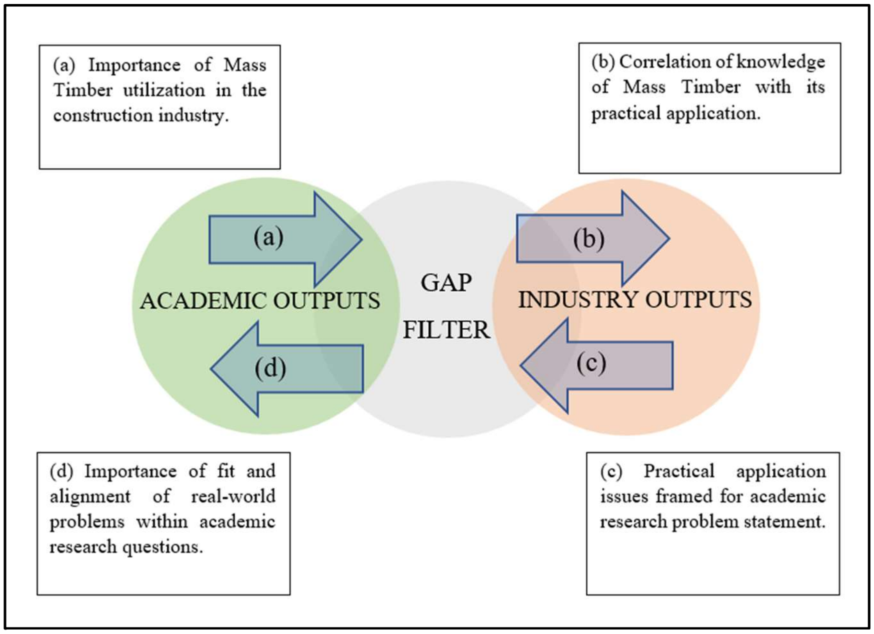


Figure 1.10: Model Demonstrating Academic & Industry Outputs

One area that requires research is the perceptions and attitudes of academia towards mass timber. While there is a lot of research available on the industry professional's attitudes towards mass timber as a building material, there is a significant gap in our understanding of how the faculty and students perceive this building material. Faculty members play a pivotal role in educating the future workforce, making their perspectives crucial in shaping decisions related to mass timber. Addressing this gap can contribute valuable insights, offering a nuanced understanding of the industry's future. Combining academia and industry into a single study is essential to provide a holistic view of the stakeholders involved in the adoption of mass timber (Laguarda M. M., 2017).

Studying them together will illuminate the educational needs and preferences of future professionals, ensuring that the industry workforce is well-informed about mass timber.

Another research need is to understand how industry professionals at different levels of experience think about it. Such as architects, owners, contractors, engineers, and developers' views over mass timber as a building material and their willingness to adopt it in their projects. Uncovering these attitudes is essential, as they hold the potential to influence decision-making processes within the industry. By combining insights from both academia and industry professionals, this research aims to provide a comprehensive understanding of various stakeholder's views on mass timber, offering valuable insights into its adoption and implication for the future of the construction Industry. The significance of studying both academia and industry in tandem lies in the comprehensive understanding it offers, capturing the entire spectrum of perspectives that can influence the acceptance and integration of mass timber in construction practices. This integrated approach is crucial for developing informed strategies and recommendations that cater to the diverse needs and expectations of all stakeholders involved.

Investigation of the barriers to the use of mass timber is crucial as the study can then offer ideas to get through the challenges and increase the adoption of mass timber. This study can also help identify potential areas of improvement in the industry, such as changes in regulations and guidelines.

1.3 RESEARCH GOALS AND OBJECTIVES

This research aimed to better understand the attitudes, beliefs, and barriers towards the adoption of mass timber as a structural building material considering two main groups:

1) Academia (students and faculty)
2) Industry

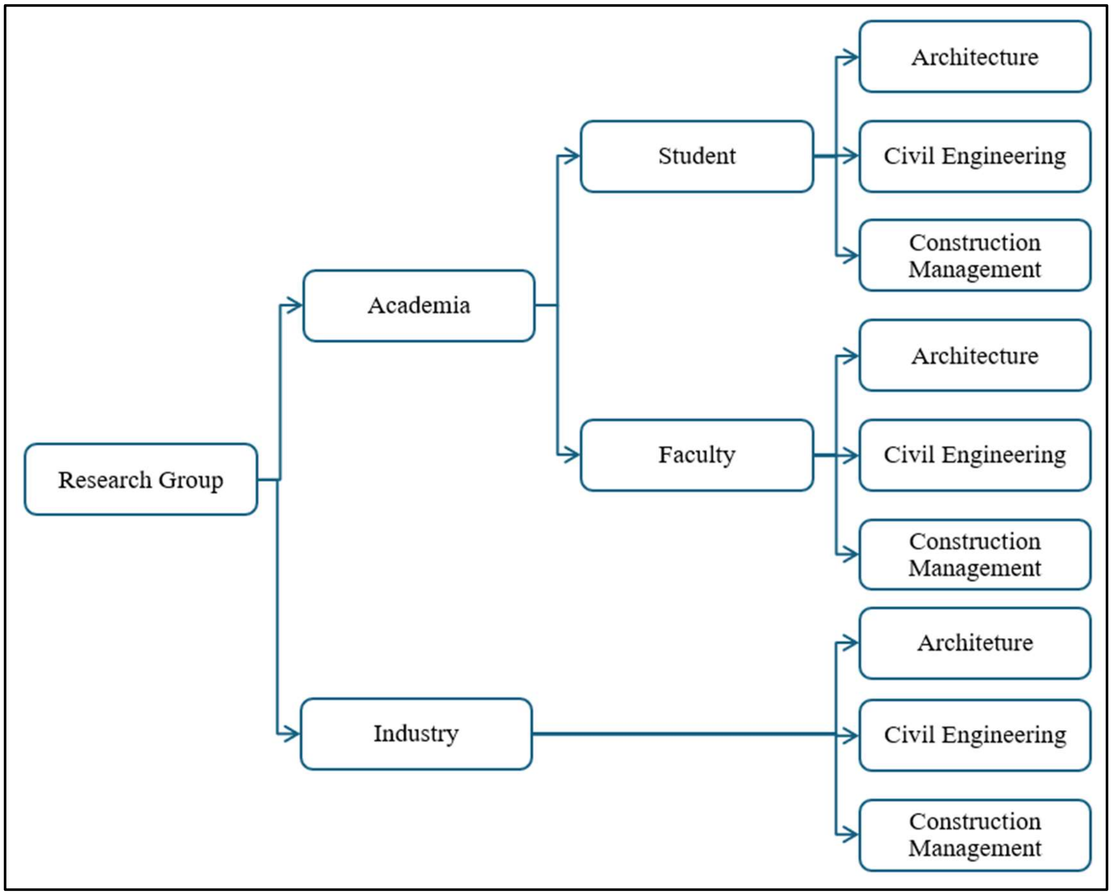


Figure 1.11: Target research group model

Within academia, it was essential to differentiate between students and faculty, as their perceptions are both individually significant and collectively influential. This distinction is crucial because students, trained by faculty, eventually transition into the industry where they encounter real-world challenges. These challenges often feed back into academic research and development, creating a continuous cycle of knowledge transfer and application. Understanding the perspectives of these two subgroups separately, as well as their interconnected role in the educational and professional cycle, provides a more comprehensive view of mass timber knowledge propagated and applied.

To delve deeper the research further subdivided the three groups- Students, Faculty, and Industry into specific disciplines within the Architecture, Engineering, and Construction (AEC) sectors, including architects, civil engineers, and construction management professionals. These subgroups were analyzed in detail to capture variations in perceptions as they are the key decision-makers in the industry. Their views are critical in understanding the broader acceptance and potential barriers to mass timber adoption.

The study considered the perspectives of experienced professionals from the industry, including architects, engineers, and contractors as well as faculty and students in academia, who are responsible for preparing the future workforce. This research aligns with the NSF grant, awarded to Michigan State University, to develop ground groundbreaking mass timber design and construction curriculum.

By identifying key knowledge gaps and barriers, the study supports MSU's initiative to enhance mass timber education and adoption. The NSF funding will help MSU, and its partners develop cutting-edge curricula and outreach strategies, which this research will complement by providing updated insights into current attitudes and perceptions. This alignment with the NSF's grant goals underscores the relevance of this study in contributing to the border effort of making mass timber a mainstream construction material.

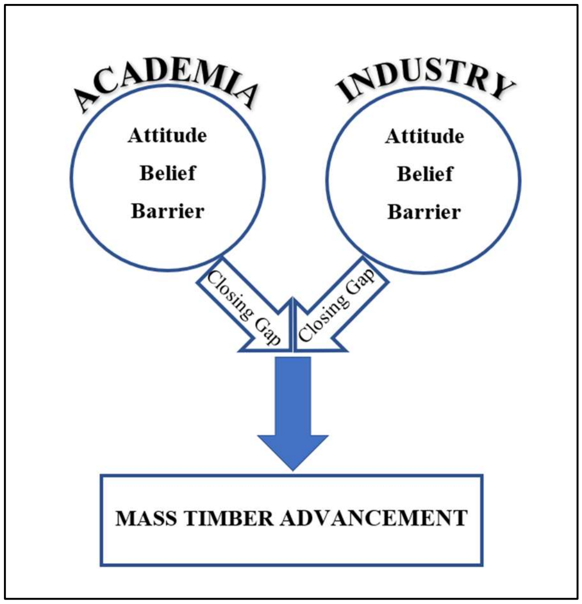


Figure 1.12: Research Base Model

The study aimed to explore:

1. The key knowledge gap between Academia and Industry related to mass timber
2. Differences in perception of mass timber between Academia and Industry and what factors influence this perception
3. Factors influencing the adoption of mass timber if they are the same between Academia and Industry professionals
4. Patterns and trends in attitudes, beliefs, and barriers among the different subgroups.

By understanding the present attitudes, beliefs, and barriers of these groups, this study contributes to the existing body of knowledge and helps develop updated data for future studies and developments.

1.4 RESEARCH METHODS

This section outlines the research method employed to accomplish the goals and objectives:

Earlier in the proposal phase, a mixed-method approach was proposed for this study, incorporating both quantitative and qualitative data collection analysis techniques. However, upon further consideration and in light of practical considerations, the decision was made to proceed with the quantitative methods, specifically the online survey.

This study utilized a random sampling technique and later categorized participants into experienced and inexperienced professionals from the industry including, architects, engineers, and contractors as well as academic faculty and students from the AEC community such as architecture, civil engineering, and construction management.

The survey preparation process underwent rigorous procedures to ensure accuracy and precision. This involved conducting a pilot test with a diverse group of 15 participants, compromising industry professionals, faculty, and students. The aim was to identify and rectify any potential issues in the survey content and structure.

1.4.1 Data Collection

Data collection entailed distributing online surveys to academia (faculty and students) across departments such as architecture, civil engineering, and construction management, as well as Industry professionals including architect engineers, and contractors. The survey was designed to gather quantitative data on attitudes and beliefs about mass timber, demographic information, and level of experience with mass timber. Likert scale questions were incorporated to measure the strength of opinions.

1.4.2 Data Analysis

The collected data underwent thorough preprocessing of data to address missing information and inconsistency response patterns. And were further analyzed considering both among-group and between-group comparisons.

For between-group comparisons, the data was classified into the following categories:

- Academia (Student and Faculty) vs. Industry

For among-group comparisons, the data was classified into the following categories:

- Academics (Student and Faculty): Discipline (Architect vs. Engineer vs. Contractor)
- Industry: Discipline (Architect vs. Engineer vs. Contractor)
- Industry: Experience level (<1yr vs. 1-5yrs vs. 5-10yrs vs. 10-20yrs vs. > 20 yrs.)

1.4.3 Considerations for Ethics

The Institutional Review Board (IRB) of Michigan State University examined and approved the research design and methods to ensure adherence to ethical standards. (MSU I. , 2023)

Participants were informed about the study's objectives, their legal rights, and voluntary participation. The data collected was kept confidential and used exclusively for research purposes.

1.5 RESEARCH SCOPE AND LIMITATIONS

While the study aims to provide insights into the attitudes, beliefs, and barriers of various groups towards mass timber, it is constrained by several factors.

The data collection method relies solely on online surveys, which inherently introduced limitations associated with self-reported data. This may have led to biases or socially acceptable responses, potentially affecting the accuracy of the findings. Although all the efforts have been made to ensure the survey questions were unbiased and neutral, participants may have also struggled to recall their opinions and beliefs accurately.

The study was conducted over a limited time frame, which restricted its ability to capture changes in attitudes and beliefs over a longer period. This time constraint could have hindered the study's ability to provide a comprehensive understanding of evolving perspectives on mass timber within industry and academia.

While efforts were made to include a diverse range of participants from industry and academia, there may still have been inherent biases in the sample population. Certain groups or demographics may have been underrepresented, impacting the generalizability of the study's findings.

Despite these limitations, the study provided valuable insights into the adoption of mass timber and its implications for the construction industry. By acknowledging these limitations, the study sought to ensure transparency and integrity in its findings, allowing for a more nuanced interpretation of results.

2 CHAPTER: LITERATURE REVIEW

As we acknowledge, mass timber stands as a relatively recent entrant into the US construction industry. Originating in Austria and Germany in the 1990s, mass timber has played a pivotal role in the construction sector across European countries. Its rapid ascent to prominence can be attributed to its inherent sustainability, global abundance, and versatility compared to traditional carbon-emitting materials like steel and concrete. Despite these attributes, the widespread adoption of mass timber in the US faces several challenges. Therefore, this thesis delves into the attitudes and perceptions surrounding mass timber, examining not only its reception within the construction industry but also among academic circles. The aim is to illuminate the factors influencing its acceptance and identify potential challenges.

2.1 ATTITUDES TOWARDS MASS TIMBER IN THE US CONSTRUCTION INDUSTRY

Research so far has found a varied number of attitudes of different people working in the construction industry such as architects, contractors, etc. over mass timber used as a building material, though not much information is available on the attitudes of the academia towards it.

According to study results from expert interviews based on (Laguarda & Espinoza, 2014), Cross laminated timber (CLT) offers performance comparable to concrete or steel, with a reduction of weight. The layered arrangement gives good rigidity, stability, and mechanical properties making it usable for the construction of walls, floors, roofs, elevators, shafts, stairways, etc. Another research finding based on expert's views from the fields of architecture and other US construction practitioners was that the level of awareness of mass timber in the United States was very low ((Laguarda Mallo M. F., 2014); (Laguarda Mallo & Espinoza, 2015); (Mallo & Espinoza, 2018); (Shafayet & Ingrid, 2020).

As per (Shafayet & Ingrid, 2020) findings, several challenges hinder the widespread adoption of mass timber construction. These challenges include a lack of experience in timber construction, the presence of unskilled workers contributing to on-site accidents and delays, poor coordination among project parties, design-related complexities, and the elevated cost of mass timber panels along with associated fire hazards.

In their 2022 study, Ahmed and Arocho noted that a significant number of participants engaged in mass timber projects reported having experience levels between 1 and 5 years, signaling that the understanding of mass timber is still in its early stages. Identified drawbacks include the absence of timber manufacturing plants, a shortage of experienced personnel, high costs associated with engineered wood, and limitations in building codes. The study suggests that Cross-Laminated Timber (CLT) may be cost-competitive for certain construction types, such as high-rise commercial or multifamily residential buildings and low-rise commercial and industrial structures where a wood frame system is applicable (Ahmed, 2022). However, respondents concurred that CLT might not be cost-competitive in scenarios where light wood frame construction is a viable option (Laguarda Mallo M. F., 2014). Additionally, according to (Laguarda Mallo & Espinoza, 2015), CLT applications are deemed suitable for residential single-family buildings but less optimal for industrial structures.

2.2 PERCEPTIONS OF MASS TIMBER IN SUSTAINABLE BUILDING

The perceptions of mass timber in the United States construction industry vary depending on various factors, such as an individual's experience working with mass timber, knowledge in the field, and role in the industry. According to research by (Laguarda Mallo & Espinoza, 2015) and (Mallo & Espinoza, 2018), some professionals view mass timber as a sustainable and innovative building material whose aesthetic characteristics and structural and environmental performance are ranked the highest making the system highly competitive against concrete or steel. Hence marking its potential to revolutionize the industry. Others are more skeptical and cautious about its use due to some major challenges such as lack of knowledge about mass timber, lack of technical information, lack of durability of wood, misperceptions about wood as a building material, mass timber fire performance, initial and total cost of construction as compared to that of the traditional construction, structural capability, etc.

According to (Laguarda & Espinoza, 2014), barriers to the adoption of CLT were building code compatibility, CLT availability in the domestic market, and misconceptions about wood as a building material. The author said that in the current state, the US is required to import CLT elements from Canada or Europe adding to the total construction costs. They found CLT was promising and has been adopted nationwide, yet skepticism exists as experts believe CLT would end up finding a niche market in some regions but not in others where traditional construction materials such as steel and concrete are still dominant.

Apart from this as witnessed in (Laguarda Mallo & Espinoza, 2015) research, the lowest-ranked feature of CLT was post-construction maintenance due to the common belief that wood is susceptible to deterioration due to its organic nature and requires more maintenance. From this research, it was also noted that the respondents also showed concerns regarding compatibility issues with the building codes leading to wide adoption of the system in the US. In addition to all the concerns mentioned above vibration and acoustic performance were also brought up in the research conducted by (Mallo & Espinoza, 2018) which ranked the lowest. Resulting from expert interviews for research based on (Laguarda & Espinoza, 2014), technical drawbacks were observed such as acoustic and vibration performance, Construction experts believed using acoustic membranes on one side was a must. Another concern raised was about the volume of wood utilized. One expert believed CLT panels use three times more wood than a wood frame system.

On the other hand, there are a few advantages of using mass timber one of the key advantages of mass timber is it's a versatile engineered wood product, sustainable in nature with good strength, durability, and environmental benefits. The wood itself is a natural and renewable resource which is advantageous over the energy-intensive and non-renewable traditional material (Laguarda & Espinoza, 2014). Mass timber construction has many environmental benefits one such being environmentally friendly material leading to carbon footprint reduction as compared to that of steel or concrete. Also, CLT requires less time and labor for construction, and it's available in prefabricated systems, reduces on-site waste and accidents, and construction noise, and is cost-effective overall (Laguarda Mallo & Espinoza, 2015).

However, issues with fire safety and durability continue to be a major obstacle to adoption. Some experts are still skeptical about the performance of mass timber in large-scale fires, despite the fact that it can be constructed to adhere to high fire safety regulations (Barber, 2018). Furthermore, experts believe that mass timber buildings may be more vulnerable to moisture damage and deterioration than conventional building materials. According to (Shirmohammadi, Leggate, & Redman, 2021) when assessing the usage of mass timber in buildings, experts also take cost into account. Although the use of mass timber might result in long-term cost advantages because of its durability and energy efficiency, it can be more expensive initially due to a lack of qualified workers and adequate production facilities. Despite these reservations, mass timber building is becoming more popular in the US, and curiosity to understand its potential benefits as well as its drawbacks is increasing. Many experts are working hard to create best practices for mass timber building and find solutions to the problems it presents (Kremer & Symmons, 2016).

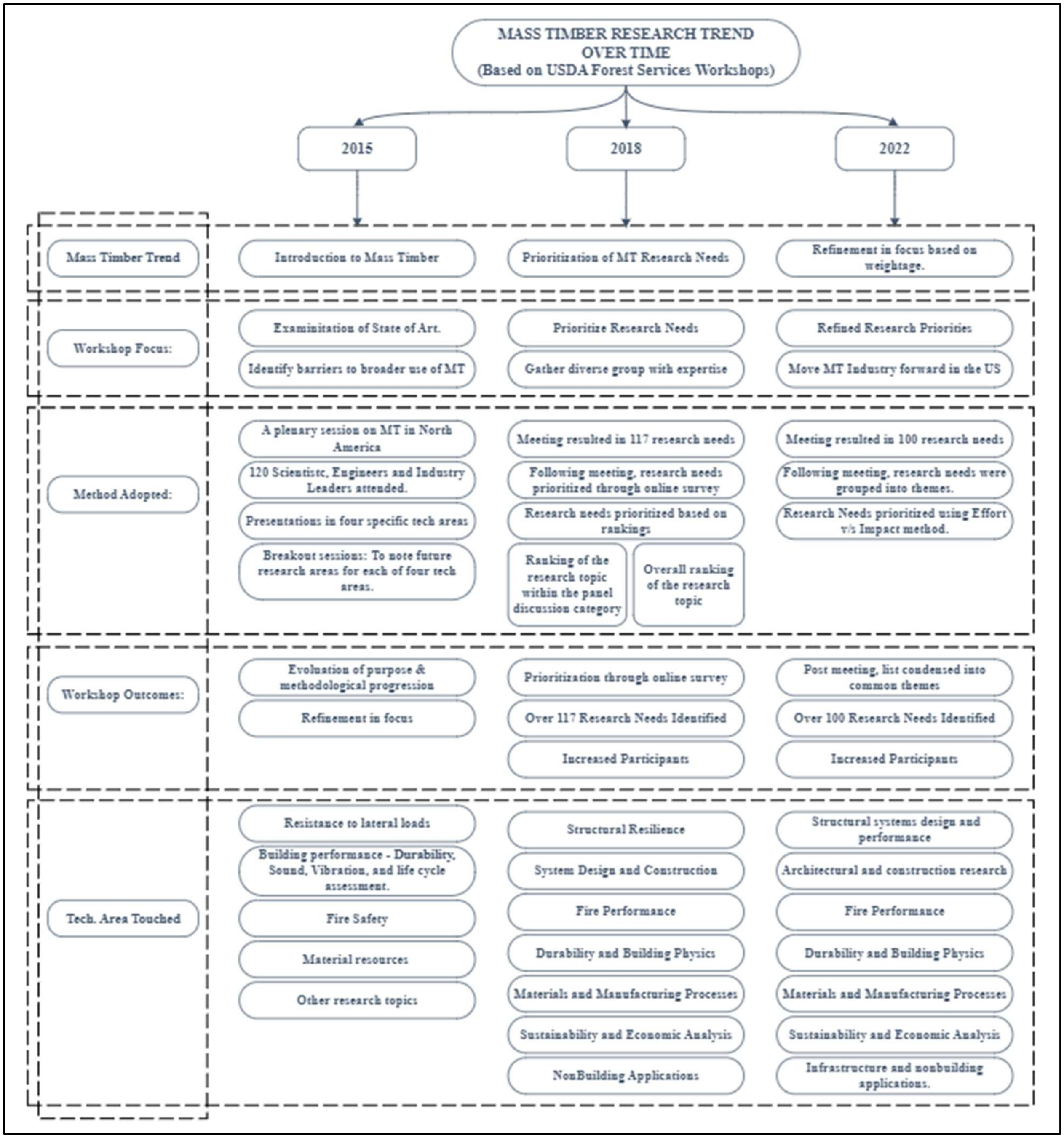


Figure 2.1: Mass Timber Research Trend Overtime
(Williamson & Ross, 2015) (2018) (Lo Ricco M. T., et al., 2022)

2.3 THE IMPERATIVE OF A SKILLED WORKFORCE IN MASS TIMBER CONSTRUCTION

In the heart of the United States construction industry, a quiet revolution is taking place. Wherein the AEC community is rediscovering an age-old material i.e., Wood, but with a modern twist, engineered wood known as mass timber. Which now seems the future's most preferred building material to build skyscrapers instead of using other traditional materials. Hence, amid a transformative era in construction, it becomes increasingly evident that a well-trained workforce is a key to successful integration and perception of mass timber within the United States Construction industry.

2.3.1 The Timber Revolution

Mass timber, characterized by engineered wood products such as CLT and glulam, signals an innovation in construction practices and has captured the imagination of architects, developers, and environmentalists. In addition to being environmentally friendly, it is also architecturally flexible, cost-effective, and offers speedy construction. However, these and other such advantages of mass timber can only be utilized if there is an adequate workforce available and if the workforce has the knowledge and skills required.

As we know adoption of a new material is a task and needs a lot of effort to prove the advantages of such material in order to make a smooth entry into the market. Mass timber also faced challenges entering the United States market with various concerns but overcame a few such as misconceptions about wood as a building material, general awareness, availability, fire, etc. (Laguarda & Espinoza, 2014) & (Unpublished Data, 2022) with the emergence of the building code, but a few other concerns are still observed to emerge over the years. It has been observed that since 2014 workforce development-related challenges remain as barriers to the vast adoption of mass timber as a building material as stated by (Laguarda & Espinoza, 2014) In her research respondents stated the difference between being aware and being proficient in mass timber adoption, they surely lacked the education required for the smooth adoption.

Hence, the issues arising due to this, such as poor coordination and lack of mass timer-specific skills all of this can be solved by educating the target audience and by providing various educational programs as also recommended by research (Laguarda Mallo & Espinoza, 2015) and these trends seemed to be the same as noted by research (Mallo & Espinoza, 2018).

Survey participants' responses regarding their familiarity with CLT. N = 351.

Awareness	Count of respondents	Percent of respondents (%)
Very familiar	15	4.3
Somewhat familiar	133	37.9
Not very familiar	137	39.0
Have not heard about it	65	18.5

Table 2.1: Survey Participants Responses,
(Laguarda Mallo & Espinoza, 2015)

Table 5. Familiarity with CLT reported by respondents? N=113.

Familiarity with CLT	Count of respondents	Percent
Very familiar	13	11.5%
Somewhat familiar	29	25.7%
Not very familiar	45	39.8%
Have not heard about it	22	19.5%
Unanswered	4	3.5%

Table 2.2: CLT Familiarity Data (Mallo & Espinoza, 2018)

Due to this lack of a skilled workforce, obviously does exist and has been cited as a safety concern over the years. Hence, to fill this gap a few researchers across various regions including Australia and the United States have identified common themes. (Zaman, Chan, Jonescu, & Stewart, 2022) researched the industry perceptions in Australia and his research found that among the critical challenges, the need for a trained workforce is extremely crucial. The research also marks the importance of an equipped workforce not only with traditional carpentry woodworking skills but also with the modern advanced structural and environmental principles of mass timber.

Talking about the United States mass timber construction industry, (Shafayet A. & Ingrid, 2021) conducted a feasibility assessment of mass timber as a mainstream building material and their findings illuminate the necessity of a well-trained workforce in overcoming the existing challenges. The authors also emphasize that in order to take full advantage of mass timber's potential, industry stakeholders must invest in workforce development to bridge the gap of skills and ensure workers and efficiently handle mass timber projects. In another such research highlighting the critical gap about training and skills requirements conducted by (Lehmann & Kremer, 2023) expresses the necessity of education and training programs tailored to the unique demands of mass timber construction.

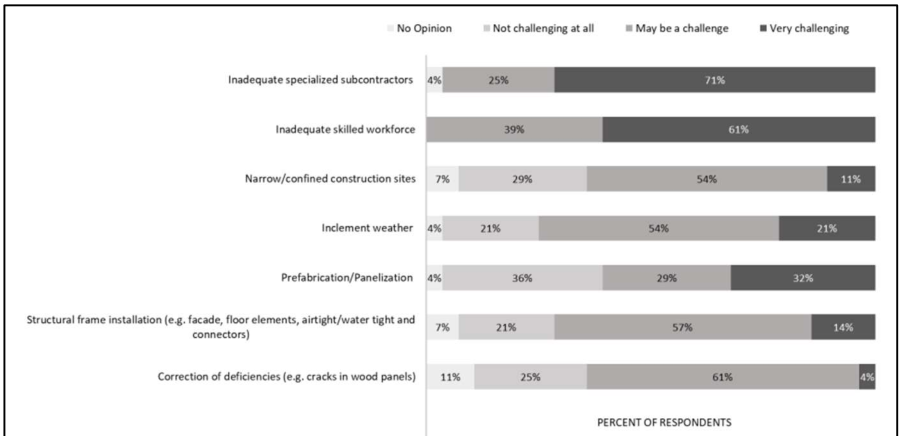


Figure 6a. Mass Timber “construction challenges” in Canada (N=28).

Figure 2.2: MT Construction Challenges in Canada (Syed, 2020)

In Canada, (Syed, 2020) research on priorities, barriers to adoption, and challenges in the engineering, procurement, and construction (EPC) phases of mass timber projects. Identifies a common theme running through the challenges, which is a shortage of skilled workforce and inadequate specialized subcontractors, particularly professionals who are well versed in the field of mass timber. This shortage of trained workforce not only hampers industry progress but also emphasizes the need for focused efforts to train and develop the workforce quickly.

Hence, to address these needs Woodworks has initiated an excellent solution the Wood Works Mass Timber Design Manuals, consisting of Volume 1 and Volume 2. These manuals play a vital role in educating professionals such as architects, engineers, contractors, and students interested in mass timber construction. In light of the growing demand for expertise in mass timber. Woodworks has launched the Mass Timber Construction Management Program. This program focuses on the project managers and installers to equip them with the necessary skills to excel in the industry. The manuals are a great initiative and ensure the development of a competent workforce essential for driving the growth of the mass timber industry in the United States (Wood, 2021) (Wood, 2022).

Across diverse geographical contexts and various research perspectives, a theme appears pointing toward the need for a skilled workforce in the mass timber construction sector. This study demonstrates the need for education, training, and other certification programs to equip workers with the necessary skills and knowledge required to navigate the unique challenges presented by the mass timber construction industry.

In essence, a skilled workforce is like the cornerstone that holds together and supports this sustainable and innovative construction method.

2.4 FROM FOREST TO SKYLINES: MASS TIMBER'S GREEN REVOLUTION IN THE U.S.

In the U.S. construction industry, mass timber is sweeping in with a silent revolution. This revolution doesn't lead to noises of the machinery of steel but whispers through the forest leaves. Mass Timber with its eco-friendliness and sustainable nature is entering the US construction landscape, redefining not just the aesthetics but also the environmental conscience. This section explores the environmental and carbon performance of mass timber in the United States, where two distinct responses have taken shape.

On one hand, some believe mass timber is a remarkable carbon-storing system where the carbon is held within the building throughout the life cycle, mitigating the carbon footprint of the built environment. But on the other hand, concerns are raised about the impact on forests, highlighting the need for sustainable forest practices. Hence, exploring the transformation from the carbon-storing capability of mass timber to the challenges of deforestation and other concerns.

Utilizing wood products as a construction material represents a significant climate solution due to their lower energy and carbon emission footprint during manufacturing and also due to their ability to store carbon throughout their lifespan.

The 2016 report from the UN Food and Agriculture Organization, titled “Forest for a Low Carbon Future”, highlights six strategies for incorporating forests and wood products into climate change mitigating efforts:

1. Increasing Tree Plantation
2. Enhancing carbon density in existing forests.
3. Augmenting carbon storage in wood products
4. Mitigating deforestation and degradation
5. Substituting biomass for fossil fuels in energy generation
6. Employing wood products in construction materials to reduce emissions associated with manufacturing higher-emissions alternatives (Wood, 2022)

Hence utilizing wood products is an important and effective practice that can work alongside various other ways forests are used, leading to positive outcomes for climate and conservation efforts.

The research by (Cover, 2020), signifies the potential of mass timber in tall buildings, emphasizing its role as a sustainable choice. Stating one key advantage is carbon storage. Trees absorb carbon dioxide during its growth and when they are harvested to use as a building material this carbon remains in the wood and doesn't emit into the atmosphere, therefore acting as carbon sinks, mitigating the carbon footprint of the built environment.

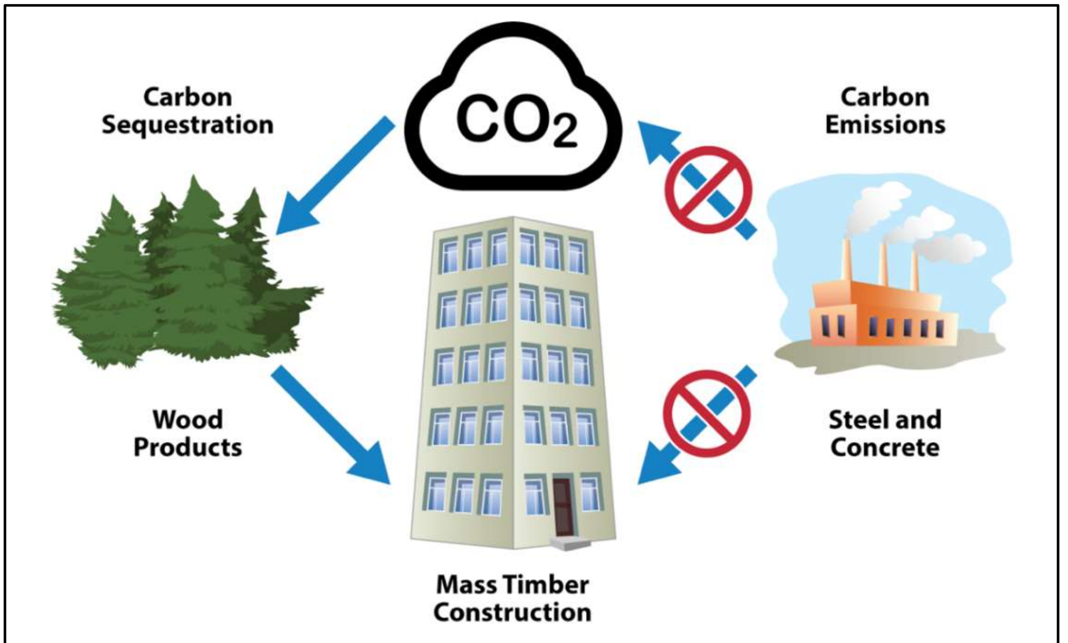


Figure 1. A simplified illustration of the dual potential carbon benefits of mass timber construction: (1) storing sequestered carbon in the wood building materials and (2) avoiding carbon emissions associated with production of alternative materials.

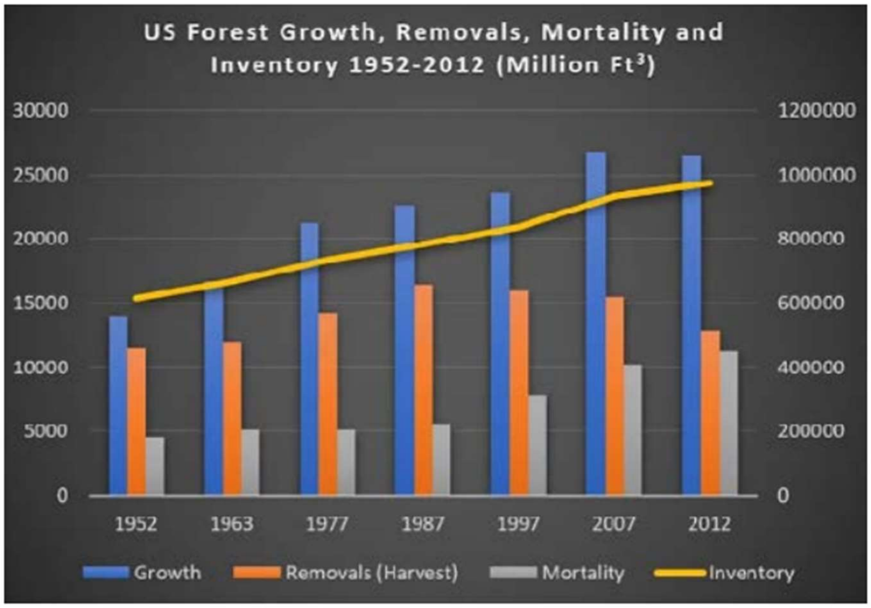
Figure 2.3: Dual Potential Carbon Benefits of Mass Timber Construction

Despite the many advantages of mass timber, concerns about deforestation still exist. (Himes, 2020) research explores the potential for responsible forestry practices to mitigate deforestation concerns. The utilization of sustainable sources of timber with responsible land management ensures the environmental benefits of mass timber construction without risks. This deforestation concern doesn't seem to be a part of the latest trend but emerged as people's attitude since the research conducted by (Damette, 2011) brought to the forefront the same issue, the impact of unsustainable timber harvested and its potential for deforestation. Pointing out towards responsibly sourcing timber and ensuring that the environmental benefits are not overshadowed by the deforestation risks.

With the increase in interest in mass timber, many builders and architects have concerns regarding the increasing demand for wood products and its potential negative effects on forests. However, empirical evidence and economic models have shown that this demand leads to more forest land and not less. A recent report by the USFS highlights a few key points such as:

- The Forest and woodland areas in the United States are leveled up at 823 million acres, covering over one-third of the U.S. Landscape and containing 1 trillion cubic feet of wood volume.
- The forest industry in the United States makes up 17% of the global round wood production and the nation's high industrial round wood consumption per capita.
- Although 67% of the forest land is available to harvest, only 2% of it has been cut down per year. While natural events like insects, various diseases, and fires disturb a significant percentage.

- A significant threat to the forest is due to wildfires and insects and other diseases, necessitating active forest management practices, including thinning to reduce wildfire severity and accelerate carbon absorption (Wood, 2021).



USFS 2014 US Forest Resources Facts and Historical Trends.

Figure 2.4: US Forest Resources Facts and Historical Trends (USFS 2014)

U.S. Forest Services have revealed a relationship between industrial timber harvest and sustainable forest management. Regions with a higher level of timber harvest and forest output tend to have lower rates of deforestation. Market demand drives the economic justification for sustainable forests and forestry practices. The timber revenue plays an important role in supporting forest management and brings in policies favoring sustainability. The U.S. Forest Service also emphasizes the importance of timber revenues in sustainable forest management and maintenance of economic viability. The U.S. Forest Services also monitors the health of the U.S. forests through its Forest Inventory Analysis (FIA) program. This program offers insights into the forest trends, ownerships, and impacts of growth over time. On the other hand, if the timber value decreases due to low-value use or limited demand the sustainability of the forest becomes compromised. The Intergovernmental Panel on Climate Change (IPCC) also recognizes the role of sustainable forest management in lowering greenhouse gas emissions and contributing to adaptation efforts. Also, the increase in demand for timber can lead to greater carbon storage in product stocks and offer substitution benefits. According to the Forest Climate Working Group, currently, the United States is estimated to store 1.5 billion metric tons of carbon which is equivalent to 5.4 billion tons of CO2. Most of this comes from the housing stock with 80% being wood frame construction. Hence by promoting wood in the construction sector, there is significant potential to achieve substantial carbon benefits which is comparable to removing millions of cars from the road annually (Wood, 2021).

According to the USDA Forest Service FIA Data, projections were made regarding the supply of softwood timber in the United States to meet the expected high-volume demand for mass timber consumption in 2023. These projections considered the entire United States as three distinct geographic regions: North, South, and West.

The analysis shows the U.S. Forest growth is anticipated to exceed harvest levels by 18% even after accommodating the incremental demand for both lumber and mass timber by 2035 (Wood, 2022).

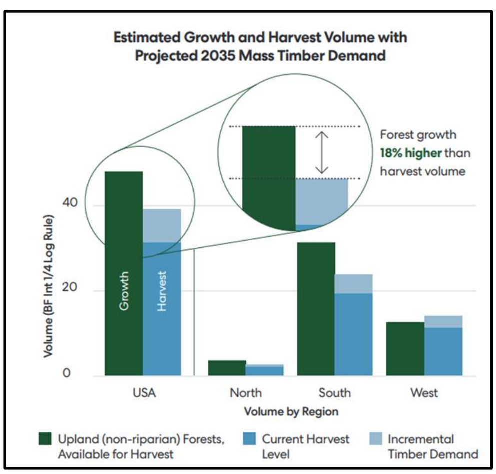


Figure 2.5: Estimated Growth and Harvest Volume with Projected 2035 MT Demand, (Woodworks Mass Timber Vol 2, 2022)

Apart from this evidence, research also signifies addressing psychological barriers. Since wood in the physic mind itself is believed to be a not-so-strong material, and prone to decay, etc. Hence, beyond technical aspects, the perceptions, and attitudes of individuals towards the use of "Wood" play a vital role in material selection. (Kremer & Symmons, 2016) in their research have explored this to make mass timber a commonly used and fully integrated material for construction practices. In evaluating the carbon and environmental performance of mass timber in the United States, it is evident that mass timber offers advantages as a carbon-storing construction building material. However, a comprehensive strategy that considers the entire lifecycle and ensures sustainable forestry practices is crucial. The current discussion surrounding mass timber highlights its potential to be used as an eco-friendly building option, provided that the environmental considerations are put into practice.

2.5 BROADENING HORIZONS: A COMPREHENSIVE LOOK AT MASS TIMBER'S DIVERSE PERFORMANCE

As we begin to embark on the exploration of mass timber's overall performance, it is important to check the complexities and variations that define the building material. In this section, the author plans to expand knowledge by exploring the general performance of the new material.

2.5.1 Fire Performance of Mass Timber

Results from a nationwide survey of United States architect firms conducted by the research of (Laguarda Mallo & Espinoza, 2015) marked fire performance as the major perceived disadvantage. Hence, the fire performance of mass timber is an important aspect when evaluating its viability as a building material within the United States. As wood is often mistakenly assumed to behave poorly in case of fires (Mehaffey, 2014) although research is evidence of it performing exceptionally well (Schmid, Konig, & Kohler, 2010) & (Frangi, Fontana, & Jubstl, 2009). With the introduction of Wood as a building material and as it gained prominence as a sustainable and innovative building material, in the US construction industry there has been noticed a growing interest in understanding the fire performance of mass timber. To address this concern, it is important to examine the standards that govern fire safety in construction. The fire safety requirements for mass timber construction are mostly determined by building regulations, fire ratings, and industry standards. In order to ensure compliance and safety, it is essential to understand these requirements.

2.5.1.1 Fire Resistance and Safety Measures

The assessment of mass timber fire resistance is the foundation for determining its safety and its performance during an event of fire. Many researchers have conducted extensive investigations to evaluate how the different mass timber components such as Cross Laminated Panels, Glulam beams, and columns behave when tested for fires under controlled conditions (Laguarda Mallo & Espinoza, 2015).

These tests include exposing mass timber specimens to high temperatures and checking for the rate of charring and structural integrity under high heat conditions.

Studies in this field reveal insights into the behavior of the mass timber during a fire, highlighting the mass timber's ability to retain structural integrity and ensure occupant safety. This knowledge is extremely crucial for architects, engineers, and policymakers as they formulate building codes and standards specific to mass timber.

2.5.1.2 Charring Rates & Predictive Models

The charring of mass timber is the gradual burning of the outer layer of wood when exposed to fire conditions. It is considered to be a natural resistant mechanism in wood-based materials like CLT, Glulam, and other mass timber components (Crespell, 2011). When a mass timber component burns in fire its outer layer chars or burns slowly creating a barrier that insulates the core of the timber. The charring process is considered to be beneficial in fire safety because it helps prevent the structural integrity of the mass timber element. As the outer layer of mass timber chars, it forms a protective shield around the element and prevents the fire from reaching the core (Laguarda & Espinoza, 2014). This process of charring slows down the rate at which timber loses its strength during a fire event, and also provides time for the occupants to evacuate the building and for the firefighters to take full control. Researchers have worked (Mehaffey, 2014) on predictive models to estimate the depth and duration of charring for various mass timber components under standard fire conditions. These models help to design fire-resistant structures by providing insights into how different mass timber components behave and their impact on charring rates and structural stability. According to (USDA Wood Handbook, Wood as an Engineering Material, 2010) a char depth of 1.5 inches at 1 hour is generally expected for structural wood members. As per (Laguarda Mallo & Espinoza, 2015)research, when a CLT wall was tested to fire, lasted more than 80 min before collapsing.

These predictive models guide the AEC community to make informed decisions regarding fire safety measures and structural designs.

2.5.1.3 High Heat Conditions

(Laguarda & Espinoza, 2014) & (Laguarda Mallo & Espinoza, 2015) research marks an important point in reference to the high heat conditions where the Massiveness and tightness of the CLT Panels provide and barrier for gases and high temperatures during a fire situation and improve compartmentalization.

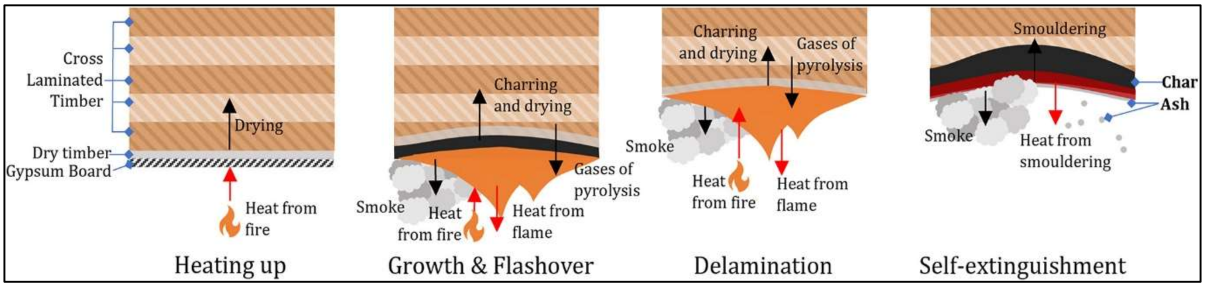


Figure 2.6: Mass Timber in High Heat Conditions (Fire and Material, 2022)

2.5.1.4 Fire-Resistant Coatings and Treatments

The process of improving the fire resistance of mass timber has become the focal point of research and innovation. Various fire-resistant coatings and insulated material and other surface treatments have been explored to deal with the impact of fire.

A continuous effort has been made by researchers to refine these fire-resistant solutions to improve their effectiveness, durability, and environmental impact.

2.5.2 Durability

A crucial consideration in mass timber construction is to ensure the durability and long-term resilience of the wooden structure. The durability of wood is often questioned as compared to that of other traditional materials. In order to address this concern, it's essential to improve our understanding of construction science and building physics, especially to manage the moisture content and prevent decay. Threats to wooden structures include insects, fungi, termites, and moisture damage. One approach is to use the most naturally durable wood species, particularly in regions with challenging climates. Such as tropical or extreme climates (Shirmohammadi, Leggate, & Redman, 2021).

Designing for longevity and durability involves effective treatments, weather protection, and strategies to prevent water ingress and trapped moisture in ventilated wooden structures. It's important to see timber where it makes the most sense as a building material. However, the complexity and precision required for timber construction pose challenges that need to be addressed (Lehmann & Kremer, 2023)

Proper waterproofing is essential to avoid moisture buildup in the interior of the walls leading to structural deterioration. Research should also explore the effectiveness of moisture monitoring devices installed on the waterproof membranes to track the trends in moisture and take corrective actions. Structural monitoring can contribute to long-term structural health. Additionally, treating the affected wooden surface can extend the lifespan of the building.

Hence, to promote the use of mass timber in construction architects must adopt a different approach, integrating structural considerations and moisture management from the initial stage of design. Enhancing the durability of wooden structures is essential for the future of mass timber construction (Frearson, 2023).

2.5.3 Architecture & Construction

Architecture and construction is a newly observed topic that was shed light on during the Mass Timber Research Needs Workshop of 2023 by USDA. (Williamson & Ross, Proceedings: Mass Timber Research Workshop 2015, 2015) (Zelinka S. L., Williamson, Martinson, & Ritter, 2018) various areas were discussed, refer to Table 2.3.

Table 6—Research topics for architectural and/or construction		
Topic	Description	Notes
1	Biophilic advantages of exposed mass timber spaces	Several groups mentioned that the wording is ambiguous. Data are already available from InnoRenew, FPInnovations, and German institutions. The difficulty comes from which metrics to measure and report.
2	Vibration design and criteria for different building types	Groups talked about resources that are already available. Woodworks (vibration) design guide. Canadian code equation, APA also has a guide. However, more details on an "intermediate difficulty" approach would be useful. This approach was offered as a new topic (item B) in one group.
3	Acoustics assemblies, especially for higher performance (matching or exceeding concrete)	This was looked at as a continual need, you can always add more assemblies to a database.
4	Insulative qualities and humidity mitigation of CLT walls	The energy codes do not recognize the insulative properties of mass timber even though the thermal conductivity of wood/mass timber are well known. Other related questions include the following: Does CLT act as a moisture barrier? How does mass timber affect MEP/HVAC systems?
5	Repair methodologies—in-situ lamination and replacement	
6	Repair methodologies—dowel-fastener reinforcement	Many groups suggested that topics 5–7 be combined into one topic. Little work has been done in this area.
7	Repair methodologies—advanced techniques (polymer injection, FRP applications, etc.)	
8	Construction: Sequencing and installation of rocking wall components	Rocking walls will be necessary if we want to build mass timber buildings without concrete cores. Work at Oregon State Univeristy and University of California–San Diego shake table has answered these questions related to sequencing and installation. The problems are not sequencing but rather code approval of rocking wall systems.
9	Construction: Beam to column connections and column to column connections	Two groups suggested that standardizing connections would address constructability issues or bottlenecks.
10	Difficulty and added costs of solid walls in regard to outlets/switches/conduits/junction boxes coordination	Only one group scored this topic with no comments.
A	Repairs are unsufficient, replacement MT products required	See items 5–7.
B	Vibration guidelines medium difficulty	See item 2.
C	Research on constructability of mass timber	No comments.
D	Create content to train workforce so that it is easier to assemble the proper teams to do mass timber construction.	No comments.
E	Design: Getting rocking wall into code, getting literature on how to design rocking wall and other MT lateral systems	No comments.
F	Design: Beam to column connections and column to column connections	This would include a complete design that accounts for deformation compatibility, biaxially stress states, fire design

[a] Topics 1–10 were preselected. Topics identified with a letter were offered during the meeting.

Table 2.3: Research topics for architectural and/or construction, (Williamson and Ross 2016, Zelinka and others 2018)

Since the objective of the workshop was to go beyond just ranking and gather results based on prioritization, an effort vs. impact method of prioritization was created, results from which were then analyzed. This method has 4 quadrants where,

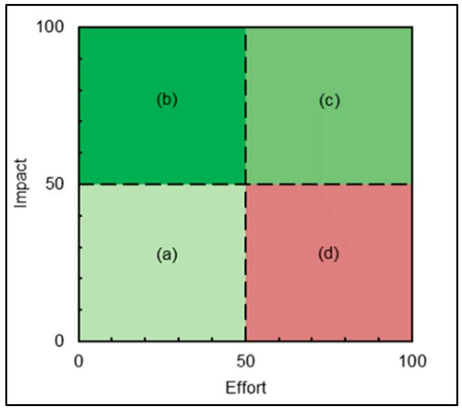


Figure 2.7: Effort v/s Impact

a. Low effort, low impact.

b. Low effort, high impact,

c. High effort, high impact, and

d. High effort, low impact.

Hence the analyzed results based on the method were.

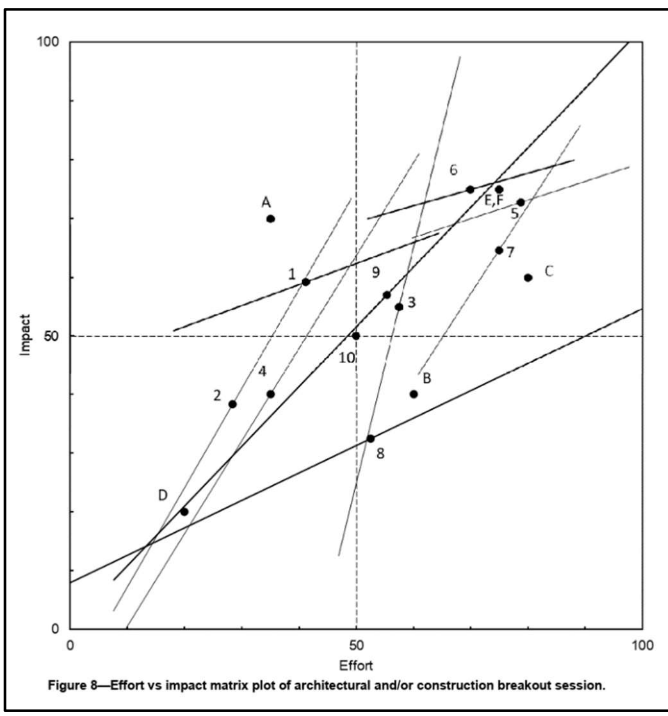


Table 7—Average effort and impact for topics of architectural and/or construction with coefficient of variation between rooms

	Average		COV	
Topic	Effort	Impact	Effort	Impact
1	41	59	56%	14%
2	28	38	73%	92%
3	58	55	18%	77%
4	35	40	74%	102%
5	79	73	24%	8%
6	70	75	26%	7%
7	75	65	19%	33%
8	53	33	101%	76%
9	55	57	86%	85%
10	50	50	–	–
A	35	70	–	–
B	60	40	–	–
C	80	60	–	–
D	20	20	–	–
E	75	75	–	–
F	75	75	–	–

Figure 2.8: Effort v/s Impact Matrix based on the results in the breakout session

2.6 EXPLORING THE PROSPECTS OF MODULAR MASS TIMBER CONSTRUCTION IN THE US CONSTRUCTION MARKET

In recent years, it has been observed that the interest in innovative and sustainable building techniques is growing in the United States construction industry. Among these modular construction and mass timber have become popular as promising approaches to address the challenges of sustainability, efficiency, and affordability in the construction sector. This section speaks about the potential of modular mass timber construction within the US Construction industry examining the key drivers, advantages, challenges, and emerging trends associated with this construction method.

2.6.1 Modular Mass Timber Construction- Key Drivers

The adoption of mass timber construction in the US construction industry is led by several critical drivers. One of which is the increasing emphasis on sustainability and environmental consciousness. Mass timber, being a renewable and carbon-friendly material, aligns well with the construction industry's efforts to reduce its ecological footprint. Additionally, with its potential for reducing waste, faster project timeline and cost savings has gained traction as a response to the demand for more efficient construction methods.

2.6.2 Advantages of Modular Mass Timber Construction

Modular Mass Timber Construction offers various advantages making it a popular option among builders, developers, and stakeholders in the US Construction Industry. These advantages are as follows:

- Sustainability- Since Mass Timber is a renewable resource its use in construction can help lower the carbon footprint and promote sustainable building practices.

- Speed and Efficiency- The modular mass timber construction allows off-site fabrication and On-site assembly, making shorter construction schedules and reducing labor costs.
- Design Flexibility- Mass timbers versatility in terms of shape and size leads to innovative architectural designs, offering a distinctive aesthetic appeal.
- Cost Savings- Reduced construction time with minimal waste and efficient project management can result in significant cost savings over traditional construction methods.
- Energy Efficiency- Energy efficiency and occupant comfort are achieved since mass timber buildings often exhibit excellent thermal performance (Carvalho , Carvalho, & Jeronimo, 2020).

2.6.3 Challenges and Considerations

Despite having so many advantages modular mass timber is facing certain challenges in gaining widespread adoption in the US Construction Industry. Such as:

- Regulatory and Code Compliance- Compliance with the local building codes and regulations is necessary and this can be a hurdle.
- Connections- Lack of research on connections for modular construction of CLT under extreme loading events (Zelinka S. L., Williamson, Martinson, & Ritter, 2018).
- Awareness and Education- The awareness and education about the techniques seem to be lacking among the US Construction Industry Stakeholders and hence it is important to educate them about the benefits, safety measures, and proper construction techniques associated (Lehmann & Kremer, 2023).
- Supply Chain- Upscaling the production and supply of mass timber material is necessary in order to meet the increasing demand that poses the logistics challenges.

- Initial Costs- Mass timber construction ensures long-term savings, but the upfront costs of mass timber and modular construction may lead to discouragement among stakeholders.

2.6.4 Emerging Trends

With the evolution of the Construction Industry in the United States, several emerging trends suggest a favorable environment for the growth of mass timber construction. That includes:

- Research and Development: The ongoing research and developments in the fields of construction are focused on improving the performance, safety, and cost-effectiveness of mass timber construction.
- Government Support: Various incentives, grants, and policy support from the federal and state governments are encouraging the use of mass timber.
- Industry Collaboration: The collaborations among the AEC community, i.e., Architect, Engineers, Contractors, and other stakeholders are fostering innovation and streamlining the adoption of modular mass timber construction.

2.7 POTENTIAL OF MASS TIMBER CONSTRUCTION FOR AFFORDABLE HOUSING IN THE U.S. CONSTRUCTION INDUSTRY

Mass timber construction is becoming more popular as a potential solution to the current issues with sustainability, affordability, and efficiency in the U.S. Construction Industry. Examining the use of mass timber in affordability housing projects is particularly significant. This section analyzes the possibilities and consequences of using mass timber in affordable housing projects in the U.S. Construction market.

2.7.1 Sustainable and Cost-Efficient Housing Solution

Mass timber has been extensively investigated as a prime contender for affordable housing initiatives in response to the growing need for environmentally friendly and economically practical housing. Because of its renewability, potential for carbon sequestration, and relatively low embodied energy, mass timber exhibits environmentally friendly qualities that are closely aligned with the industry's growing commitment to environmentally sustainable construction methods.

2.7.2 Expedited Construction Timelines

Mass timber construction's ability to complete the project in less time as compared to the traditional methods is an advantage for its adoption in affordable housing projects. The construction process is accelerated since mass timber is prefabricated off-site and is assembled on-site. Such efficiencies result in significant time and labor cost reductions, making mass timber an appealing choice for developers of affordable housing projects.

2.7.3 Structural Integrity and Safety

An important factor leading to the uptake of mass timber in affordable housing is its structural attributes, including robustness, stability, and fire resistance. This characteristic marks mass timber as a safe and dependable choice for multistory affordable housing structures.

2.7.4 Aesthetic Appeal and Comfort

In addition to the structural characteristics, mass timber is naturally aesthetical with its exposed wooden surface creating a welcoming and aesthetically pleasing ambulance with the housing units. This aesthetic appeal can be attractive to both the developers and the residents. Moreover, the favorable thermal performance of mass timber helps enhance energy efficiency and occupant comfort, aligning with the emphasis on well-designed and energy-efficient affordable housing.

2.7.5 Challenges and Considerations

While the mass timber's potential in affordable housing is promising, challenges yet exist. These include the need for regulatory updates to consider mass timber construction in affordable housing projects as well as concerns regarding cost competitiveness with conventional material, especially in the context of affordable housing budgets (Lehmann & Kremer, 2023).

2.8 "SAFETY" IN MASS TIMBER CONSTRUCTION

Safety in mass timber construction is a crucial subject influencing material choices and construction practices. In this section, we dive deeper into the existing literature on safety considerations associated with mass timber construction.

One of the significant advantages of mass timber construction is its prefabricated nature. The research (Shafayet A. & Ingrid, 2021) highlights key pointers, as mass timber components are manufactured off-site greatly minimizing the requirement for labor-intensive on-site operations. This also minimized the frequency of welding operations on site which lowers the safety risks that are often associated with welding in construction environments.

One major factor in creating a safer construction environment is the high efficiency of assembly. The rapid installation of the prefabricated mass timber elements, which is frequently made possible by crane operations not only shortens the construction timeline but also minimizes the potential for accidents that are usually associated with traditional construction activities. This is consistent with the research conducted (Shafayet A. & Ingrid, 2021) which highlights the link between effective assembly and increased on-site safety.

The qualitative content analysis, method employed by the researcher (Shafayet A. & Ingrid, 2021)

Construction-Related Advantages of Mass Timber Material	Keyword
Prefabricated for assembly on site	Prefabricated
Installation, level of care given by the Specialty Trade that is installing it. Cleanliness of activities. Less welding activities overhead.	1. Small Manpower 2. Short Installation Time
We utilize the same basic safety principles while building with mass timber, but the advantage with timber is that the decks can be safe to walk on sooner that with a steel structure.	Prefabricated
1. Prefab 2. easy installation 3. Less workers	1. Prefabricated 2. Small Manpower 3. Easy Installation
Pre-fabrication process of the panels Smaller crew size to install Seismic protection	1. Small Manpower 2. Short Installation Time 3. Seismic Protection
Easy installation, factory fabrication, small crew	1. Prefabricated 2. Small Manpower 3. Easy Installation
Never been involved in a mass timber project so not exactly sure. However, a major leading indicator would be prefabricated nature of timber panels which is safer than the other options.	Prefabricated
Prefab nature Small crew size Less variables	1. Prefabricated 2. Small Manpower 3. Easy Installation
The installation process is much leaner than the other types of construction. Less labor work as panels are lifted by crane or any other mechanical instrument. All panels are prefabricated that reduces the work load.	1. Prefabricated 2. Small Manpower 3. Easy Installation
All panels are prefabricated that reduces work time and improve safety. Timber panels are easy to install. Installation process requires less workforce	1. Prefabricated 2. Small Manpower 3. Easy Installation
It has shown to have the required strength for the applications it's used in, It is flexible to withstand more movement, don't have a third.	Structural Strength

Figure 2.9: Data processing in the Qualitative content analysis method, (Shafayet A. & Ingrid, 2021)

is detailed in Figure 2.9. This systematic approach involves the transformation of the participant responses on mass timber advantages into relevant themes or codes. This method includes putting together the responses in Excel, where keywords like "prefabricated" are generated to encapsulate the essence of each response. Refer to Figure 2.9 for a comprehensive overview of the data processing steps in this qualitative analysis.

In contrast to the traditional steel and concrete construction mass timber construction prefabricated nature fosters a safer working construction site. Hence this more regulated and secure working environment is achieved leading to the reduction of extensive welding or other activities and a smaller crew for installation. It is also noteworthy that as compared to steel construction, walking on the mass wood decks during installation is considered safer (Shafayet A. & Ingrid, 2021) (Laguarda & Espinoza, 2014).

Researchers have concurred that the benefits of mass timber contribute directly to a safer construction industry. These studies demonstrate the relationship between increased safety and mass timber's prefabricated nature, highlighting the possibility of fewer mishaps, better working conditions, and on-time project completion.

3 CHAPTER: METHODOLOGY

3.1 INTRODUCTION

The methodology chapter provides a comprehensive overview of the approach undertaken to explore knowledge gaps and factors influencing perceptions of mass timber adoption within the U.S. construction industry, while also considering variations among students, faculty, and industry professionals.

A structured approach was employed to achieve this comprehensive understanding, primarily utilizing quantitative techniques through online survey-based research methods. The methodology section details the research design, survey instrument development, participant sampling, and analysis procedures.

It is also worth noting that the research chose to go ahead with survey methods only although it had a backup plan of using qualitative methods, such as interviews, which was initially planned as if the surveys would have failed to give enough evidence.

The focus was primarily on the following:

1. To identify key knowledge gaps related to mass timber between academia and industry.
2. Factors influencing perceptions of mass timber.
3. To examine the key factors influencing the adoption of mass timber.

Through the chosen methods, fresh insights have been offered that contribute to the ongoing development of the U.S. construction industry.

3.2 RESEARCH DESIGN

The research design served as the blueprint for navigating the landscape of the study, which aimed to explore knowledge gaps and factors influencing perceptions of mass timber adoption within the U.S. construction industry. This section outlines the selected research strategy, centered around a structured survey, as well as the formulation of hypotheses, sample size determination, and data collection methods.

3.2.1 Research question and hypotheses

The central research question driving the study is "What are the key knowledge gaps and factors influencing perceptions of mass timber in the U.S. Construction Industry and how can these insights inform strategies for enhancing the adoption and interaction considering two main groups, academia (Faculty and Students), and industry professionals?"

The hypotheses formulated to address these questions are as follows:

1. What are the key knowledge gaps related to mass timber in the U.S. Construction Industry?
    - H0: There is no significant difference in the knowledge gaps related to mass timber among academia and industry professionals in the U.S. Construction Industry.
    - H1: There are significant differences in knowledge gaps related to mass timber among the academia and industry professionals in the U.S. Construction Industry.
2. What factors influence perceptions of mass timber in the U.S. Construction Industry?
    - H0: Perceptions of mass timber in the U.S. construction Industry do not differ between the academic group and the Industry Professionals.
    - H1: Perceptions of mass timber in the U.S. Construction Industry differs between academia and Industry professionals.

3. What are the key factors influencing the adoption of mass timber in the U.S. Construction Industry?
    - H0: Factors influencing the adoption of mass timber are similar among academia and industry professionals.
    - H1: Factors influencing the adoption of mass timber vary significantly between academia and industry professionals.

VARIABLES LIST					
IV's and DV's	Variables	Type	Description	Level	Survey Q's
Dependent Variables	Knowledge towards MT	Ordinal	Respondents knowledge about MT on a scale	1 - Strongly Disagree & 5 Strongly Agree	Section 2 - Q1, Q4, Q10 Section 3 - Q1, Q12
Dependent Variables	Perception about MT	Ordinal	Respondents beliefs about MT on a scale	1 - Strongly Disagree & 5 Strongly Agree	1. Performance: Section 2 - Q7, Q8, Q9, Section 3 - Q5, Q6, Q8, Q10, Q11 2. Sustainability & Environmental impact: Section 2 - Q2 Section 3 - Q2, Q3, Q4 3. Safety and Regulatory Compliance: Section 2 - Q6 Section 3 - Q7, Q9
Dependent Variables	Attitude towards adoption of MT	Ordinal	Respondents attitude towards adoption of MT on a scale	1 - Strongly Disagree & 5 Strongly Agree	1. Regulatory Support: Section 2 - Q11 2. Educational and Workforce Development: Section 2 - Q5 3. Collaborative Efforts: Section 3 - Q15 4. Environmental and Sustainability Factors: Section 3 - Q2, Q3, Q4, Q12 5. Market Perception: Section 6 - Q1, Q2, Q3
Independent Variable	Age	Continuous	Age of respondents	Year born	General Demographic Info. Q1
Independent Variable	Discipline	Nominal Categorical	Category the respondent belong to.	Academic or Industry	General Demographic Info. Q2
Independent Variable	Education Level	Ordinal Categorical	Highest level of education attained.	Bachelors, Masters, Ph.D.	General Demographic Info. Q3
Independent Variable	Academic Discipline	Nominal Categorical	Academic field of study or discipline	Architecture, Construction Management, Civil Engineering, Interior Designing	General Demographic Info. Q4
Independent Variable	Experience Level - Academia	Ordinal Categorical	Experience level in academia.	1-5 Years or More than 5 years	Academia Demographic Info. Q1
Independent Variable	Industry Sector	Nominal Categorical	Sector within the construction industry respondents belong to.	GC, Subs, Engineering firm, Architecture firm, Consultant	Industry Demographic Info. Q1
Independent Variable	Experience Level - Industry	Ordinal Categorical	Experience level in the construction industry.	1-5 Years or More than 5 years	Industry Demographic Info. Q3
Independent Variable	Company Size	Ordinal Categorical	Size of the company respondents belong to.	>50, 50-250, 250 - 500, etc.	Industry Demographic Info. Q2
Independent Variable	Experience Level - MT Construction	Ordinal Categorical	Experience level working with MT projects.	No exp, 1 MT Project, 2-5 MT Projects, etc.	Industry Demographic Info. Q4
Independent Variable	Geographic Location	Nominal	Respondents geographical location.	Various states in the US.	General Demographic Info. Q5
Independent Variable	Professional Journey	Nominal	Professional journey transitions.	Transitions between industry and academia and vice versa options	General Demographic Info. Q6

Table 3.1: List of Independent and Dependent Variables

3.2.2 Survey Methodology

The online survey method adopted in the study gathered data related to the knowledge, perception and adoption of mass timber on the following major aspects:

1. Current knowledge of the respondent
2. Familiarity with Mass Timber Concepts
3. Performance of mass timber
4. Sustainability and Environmental Impact
5. Safety and Regulatory Compliance
6. Current U.S market for mass timber
7. Regulatory and policy factors
8. Market Availability
9. Acceptance
10. Educational and Collaborative Efforts
11. Future workforce development
12. Future outlook

While keeping in mind some other considerate factors that will be discussed further in the section.

3.2.3 Sample size determination

Choosing an appropriate sample size is a crucial aspect of survey research as it directly impacts the reliability and validity of study findings. The objective is to select a sample size that ensures a balance between statistical confidence and manageable resource allocation. In this study, the method proposed by (de leeuw, 2008) to determine the sample size required for the research objectives was employed (Laguarda Mallo M. F., 2014).

(de leeuw, 2008) suggests an approach for estimating the sample size based on the desired confidence level and margin of error. The formula for calculating the sample size is as follows:

$$\text{Sample size} = \frac{Z^2\, s^2}{H^2}$$

$$\text{Sample size} = \frac{1.96^2 \times 0.5^2}{0.05^2} = 384$$

Where:

- n = sample size
- Z = inverse of the normal distribution corresponding to the desired confidence level

  (e.g., 1.96 for a 95% confidence level)
- s = estimated proportion of the population exhibiting the attribute of interest

  (0.5 for maximum variability)
- H = margin of error, set at 5% (0.05) for this research

In this study, the above formula was used to determine the appropriate sample size. Given the desired confidence level of 95% and a margin of error of 5%, the conservative estimate of s =0.5 was considered to account for maximum variability in the population which yielded a sample size of 384.

3.2.4 Survey Design

The survey instrument was thoughtfully crafted to align with the research objective and address the hypotheses. Questions for the survey were designed based on a thorough literature review to gather information on participants' knowledge, perception, and attitudes towards mass timber.

Consideration was given to including the latest insights from the fields and referencing existing literature to inform the survey structure. This helped ensure the questions were relevant and comprehensive.

However, after the questionnaire was built all the required formalities were completed before publishing the survey and the following is the road map of the same.

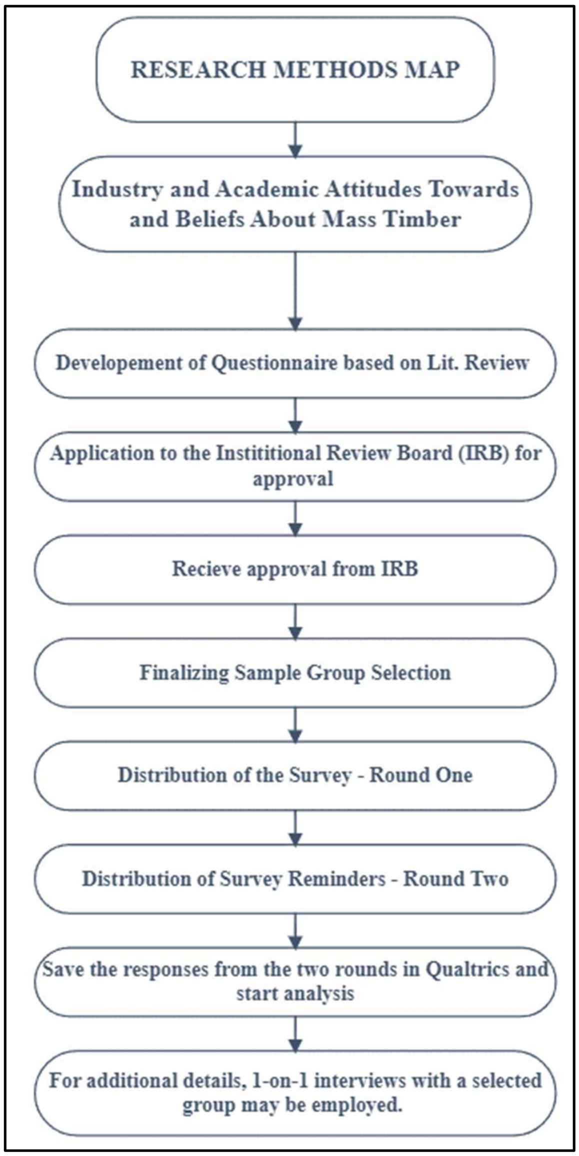


Figure 3.1: Research Methods Map, (Ahmed and Archo, 2021)

Qualtrics was employed to design and distribute the survey, which is a widely used survey software solution. This software offers versatility and robust functionality, allowing for the customization of survey questions and the efficient collection of responses (MSU Q. , 2023).

Leveraging the resources provided by Michigan State University, access to Qualtrics was facilitated, enabling seamless survey administration.

Initially, the plan was to distribute the survey to target groups within the AEC community I.e. Architecture, Engineering, and Construction, including organizations like AIA, ASC, CMAA, ASCE, NAHB, BOMA, AGC, and ABC refer the Table 3.2

TARGET RESEARCH GROUPS	
Sr. No.	**Association**
	Construction Management
1	Associated Schools of Construction (ASC)
	Owners US Based
2	National Association of Home Builders (NAHB)
3	Building Owners and Managers Association (BOMA)
4	APPA - Leadership in Educational Facilities
	Owners MI Based
5	Construction Owners Association of America (COAA) - Michigan Chapter
	GC US Based
6	Associated General Contractors of America (AGC)
7	National Association of Home Builders (NAHB)
	GC MI Based
8	Associated General Contractors of Michigan (AGC Michigan)
	Subcontractor US Based
9	Associated Specialty Contractors (ASC)
	Subcontractor MI Based
10	Associated Builders and Contractors (ABC)
	CM Associations MI Based:
11	Associated General Contractors of Michigan (AGC Michigan)

Table 3.2: List of Target Research Groups

However, after waiting for a month without significant responses, alternative methods were explored to increase participation.

Below mentioned are a few approaches undertaken:

1. University outreach: A list of universities offering Construction Management programs was obtained from the (News, 2024) web page. Thereby selecting each name from this list, each university page was visited to compile the faculty's list and publicly available email IDs. Then an email was sent to these professors with the details of the research and the survey link. This approach ensured coverage of universities across the United States offering Construction Management Course.
2. NAAB list utilization: The NAAB list provided information on architecture schools across the United States, although it only included names. To gather the contact information, the webpage of each school has been visited to access the faculty list and tailored emails were sent out. This list helped get in touch with 98 schools across the U.S. (NAAB, 2024)
3. LinkedIn engagement: Active participation on LinkedIn was leveraged to increase visibility for research. Posts about the research were made frequently. Polls along with the post and the survey link were also done to attract audience engagement, Additionally, outreach efforts were made to a large number of students via the "Add a note" feature on LinkedIn, which allows one to connect with individuals. Where the research introduction was stated with the survey link. Moreover, the survey link along with the research information had been posted in the comment section of relevant posts (LinkedIn, 2024).
4. Collaboration with Professors and committee advisor: Dr. Berghorn and Dr. Bob assisted by forwarding the survey to ABC and AGC and including it in their newsletter. This collaboration helped to expand the reach of the survey within academic and industry

networks. Dr. Sandra provided valuable support by featuring the thesis article in the Mass Timber newsletter and ensured regular reposts on LinkedIn. This contributed to increased visibility and awareness of the research among relevant stakeholders. Refer Appendix E for more details.

5. MSU Alumni Engagement: Contact was established with MSU alumni, particularly those in the Construction Management program, a list of 78 MSU Construction Management alumni was obtained via the GSAC committee at MSU, and they were approached to participate in the survey. Coty Fournier facilitated connections with a few other MSU alumni across the AEC community, which further expanded the outreach efforts. Refer Appendix D for more details.
6. Social networking app support: Efforts were made to reach the WhatsApp groups of the university's AEC students groups, to spread the word via fellow student’s support (WhatsApp, 2024).
7. Support from Toebe Construction: Toebe Construction assisted by sending out emails within their company about the research, encouraging employees to participate in the survey. The collaboration helped to reach professionals within the construction industry and increase participation rates. Refer Appendix D for more details (Construction, 2024).

These efforts collectively contributed to generating responses from a diverse range of participants, enhancing the validity and comprehensiveness of the survey data.

3.3 DATA COLLECTION METHOD

In light of the research, the selection of the data collection methods was a significant step to be undertaken as it would further direct the type and quality of data being extracted that forms the bedrock of the whole analysis. This section outlines the thoughtfully devised data collection method employed for investigating mass timber adoption within the U.S. Construction Industry.

3.3.1 Survey

A structured survey emerged as the primary means of data collection, offering a comprehensive approach to gathering relevant information. This survey, including a detailed questionnaire, targeted two primary cohorts: academia (compromising faculty and students) and industry professionals. Working together with the big organization groups helped reach a larger audience.

The survey had multiple sections, strategically designed to solicit diverse perspectives. Commencing with inquiries into participants' backgrounds, it transitioned to assessing their knowledge and awareness of mass timber. Subsequently, sections delve into participant's perceptions, attitudes, and future expectations regarding mass timber's role in the construction sector. Notably, the survey directed the participants to the questions based on the discipline they selected in the survey viz. student, faculty, and industry professional. A specific set of questions that included Sections 1, 2, 3, 4, and 6 were asked to students and faculty while sections 1, 2, 3, 5, and 6 were asked to industry professionals (Refer table 3.3).

SURVEY QUESTIONNAIRE SECTIONS	
Section No.	**Title**
1	Demographics
2	Mass timber knowledge and awareness
3	Mass timber perceptions and attitude
4	Academic prespective
5	Industry prespective
6	Future expectations

Table 3.3: Survey questionnaire sections

To increase the response rate and outreach, varied distribution channels were employed, including email, social media, and direct outreach. Additionally, proactive engagement with educational institutions and industry stakeholders nationwide broadened the survey's reach and enriched the dataset with diverse viewpoints.

The cumulative efforts resulted in a rich database that offers insights into the mass timber adoption trends within the US construction industry.

3.4 DATA COLLECTION INSTRUMENT

It is crucial to ensure the reliability and validity of research findings and to maintain the integrity and credibility of the study. In order to achieve this the study plans to employ robust strategies, that include pilot testing, and random sampling.

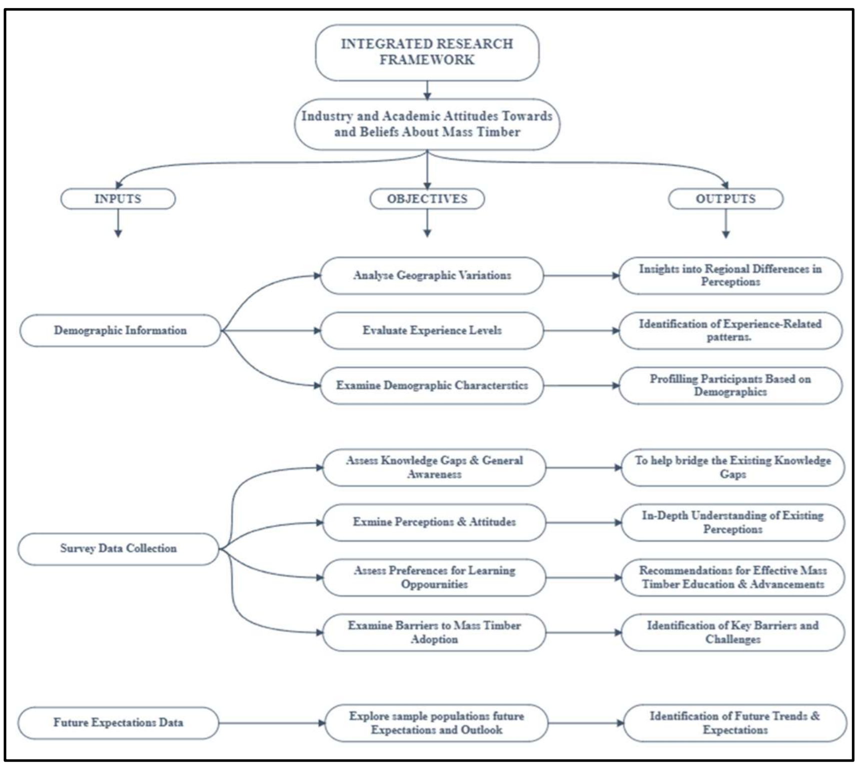


Figure 3.2: Integrated Research Framework

3.4.1 Pilot Testing

Pilot testing was conducted to ensure the reliability of the survey instrument before the main data collection phase. Reliability, in this context, refers to the degree of consistency or precision in measurement (Radhakrishna, 2007).

For the pilot test, a small group comprising students, faculty, and industry professionals was formed. This group served as a trial run for the data collection process. The survey was circulated among them to assess its clarity and comprehensibility. The aim was to identify any potential issues with question interpretation and to ensure that the survey was understandable to all participants.

Feedback from the pilot study participants was collected and used to refine and improve the survey instrument. This process helped to enhance the overall quality and feasibility of the research design. Some of these responses are included in appendix B for reference.

3.4.2 Random Sampling

The study plan involves the use of random sampling, a foundational technique in quantitative research. A robust and well-structured research design is essential for ensuring the credibility and accuracy of the findings. By employing random sampling, every individual in the sample frame,

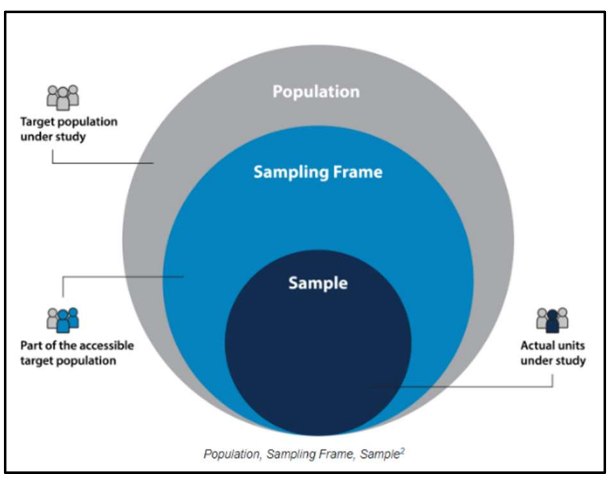


Figure 3.3: Representation of sampling strategy (NIH Learning)

whether from academia or industry, has an equal chance of being selected for participation in the study (Singh & Masuku, 2014).

This approach helps minimize bias and ensure that the data collection process is fair and representative of the broader population within the Architecture, Engineering, and Construction (AEC) Community. By gathering data in this manner, the aim is to produce results that are reliable and generalizable, allowing for meaningful conclusions about the larger population as a whole.

3.5 DATA ANALYSIS

The study utilized statistical software IBM SPSS, accessed via MSU VDI (Virtual Desktop Infrastructure) (VDI, 2024), to process the data collected from the primary survey. The initial steps involved preprocessing the data which included the following steps:

1. Removing redundant data: Identified the responses where no data was filled and subsequently removed them from the final data set. Further also identified responses not relevant to the field of study and excluded them.
2. Arranging data as per discipline: The final datasheet downloaded from Qualtrics had participants arranged in random order as and when the survey was completed by the participants. For ease of analysis, this data was then filtered to arrange all the participants as per their discipline.
3. Standardizing Data: Since the responses were on a Likert scale it needed to be transformed into a standardized format to facilitate comparability and analysis. Hence the responses were then converted into a numerical scale ranging from 0 to 5 with 0 representing the lowest level of agreement or intensity and 5 representing the highest.
4. Handling Missing Values: Identified variables in the data set that had missing values and imputed them using the mode imputation method. Where the value that appears more

frequently from the non-missing observation for that variable is used (Quynh & Dung, 2021) (Goh, Huong, Thong, Seah, & Yeong, 2023).

5. Correcting Errors: Identifying and correcting errors or inconsistencies in the dataset, such as typos, incorrect data formats, or mislabeled categories.

Once the data was processed, the data was ready to be used for analysis. The variable Table 3.1 was revisited to look at the dependent variables and the independent variables along with the research question and the hypothesis that were to be tested.

A list of possible dependent variables was linked to the independent variables to test the hypothesis. Based on this these pairings data sheets were prepped using MS Excel which were later imported into IBM SPSS for analysis (D & P, 2019) (MS Excel Version 2403).

For the analysis most of the tests assume a normal distribution of data, hence it was cardinal to test the data for normality. Shapiro-Wilk test was conducted in SPSS, and then an appropriate analysis method was implemented to test the hypothesis. In this use case, it was either One-way ANOVA which assumes a normal distribution of data, or Kruskal-Wallis which is a non-parametric test and does not assume a normal distribution of data (Yazici & Yolacan, 2007).

These analyses provided a comprehensive understanding of the data, ensuring the thorough achievement of research objectives. The results of the tests are discussed further in the results chapter.

3.6 ETHICAL CONSIDERATIONS

During this research, ethical standards were meticulously observed to safeguard the rights and well-being of all the participants involved, while also ensuring the integrity and validity of the study. This section explains the ethical guidelines supporting this study, detailing the measures taken to uphold ethical standards throughout its conception, execution, and dissemination.

3.6.1 Attendance of ethics in research courses.

This study is built on a strong ethical foundation. Simultaneously while working on the research the author made sure to learn about ethical standards by attending relevant courses offered by Michigan State University on research ethics. These courses taught about the important principles and dilemmas in research ethics, helping the author how to conduct the study ethically.

3.6.2 Institutional Review Board (IRB)

Before starting the data collection, the survey was first sent to the IRB at Michigan State University accompanying the other research details. Which was then reviewed and approved by the board. This board ensures that research follows ethical guidelines and protects the rights and well-being of the participants.

3.6.3 Informed consent

Getting permission from participants is crucial in research. At the beginning of this study's survey participants were given clear information about what the research was about, what they would do, and any potential risks or benefits. They were then asked if they agreed to take part in the study, making sure their decision was voluntary.

3.6.4 Privacy and Confidentiality Measures

Keeping participant's information private and safe is very important. The survey only asked for basic demographic details such as age and job role, making sure no respondent could be identified. Respondents were assured that any personal information they chose to share, like their names or contact details, would be kept confidential and only be used for this research-related communications.

3.7 LIMITATIONS

This section discusses the potential limitations that may have affected the scope and findings of the study.

3.7.1 Sampling Bias

One significant limitation of this study is the potential for sampling bias. Despite efforts to design survey procedures impartially, there remains a possibility of bias towards individuals with strong opinions about wood or mass timber, or those actively involved in the industry. As a result, certain viewpoints and experiences may be disproportionately represented in the data.

3.7.2 Self-Reporting Survey

The reliance on self-reporting surveys introduces various biases, including socially desirable bias respondent bias, and recall bias. Participants may provide answers that they perceive as socially acceptable rather than truthful, impacting the reliability and accuracy of the data. Additionally, difficulties in recalling specific instances may lead to measurement errors.

3.7.3 Limitations on Generalizability

The study focuses on a specific geographic location, i.e. the United States, which limits the generalizability of the findings to other populations or regions. Caution is warranted when applying the study's conclusions to a population beyond the chosen sample.

3.7.4 Cross-Sectional Design

The adoption of a cross-sectional design restricts the study from capturing participant's perceptions and beliefs at a single point in time. This approach overlooks the evolution of an individual's knowledge and ideas over time, potentially constraining the study insights.

3.7.5 Non-Responses Bias

Non-response bias presents another limitation, as the perspective of individuals who choose not to participate in the survey is not captured. This omission may overlook valuable insights or noteworthy viewpoints held by non-respondents.

3.7.6 Survey Questionnaire

The effectiveness of the survey questionnaire in capturing participant's opinions and knowledge may be limited by its clarity and comprehensiveness. While efforts were made to pilot-test the survey instrument, certain perspectives may not have been fully captured. Also, external factors such as economic trends or industry advancements, which were not addressed in the study, may have influenced participants.

3.7.7 Generic survey link

One limitation of the study stems from the distribution method of the survey via a generic link on Qualtrics. While this approach was intended to reach the target audience effectively, it also resulted in the collection of random responses from individuals interested in mass timber from other sectors. Unfortunately, these responses were not useful for the specific focus of the study.

4 CHAPTER: RESULTS

In the preceding chapters, the methodological framework guiding the exploration of knowledge gaps and perceptual determinants regarding mass timber adoption within the U.S. construction industry was meticulously outlined. With a focus on quantitative methodologies, this research aimed to provide insightful contributions to the sector's ongoing development. In this chapter, we transition from methodological exploration to the empirical unveiling of findings derived from our rigorous investigation endeavors.

This chapter is devoted to representing the results of the study, focusing on three primary objectives:

1. Identifying key knowledge gaps
2. Factors influencing perceptions of mass timber adoption.
3. Examining variation among students, faculty, and industry professionals in their understanding of mass timber.

The study's findings contribute significantly to both theoretical understanding and practical applications in construction. By identifying key insights, it offers valuable guidance for both the academic and industry stakeholders to navigate this intricate landscape. Furthermore, by recognizing variations in perceptions across different demographics, the study lays the groundwork for targeted interventions aimed at fostering inclusive discourse within the industry.

4.1 DESCRIPTIVE STATISTICS

This section offers an analysis of essential descriptive statistics derived from the survey responses gathered for the study. A total of 626 responses were received by the survey's end, out of which 440 were deemed usable following data cleaning. Figures 4.1, 4.2, and 4.3 illustrate the geographical distribution of respondent universities in the case of students and faculty, and the locations of companies in the case of industry professionals within the United States. This indicates strong support and responsiveness from the target population, affirming the robustness of the study's data collection efforts.

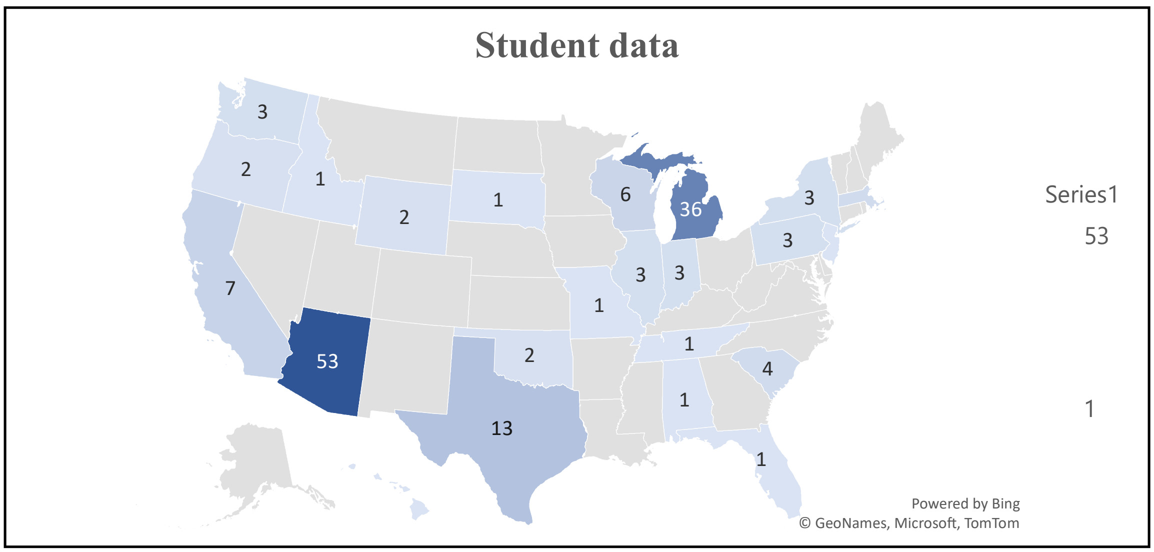


Figure 4.1: Student response diversity

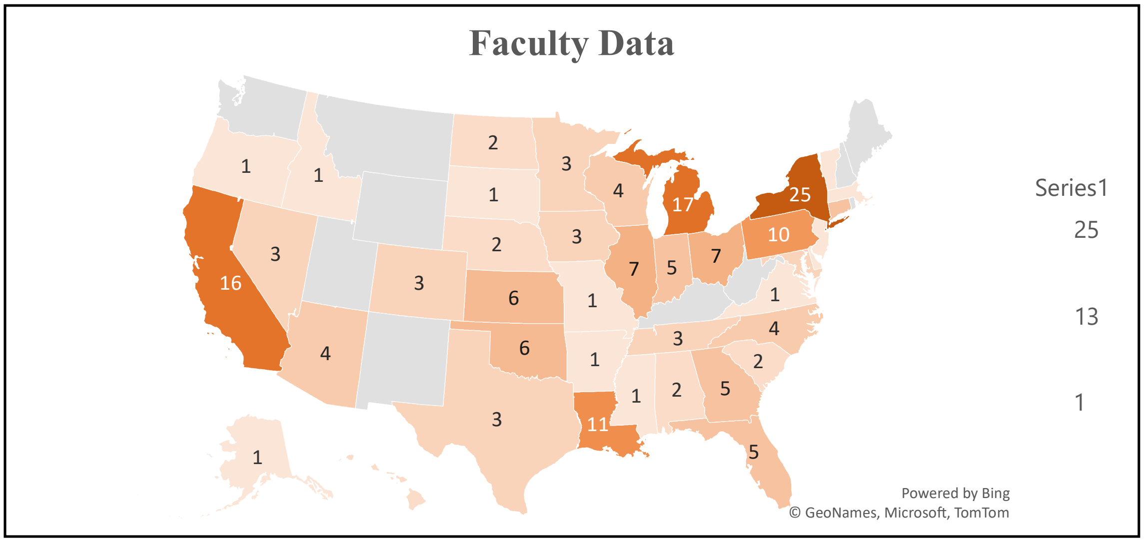


Figure 4.2: Faculty response diversity

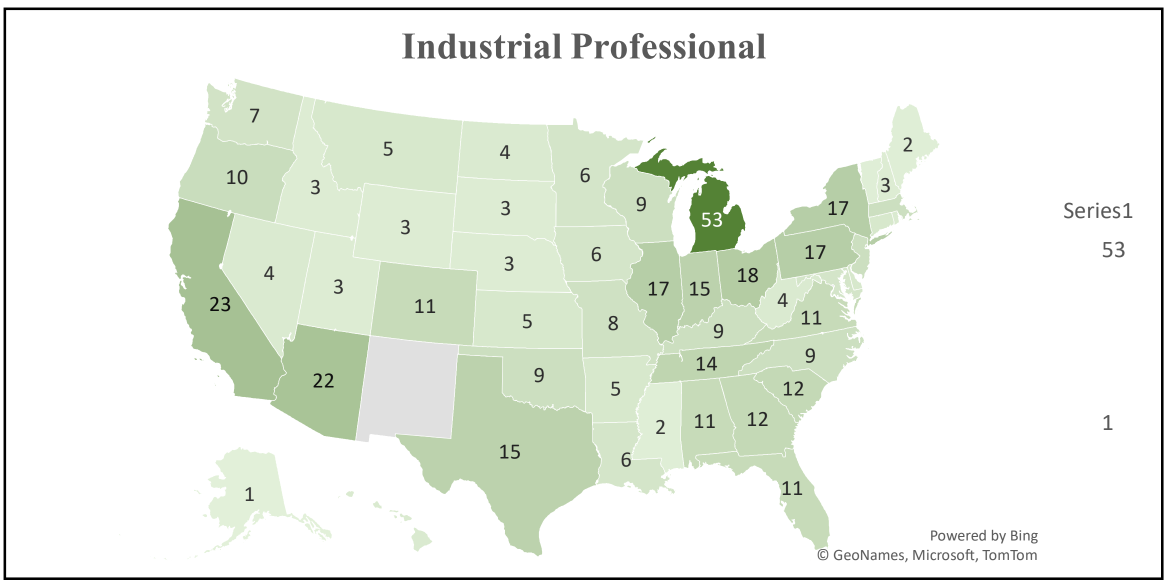


Figure 4.3: Company locations for Industrial responses

4.1.1 Region's v/s No. of respondents

Following the analysis of the survey response data, a descriptive examination was conducted to explore the distribution of responses from academia and industry across different geographic regions in the United States. Findings reveal regional variation in the involvement of academia and industry in mass timber construction. This additional insight enhances the comprehension of the geographic engagement with mass timber within the U.S. construction sector.

Regions	Student	Faculty	Industry Professional	Grand Total
Midwest Region	39	44	37	120
West Region	66	26	21	113
Northeast Region	19	46	11	76
South Region	20	35	13	68
Multi-region	7	14	42	63
Grand Total	151	165	124	440

Table 4.1: Region's v/s No. of respondents

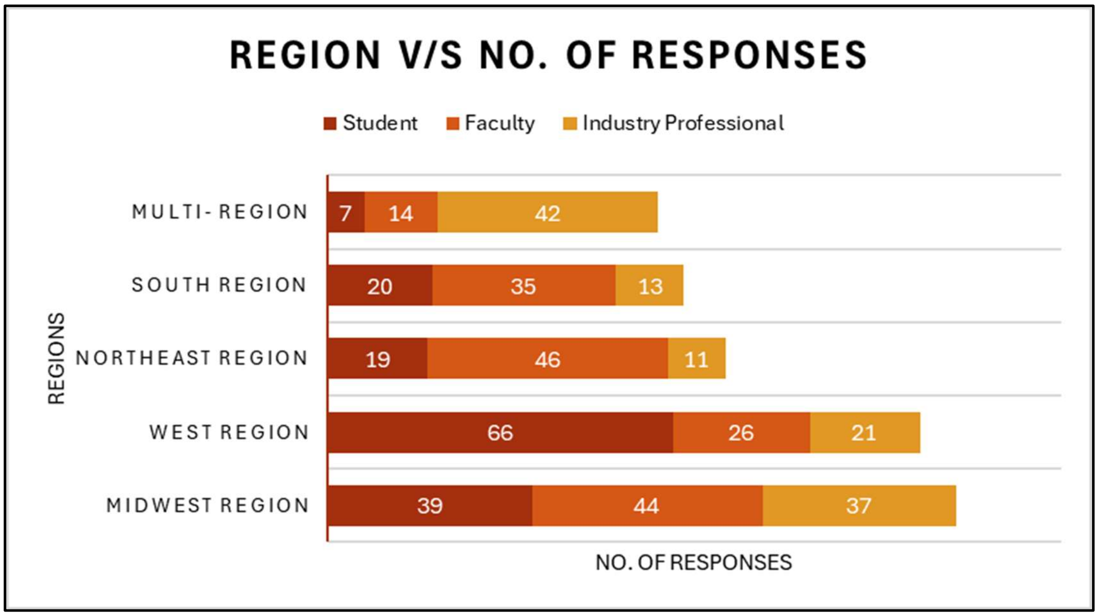


Figure 4.4: Region V/s responses descriptive

For instance, the West region exhibited a higher number of responses from academia compared to industry suggesting a potentially stronger academic presence or interest in mass timber construction education and research in that area. Conversely, the Midwest region also showed a significant number of responses across all groups, indicating robust regional engagement. The multi-region showed a higher number of industrial responses indicating a possible concentration of industry activities over multiple regions, indicating a possible concentration of industry activities or interest in mass timber construction projects.

These findings highlight the regional distribution of survey responses and underscore the importance of considering geographic context when interpreting the data. While the number of respondents from each region provides valuable insights into geographic engagement with the survey, it does not necessarily imply a corresponding level of experience or knowledge within the region's academic and industry sectors. Addressing these regional biases in future studies could help provide a more balanced perspective on mass timber adoption across the U.S.

4.1.2 Insights from the Industry Responses

The pie chart below shows the distribution of Industry professional responses among different sectors of the U.S. Construction Industry. The pie chart is divided into 4 major sections Construction Management, Architecture, Civil Engineering, and others. These sections are further divided as per their company's primary role in the industry.

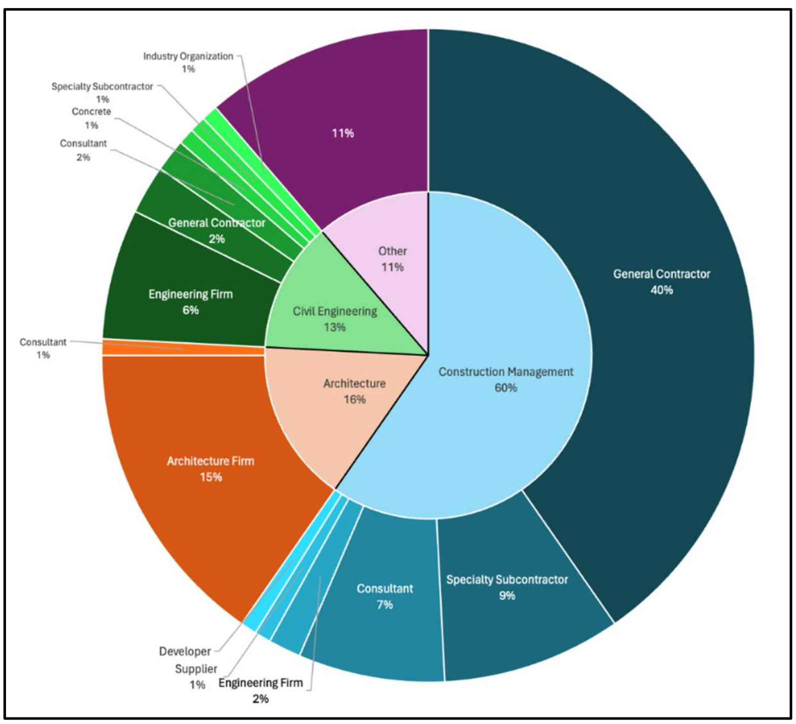


Figure 4.5: Insights into Industry responses

4.1.3 Industry response diversity- MT experience v/s no experience

Here is a pie chart representing the diversity of industry responses based on experience with mass timber. The charts show that out of the total 124 industry responses that were received, 36% were from respondents with mass timber experience, while 64% were from those without any mass timber experience.

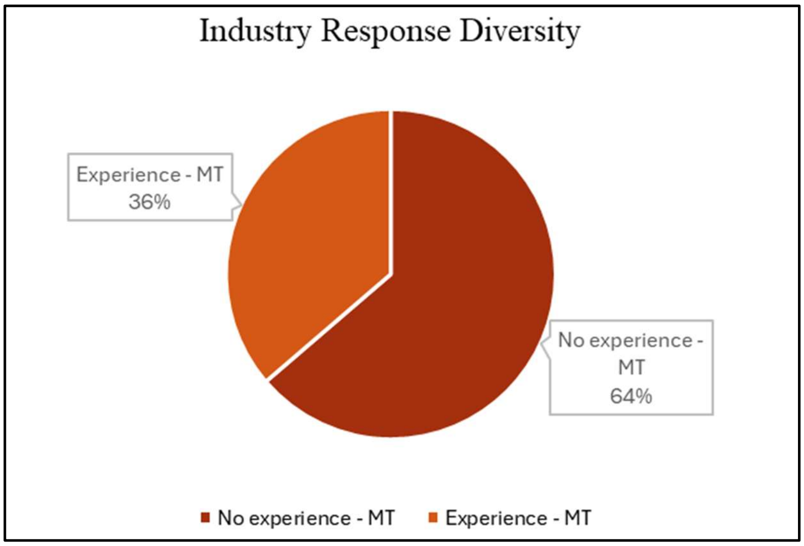


Figure 4.6: MT experience v/s No MT experience

This distribution suggests that a majority of industry professionals surveyed lacked direct experience with mass timber, which is crucial for a well-rounded analysis. Interestingly, this lack of experience among the majority of respondents strengthens the study. It indicates that the findings are less likely to be skewed by a strong inclination towards mass timber, thereby offering a more balanced and unbiased perspective on the current knowledge and perceptions within the industry.

This diversity in experience levels among the respondents provides a robust foundation for understanding the broader attitudes towards mass timber across various sectors of the construction industry.

4.1.4 Mass timber availability v/s Industrial experience

Scale	Response on Mass timber's market availability in the U.S. market.	1 MT Project	2 - 5 MT Projects	5+ MT Projects	No experience with MT	Grand Total
1	I Don't Know		1		7	8
2	Strongly Disagree	1	1		1	3
3	Disagree				1	1
4	Neither Agree nor diagree	1	1	3	7	12
5	Agree	4	7	2	29	42
6	Strongly Agree	7	10	7	34	58
Grand Total		13	20	12	79	124

Table 4.2: Mass timber availability v/s Industrial experience

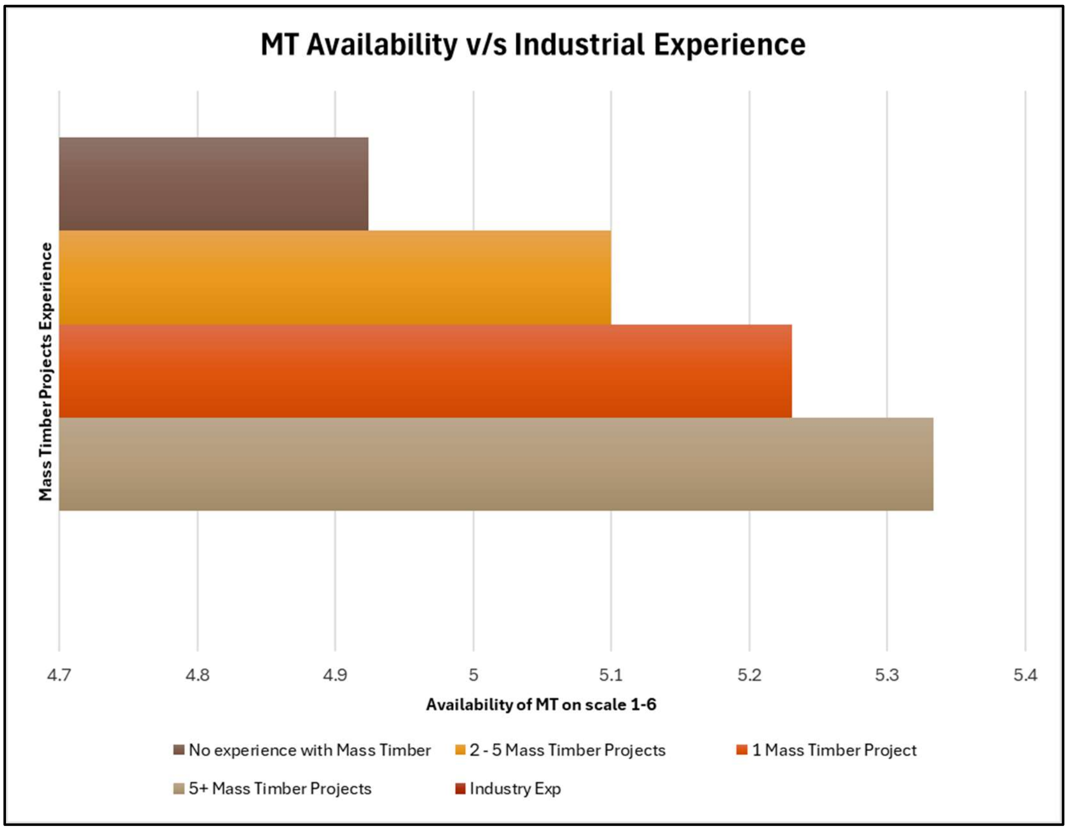


Figure 4.7: MT availability Vs Industrial Experiences

The analysis of industry experience versus the perceived availability of Mass Timber material in the United States reveals compiling insights into stakeholders' perspectives. Among the total 124 industry professionals respondents, a diverse range of experiences was observed. Notably, 13 individuals reported involvement in a single mass timber project while 20 participants worked on two to five such projects. Additionally, 12 respondents boasted of their experience with over 5 Mass Timber projects. There is a substantial portion of respondents yet to engage in any mass timber project. It should be noted that while plotting the data a means was considered for each group response. When assessing respondents' perceptions on a scale from 1 to 6 with 1 representing uncertainty and 6 indicating strong agreement, noteworthy patterns emerged for those with extensive experience in mass timber projects particularly with over 5 projects expressing strong agreement regarding mass timber availability in the United States market. This sentiment was echoed by respondents with involvement in a single mass timber project, followed closely by those engaged in two to five projects. Such findings signify a positive indication of mass timber accessibility within the United States market.

4.1.5 The state-wise mean difference in knowledge perception and attitude towards mass timber adoption relative to the number of local mass timber projects

This section represents a comprehensive analysis comparing the mean differences in knowledge, perception, and attitude towards the adoption of mass timber among students, faculty, and industry professionals across various states in the United States. The analysis is based on the responses collected, and it aims to provide insights into regional variations in the aspects.

- Visualization and Interpretation

The visualization used in this analysis features heat maps across the states of the United States that denote the mean score on a scale of 1 to 5. These mean scores reflect the respondent's knowledge, perception, and attitude towards mass timber. Additionally, the size of the circles on the map represents the number of mass timber projects as of 2024 as per (WoodWorks, 2024) in each state that provided responses for the study.

- Purpose and Curiosity

This descriptive analysis was conducted out of curiosity to explore how students, faculty, and industry professionals from various states perceive mass timber concerning no of mass timber projects in their respective states. The underlying hypothesis was that respondents from states with a higher number of mass timber projects or greater mass timber awareness might exhibit different attitudes and perceptions compared to those from regions with fewer projects or less awareness.

4.1.5.1 The state-wise mean difference in Student respondents' knowledge perception and attitude towards mass timber adoption relative to the number of local mass timber projects

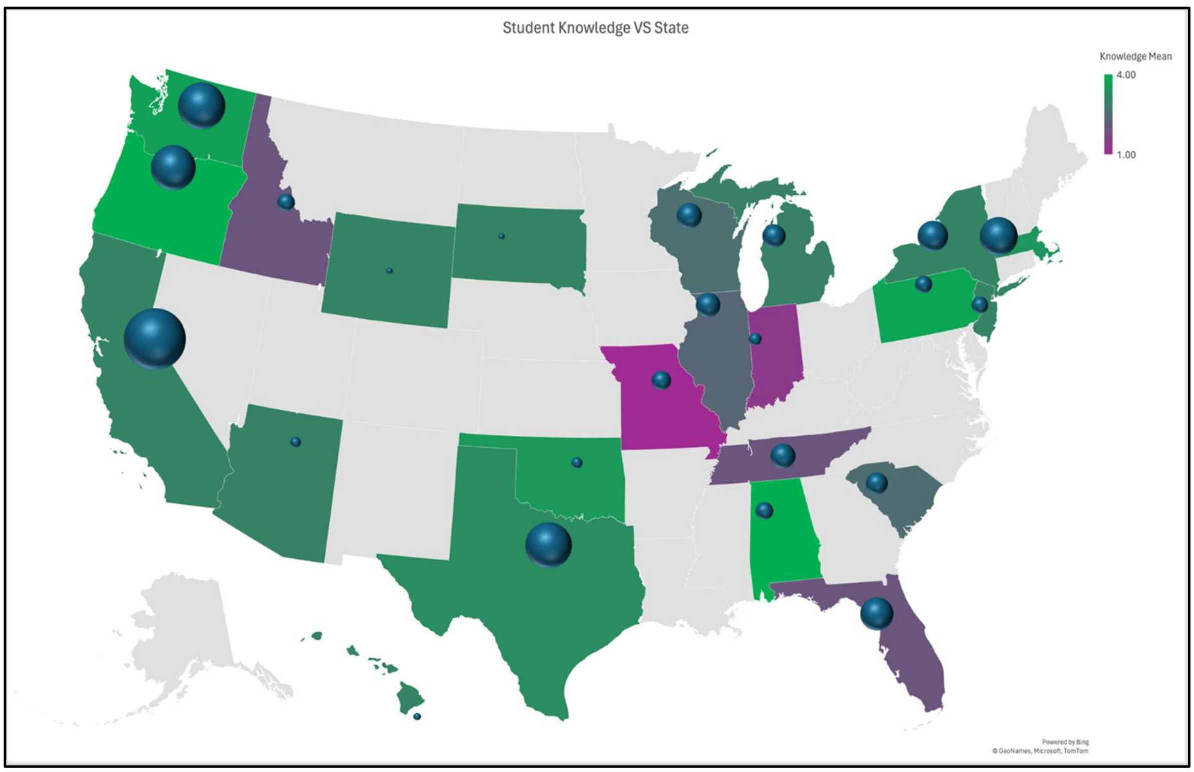


Figure 4.8: State-wise mean difference in Student respondents' knowledge

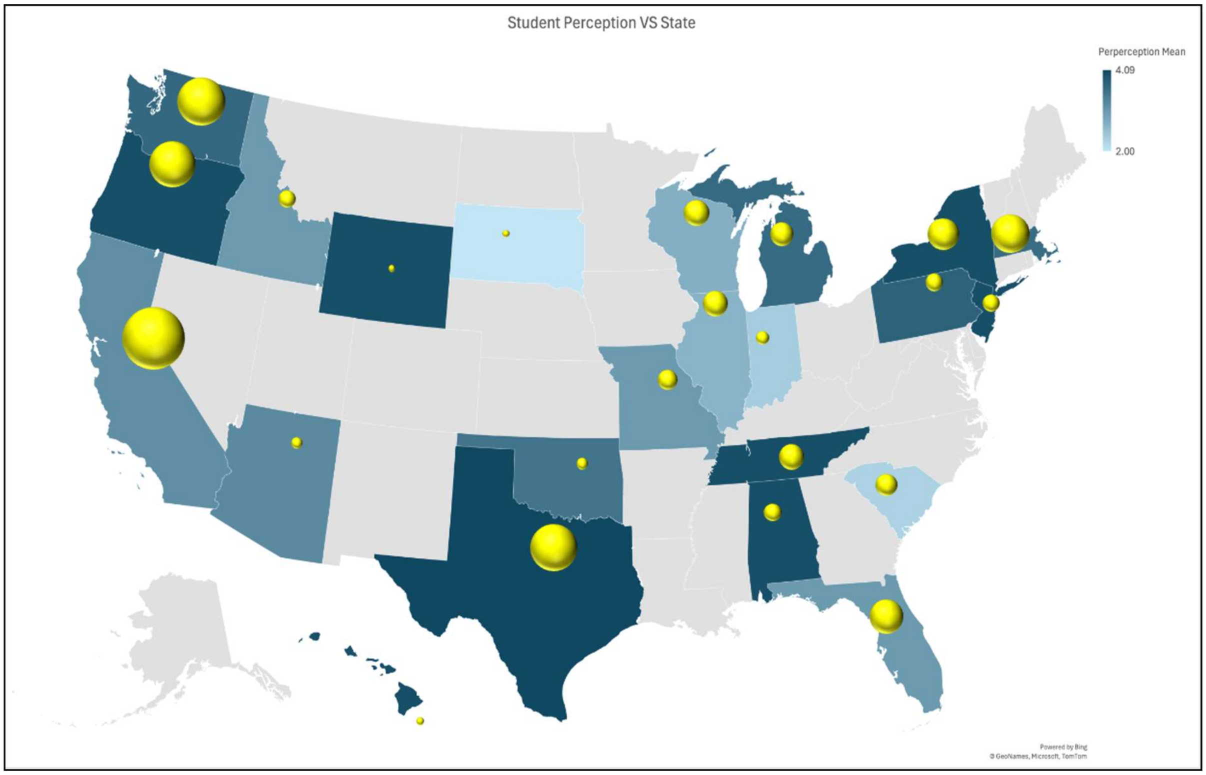


Figure 4.9: State-wise mean difference in Student respondents perception

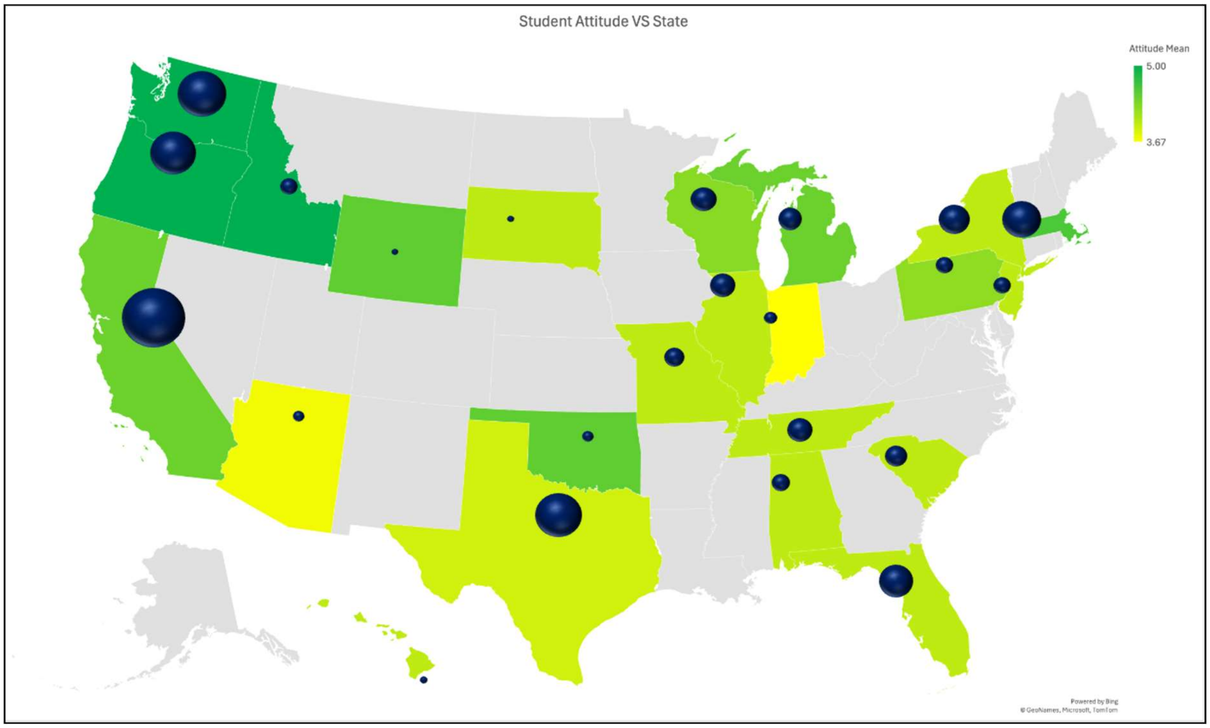


Figure 4.10: State-wise mean difference in Student respondents' attitude

4.1.5.2 The state-wise mean difference in Faculty respondents' knowledge perception and attitude towards mass timber adoption relative to the number of local mass timber projects

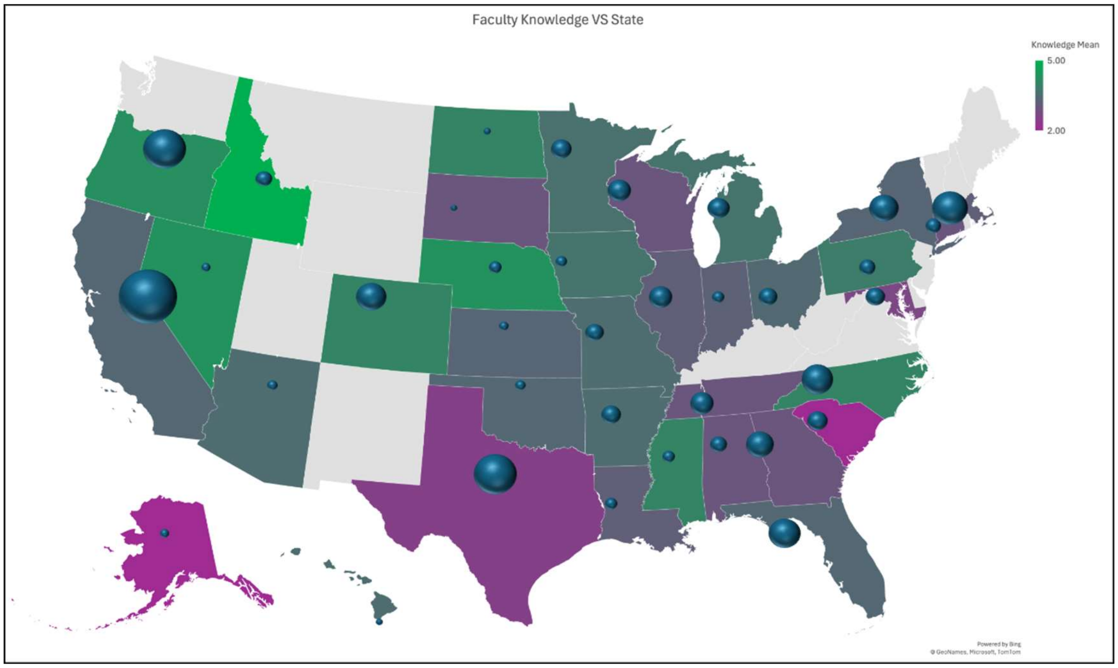


Figure 4.11: State-wise mean difference in Faculty respondents' knowledge

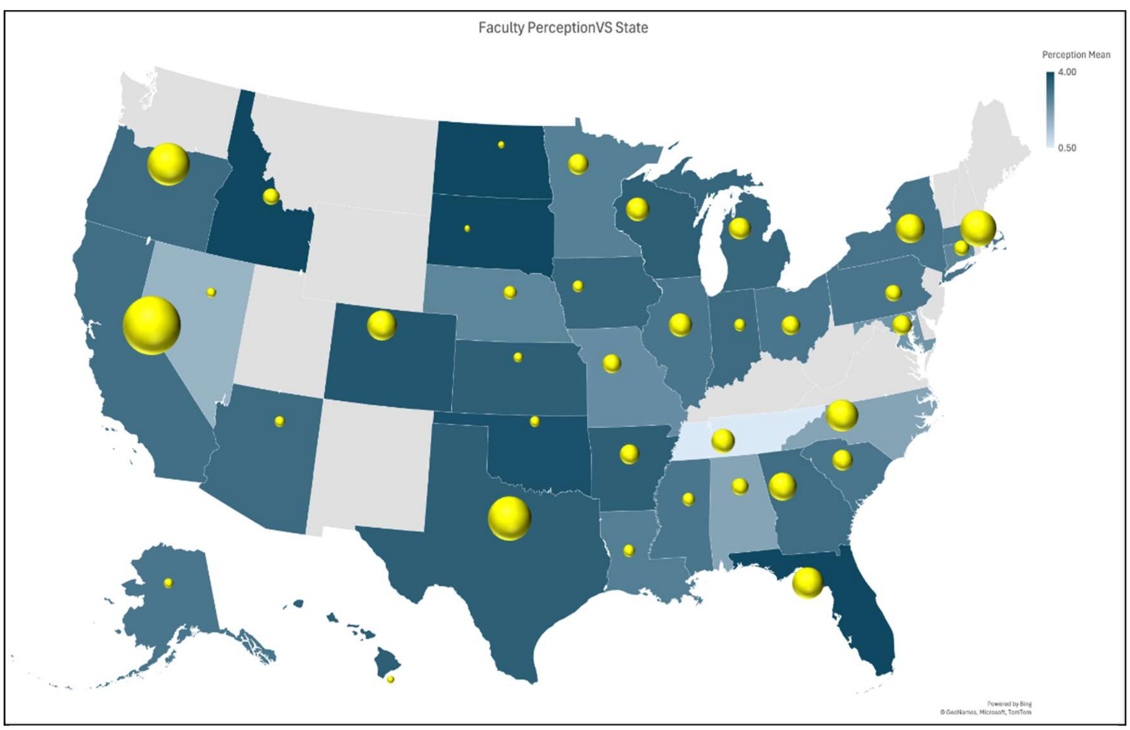


Figure 4.12: State-wise mean difference in Faculty respondents' perception

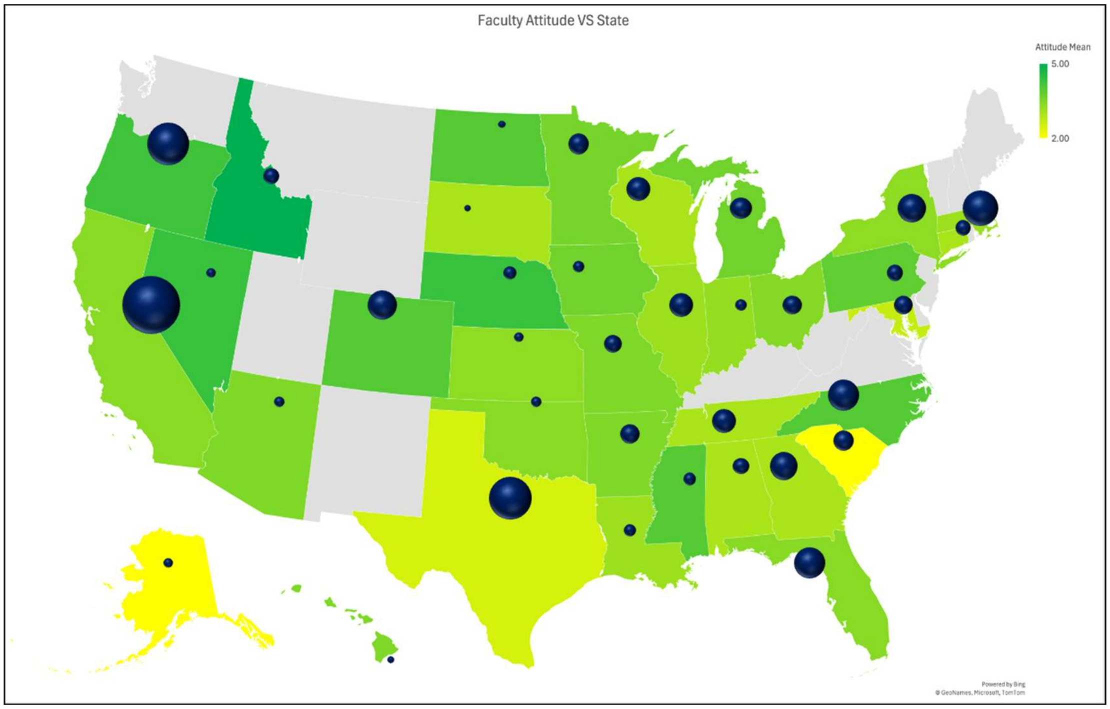


Figure 4.13: State-wise mean difference in Faculty respondents' attitude

4.1.5.3 The state-wise mean difference in Industry respondents' knowledge perception and attitude towards mass timber adoption relative to the number of local mass timber projects

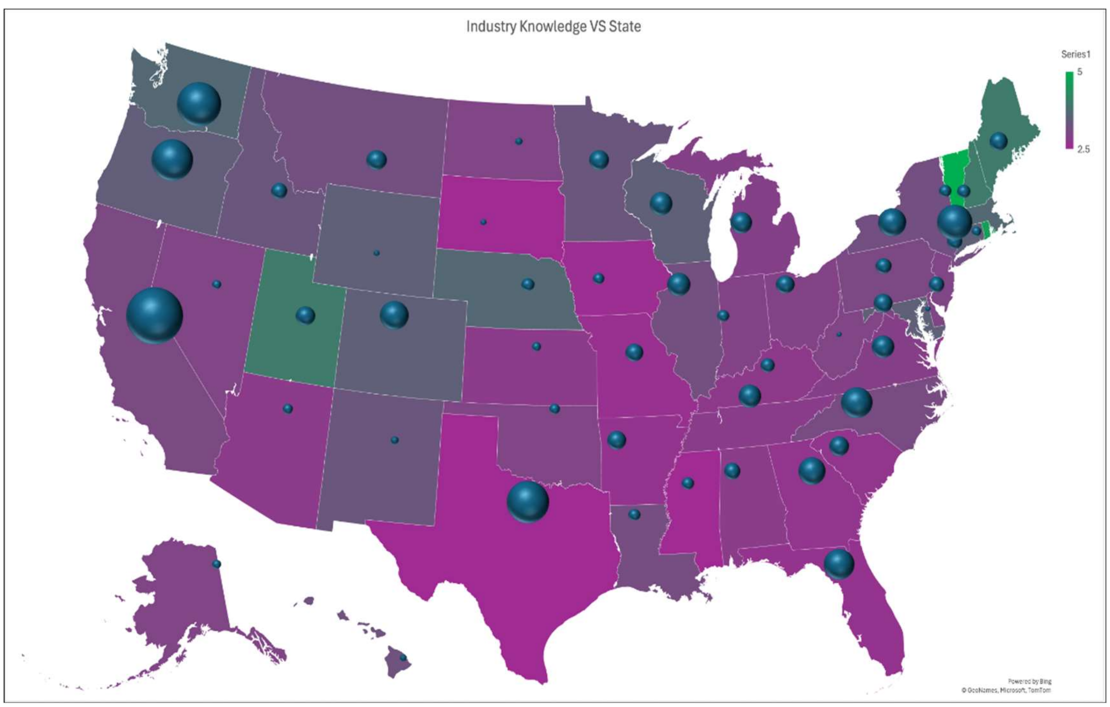


Figure 4.14: State-wise mean difference in Industry respondents' knowledge

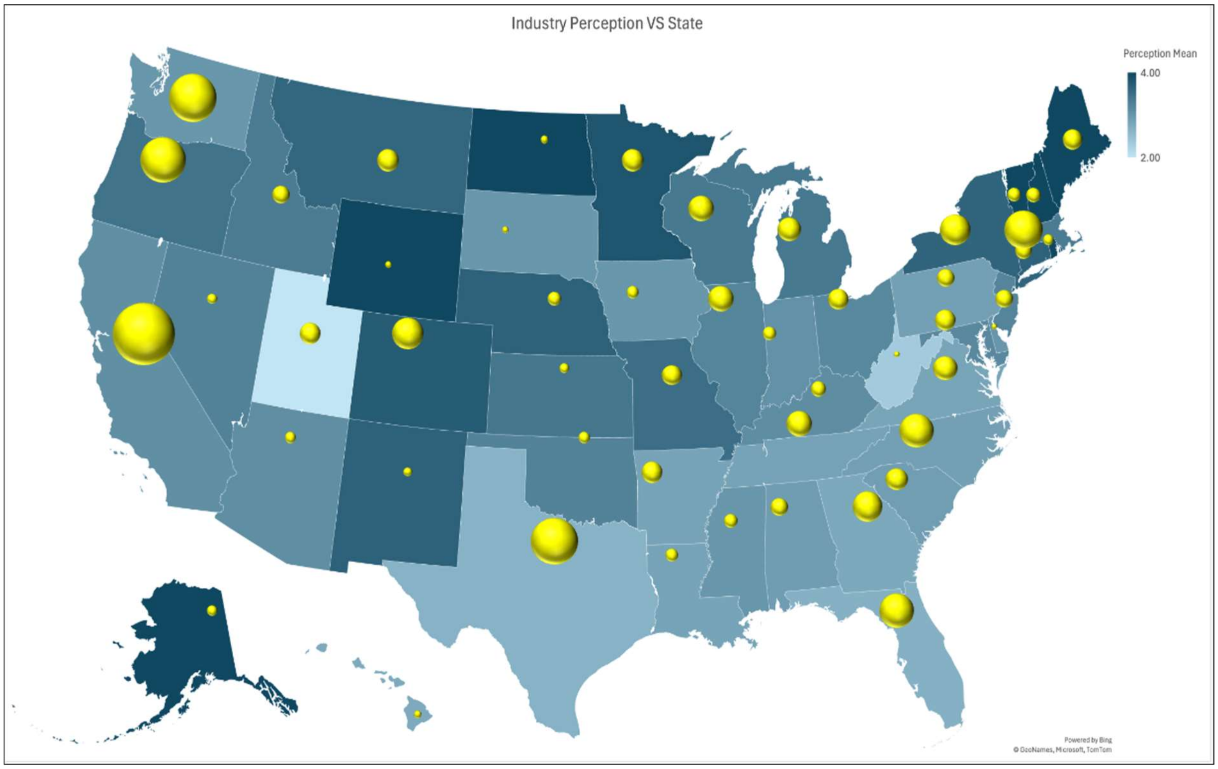


Figure 4.15: State-wise mean difference in industry respondents' perception

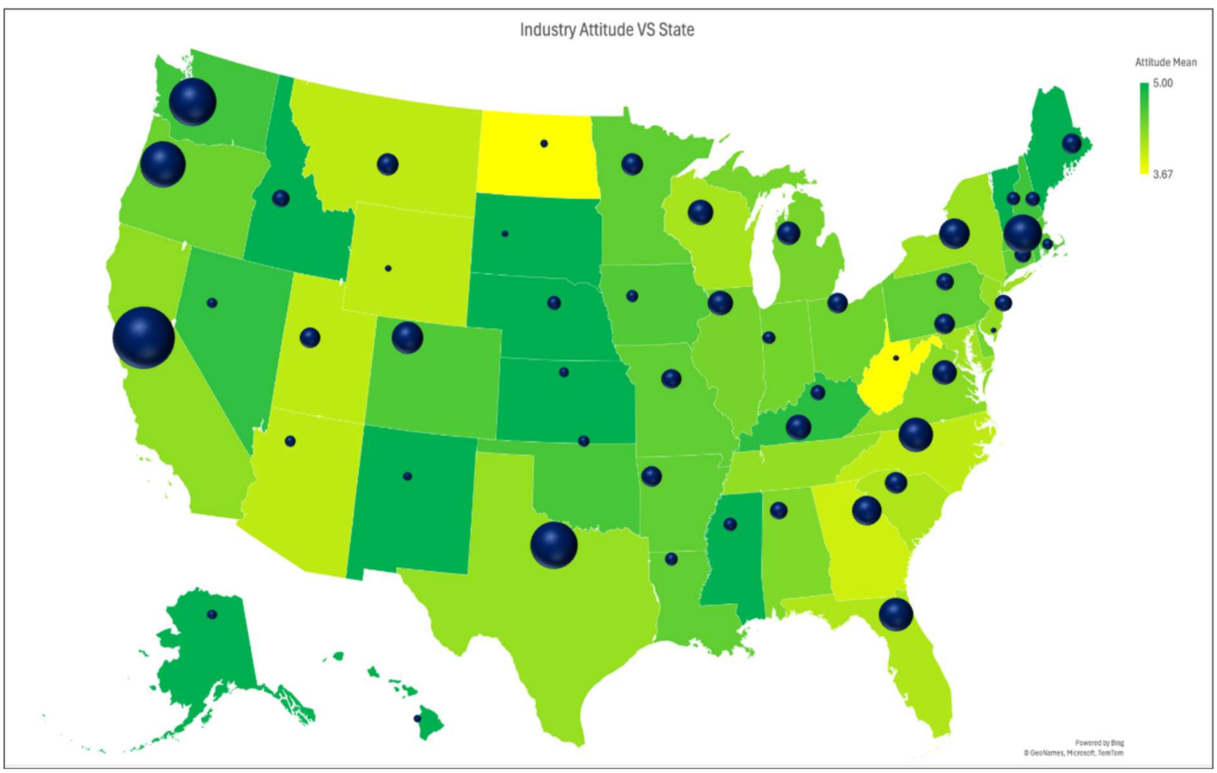


Figure 4.16: State-wise mean difference in Industry respondents' attitude

Key findings:

1. Regional Variations in Mean Scores: The shades on the heat map indicate that there are notable regional differences in mean scores. States with more extensive mass timber projects tend to show higher mean scores, indicating greater knowledge and more positive perceptions and attitudes towards mass timber.
2. Impact of Project Density: The size of the circles represents the number of mass timber projects in each state. This visualization helps us examine whether a higher density of projects in a state correlates with increased knowledge, perception, and attitudes towards mass timber adoption among respondents.
3. Stakeholder differences: By comparing the responses of students, faculty, and industry professionals, the analysis highlights distinct differences in their views. For instance, industry professionals might have more practical knowledge and a more favorable attitude towards mass timber due to their direct involvement in projects, while students and faculty might approach the subject from a more theoretical perspective.

This section underscores the importance of regional context in understanding the adoption of mass timber. The findings suggest that geographic location and the prevalence of mass timber projects significantly influence the knowledge, perceptions, and attitudes of different stakeholder groups. These insights can be valuable for policymakers, educators, and industry leaders aiming to promote the adoption of mass timber across diverse regions.

4.2 EXPLORATORY DATA ANALYSIS: BETWEEN GROUPS

4.2.1 Current knowledge about mass timber

Statistical analysis was conducted to address the first part of the research question, which focuses on identifying the key knowledge gaps related to mass timber in the US construction industry. The null hypothesis (H0) posits that there is no significant difference in the knowledge gaps across the demographic groups, while the alternative hypothesis (H1) suggests that there is a significant difference. Before proceeding with the inferential analysis, the normality of the data distribution was assessed as most of the tests including ANOVA work on the assumption of the data being normally distributed. Hence to test the normality Shapiro- Wilk test was conducted for all three groups students, faculty, and industry where the assumed alpha was 0.05.

Additionally, normality was assessed using measures of Skewness and Kurtosis, checking if the z scores fell within the range of -1.96 to +1.96, which also indicates normality.

The results as shown in Table 4.3 show that the observed significance (*p*) is less than the assumed alpha of 0.05 for students and industry thus indicating the data is not normally distributed. Therefore, non-parametric tests were deemed appropriate for further analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.194	0.197	-0.111	0.189	0.361	0.217
Z Score	-0.98		-0.59		1.66	
Kurtosis	0.244	0.392	-0.413	0.376	-0.392	0.431
Z Score	0.62		-1.10		-0.91	
p -value	0.033		0.108		0.019	
Result	Not Normal		Normal		Not Normal	

Table 4.3: Knowledge data test of normality using Shapiro-Wilk

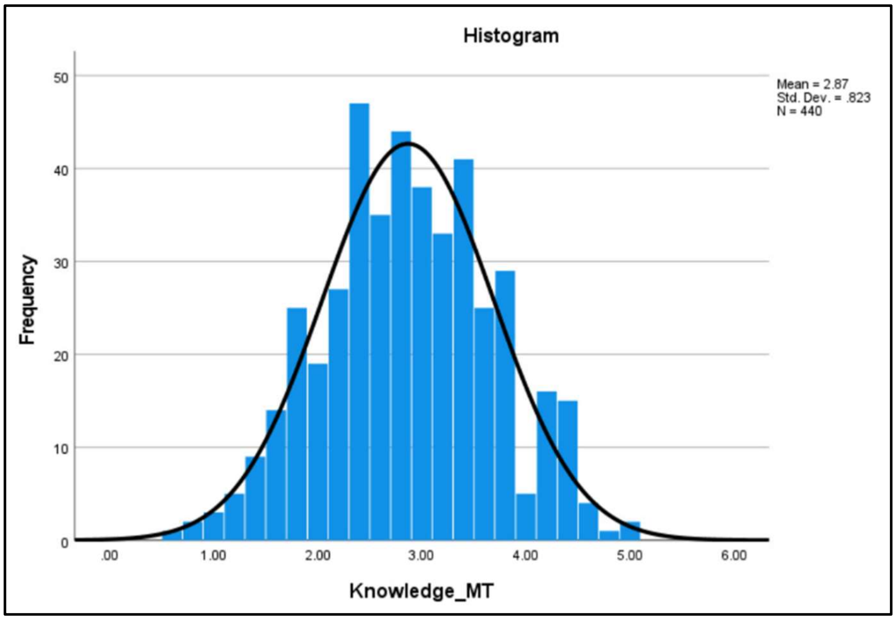


Figure 4.17: Histogram plot for test of normality on Mass Timber knowledge

To investigate potential differences in current knowledge among the groups, the Kruskal-Wallis test was employed. The results indicated a significant difference, x^2 (2, N = 440) = 16.83, $p <$ 0.001, leading to the rejection of the null hypothesis. Hence, there is a significant difference in the knowledge gaps related to mass timber among academic groups and industry professionals in the US construction industry. Refer to Figure 4.18, a box plot illustrating the distribution of current knowledge across the groups (Alessandro, 2020).

Subsequently, pairwise comparisons were conducted to explore the specific differences between disciplines. The adjusted significance values revealed a notable knowledge gap between the industry and faculty groups, with a significance level of <0.00, falling below our assumed alpha value of 0.05. Refer to Figure 4.19, which presents the pairwise comparison of discipline by mean rank.

MT_Current Knowledge					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	2.82	2.80	2.76	215.90
Faculty	165	3.05	3.20	3.50	249.19
Industry	124	2.66	2.60	2.48	187.92
Total	440				

Table 4.4: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Knowledge_MT is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

Table 4.5 Kruskal-Wallis pairwise test results for knowledge of mass timber

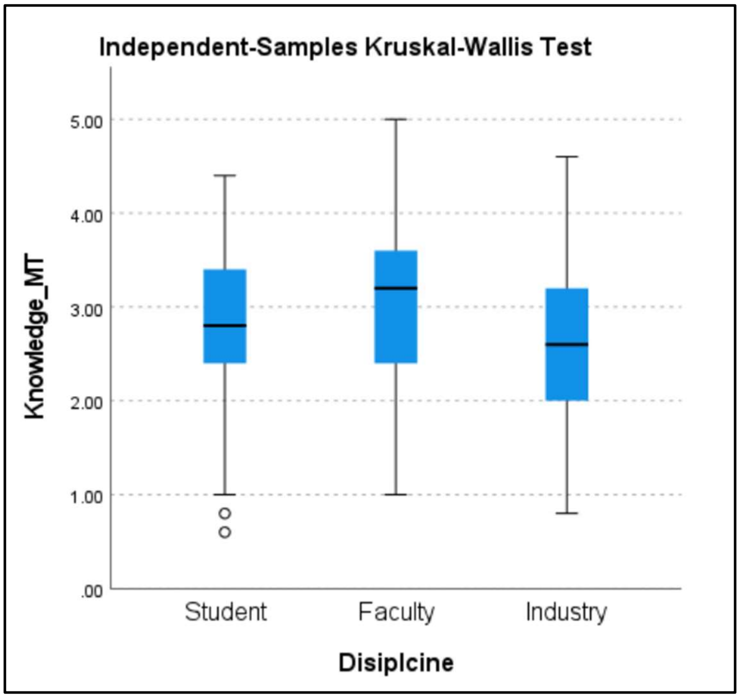


Figure 4.18: Box plot results for knowledge of mass timber across disciplines

Pairwise Comparisons of Disiplcine

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Industry-Student	27.981	15.367	1.821	.069	.206
Industry-Faculty	61.275	15.070	4.066	<.001	.000
Student-Faculty	-33.293	14.280	-2.331	.020	.059

Table 4.6: Pairwise test results

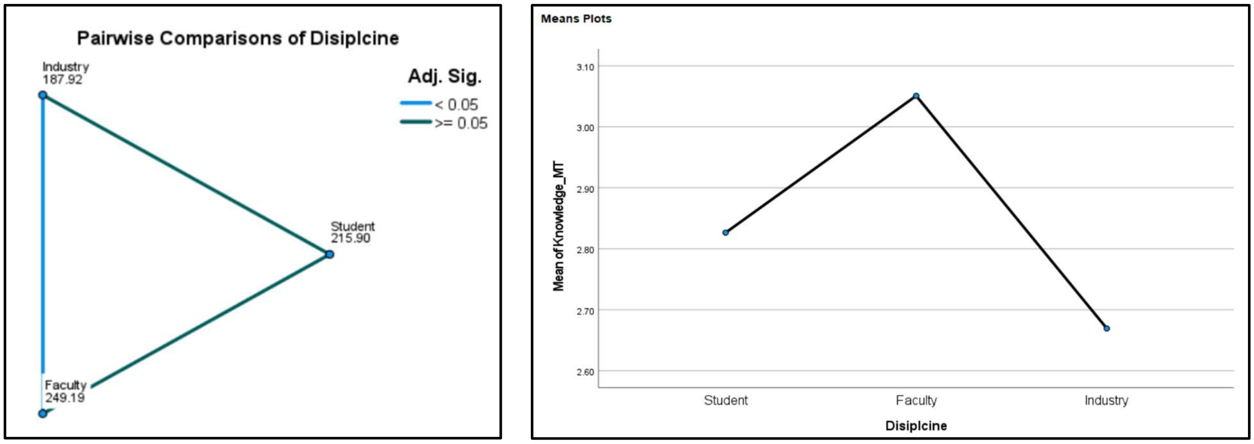


Figure 4.19: Pairwise Comparisons and Means Plot

4.2.2 Perception of mass timber

Statistical analysis was conducted to address the second part of the research question, which focuses on identifying the factors influencing the perceptions of mass timber in the US construction industry. The null hypothesis (H0) posits no significant difference in the perceptions between academia and industry while the alternative hypothesis (H1) suggests a significant difference.

To delve into perceptions, survey questions were further sub-categorized into three distinct areas refer to Table 3.1:

1. Based on the performance of mass timber
2. Based on sustainability and environmental impact
3. Based on safety and regulatory compliance

For each of these areas, the data underwent a normality test followed by Kruskal Wallis analysis. The results of these analyses are further discussed and illustrated to provide insights into the factors influencing the perceptions of mass timber within the US—construction industry.

4.2.2.1 Based on the performance of mass timber

To test the normality of the data Shapiro- Wilk test along with Skewness and Kurtosis was conducted for all three groups students, faculty, and industry. Where the assumed alpha was 0.05. The results as shown in Table 4.7 show that the observed significance is less than the assumed alpha of 0.05 for all the three groups thus indicating the data is not normally distributed. Therefore, non-parametric tests were deemed appropriate for further analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.486	0.197	-1.165	0.189	-1.14	0.217
Z Score	-7.54		-6.16		-5.25	
Kurtosis	2.463	0.392	1.153	0.376	0.425	0.431
Z Score	6.28		3.07		0.99	
p -value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.7: Perception data test of normality-(Shapiro-Wilk)

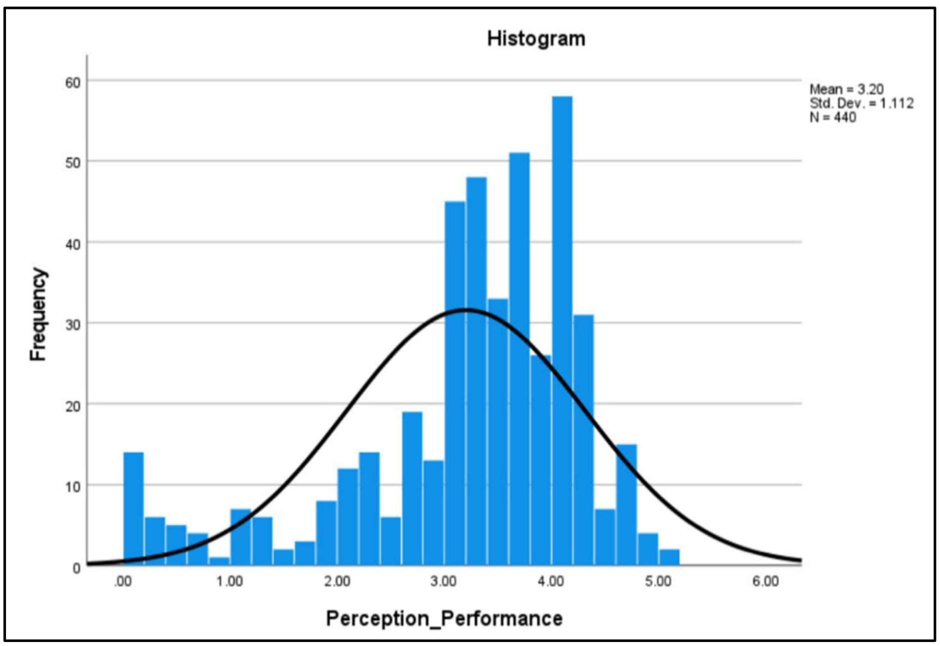


Figure 4.20: Histogram plot for test of normality on performance perception

To assess whether there was a significant difference in perceptions based on the performance of mass timber among the groups, the Kruskal Wallis test was employed. The results indicated a significant difference, x^2 (2, N = 440) = 8.86, p = 0.012, promoting the rejection of the null hypothesis. Hence, perceptions based on the performance of mass timber in the construction industry differ between the academic group and industry professionals. Refer to Figure 4.21, which illustrates a box plot showing the distribution of perception based on performance across the groups.

Additionally, pairwise comparisons were conducted to pinpoint specific differences between disciplines. The adjusted significance values highlighted a significant distinction in perceptions between the industry and student groups, with a significance level of 0.09. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.22, which presents the pairwise comparison of discipline by mean rank.

Perception_Performance					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.37	3.63	4.15	242.01
Faculty	165	3.21	3.50	4.08	219.01
Industry	124	2.95	3.25	3.85	196.29
Total	440				

Table 4.8: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Perception_Performance is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	.012	Reject the null hypothesis.

Table 4.9: Kruskal-Wallis pairwise test results for perception of performance across disciplines

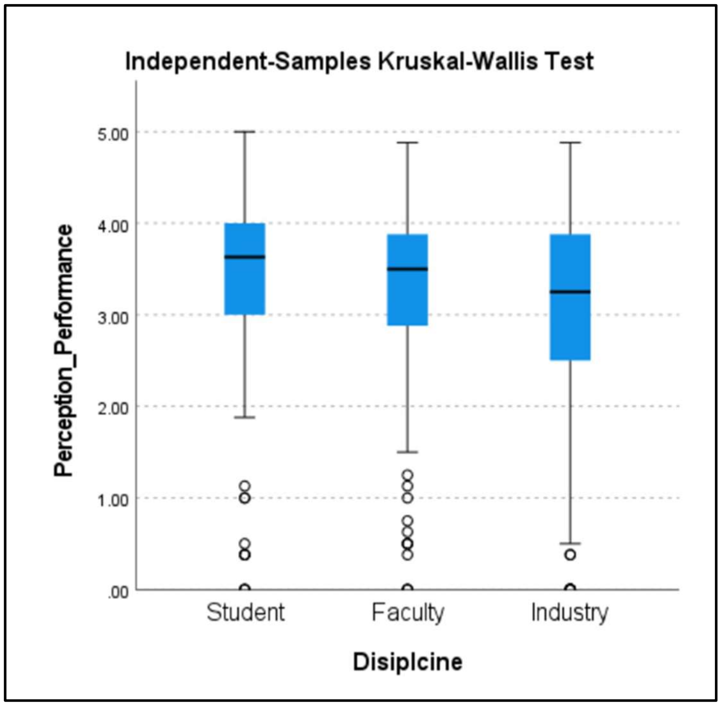
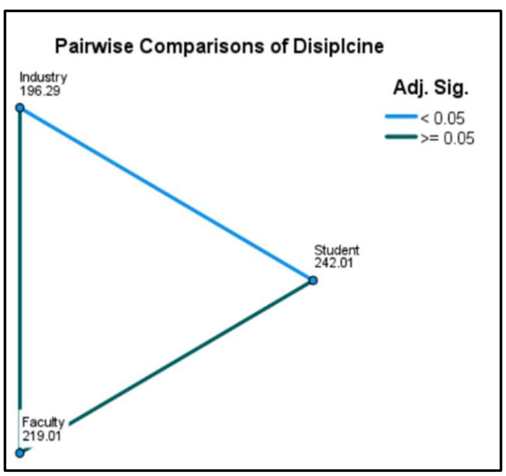


Figure 4.21: Box plot results for perception based on performance of mass timber across disciplines

Pairwise Comparisons of Disiplcine

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Industry-Faculty	22.712	15.092	1.505	.132	.397
Industry-Student	45.716	15.389	2.971	.003	.009
Faculty-Student	23.004	14.301	1.609	.108	.323

Table 4.10: Pairwise test results



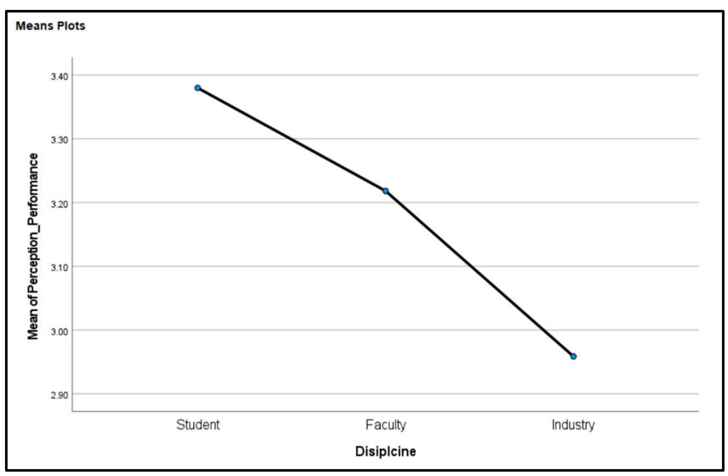


Figure 4.22: Pairwise Comparisons and Means Plot

4.2.2.2 Sustainability and Environmental Impact

Similar to the above, the normality of the data for the three groups was assessed using the Shapiro-Wilk, Skewness, and Kurtosis test with a predetermined alpha level of 0.05. The results displayed in Table 4.11 reveal that the observed significance is below the assumed alpha of 0.05 for all three groups, indicating the non-normal distribution of the data. Consequently, non-parametric tests were considered more suitable for subsequent analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.253	0.197	-1.269	0.189	-1.022	0.217
Z Score	-6.36		-6.71		-4.71	
Kurtosis	1.82	0.392	1.458	0.376	0.444	0.431
Z Score	4.64		3.88		1.03	
p -value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.11: Sustainability and Environmental Impact Perception data test of normality-(Shapiro-Wilk)

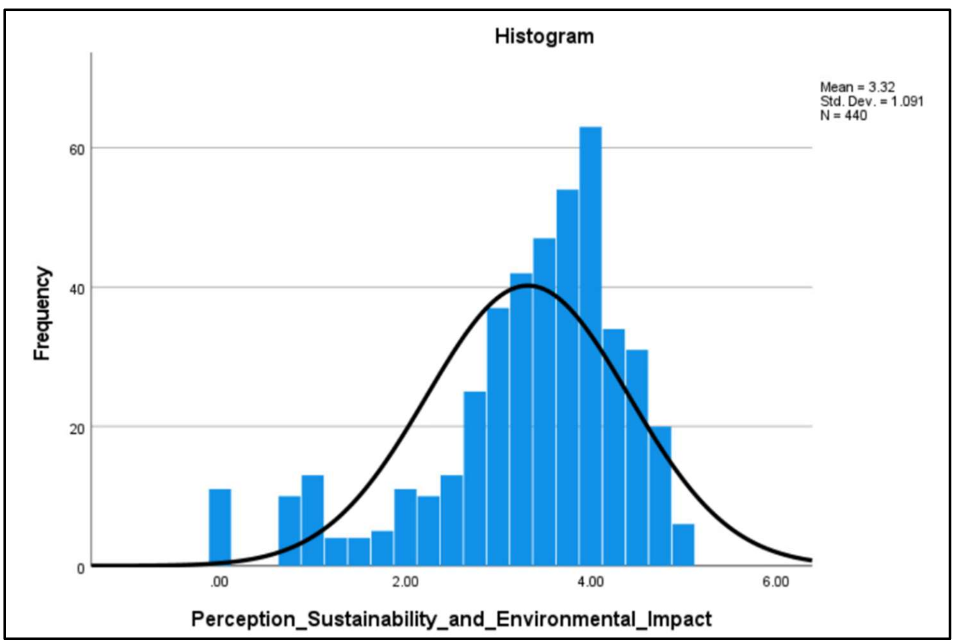


Figure 4.23: Histogram plot for test of normality on Sustainability and Environmental Impact perception

To determine if there was a significant variance in perception based on sustainability and environmental impact of mass timber among the groups, the Kruskal Wallis test was utilized. The outcomes revealed a significance level of x^2 (2, N = 440) = 3.99, p = 0.135, indicating the acceptance of the null hypothesis. Hence, perceptions based on the sustainability and environmental impacts of mass timber in the construction industry do not differ between the academic group and industry professionals. Refer to Figure 4.24, a box plot illustrating the distribution of perception based on sustainability and environmental impact across the groups.

Perception_Sustainability and Environmental Impact					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.43	3.75	4.39	233.59
Faculty	165	3.35	3.75	4.55	221.68
Industry	124	3.14	3.25	3.47	202.99
Total	440				

Table 4.12: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.a,b	Decision
1	The distribution of Perception_Sustainability_and_Environmental_Impact is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	.135	Retain the null hypothesis.

Table 4.13 Kruskal-Wallis pairwise test results for perception of Sustainability and Environmental Impact across disciplines

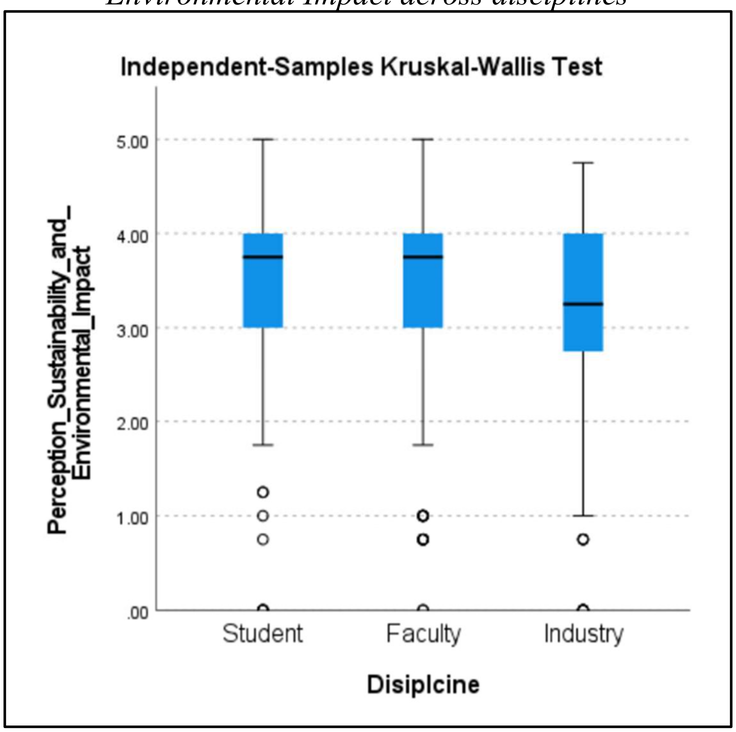


Figure 4.24: Box plot results for perception of Sustainability and Environmental Impact across disciplines

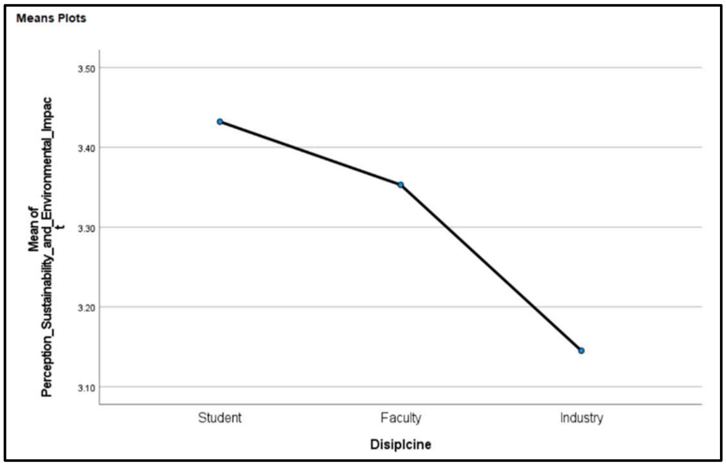


Figure 4.25: Means Plot

4.2.2.3 Safety and Regulatory Compliance

Similarly to the previous analysis, before conducting the test for perceptions of mass timber based on safety and regulatory compliance, the normality of the data for the three groups was evaluated using the Shapiro-Wail test, Skewness, and Kurtosis with an alpha level of 0.05. The results depicted in Table 4.14 demonstrate that the observed significance level is lower than the assumed alpha of 0.05 for all three groups, indicating non-normal data distribution. Therefore, non-parametric tests were deemed more appropriate for further analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.174	0.197	-0.957	0.189	-0.83	0.217
Z Score	-5.96		-5.06		-3.82	
Kurtosis	0.884	0.392	0.293	0.376	-0.433	0.431
Z Score	2.26		0.78		-1.00	
p -value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.14: Safety and Regulatory Compliance Perception data test of normality-(Shapiro-Wilk)

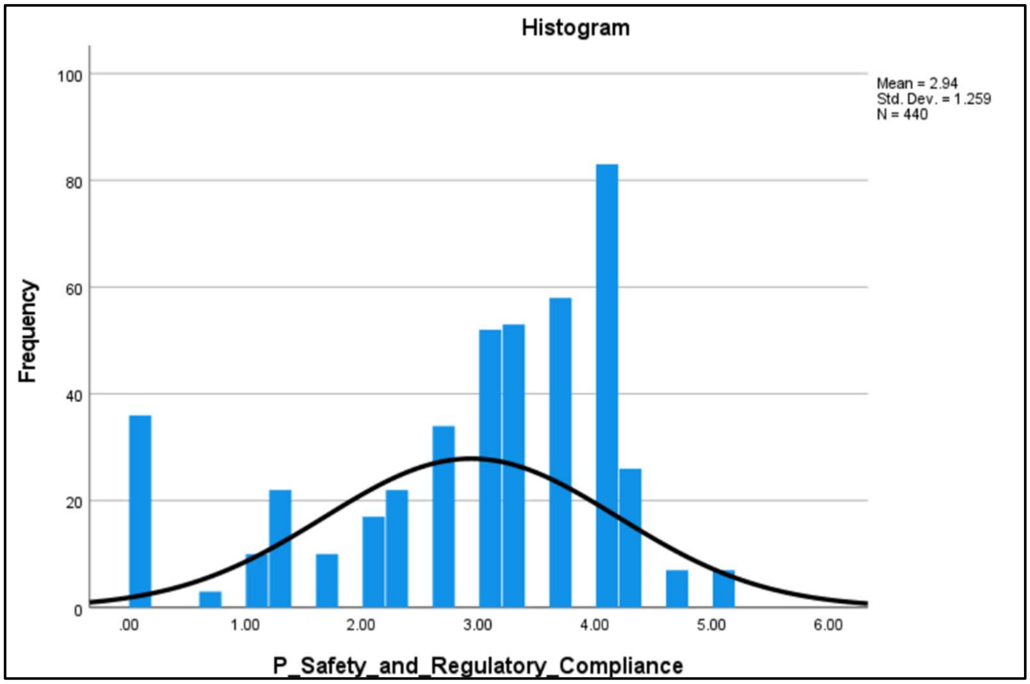


Figure 4.26: Histogram plot for the test of normality on Safety and Regulatory Compliance perception

To ascertain whether there was a significant difference in perception based on safety and regulatory compliance of mass timber among the groups, the Kruskal Wallis test was employed. The results indicated a significance level of x^2 (2, N = 440) = 10.646, p = 0.005, leading to the rejection of the null hypothesis. Hence, perceptions based on the safety and regulatory compliance of mass timber in the construction industry differ between the academic group and industry professionals. Refer to Figure 4.27, a box plot illustrating the distribution of knowledge gaps across the groups.

Furthermore, pairwise comparisons were conducted to identify specific differences between the disciplines. The adjusted significance value revealed a notable distinction in perception between industry and student groups, with a significance of 0.003. This significance level is below the predetermined alpha value of 0.05. Refer to Figure 4.28, which presents the pairwise comparison of discipline by mean rank.

Perception_Safety and Regulatory Compliance					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.13	3.33	3.73	242.36
Faculty	165	2.95	3.33	4.09	221.56
Industry	124	2.65	3.00	3.70	192.47
Total	440				

Table 4.15: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of P_Safety_and_Regulatory_Compliance is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	.005	Reject the null hypothesis.

Table 4.16: Kruskal-Wallis pairwise test results for perception of Safety and Regulatory Compliance across discipline

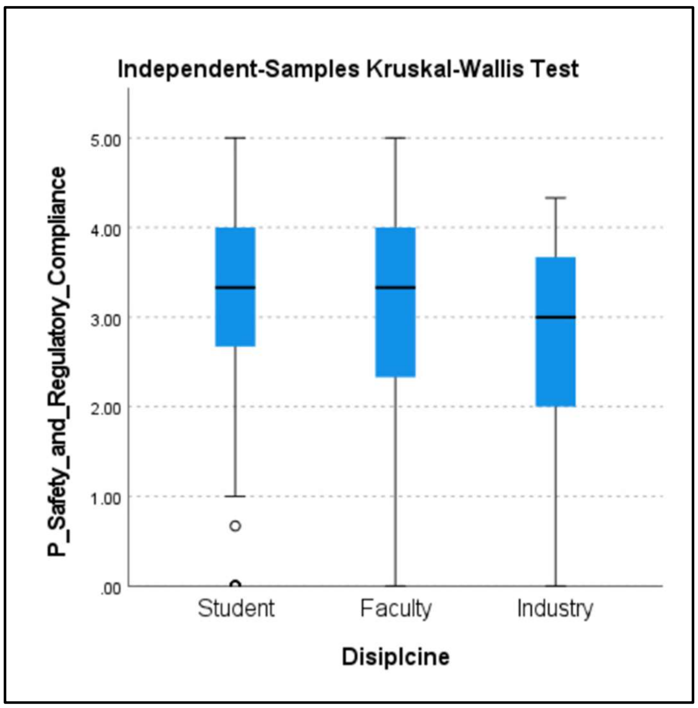


Figure 4.27: Box plot results for perception based on Safety and Regulatory Compliance of mass timber across disciplines

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Industry-Faculty	29.089	15.007	1.938	.053	.158
Industry-Student	49.886	15.303	3.260	.001	.003
Faculty-Student	20.797	14.221	1.462	.144	.431

Pairwise Comparisons of Disiplcine

Table 4.17: Pairwise test results

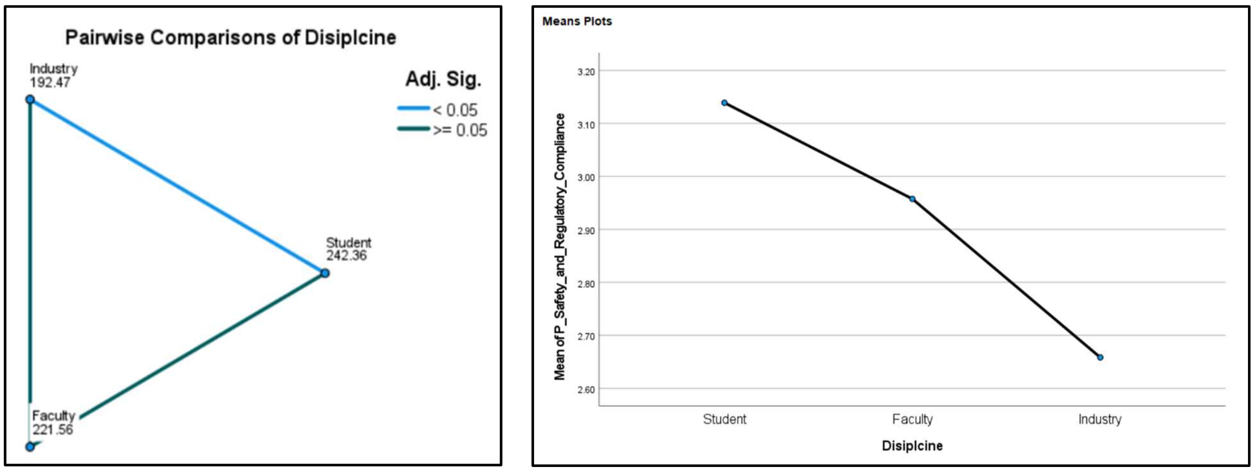


Figure 4.28: Pairwise Comparisons and Means Plot

4.2.3 Adoption of mass timber

To explore the key factors influencing the adoption of mass timber in the us construction industry, statistical analysis was conducted, addressing the third and final part of the research question. The null hypothesis (H0) posited that there is no significant difference in the factors influencing adoption between academia and industry, while the alternative hypothesis (H1) suggested otherwise.

To delve into the factors impacting adoption, survey questions were further categorized into five distinct areas refer to Table 3.1:

1. Based on regulatory support
2. Based on educational and workforce development
3. Based on collaborative efforts

4. Based on environmental and sustainability factors
5. Based on market perception factors

For each of these subcategories, the data underwent initial normality testing followed by Kruskal-Wallis analysis. The results of these are further discussed and illustrated to provide insights into the factors influencing the adoption of mass timber within the US construction industry.

4.2.3.1 Regulatory Support

The Shapiro-Wilk test along with Skewness, and Kurtosis was used to assess the normality of the data for all three groups: students, faculty, and industry, with a set alpha of 0.05. The results depicted in Table 4.18 indicate that the observed significance is below the assumed alpha level of 0.05 for each of the three groups, suggesting that the data does not follow a normal distribution. Consequently, non-parametric tests were considered more suitable for analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.29	0.197	-1.308	0.189	-1.009	0.217
Z Score	-6.55		-6.92		-4.65	
Kurtosis	0.876	0.392	1.323	0.376	0.767	0.431
Z Score	2.23		3.52		1.78	
p-value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.18: Adoption of Regulatory and Policy Factors data test of normality

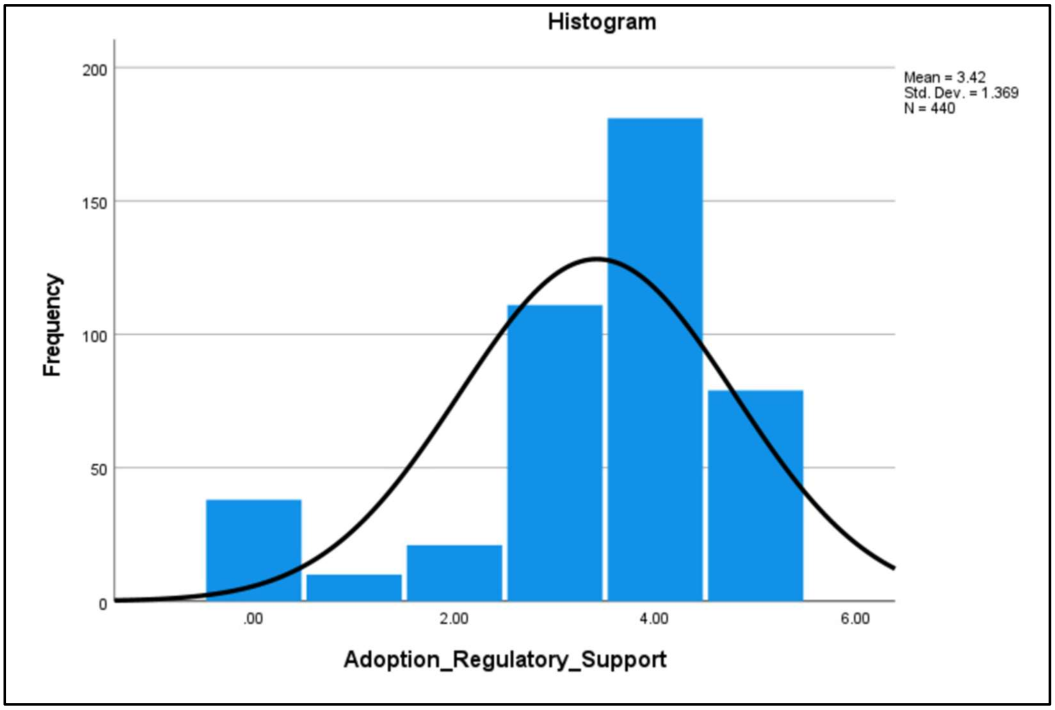


Figure 4.29: Histogram plot for test of normality on Adoption of Regulatory and Policy Factors

To determine if there was a notable variance in adoption based on regulatory and policy factors of mass timber among the groups, the Kruskal-Wallis test was conducted. The results showed a significance level of x^2 (2, N = 440) = 0.459, p = 0.795, suggesting the acceptance of the null hypothesis. Hence, the factors influencing the adoption of mass timber appear to be consistent between academic groups and industry professionals. Refer to Figure 4.30, a box plot illustrating the distribution of knowledge gaps across the groups.

Adoption_Regulatory Support					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.34	4.00	5.32	217.05
Faculty	165	3.47	4.00	5.06	218.01
Industry	124	3.43	4.00	5.14	225.53
Total	440				

Table 4.19: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Adoption_Regulatory_Support is the same across categories of Discipline.	Independent-Samples Kruskal-Wallis Test	.795	Retain the null hypothesis.

Table 4.20: Kruskal-Wallis pairwise test results for Adoption of regulatory support of mass timber across discipline

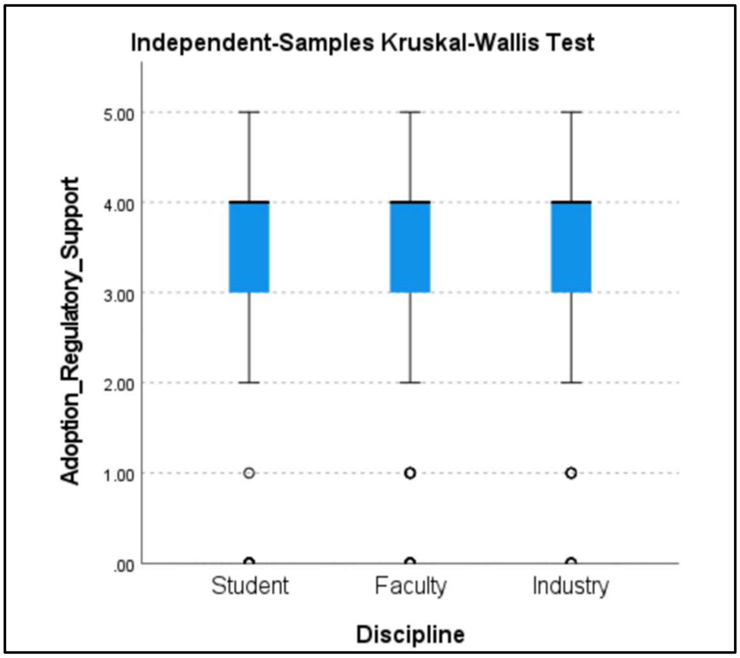


Figure 4.30: Box plot results for Adoption of Regulatory and Policy Factors

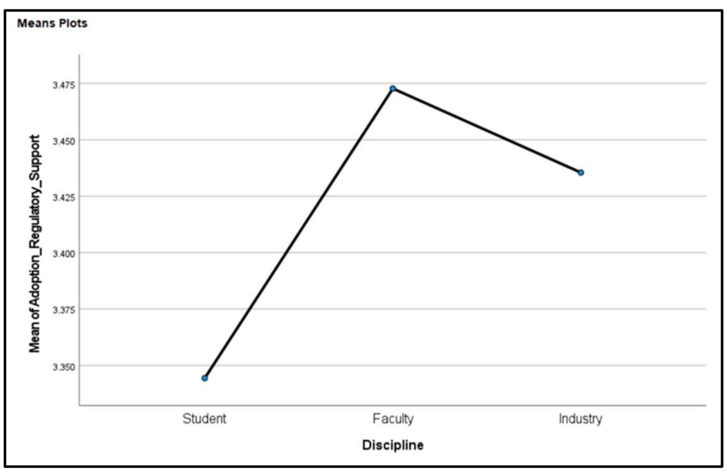


Figure 4.31: Means Plot

4.2.3.2 Educational Workforce Development

The normality of the data was assessed using the Shapiro-Wilk, Skewness, and Kurtosis test which was conducted for all three disciplines with an alpha of 0.05. The results displayed in Table 4.21 indicate that the observed significance level falls below the assumed alpha. This suggests that the data does not adhere to normal distribution. As a result, non-parametric tests were considered more suitable for further analysis.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.93	0.197	-0.25	0.189	-0.447	0.217
Z Score	-4.72		-1.32		-2.06	
Kurtosis	0.312	0.392	-0.085	0.376	-0.56	0.431
Z Score	0.80		-0.23		-1.30	
p-value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.21: Adoption of Educational Workforce Development data test of normality (Shapiro-Wilk)

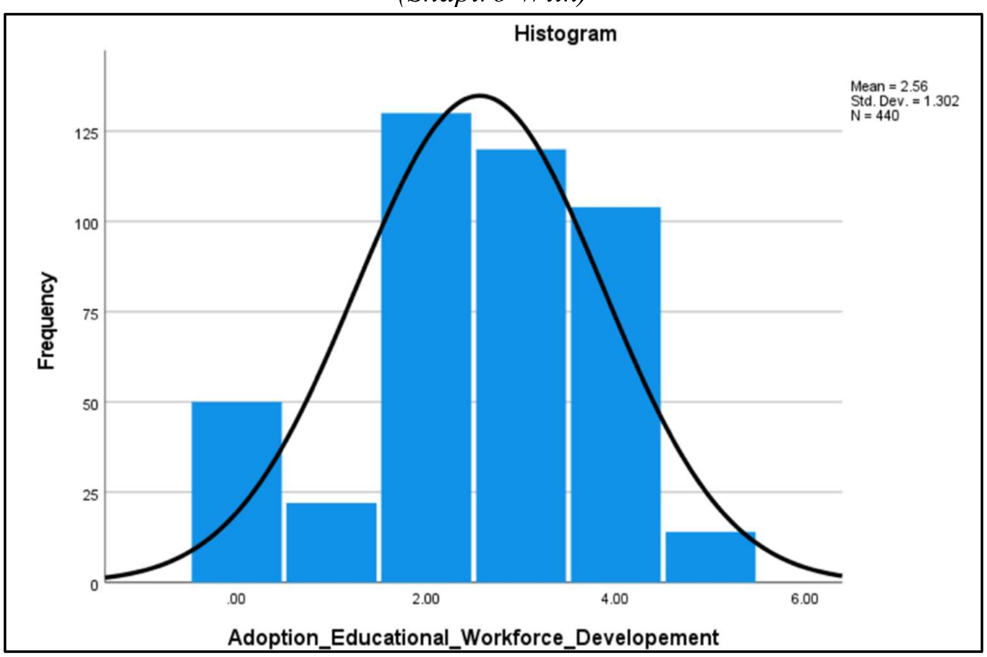


Figure 4.32: Histogram plot for test of normality on Adoption of Educational Workforce Development data

Adoption_Educational Workforce Development					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.05	3.00	2.90	272.17
Faculty	165	2.24	2.00	1.52	184.78
Industry	124	2.38	2.50	2.74	205.11
Total	440				

Table 4.22: Mean & Median across groups for regulatory and policy factors

To evaluate whether there existed a significant disparity in adoption based on educational and workforce development of mass timber among the groups, the Kruskal Wallis test was utilized. The results revealed a significance of x^2 (2, N = 440) = 42.34, $p < 0.001$, leading to the rejection of the null hypothesis. Hence, significant variation indicates that the factors influencing the adoption of mass timber differ between academic groups and industry professionals. Refer to Figure 4.33, a box plot illustrating the distribution of knowledge gaps across the groups.

Furthermore, pairwise comparisons were conducted to identify specific differences between the disciplines. The adjusted significance values demonstrated a significant distinction in adoption between the industry and student groups, as well as between faculty and student groups, with a significance level of 0.00. This significance level is below our predetermined value of 0.05. Refer to Figure 4.34, which presents the pairwise comparison of discipline by mean rank.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Adoption_Educational_Workforce _Developement is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

Table 4.23: Kruskal-Wallis pairwise test results for Adoption of Educational Workforce Development across discipline

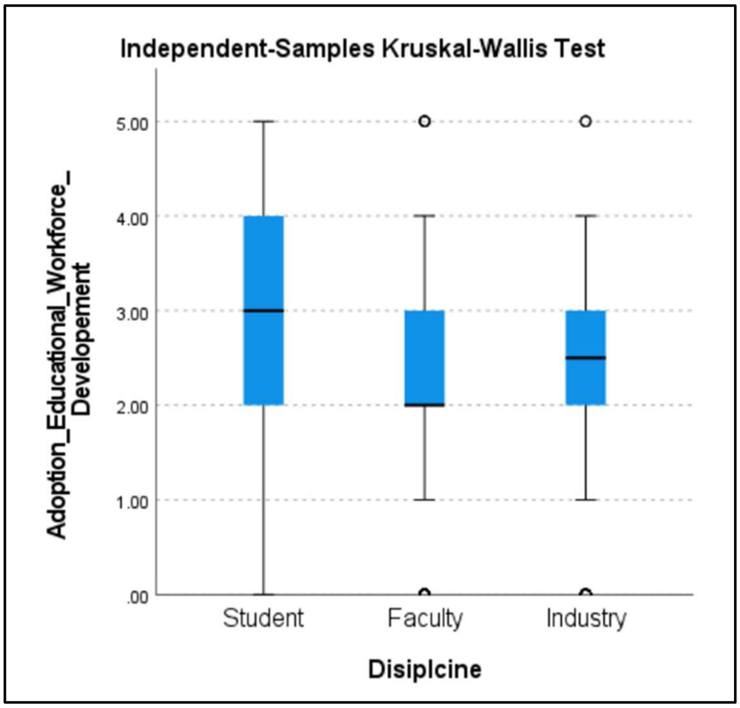
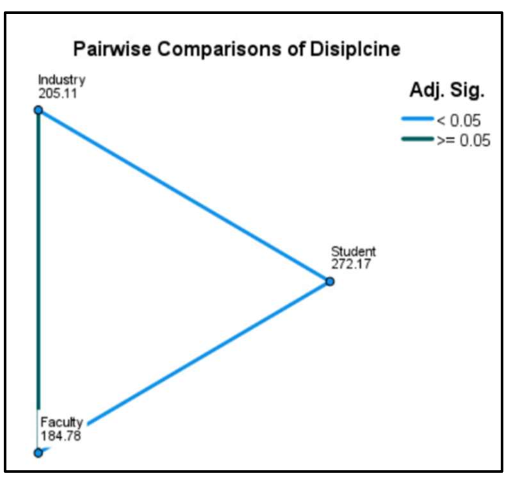


Figure 4.33: Box plot results for Adoption of Educational Workforce Development data

Pairwise Comparisons of Disiplcine

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Faculty-Industry	-20.334	14.646	-1.388	.165	.495
Faculty-Student	87.390	13.878	6.297	<.001	.000
Industry-Student	67.056	14.934	4.490	<.001	.000

Table 4.24: Pairwise test results



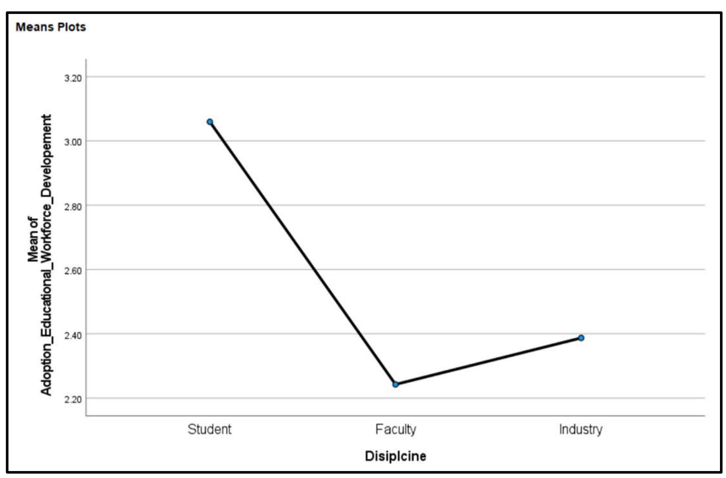


Figure 4.34: Pairwise Comparisons and Means Plot

4.2.3.3 Collaborative efforts

Similarly for the collaborative efforts the test for normality showed a significance level of less than 0.05 indicating the data to be non-normally distributed.

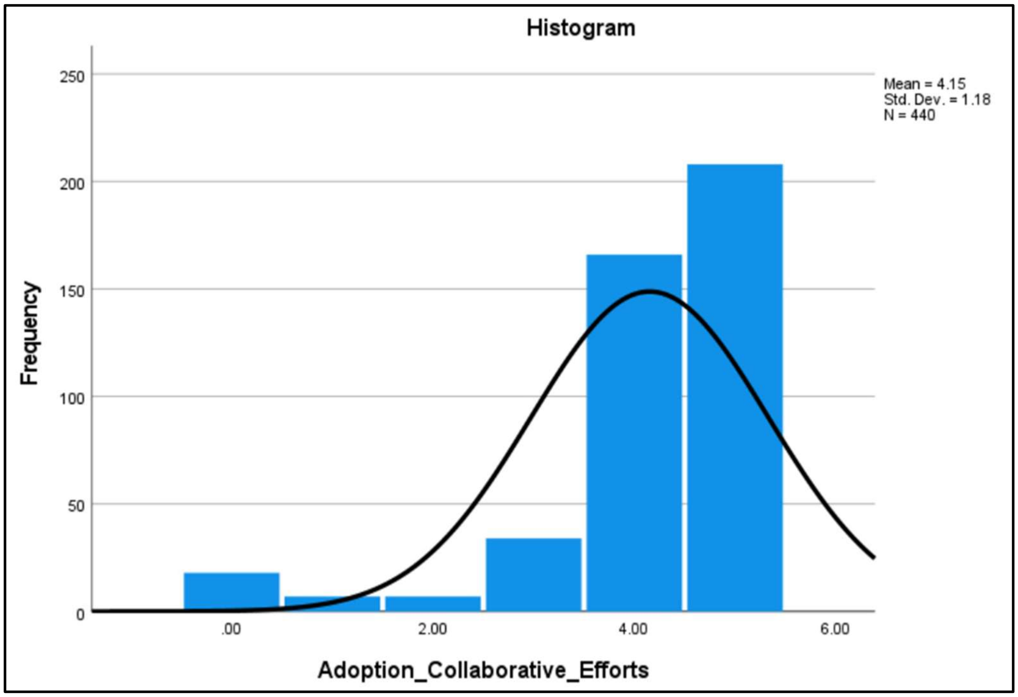


Figure 4.35: Histogram plot for test of normality on Adoption of Collaborative efforts data

Factors	Student		Faculty		Industry	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.844	0.197	-2.713	0.189	-1.86	0.217
Z Score	-9.36		-14.35		-8.57	
Kurtosis	3.988	0.392	8.475	0.376	2.917	0.431
Z Score	10.17		22.54		6.77	
p -value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.25: Adoption of Collaborative efforts data test of normality (Shapiro-Wilk)

To evaluate whether there was a significant disparity in adoption based on collaborative efforts of mass timber among the groups, the Kruskal-Wallis test was utilized. Results indicated a significance of x^2 (2, N = 440) = 16.811, $p < 0.001$, leading to the rejection of the null hypothesis. Hence, significant variation indicates that the factors influencing the adoption of mass timber differ between academic groups and industry professionals. Refer to Figure 4.36, a box plot illustrating the distribution of knowledge gaps across the groups.

Pairwise comparisons were also conducted to identify specific differences between disciplines. The adjusted significance values highlighted a significant distinction in adoption between the faculty and student, as well as between the industry and faculty, with significance levels of p = 0.00 and p = 0.042, respectively. These significance levels are below our predetermined alpha value of 0.05. Hence, there is a difference in perception related to the adoption of collaborative efforts. Refer to Figure 4.37, which presents the pairwise comparison of discipline by mean rank.

Adoption_Collaborative Efforts					
Discipline	N	Mean	Median	Median	Mean Rank
Student	151	4.00	4.00	4.00	195.29
Faculty	165	4.38	5.00	6.24	248.30
Industry	124	4.02	4.00	3.96	214.20
Total	440				

Table 4.26: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Adoption_Collaborative_Efforts is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

Table 4.27: Kruskal-Wallis pairwise test results for Adoption of Collaborative efforts

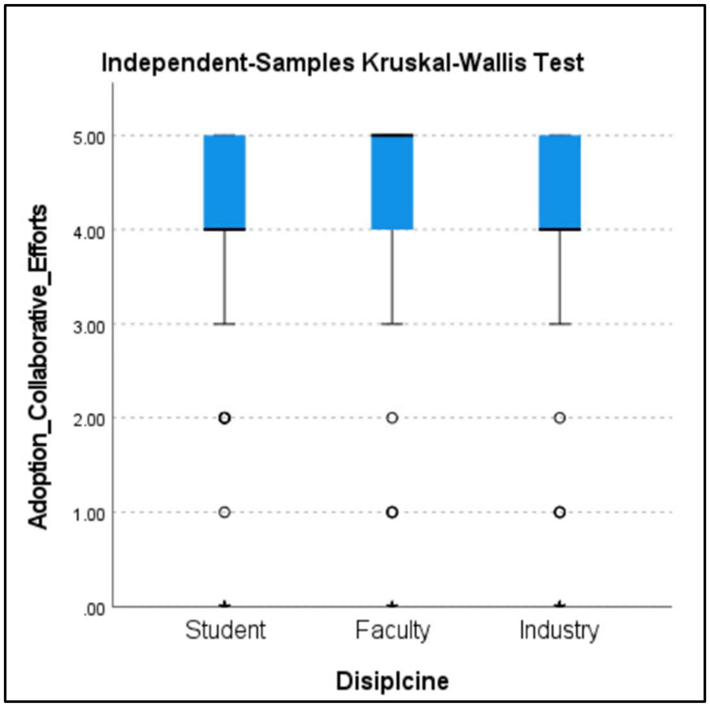


Figure 4.36: Box plot results for Adoption of Collaborative efforts

Pairwise Comparisons of Disiplcine

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Student-Industry	-18.907	14.125	-1.339	.181	.542
Student-Faculty	-53.005	13.126	-4.038	<.001	.000
Industry-Faculty	34.098	13.852	2.462	.014	.042

Table 4.28: Pairwise test results

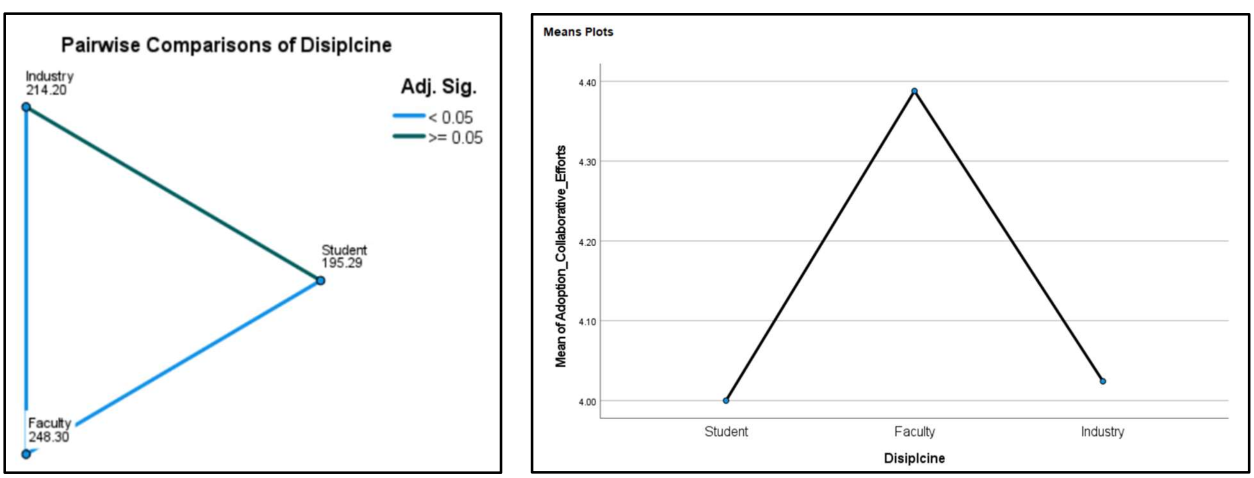


Figure 4.37: Pairwise Comparisons and Means Plot

4.2.3.4 Environmental and Sustainability Factors

To test the normality of the data Shapiro-Wilk, Skewness, and Kurtosis test was conducted alpha of which was less than 0.05 for all three groups hence the data was not normally distributed, and a non-parametric test was adopted.

Factors	Student		Faculty		Industry	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.145	0.197	-1.228	0.189	-0.979	0.217
Z Score	-5.81		-6.50		-4.51	
Kurtosis	1.666	0.392	1.573	0.376	0.346	0.431
Z Score	4.25		4.18		0.80	
p-value	<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal	

Table 4.29: Environmental and Sustainability Factors data test of normality (Shapiro-Wilk)

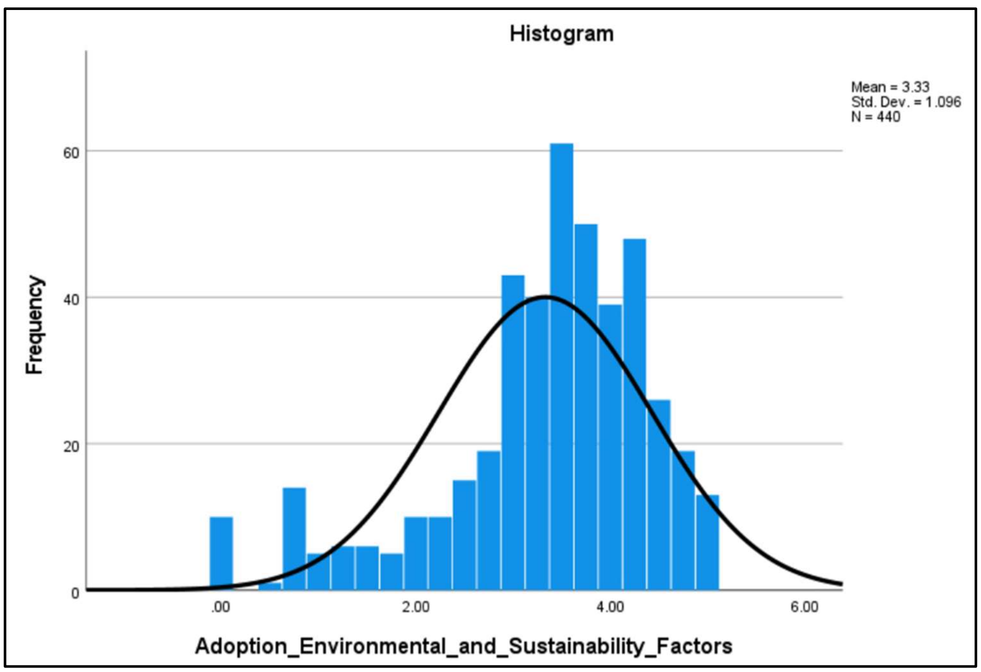


Figure 4.38: Histogram plot for test of normality of Environmental and Sustainability Factors data

To assess if there was a significant difference in adoption based on environmental and sustainability factors, a non-parametric test Kruskal-Wallis was conducted. The results of which indicated x^2 (2, N = 440) = 3.77, p = 0.152, retaining the null hypothesis. Hence, the factors influencing the adoption of mass timber appear to be consistent between academic groups and industry professionals. Refer to Figure 4.39, a box plot illustrating the distribution of knowledge gaps across the groups.

Adoption_Environmental and Sustainability Factors					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.40	3.50	3.70	227.34
Faculty	165	3.39	3.50	3.72	228.30
Industry	124	3.15	3.50	4.20	201.79
Total	440				

Table 4.30: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Adoption_Environmental_and_Sustainability_Factors is the same across categories of Disiplcine.	Independent-Samples Kruskal-Wallis Test	.152	Retain the null hypothesis.

Table 4.31: Kruskal-Wallis test results for Environmental and Sustainability Factors across discipline

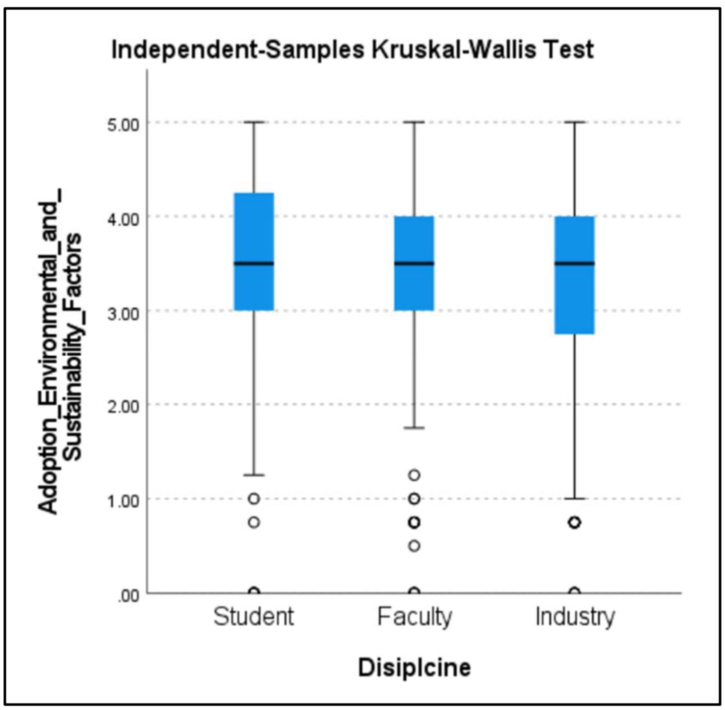


Figure 4.39: Box plot results for Adoption of Environmental and Sustainability Factors

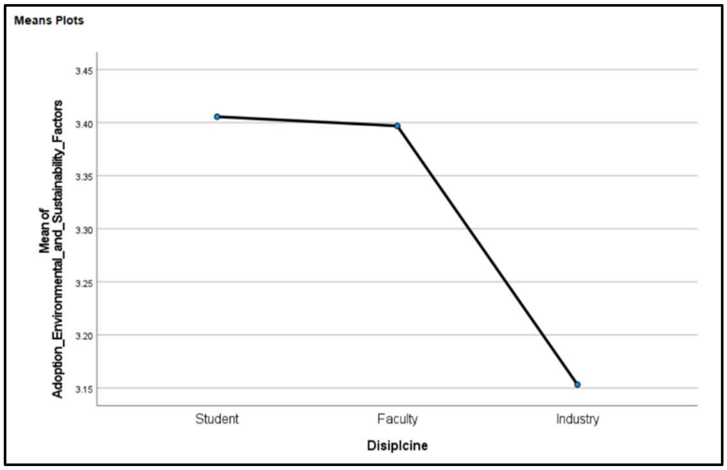


Figure 4.40: Means Plot

4.2.3.5 Market perceptions

Similar to the above, for the last parameter also the Shapiro-Wilk, Skewness, and Kurtosis normality test was conducted, and the results indicated the significance level below the assumed alpha of 0.05 for the academia, hence the data was not normally distributed.

Factors	**Student**		**Faculty**		**Industry**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.584	0.197	-0.37	0.189	-0.172	0.217
Z Score	-2.96		-1.96		-0.79	
Kurtosis	-0.132	0.392	-0.642	0.376	-0.709	0.431
Z Score	-0.34		-1.71		-1.65	
p -value	<0.001		<0.001		0.009	
Result	Not Normal		Not Normal		Not Normal	

Table 4.32: Market perceptions data test of normality (Shapiro-Wilk)

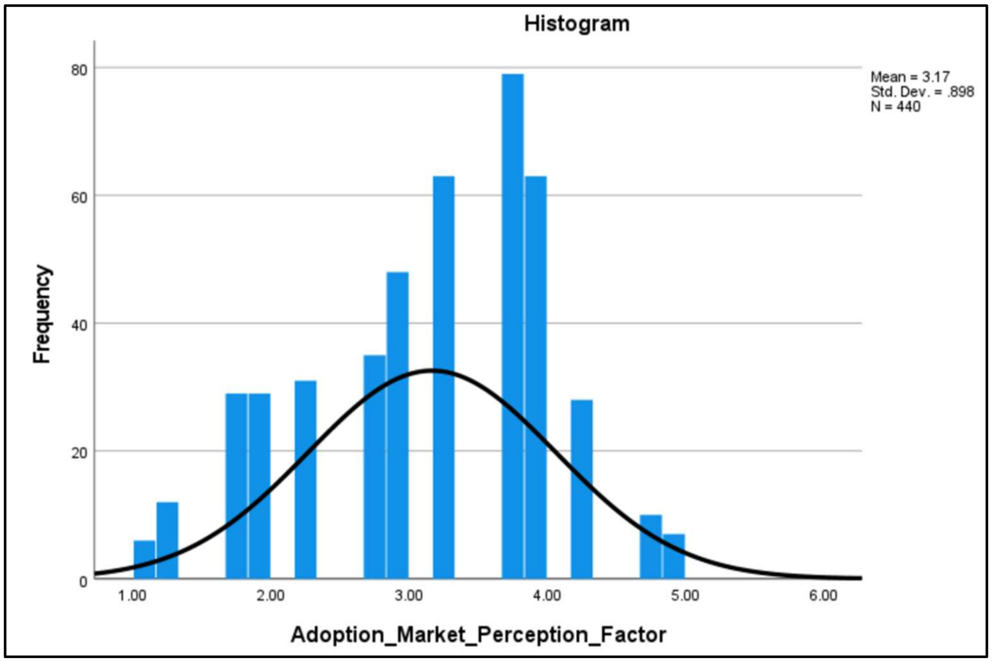


Figure 4.41: Histogram plot for test of normality of Market Perception data

To determine whether there was a significant difference in adoption based on the market perception factors of mass timber among the groups, the Kruskal-Wallis test was employed. The results showed a significance of x^2 (2, N = 440) = 13.667, p = 0.001, leading to the rejection of the null hypothesis. Hence, significant variation indicates that the factors influencing the adoption of mass timber differ between academic groups and industry professionals. Refer to Figure 4.42, a box plot illustrating the distribution of knowledge gaps across the groups.

Pairwise comparisons were conducted to identify specific differences between disciplines. The adjusted significance values revealed a significant distinction in perception between the industry.

and student groups, as well as between faculty and student groups, with significance levels of 0.01 and 0.041 respectively. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.43, which presents the pairwise comparison of discipline by mean rank.

Adoption_Market Perceptions					
Discipline	N	Mean	Median	Mode	Mean Rank
Student	151	3.40	3.67	4.21	254.83
Faculty	165	3.08	3.33	3.84	207.85
Industry	124	2.98	3.00	3.04	195.52
Total	440				

Table 4.33: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Adoption_Market_Perception_Factor is the same across categories of Discipline.	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

Table 4.34: Kruskal-Wallis test results for Market perceptions across discipline

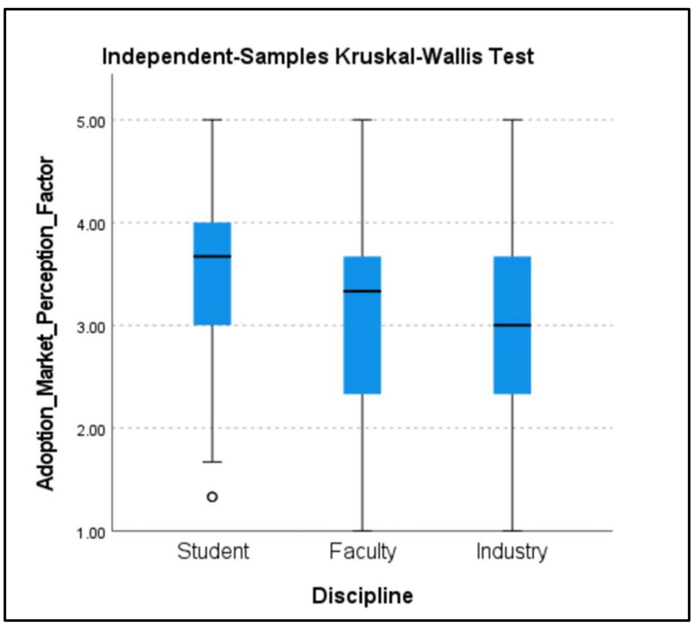


Figure 4.42: Box plot results for Adoption of Market perceptions

Pairwise Comparisons of Discipline

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Industry-Faculty	12.330	15.002	.822	.411	1.000
Industry-Student	59.304	15.297	3.877	<.001	.000
Faculty-Student	46.973	14.215	3.304	<.001	.003

Table 4.35: Pairwise test results

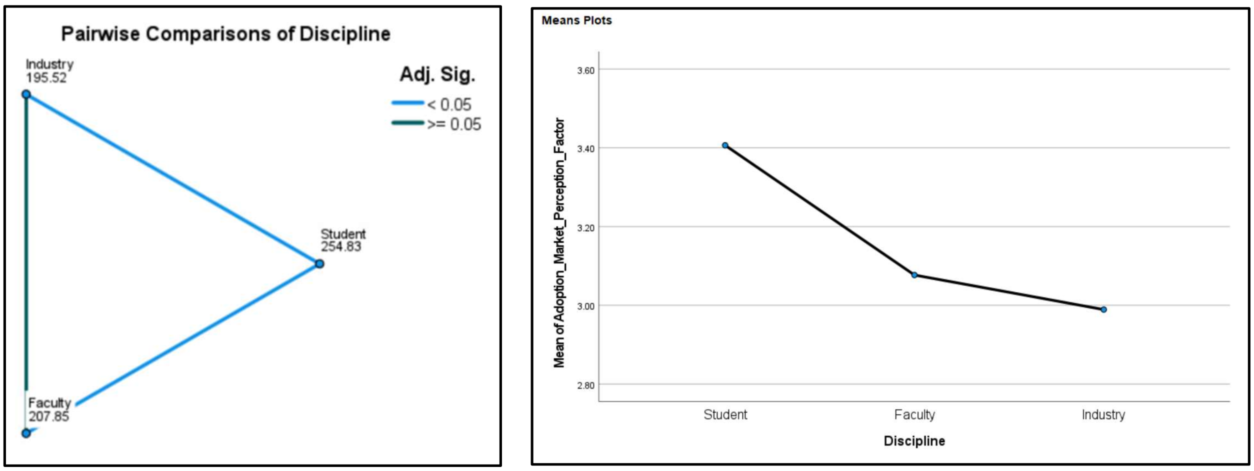


Figure 4.43: Pairwise Comparisons and Means Plot

4.3 EXPLORATORY DATA ANALYSIS: VARIANCE BETWEEN GROUPS

In analyzing the survey data, it became evident that there was a notable difference in the variability of responses between the groups: Student, Faculty, and Industry professionals. A heat map was generated to visually represent this variability, where the intensity of the color indicates the level of variance among the responses within each group. Table 4.36, represents a heat map of variability in responses across the groups

Variables	Student	Faculty	Industry
Current MT Knowledge	0.584	0.681	0.709
P_Performance	1.051	1.133	1.519
P_Sustainability and Environmental Impact	1.092	1.066	1.446
P_Safety & Regulatory Compliance	1.374	1.614	1.705
A_Regulatory Support	2.094	1.812	1.711
A_Educational & Workforce Development	1.656	1.356	1.751
A_Collaborative Efforts	1.320	1.032	1.861
A_Environmental and Sustainability Factors	1.105	1.136	1.384
A_Market Perceptions	0.619	0.807	0.936

Table 4.36: Between group - variance

In this heat map:

- Darker color represents lower variability, indicating that responses within the group were more similar.
- Lighter color denotes higher variability, suggesting greater differences in responses within the groups.

The heat map reveals that faculty and industry professionals exhibited more variability in their responses, with lighter shades indicating diverse perspectives within these groups. This contrasts with the student groups, which showed darker shades, reflecting more uniform responses. The consistency among students might indicate a tendency to provide more socially desirable answers. This visual analysis underscores the need for further investigation into the underlying factors contributing to these differences in response variability, as they could have significant implications for understanding the broader adoption of mass timber.

4.4 EXPLORATORY DATA ANALYSIS: AMONG GROUPS

After conducting the between-groups analysis, the study proceeded to examine within-group comparisons among the students, faculty, and industry professionals on various parameters discussed further to ascertain significant differences across these groups in attitudes towards mass timber adoption.

4.4.1 Current knowledge about mass timber: Students

To assess the mean difference based on the current knowledge of mass timber among groups-specifically students in architecture, civil engineering, and construction management the following analysis was conducted.

Firstly, the Shapiro-Wilk test was conducted to assess normality for all student groups, using a significance level (alpha) of 0.05. Additionally, normality was examined using measures of

Skewness and Kurtosis, ensuring the z-scores fell within the range of -1.96 to +1.96, indicative of normal distribution.

Table 4.37 presents the results, indicating that the observed significance (*p*) is less than the alpha value of 0.05 for construction management students suggesting a non-normal distribution of data whereas the significance (*p*) for architecture and civil engineering students is more than 0.05 suggesting normal distribution. Since the data is not completely normally distributed the ANOVA is not applicable and hence non-parametric tests were deemed appropriate for analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.009	0.501	0.951	0.55	-0.389	0.234	0.006	0.845
Z Score	-0.02		1.73		-1.66		0.01	
Kurtosis	-1.06	0.972	0.686	1.063	0.683	0.463	-1.628	1.741
Z Score	-1.09		0.65		1.48		-0.94	
p - value	0.256		0.092		0.012		0.831	
Result	Normal		Normal		Not Normal		Normal	

Table 4.37: Current knowledge data test of normality using Shapiro-Wilk

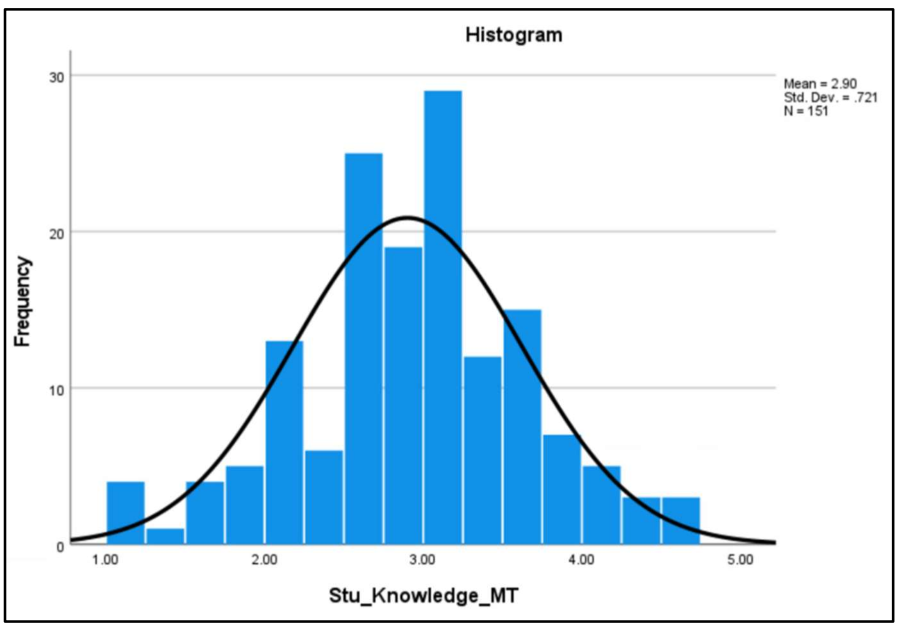


Figure 4.44: Histogram plot for test of normality on Current knowledge about Mass Timber

To explore potential differences in current knowledge among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 3.818, *p* = 0.282, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in knowledge gaps related to mass timber among student groups. Refer to Figure 4.45 for the box plot illustrating the distribution of the current knowledge across these groups.

MT_Current Knowledge					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	2.92	2.83	2.65	76.10
Civil Engineering	17	2.66	2.50	2.18	56.79
Construction Management	107	2.93	3.00	3.14	79.03
Others	6	2.91	2.91	2.91	76.00
Total	151				

Table 4.38: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_Knowledge_MT is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.282	Retain the null hypothesis.

Table 4.39: Kruskal-Wallis test results for Current knowledge about mass timber across discipline

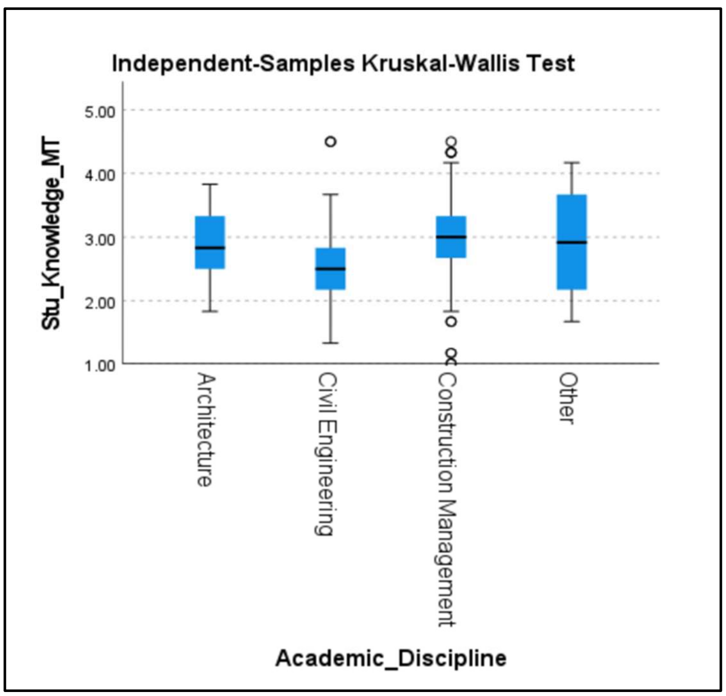


Figure 4.45: Box plot results for Current knowledge about mass timber

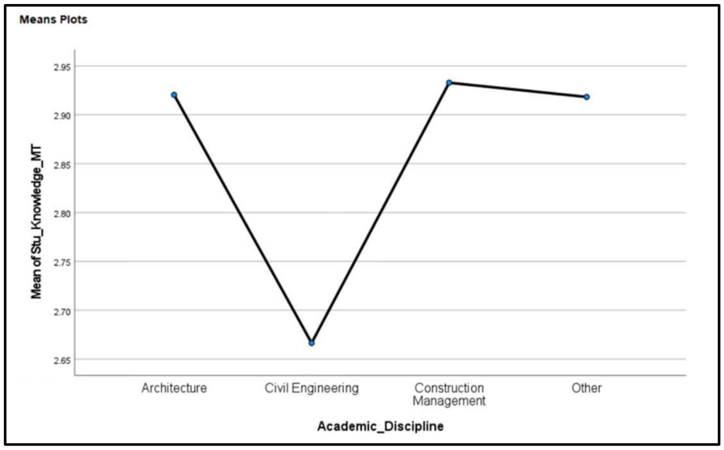


Figure 4.46: Means Plot

4.4.2 Perception of mass timber: Students

To examine perceptions among student groups, survey questions were divided further divided into six specific areas:

1. Based on the performance of mass timber
2. Based on sustainability and environmental impact
3. Based on safety and regulatory compliance
4. Curriculum Inclusion
5. Job Preparation
6. Community Beliefs

Each category was subjected to normality testing followed by further analysis. The findings from these analyses are discussed and illustrated to shed light on the factors influencing perceptions of mass timber among different student groups within the US construction industry.

4.4.2.1 Based on the performance of mass timber: Student

To analyze perception based on the performance of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first, the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.40, the observed significance for the civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.276	0.501	-1.474	0.55	-1.398	0.234	-1.892	0.845
Z Score	-0.55		-2.68		-5.97		-2.24	
Kurtosis	-0.931	0.972	2.428	1.063	2.462	0.463	4.063	1.741
Z Score	-0.96		2.28		5.32		2.33	
p-value	0.412		0.022		<0.001		0.051	
Result	Normal		Not Normal		Not Normal		Not Normal	

Table 4.40: Perception of mass timber data test of normality using Shapiro-Wilk

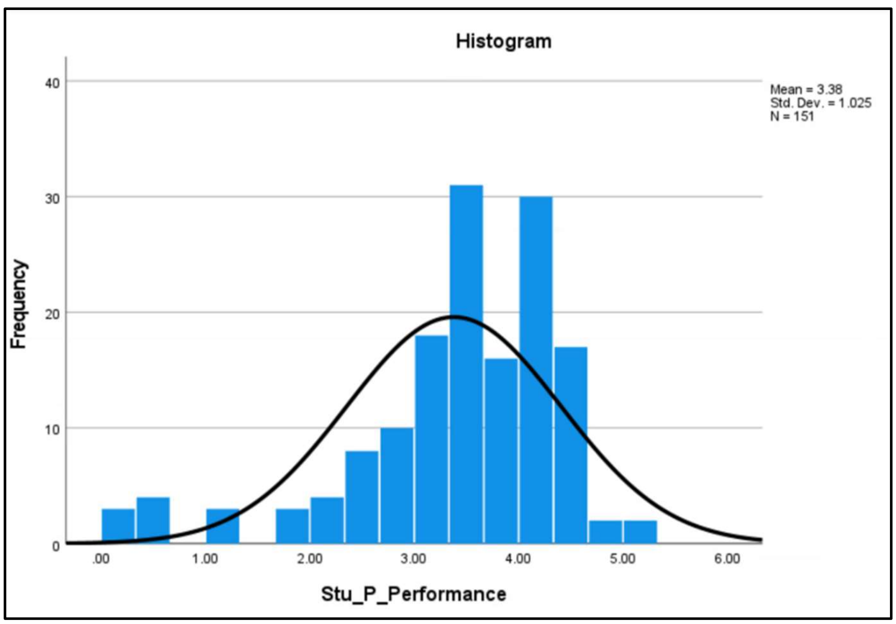


Figure 4.47: Histogram plot for test of normality on performance of Mass Timber

To explore potential differences in perceptions based on the performance of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 2.950, p = 0.399, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the performance of mass timber among student groups. Refer to Figure 4.48 for the box plot illustrating the distribution of the perceptions based on the performance across these groups.

Stu_Perception_Performance					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.01	3.13	3.37	61.26
Civil Engineering	17	3.29	3.38	3.56	74.35
Construction Management	107	3.46	3.63	3.97	79.00
Others	6	3.46	3.69	4.15	78.83
Total	151				

Table 4.41: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Stu_P_Performance is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.399	Retain the null hypothesis.

Table 4.42: Kruskal-Wallis test results for Performance of Mass Timber across discipline

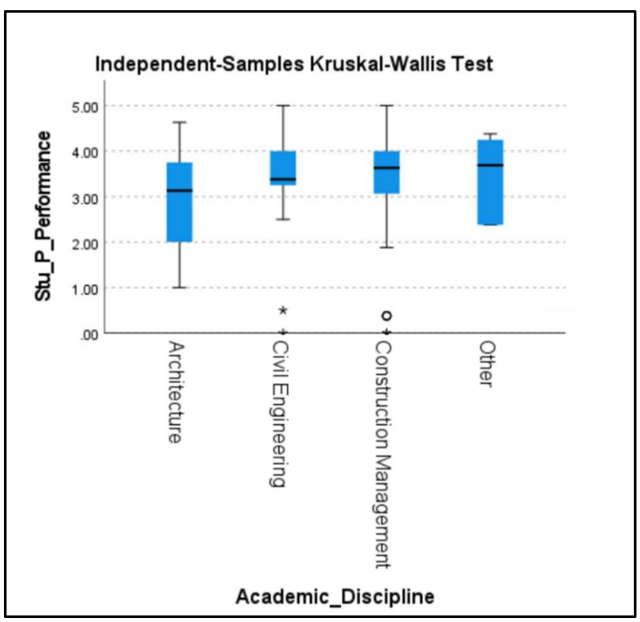


Figure 4.48: Box plot results for Performance of Mass Timber

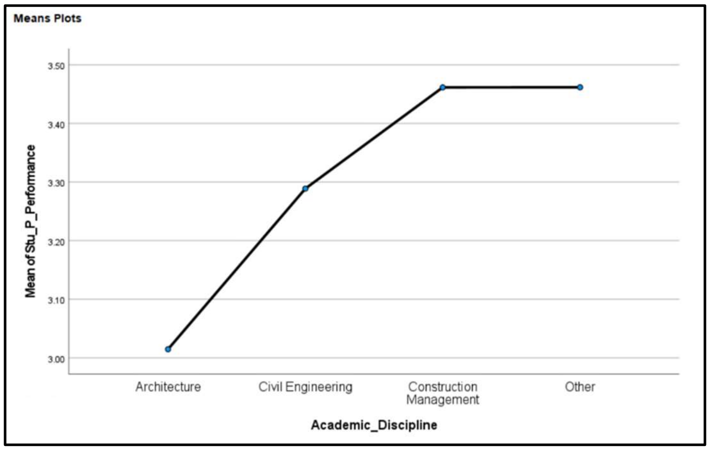


Figure 4.49: Means plot

4.4.2.2 Sustainability and Environmental Impact: Students

To analyze perception based on the sustainability and environmental impact of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.43, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.276	0.501	-1.474	0.55	-1.398	0.234	-1.892	0.845
Z Score	-0.55		-2.68		-5.97		-2.24	
Kurtosis	-0.931	0.972	2.428	1.063	2.462	0.463	4.063	1.741
Z Score	-0.96		2.28		5.32		2.33	
p-value	0.412		0.022		<0.001		0.051	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.43:Sustainability and Environmental Impact data test of normality using Shapiro-Wilk

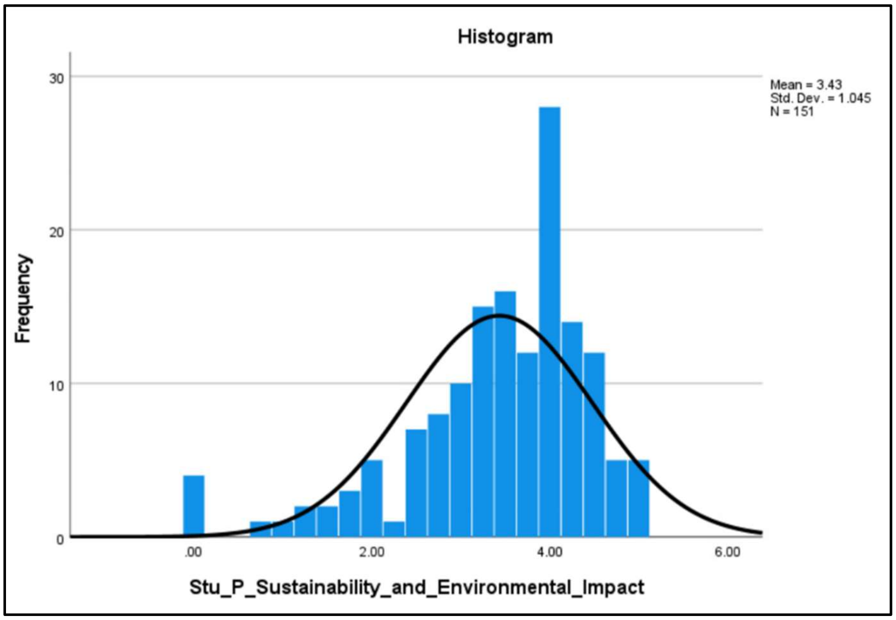


Figure 4.50: Histogram plot for test of normality on Sustainability and Environmental Impact

To explore potential differences in perceptions based on the sustainability and environmental impact of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 1.449, p = 0.694, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the sustainability and environmental impact of mass timber among student groups. Refer to Figure 4.51 for the box plot illustrating the distribution of the perceptions based on the sustainability and environmental impact across these groups.

Stu_Perception_Sustainability and Environmental Impact					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.22	3.50	4.06	65.40
Civil Engineering	17	3.38	3.50	3.74	77.62
Construction Management	107	3.47	3.75	4.31	77.69
Others	6	3.54	3.75	4.17	78.42
Total	151				

Table 4.44: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_P_Sustainability_and_Environmental_Impact is the same across categories of Academic_Discipline	Independent-Samples Kruskal-Wallis Test	.694	Retain the null hypothesis.

Table 4.45: Kruskal-Wallis test results for perception of Sustainability and Environmental Impact

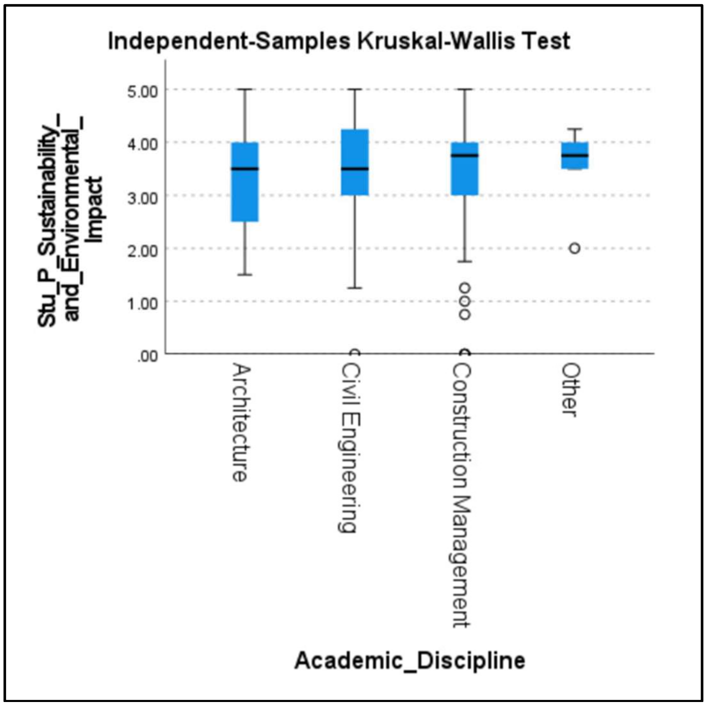


Figure 4.51: Box plot results for perception of Sustainability and Environmental Impact

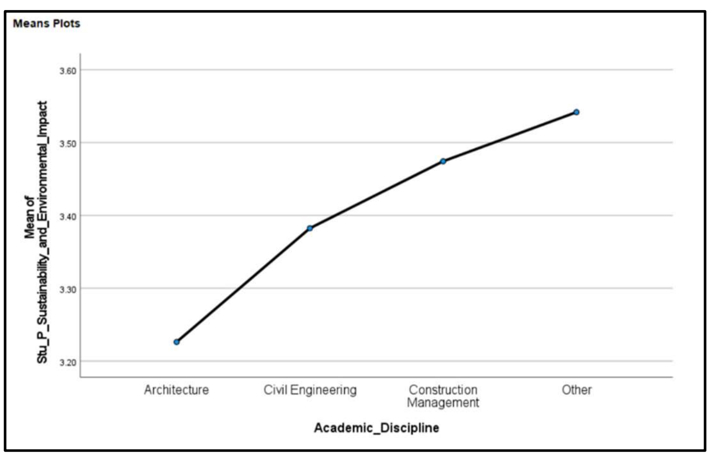


Figure 4.52: Means plot

4.4.2.3 Safety and Regulatory Compliance: Students

To analyze perception based on the safety and regulatory compliance of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first, the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.46, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.252	0.501	-0.703	0.55	-1.296	0.234	-0.463	0.845
Z Score	-2.50		-1.28		-5.54		-0.55	
Kurtosis	1.019	0.972	0.033	1.063	1.255	0.463	-0.016	1.741
Z Score	1.05		0.03		2.71		-0.01	
p - value	0.006		0.457		<0.001		0.421	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.46: Safety and Regulatory Compliance Impact data test of normality using Shapiro-Wilk

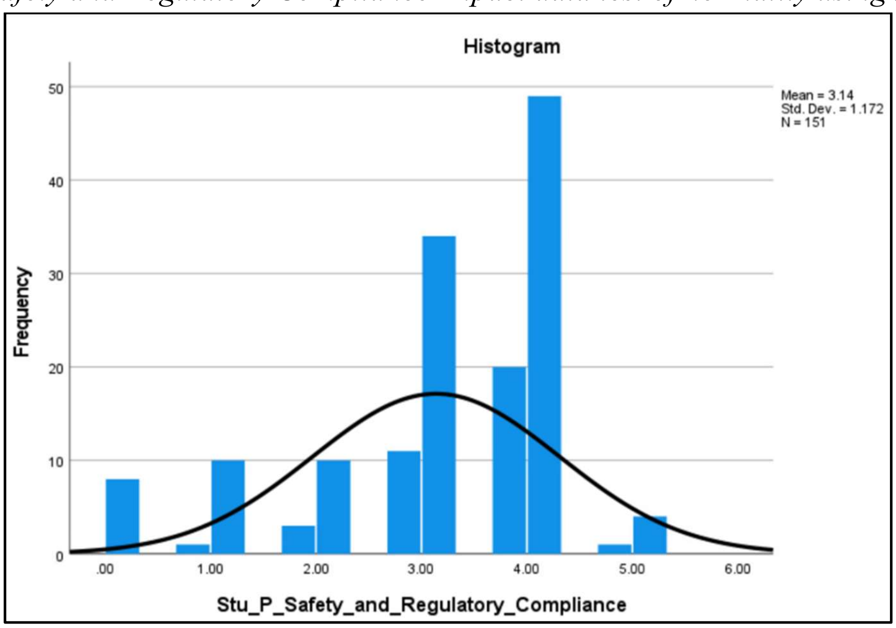


Figure 4.53: Histogram plot for test of normality on Safety and Regulatory Compliance Impact

To explore potential differences in perceptions based on the safety and regulatory compliance of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 0.919, p = 0.821, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the safety and regulatory compliance of mass timber among student groups. Refer to Figure 4.54 for the box plot illustrating the distribution of the perceptions based on safety and regulatory compliance across these groups.

Stu_Perception_Safety and Regulatory Compliance					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.12	3.67	4.77	76.67
Civil Engineering	17	2.94	3.33	4.11	68.85
Construction Management	107	3.17	3.67	4.67	77.56
Others	6	3.05	3.00	2.90	66.17
Total	151				

Table 4.47: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Stu_P_Safety_and_Regulatory_Compliance is the same across categories of Academic_Discipline	Independent-Samples Kruskal-Wallis Test	.821	Retain the null hypothesis.

Table 4.48: Kruskal-Wallis test results for perception of Safety and Regulatory Compliance across discipline

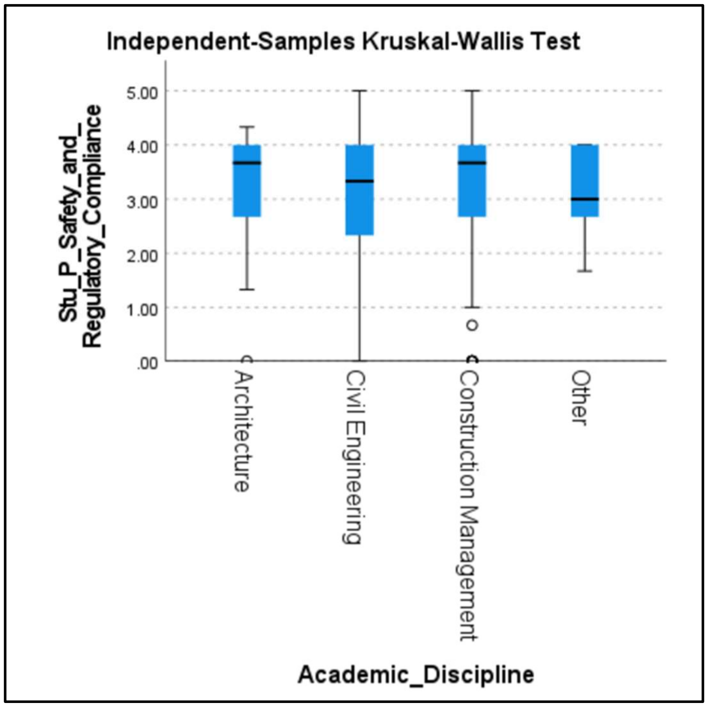


Figure 4.54: Box plot results for perception of Safety and Regulatory Compliance

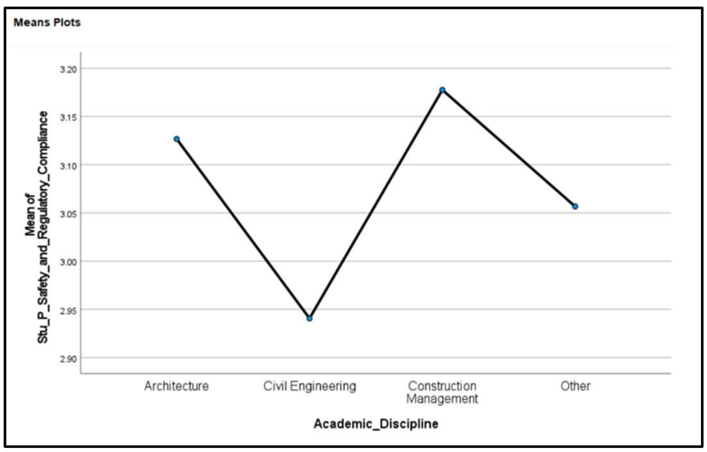


Figure 4.55: Means plot

4.4.2.4 Curriculum Inclusion: Students

To analyze perception based on the curriculum inclusion of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.49, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.483	0.501	-0.541	0.55	-1.177	0.234	-0.84	0.845
Z Score	-0.96		-0.98		-5.03		-0.99	
Kurtosis	-0.915	0.972	-1.027	1.063	1.054	0.463	-0.649	1.741
Z Score	-0.94		-0.97		2.28		-0.37	
p - value	0.028		0.026		<0.001		0.212	
Result	Not Normal		Not Normal		Not Normal		Normal	

Table 4.49: Curriculum Inclusion data test of normality using Shapiro-Wilk

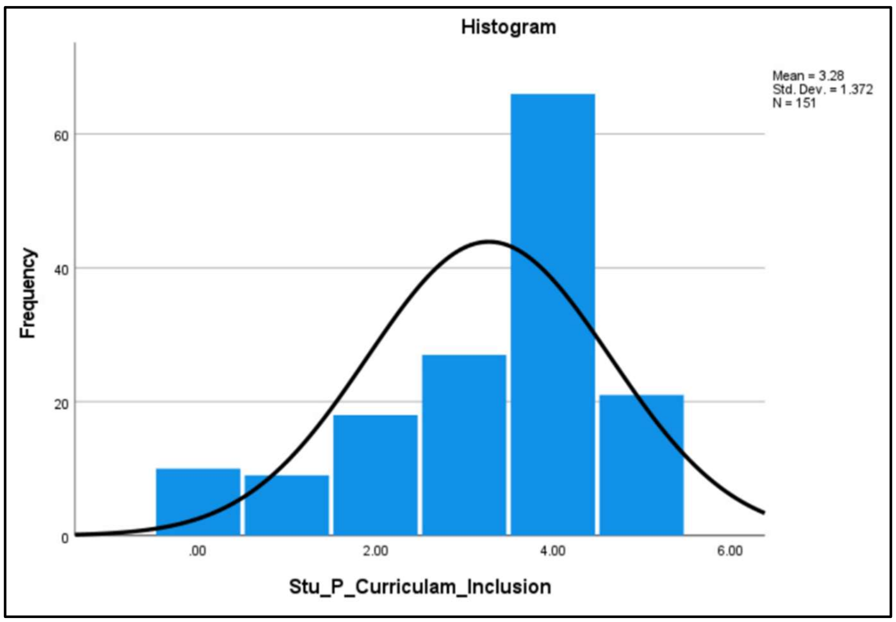


Figure 4.56: Histogram plot for test of normality on for perception of Curriculum Inclusion

To explore potential differences in perceptions based on the curriculum inclusion of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 1.598, p = 0.660, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the curriculum inclusion of mass timber among student groups. Refer to Figure 4.57 for the box plot illustrating the distribution of the perceptions based on curriculum inclusion across these groups.

Stu_Perception_Curriculam_Inclusion					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.04	4.00	5.92	69.96
Civil Engineering	17	2.88	4.00	6.24	67.18
Construction Management	107	3.38	4.00	5.24	78.39
Others	6	3.33	4.00	5.34	79.50
Total	151				

Table 4.50: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_P_Curriculam_Inclusion is the same across categories of Student_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.660	Retain the null hypothesis.

Table 4.51: Kruskal-Wallis test results for perception of Curriculum Inclusion across discipline

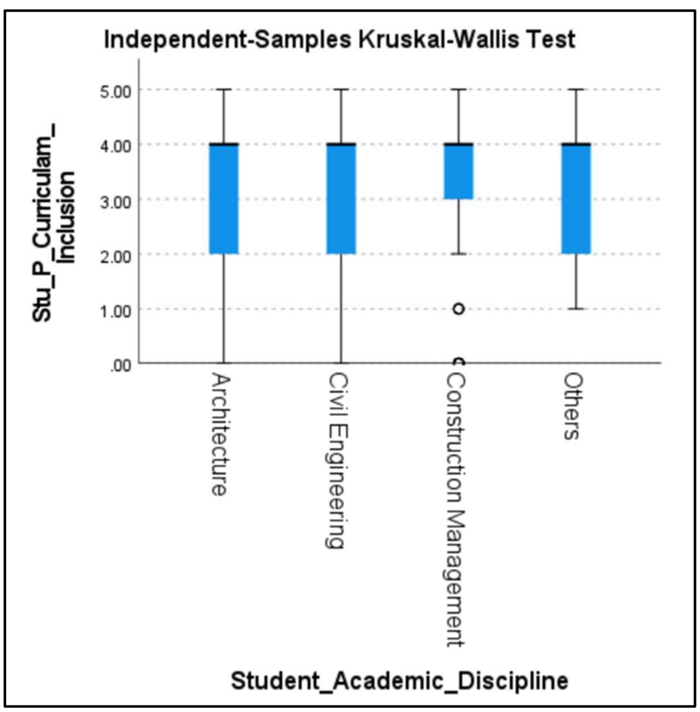


Figure 4.57: Box plot results for perception of Curriculum Inclusion

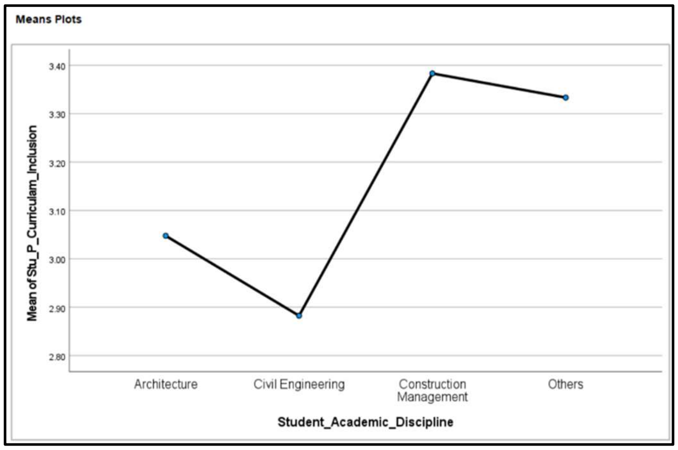


Figure 4.58: Means plot

4.4.2.5 Job Preparation: Students

To analyze perception based on the job preparation of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.52, the observed significance for the architecture, civil engineering, and construction management less is more than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.257	0.501	-0.643	0.55	-0.567	0.234	-0.857	0.845
Z Score	-0.51		-1.17		-2.42		-1.01	
Kurtosis	0.547	0.972	-0.3	1.063	0.04	0.463	-0.3	1.741
Z Score	0.56		-0.28		0.09		-0.17	
p - value	0.020		0.045		<0.001		0.091	
Result	Not Normal		Not Normal		Not Normal		Normal	

Table 4.52: Job Preparation data test of normality using Shapiro-Wilk

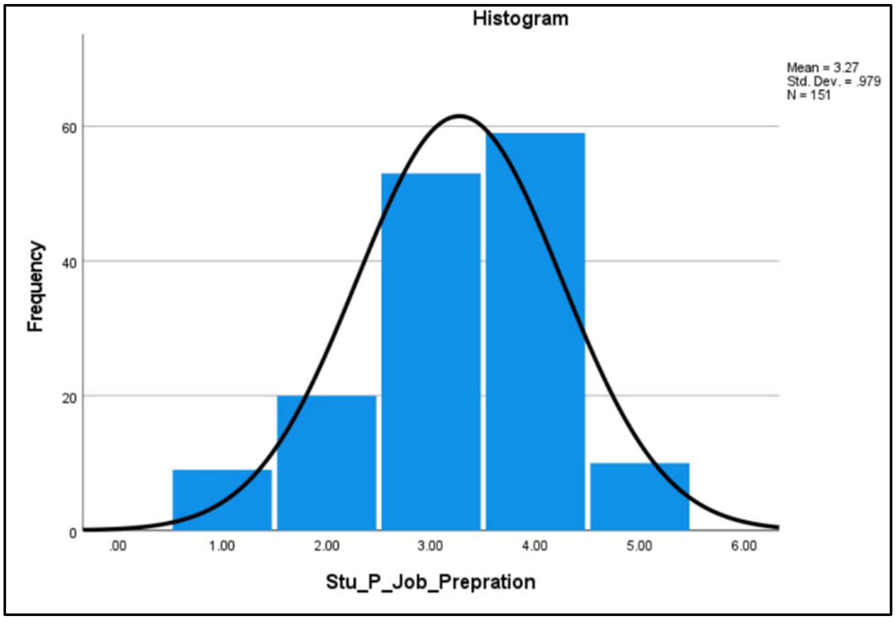


Figure 4.59: Histogram plot for test of normality on for perception of Job Preparation

To explore potential differences in perceptions based on the job preparation of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 3.261, p = 0.353, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the job preparation of mass timber among student groups. Refer to Figure 4.60 for the box plot illustrating the distribution of the perceptions based on job preparation across these groups.

Stu_Perception_Job_Prepration					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	2.95	3.00	3.10	60.90
Civil Engineering	17	3.29	4.00	5.42	79.41
Construction Management	107	3.27	3.00	2.46	78.31
Others	6	3.33	3.50	3.84	77.92
Total	151				

Table 4.53: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_P_Job_Prepration is the same across categories of Student_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.353	Retain the null hypothesis.

Table 4.54: Kruskal-Wallis test results for perception of Job Preparation across discipline

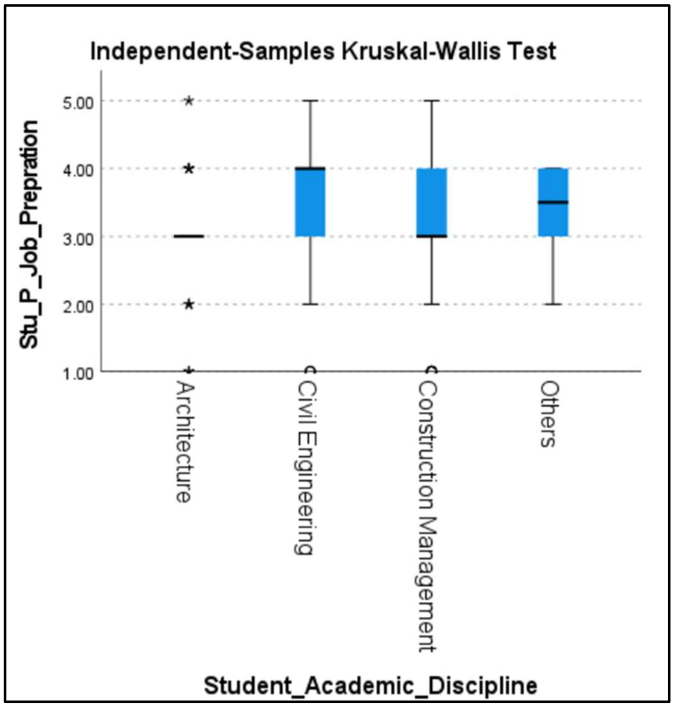


Figure 4.60: Box plot results for perception of Job Preparation

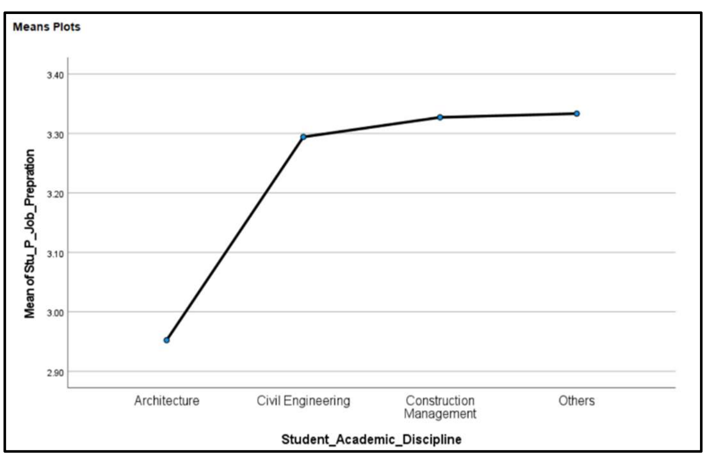


Figure 4.61: Means plot

4.4.2.6 Community Beliefs: Students

To analyze perception based on the community beliefs of the mass timber among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.55, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.817	0.501	-0.439	0.55	-1.495	0.234	0.313	0.845
Z Score	-3.63		-0.80		-6.39		0.37	
Kurtosis	2.144	0.972	-1.473	1.063	1.654	0.463	-0.104	1.741
Z Score	2.21		-1.39		3.57		-0.06	
p - value	<0.001		0.008		<0.001		0.212	
Result	Not Normal		Not Normal		Not Normal		Normal	

Table 4.55: Community Beliefs data test of normality using Shapiro-Wilk

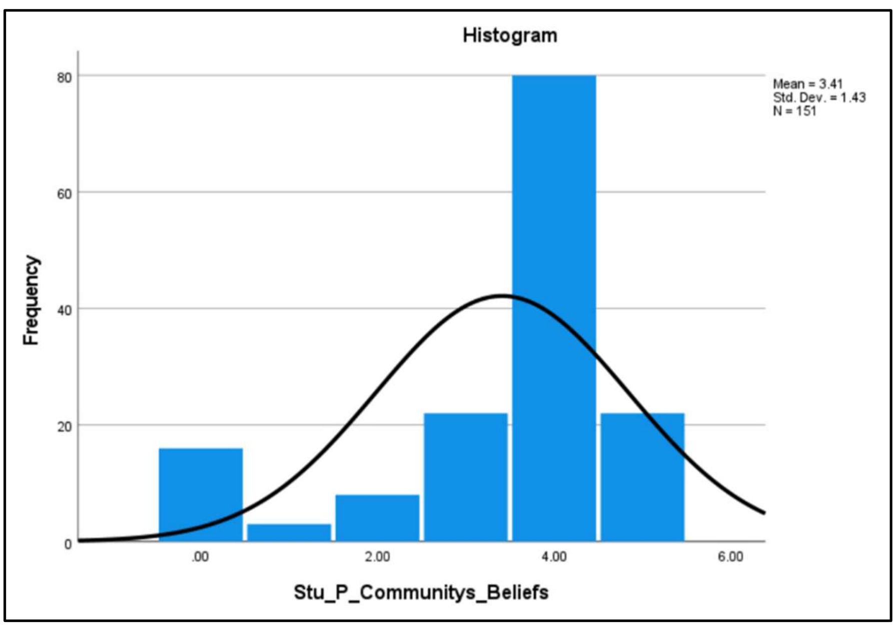


Figure 4.62: Histogram plot for test of normality on perception of Community Beliefs

To explore potential differences in perceptions based on the community beliefs of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 1.151, p = 0.765, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the community beliefs of mass timber among student groups. Refer to Figure 4.63 for the box plot illustrating the distribution of the perceptions based on community beliefs across these groups.

Stu_Perceptions_Communitys_Beliefs					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.33	4.00	5.34	73.07
Civil Engineering	17	2.82	4.00	6.36	67.47
Construction Management	107	3.49	4.00	5.02	77.65
Others	6	3.83	4.00	4.34	81.00
Total	151				

Table 4.56: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_P_Communitys_Beliefs is the same across categories of Student_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.765	Retain the null hypothesis.

Table 4.57: Kruskal-Wallis test results for perception of Community Beliefs across discipline

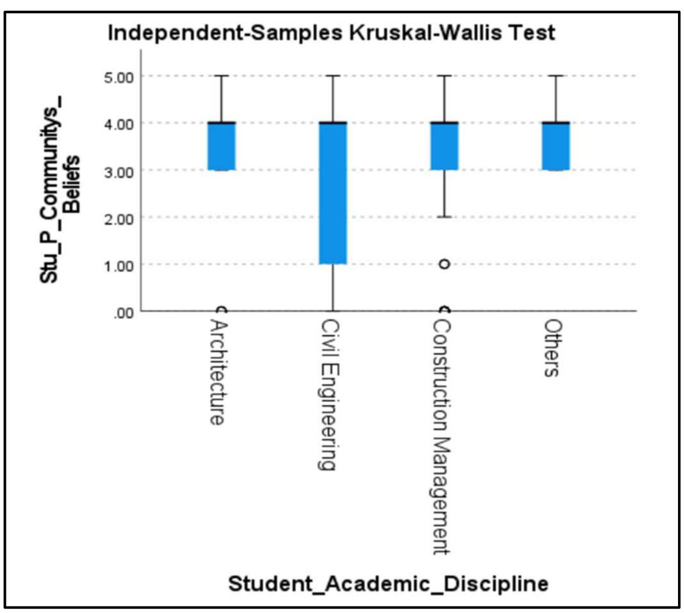


Figure 4.63: Box plot results for perception of Community Beliefs

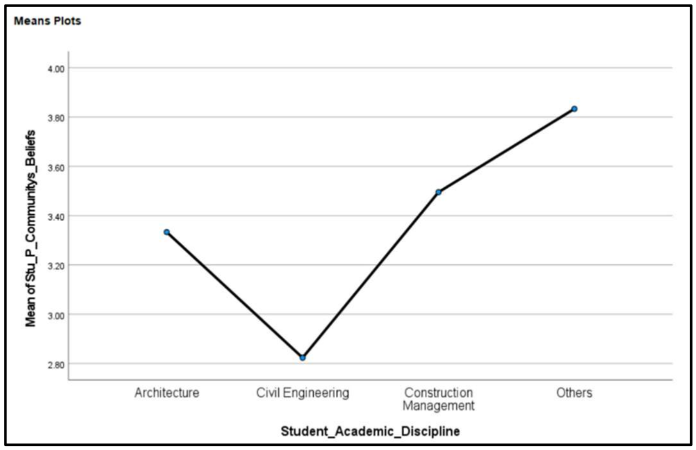


Figure 4.64: Means plot

4.4.3 Adoption of mass timber: Students

To explore the key factors influencing the adoption of mass timber among the students group in the us construction industry, statistical analysis was conducted.

To delve into the factors impacting adoption, survey questions were further categorized into five distinct areas refer to Table 3.1:

1. Based on regulatory support
2. Based on educational and workforce development
3. Based on collaborative efforts
4. Based on environmental and sustainability factors
5. Based on market perception factors

For each of these subcategories, the data underwent initial normality testing followed by further analysis The results of these are further discussed and illustrated to provide insights into the factors influencing the adoption of mass timber among the students group within the US construction industry.

4.4.3.1 Regulatory Support: Students

To analyze attitudes towards the adoption of mass timber based on the regulatory support among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.58, the observed significance for the architecture, civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.922	0.501	-0.593	0.55	-1.596	0.234	-0.608	0.845
Z Score	-1.84		-1.08		-6.82		-0.72	
Kurtosis	-0.027	0.972	-1.398	1.063	2.524	0.463	-1.843	1.741
Z Score	-0.03		-1.32		5.45		-1.06	
p - value	0.004		0.002		<0.001		0.129	
Result	Not Normal		Not Normal		Not Normal		Normal	

Table 4.58: Regulatory Support data test of normality using Shapiro-Wilk

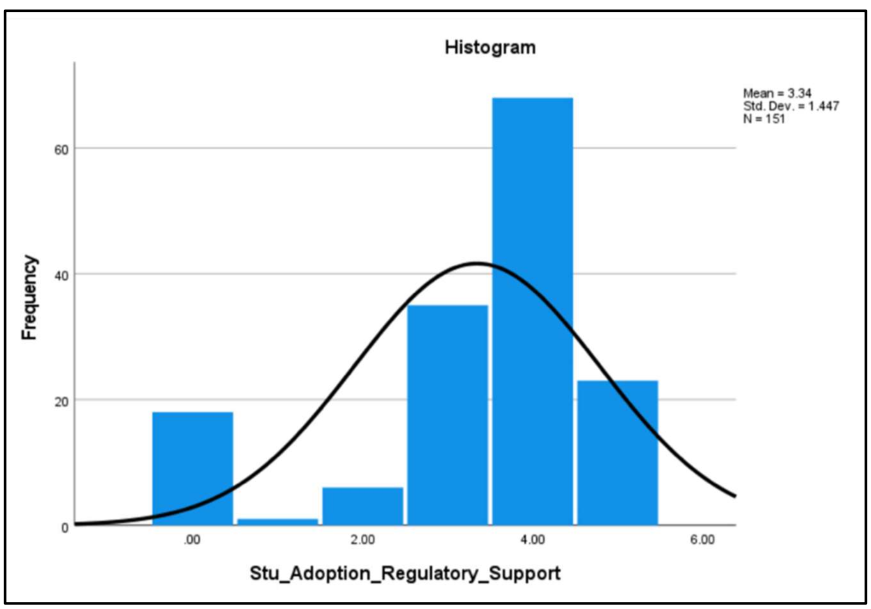


Figure 4.65: Histogram plot for test of normality on adoption of Regulatory Support

To explore potential differences in attitude towards adoption based on the regulatory support of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 2.075, p = 0.557, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the regulatory support of mass timber among student groups. Refer to Figure 4.66 for the box plot illustrating the distribution of the attitude towards adoption based on regulatory support across these groups.

Stu_Adoption_Regulatory Support					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.28	4.00	5.44	76.24
Civil Engineering	17	2.70	4.00	6.60	64.56
Construction Management	107	3.49	4.00	5.02	78.38
Others	6	2.66	3.50	5.18	65.17
Total	151				

Table 4.59: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Stu_Adoption_Regulatory_Support is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.557	Retain the null hypothesis.

Table 4.60: Kruskal-Wallis test results for adoption of Regulatory Support across discipline

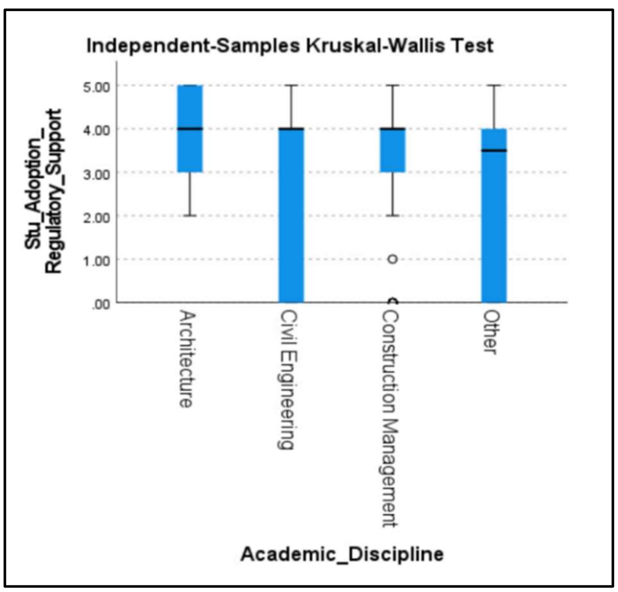


Figure 4.66: Box plot results for adoption of Regulatory

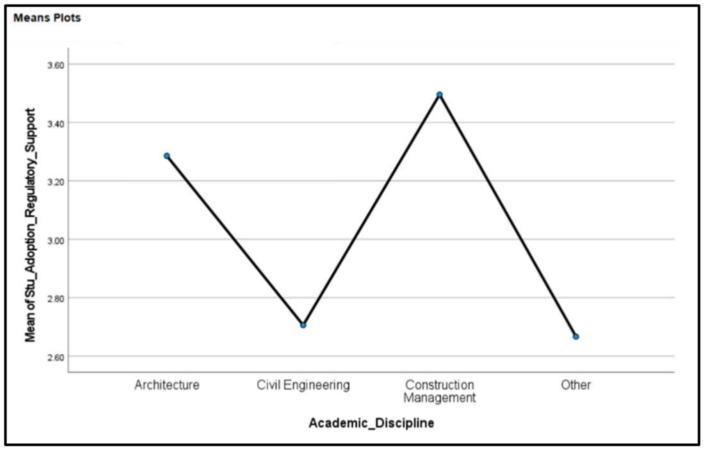


Figure 4.67: Means plot

4.4.3.2 Educational Workforce Development: Students

To analyze attitudes towards the adoption of mass timber based on the educational workforce development among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.61, the observed significance for the civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	0.057	0.501	-1.153	0.55	-1.145	0.234	-0.313	0.845
Z Score	0.11		-2.10		-4.89		-0.37	
Kurtosis	-0.579	0.972	1.231	1.063	0.903	0.463	-0.104	1.741
Z Score	-0.60		1.16		1.95		-0.06	
p - value	0.170		0.004		<0.001		0.212	
Result	Normal		Not Normal		Not Normal		Normal	

Table 4.61: Educational Workforce Development data test of normality using Shapiro-Wilk

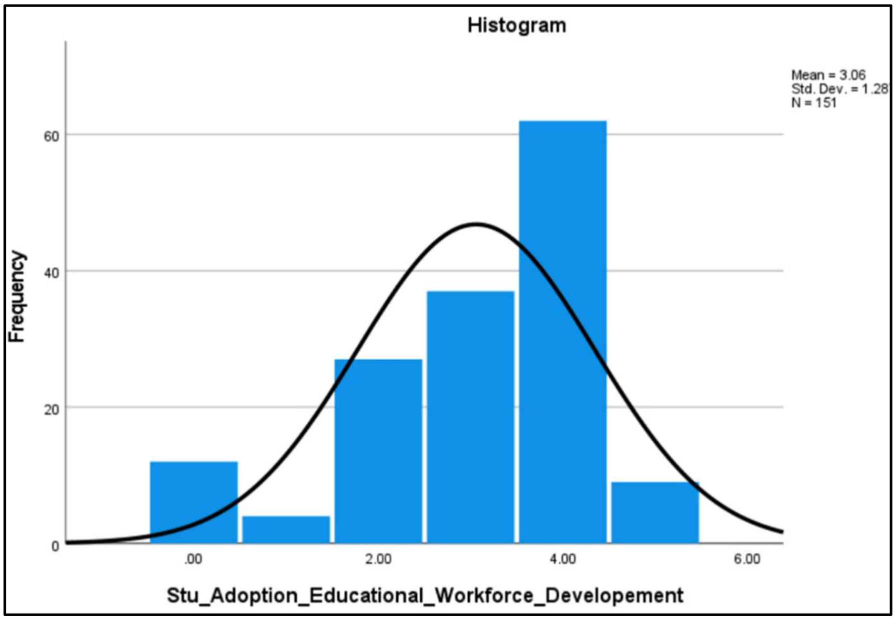


Figure 4.68: Histogram plot for test of normality on Educational Workforce

To explore potential differences in attitude towards adoption based on the educational and workforce development of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 6.977, p = 0.073, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the educational and workforce development of mass timber among student groups. Refer to Figure 4.69 for the box plot illustrating the distribution of the attitude towards adoption based on educational and workforce development across these groups.

Stu_Adoption_Educational Workforce Development					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	2.38	2.00	1.24	54.05
Civil Engineering	17	3.23	4.00	5.54	82.41
Construction Management	107	3.15	4.00	5.70	79.45
Others	6	3.16	3.00	2.68	73.17
Total	151				

Table 4.62: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Stu_Adoption_Educational_Workforce_Developement is the same across categories of Academic_Discipline	Independent-Samples Kruskal-Wallis Test	.073	Retain the null hypothesis.

Table 4.63: Kruskal-Wallis test results for adoption of Educational Workforce

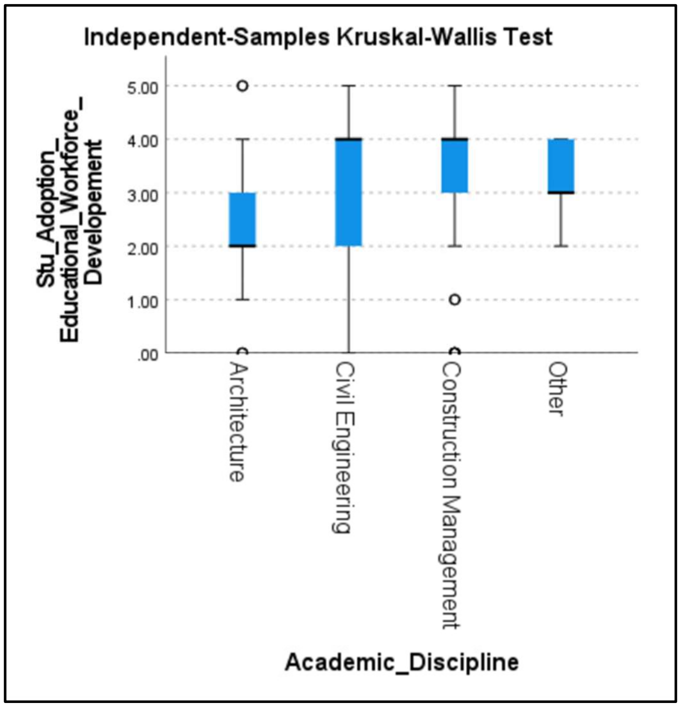


Figure 4.69: Box plot results for Adoption of Educational Workforce Development

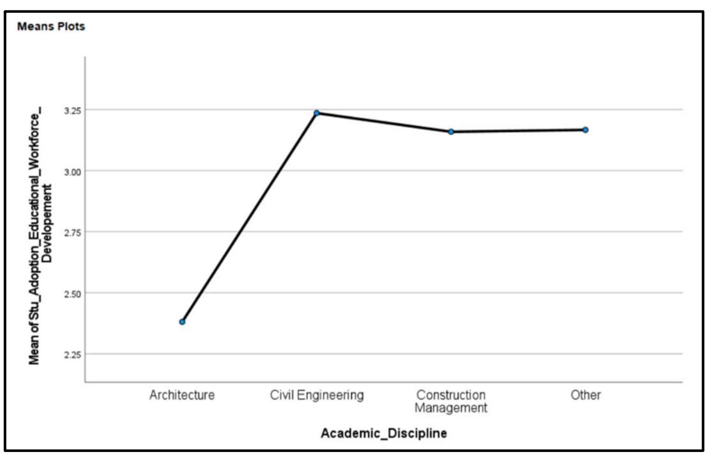


Figure 4.70: Mean plot

4.4.3.3 Collaborative Efforts: Students

To analyze attitudes towards the adoption of mass timber based on the collaborative efforts among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. Table 4.64, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-2.017	0.501	-2.156	0.55	-1.731	0.234	-0.968	0.845
Z Score	-4.03		-3.92		-7.40		-1.15	
Kurtosis	3.821	0.972	5.663	1.063	3.886	0.463	-1.875	1.741
Z Score	3.93		5.33		8.39		-1.08	
p - value	<0.001		<0.001		<0.001		0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.64: Collaborative Efforts data test of normality using Shapiro-Wilk

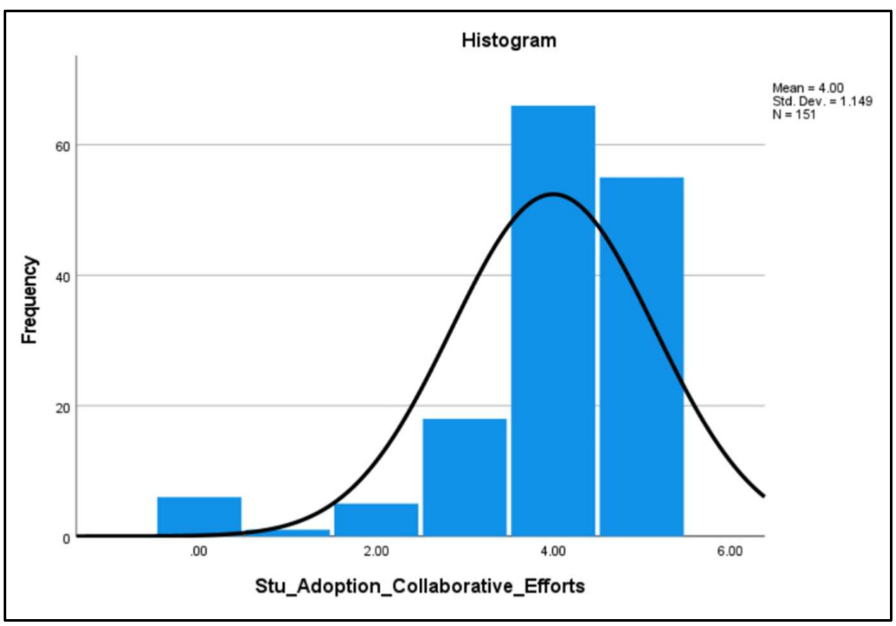


Figure 4.71: Histogram plot for test of normality on adoption of Collaborative Efforts

Stu_Adoption_Collaborative Efforts					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.95	4.00	4.10	79.71
Civil Engineering	17	4.29	5.00	6.42	89.74
Construction Management	107	3.92	4.00	4.16	71.53
Others	6	4.66	5.00	5.68	103.83
Total	151				

Table 4.65: Mean, Median, Mode and Mean Rank across all disciplines

To explore potential differences in attitude towards adoption based on the collaborative efforts of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 0.6.206, p = 0.102, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the collaborative efforts of mass timber among student groups. Refer to Figure 4.72 for the box plot illustrating the distribution of the attitude towards adoption based on collaborative efforts across these groups.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Stu_Adoption_Collaborative_Efforts is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.102	Retain the null hypothesis.

Table 4.66: Kruskal-Wallis test results for adoption of Collaborative Efforts across discipline

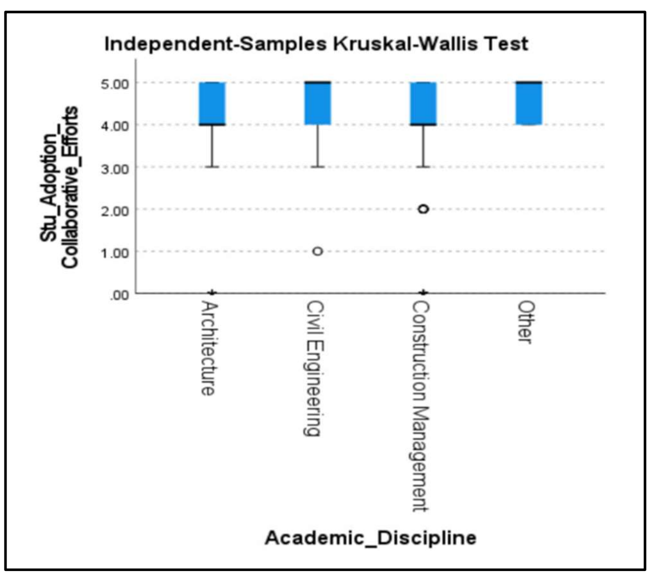


Figure 4.72: Box plot results for adoption of Collaborative Efforts

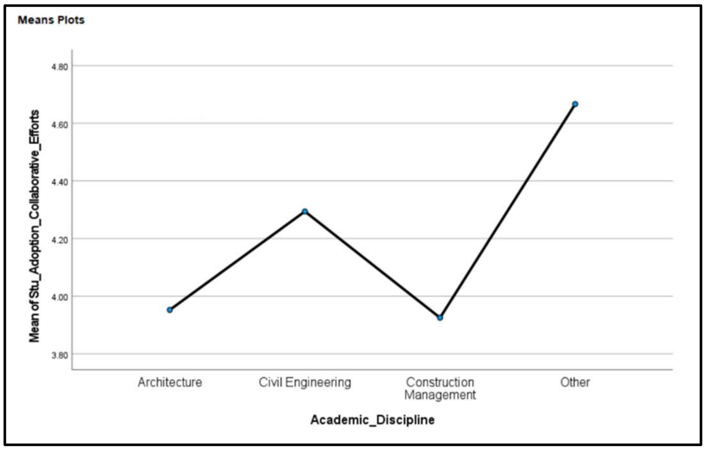


Figure 4.73: Mean plot

4.4.3.4 Environmental and Sustainability Factors: Students

To analyze attitudes towards the adoption of mass timber based on the environmental and sustainability factors among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.67, the observed significance for the construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.807	0.501	-0.694	0.55	-1.281	0.234	-1.771	0.845
Z Score	-1.61		-1.26		-5.47		-2.10	
Kurtosis	-0.077	0.972	-0.352	1.063	2.374	0.463	3.022	1.741
Z Score	-0.08		-0.33		5.13		1.74	
p - value	0.108		0.154		<0.001		0.043	
Result	Normal		Normal		Not Normal		Not Normal	

Table 4.67: Environmental and Sustainability Factors data test of normality

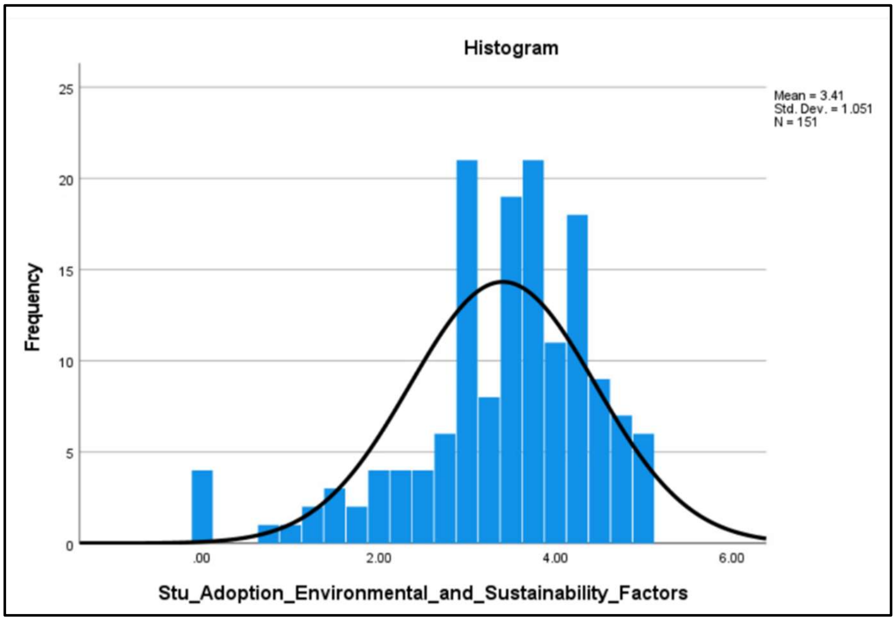


Figure 4.74: Histogram plot for test of normality on Environmental and Sustainability Factors

To explore potential differences in attitude towards adoption based on the environmental and sustainability factors of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 0.913, p = 0.822, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the environmental and sustainability factors of mass timber among student groups. Refer to Figure 4.75 for the box plot illustrating the distribution of the attitude towards adoption based on environmental and sustainability factors across these groups.

Stu_Adoption_Environmental and Sustainability Factors					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.38	3.50	3.74	74.62
Civil Engineering	17	3.45	3.75	4.35	79.15
Construction Management	107	3.39	3.50	3.72	74.92
Others	6	4.62	4.12	3.12	91.25
Total	151				

Table 4.68: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Stu_Adoption_Environmental_and_Sustainability_Factors is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.822	Retain the null hypothesis.

Table 4.69: Kruskal-Wallis test results for adoption of Environmental and Sustainability Factors

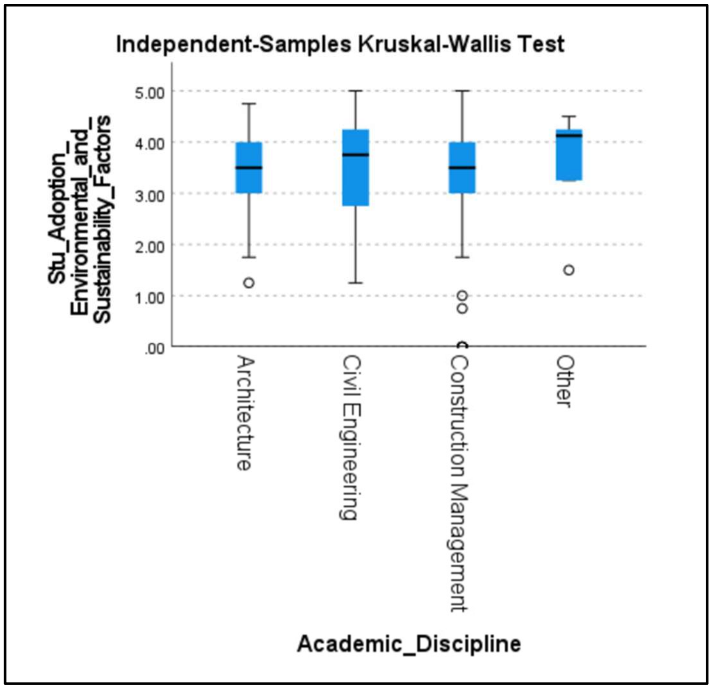


Figure 4.75: Box plot results for adoption of Environmental and Sustainability Factors

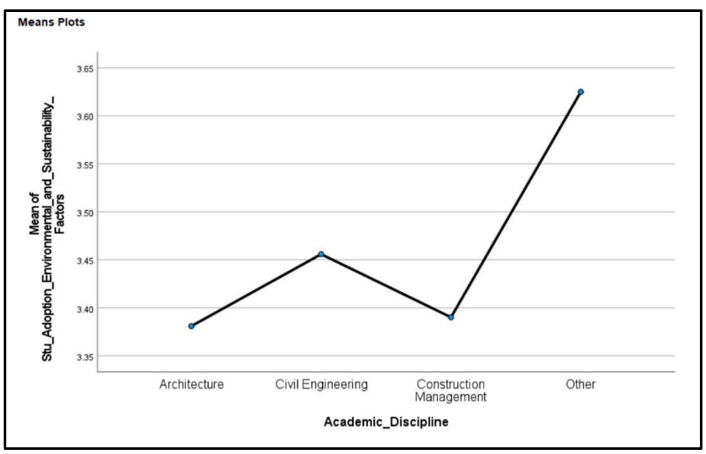


Figure 4.76: Means Plot

4.4.3.5 Market Perceptions: Students

To analyze attitudes towards the adoption of mass timber based on the market perceptions among the student's group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.70, the observed significance for the construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.773	0.501	-0.731	0.55	-0.442	0.234	-1.807	0.845
Z Score	-1.54		-1.33		-1.89		-2.14	
Kurtosis	-0.07	0.972	-0.252	1.063	-0.348	0.463	3.541	1.741
Z Score	-0.07		-0.24		-0.75		2.03	
p - value	0.085		0.141		<0.001		0.070	
Result	Normal		Normal		Not Normal		Normal	

Table 4.70: Market Perception data test of normality using Shapiro-Wilk

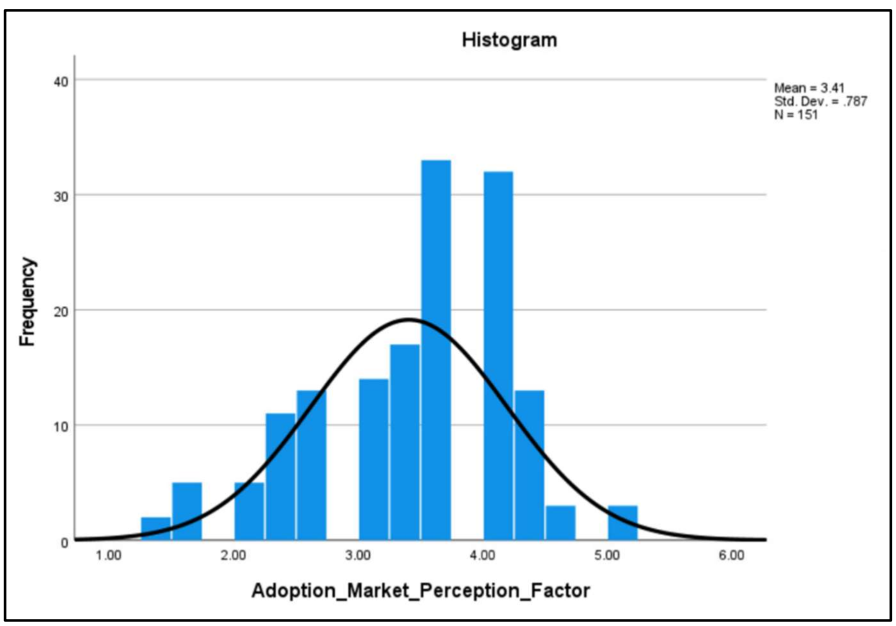


Figure 4.77: Histogram plot for test of normality on adoption of Collaborative Efforts

To explore potential differences in attitude towards adoption based on the market perception factor of mass timber among student groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=151) = 3.817, p = 0.282, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the market perception factor of mass timber among student groups. Refer to Figure 4.78 for the box plot illustrating the distribution of the attitude towards adoption based on market perception factors across these groups.

Stu_Adoption_Market Perceptions					
Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	21	3.07	3.33	3.85	59.43
Civil Engineering	17	3.47	3.67	4.07	79.44
Construction Management	107	3.45	3.67	4.11	78.11
Others	6	3.50	3.83	4.49	86.67
Total	151				

Table 4.71: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Adoption_Market_Perception_Factor is the same across categories of Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.282	Retain the null hypothesis.

Table 4.72: Kruskal-Wallis test results for adoption of Collaborative Efforts across discipline

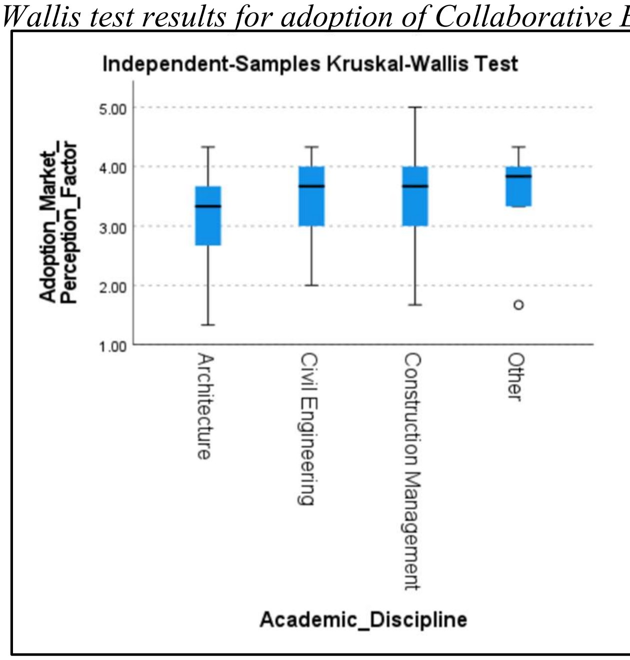


Figure 4.78: Box plot results for adoption of Collaborative Efforts

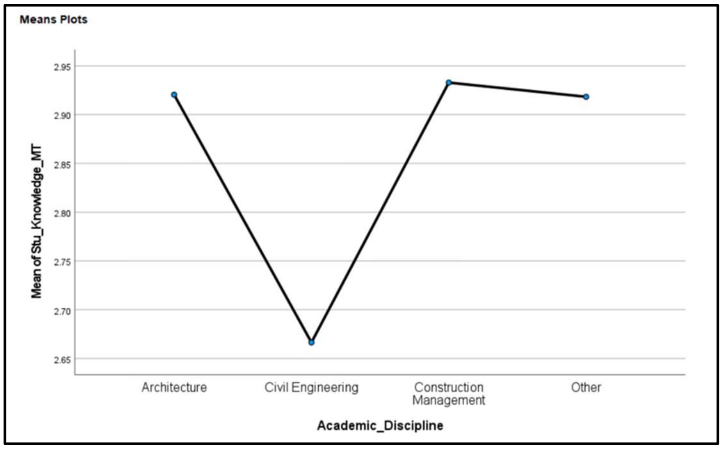


Figure 4.79: Means plot

4.4.4 Current knowledge about mass timber: Faculty

To assess the mean difference based on the current knowledge of mass timber among groups-specifically faculty in architecture, civil engineering, and construction management the following analysis was conducted.

Firstly, the Shapiro-Wilk test was conducted to assess normality for all faculty groups, using a significance level (alpha) of 0.05. Additionally, normality was examined using measures of Skewness and Kurtosis, ensuring the z-scores fell within the range of -1.96 to +1.96, indicative of normal distribution.

Table 4.73 presents the results, indicating that the observed significance (*p*) is less than the alpha value of 0.05 for architecture and civil engineering students suggesting a non-normal distribution of data whereas the significance (*p*) for construction management and other students is more than 0.05 suggesting normal distribution. Since the data is not completely normally distributed the ANOVA is not applicable and hence non-parametric tests were deemed appropriate for analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.221	0.239	1.394	0.637	0.056	0.403	0.183	0.55
Z Score	-0.92		2.19		0.14		0.33	
Kurtosis	-0.411	0.474	1.799	1.232	-0.647	0.788	-0.65	1.063
Z Score	-0.87		1.46		-0.82		-0.61	
p- value	0.408		0.037		0.560		0.237	
Result	Not Normal		Not Normal		Normal		Normal	

Table 4.73: Current knowledge about mass timber test of normality using Shapiro-Wilk

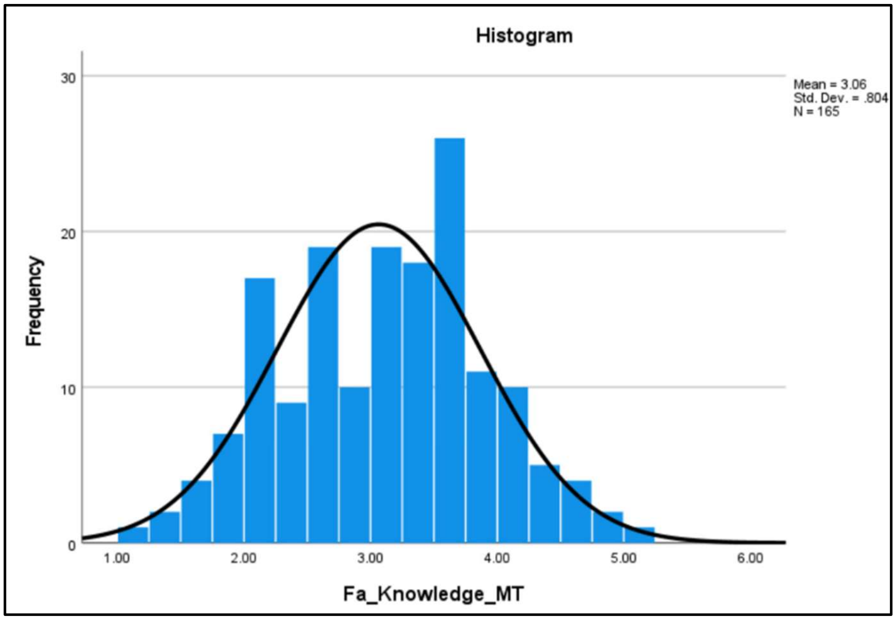


Figure 4.80: Histogram plot for test of normality on Current knowledge about mass timber

To explore potential differences in current knowledge among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 5.623, p = 0.131, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in knowledge gaps related to mass timber among student groups. Refer to Figure 4.81 for the box plot illustrating the distribution of the current knowledge across these groups.

MT_Current Knowledge					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.17	3.17	3.17	89.90
Civil Engineering	12	2.95	2.75	2.35	71.67
Construction Management	34	2.84	2.75	2.57	71.15
Others	17	2.92	3.17	3.67	73.29
Total	165				

Table 4.74: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_Knowledge_MT is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.131	Retain the null hypothesis.

Table 4.75: Kruskal-Wallis test results for Current knowledge about mass timber

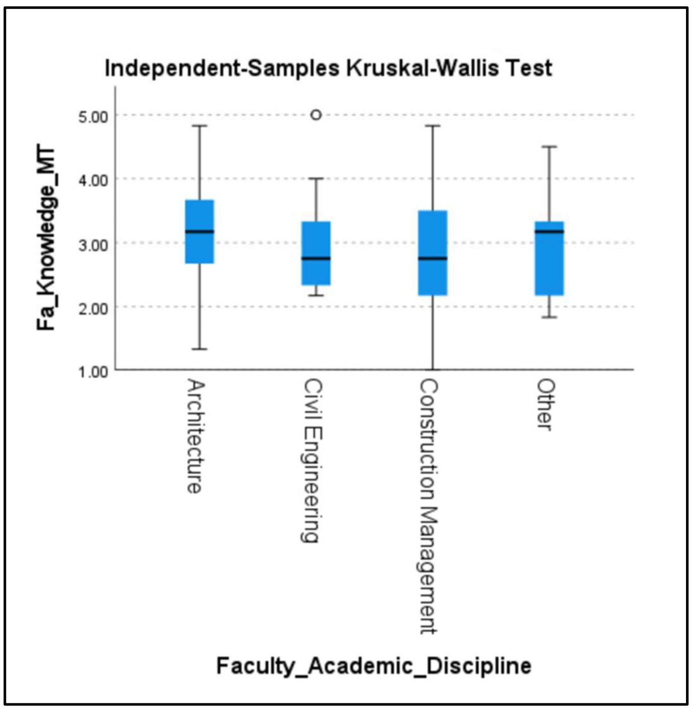


Figure 4.81: Box plot results for Current knowledge about mass timber

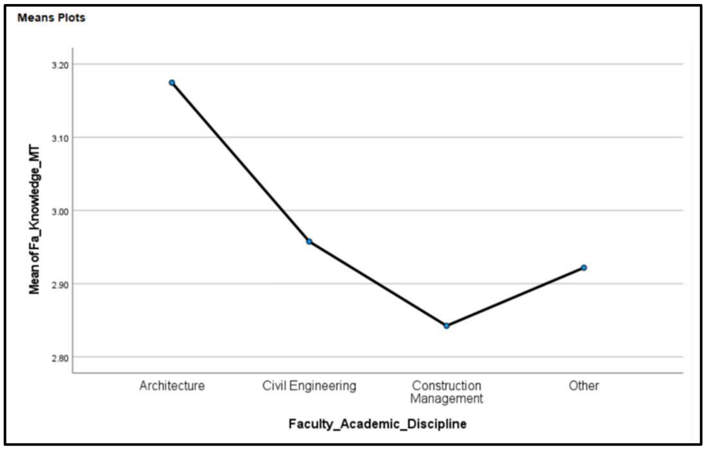


Figure 4.82: Means plot

4.4.5 Perception of mass timber: Faculty

To examine perceptions among faculty groups, survey questions were divided further divided into six specific areas:

1. Based on the performance of mass timber
2. Based on sustainability and environmental impact
3. Based on safety and regulatory compliance
4. Curriculum Inclusion
5. Job Preparation
6. Community Beliefs

Each category was subjected to normality testing followed by further analysis. The findings from these analyses are discussed and illustrated to shed light on the factors influencing perceptions of mass timber among different faculty groups within the US construction industry.

4.4.5.1 Based on the performance of mass timber: Faculty

To analyze perception based on the performance of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.76, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.159	0.239	-0.719	0.637	-1.077	0.403	-1.057	0.55
Z Score	-4.85		-1.13		-2.67		-1.92	
Kurtosis	1.846	0.474	-0.03	1.232	0.3	0.788	0.248	1.063
Z Score	3.89		-0.02		0.38		0.23	
p- value	<0.001		0.271		0.001		0.039	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.76: Perception on performance of mass timber data test of normality

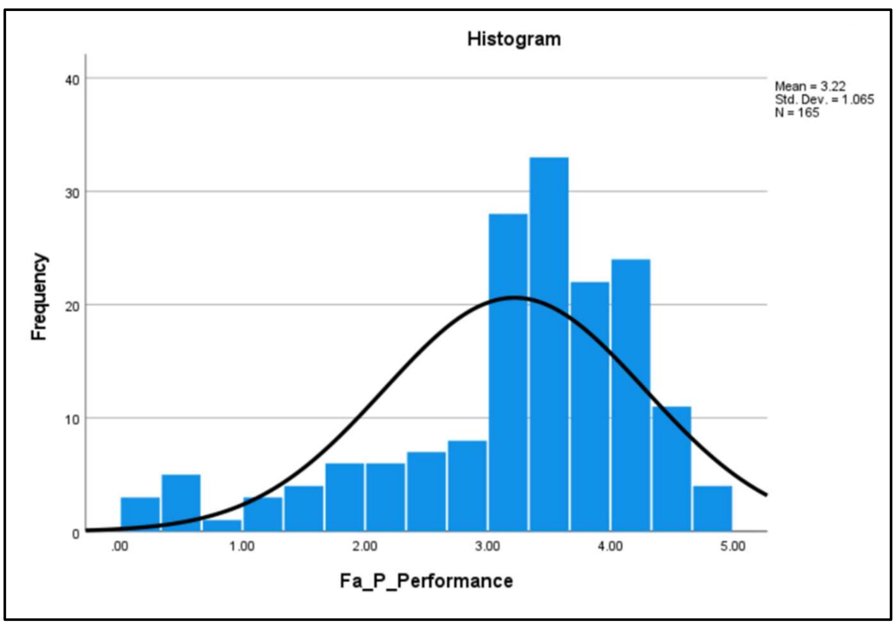


Figure 4.83: Histogram plot for test of normality on Perception of performance of mass timber

To explore potential differences in perceptions based on the performance of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (3, N=165) 7.828, p = 0.050, leading to the rejection of the null hypothesis. These findings suggest a significant difference in perceptions based on the performance of mass timber among faculty groups. Refer to Figure 4.84 for the box plot illustrating the distribution of the perceptions based on the performance across these groups.

Fa_Perception_Performance					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.40	3.50	3.70	89.89
Civil Engineering	12	2.71	3.13	3.97	54.46
Construction Management	34	2.91	3.31	4.11	73.41
Others	17	3.08	3.50	4.34	80.97
Total	165				

Table 4.77: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Fa_P_Performance is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.050	Reject the null hypothesis.

Table 4.78: Kruskal-Wallis test results for Perception of performance of mass timer

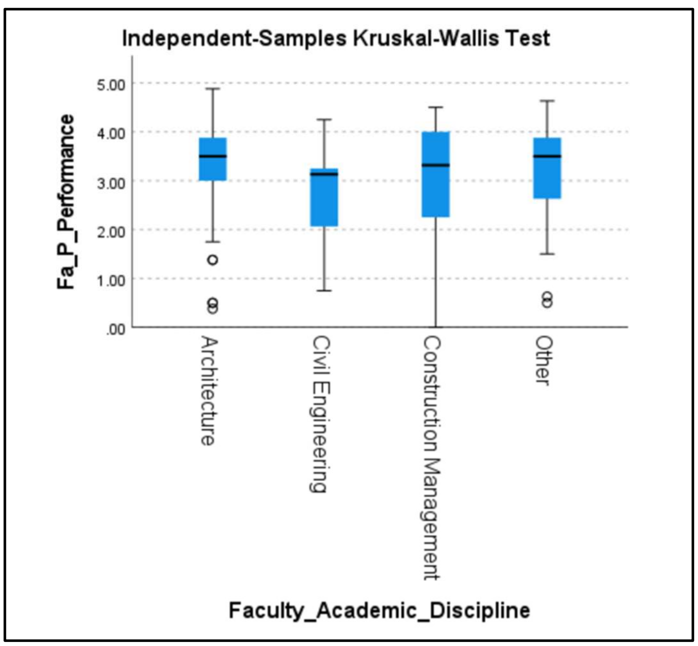


Figure 4.84: Box plot results for Perception of performance of mass timber

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted no significant distinction in perceptions groups. Refer to Figure 4.85, which presents the pairwise comparison of discipline by mean rank.

Pairwise Comparisons of Faculty_Academic_Discipline

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Civil Engineering-Construction Management	-18.953	16.019	-1.183	.237	1.000
Civil Engineering-Other	-26.512	17.988	-1.474	.141	.843
Civil Engineering-Architecture	35.434	14.560	2.434	.015	.090
Construction Management-Other	-7.559	14.172	-.533	.594	1.000
Construction Management-Architecture	16.480	9.448	1.744	.081	.487
Other-Architecture	8.922	12.498	.714	.475	1.000

Table 4.79: Pairwise test results

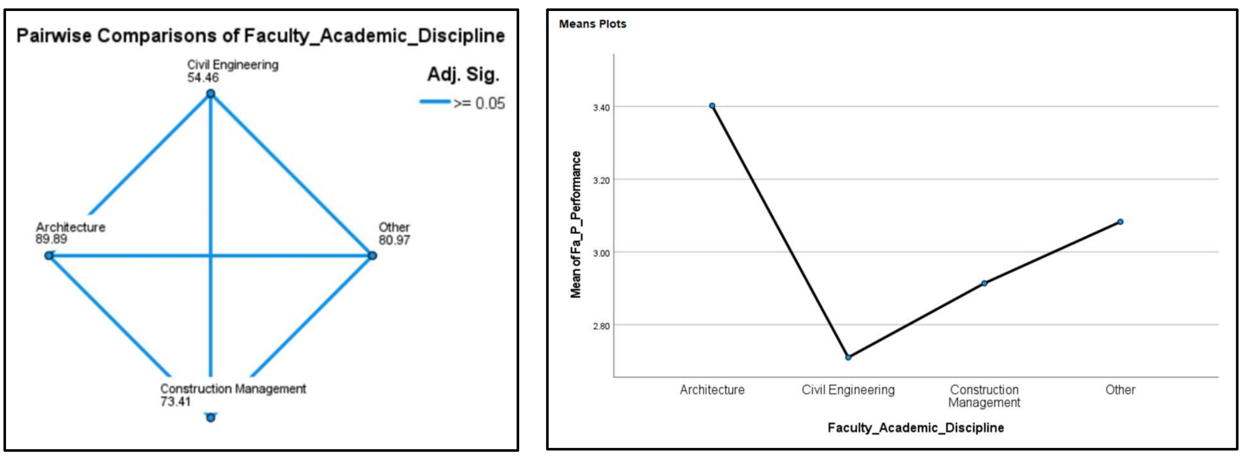


Figure 4.85: Pairwise Comparisons and Means Plot

4.4.5.2 Sustainability and Environmental Impact: Faculty

To analyze perception based on the sustainability and environmental impact of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.80, the observed significance for the architecture, civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.127	0.239	-1.962	0.637	-0.702	0.403	-0.995	0.55
Z Score	-4.72		-3.08		-1.74		-1.81	
Kurtosis	1.924	0.474	4.487	1.232	-0.415	0.788	-0.24	1.063
Z Score	4.06		3.64		-0.53		-0.23	
p- value	<0.001		0.004		0.014		0.011	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.80: Sustainability and Environmental Impact data test of normality using Shapiro-Wilk

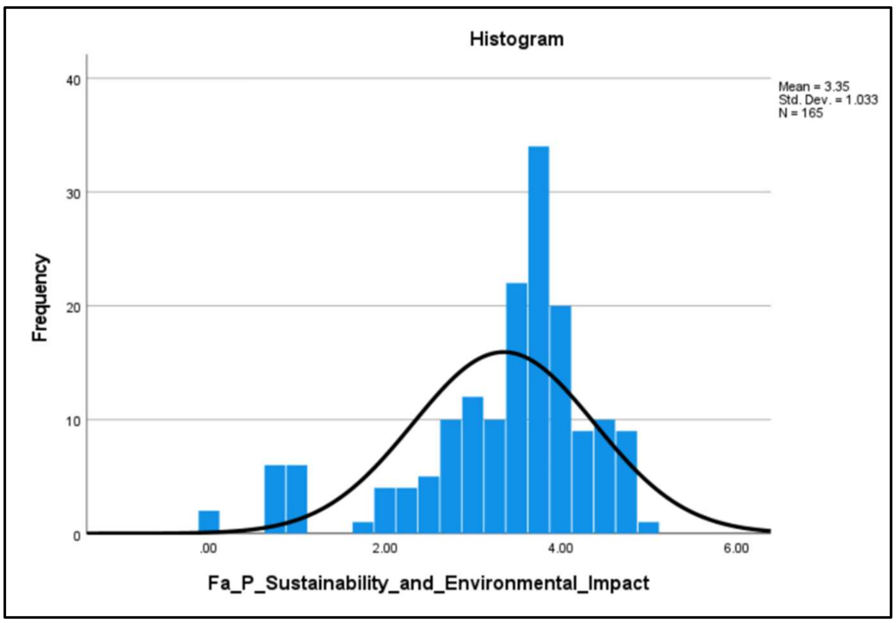


Figure 4.86: Histogram plot for test of normality on Sustainability and Environmental Impact

To explore potential differences in perceptions based on the sustainability and environmental impact of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (3, N=165) = 8.668, p = 0.034, leading to the rejection of the null hypothesis. These findings suggest a significant difference in perceptions based on the sustainability and environmental impact of mass timber among faculty groups. Refer to Figure

4.87 for the box plot illustrating the distribution of the perceptions based on the sustainability and environmental impact across these groups.

Fa_Perception_Sustainability and Environmental Impact					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.56	3.75	4.13	90.57
Civil Engineering	12	3.33	3.62	4.20	80.50
Construction Management	34	2.83	3.12	3.70	63.24
Others	17	3.16	3.50	4.18	78.85
Total	165				

Table 4.81: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.a,b	Decision
1	The distribution of Fa_P_Sustainability_and_Environmental_Impact is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.034	Reject the null hypothesis.

Table 4.82: Kruskal-Wallis test results for adoption of Sustainability and Environmental

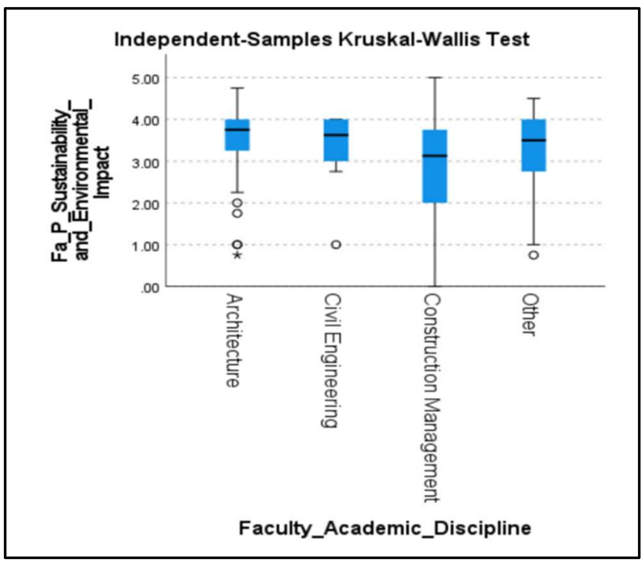


Figure 4.87: Box plot results for adoption of Sustainability and Environmental Impact

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted a significant distinction in perceptions between the construction management and architecture groups, with a significance level of 0.022.

This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.88, which presents the pairwise comparison of discipline by mean rank.

Pairwise Comparisons of Faculty_Academic_Discipline

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Construction Management-Other	-15.618	14.089	-1.109	.268	1.000
Construction Management-Civil Engineering	17.265	15.926	1.084	.278	1.000
Construction Management-Architecture	27.338	9.393	2.911	.004	.022
Other-Civil Engineering	1.647	17.883	.092	.927	1.000
Other-Architecture	11.721	12.425	.943	.346	1.000
Civil Engineering-Architecture	10.074	14.475	.696	.486	1.000

Table 4.83: Pairwise test results

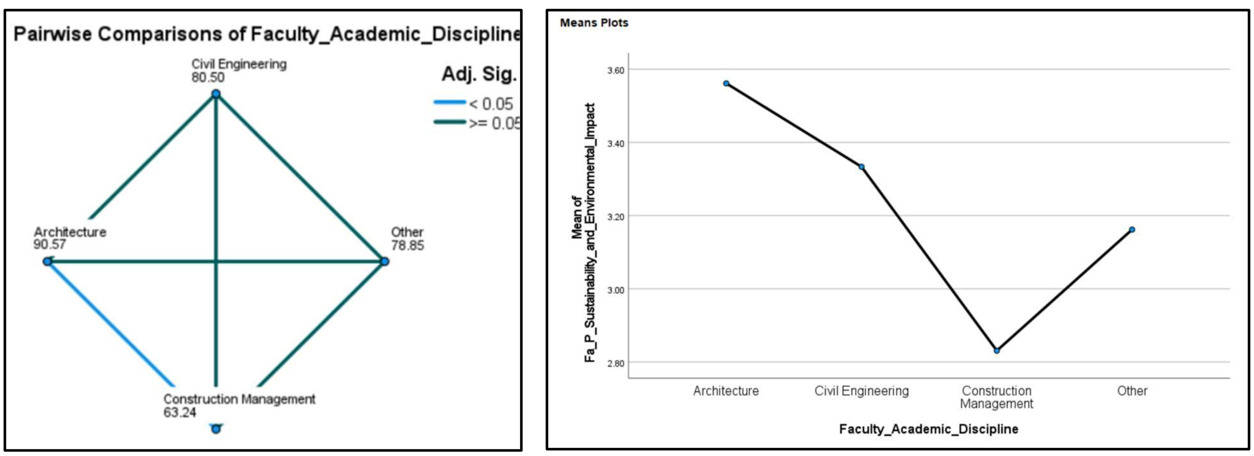


Figure 4.88: Pairwise Comparisons and Means Plot

4.4.5.3 Safety and Regulatory Compliance: Faculty

To analyze perception based on the safety and regulatory compliance of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.84, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.966	0.239	-1.083	0.637	-0.734	0.403	-1.646	0.55
Z Score	-4.04		-1.70		-1.82		-2.99	
Kurtosis	0.608	0.474	0.69	1.232	-0.803	0.788	2.365	1.063
Z Score	1.28		0.56		-1.02		2.22	
p- value	<0.001		0.113		<0.001		0.002	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.84: Safety and Regulatory Compliance data test of normality

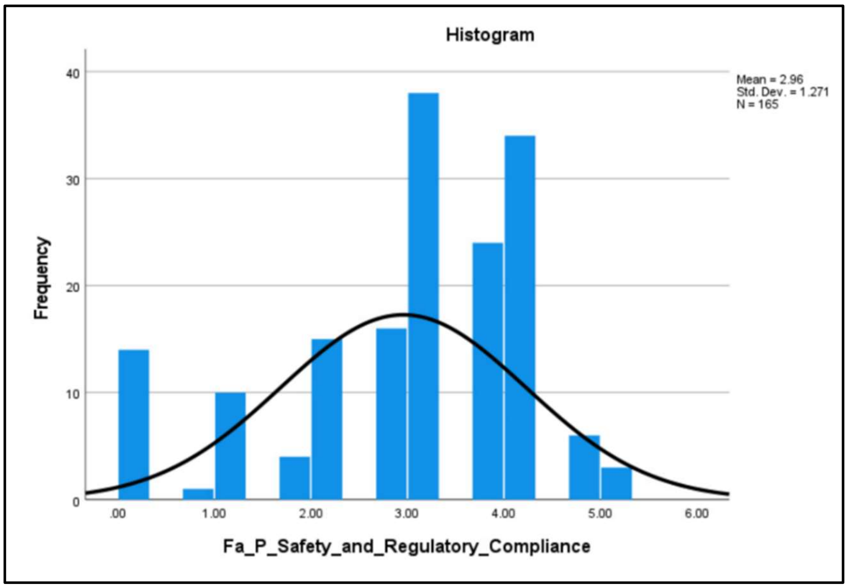


Figure 4.89: Histogram plot for test of normality on Perception of Safety and Regulatory Compliance

To explore potential differences in perceptions based on the safety and regulatory compliance of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 6.490, p = 0.090, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the safety and regulatory compliance of mass timber among faculty groups. Refer to Figure 4.90 for the box plot illustrating the distribution of the perceptions based on safety and regulatory compliance across these groups.

Fa_Perception_Safety and Regulatory Compliance					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.12	3.33	3.75	89.02
Civil Engineering	12	3.08	3.33	3.83	90.50
Construction Management	34	2.54	2.83	3.41	71.54
Others	17	2.66	3.00	3.68	64.50
Total	165				

Table 4.85: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_P_Safety_and_Regulatory_Compliance is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.090	Retain the null hypothesis.

Table 4.86: Kruskal-Wallis test results for Perception of Safety and Regulatory Compliance

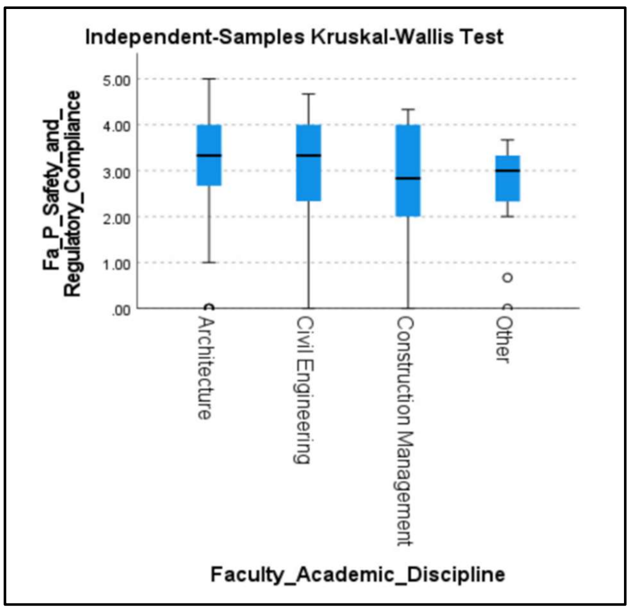


Figure 4.90: Box plot results for adoption of Perception of Safety and Regulatory Compliance

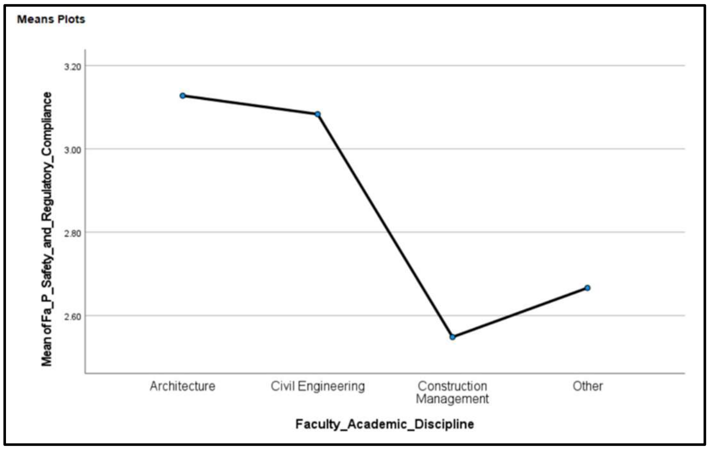


Figure 4.91: Means plot

4.4.5.4 Curriculum Inclusion: Faculty

To analyze perception based on the curriculum inclusion of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.87, the observed significance for the architecture, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.799	0.239	0.577	0.637	0.038	0.403	-0.238	0.55
Z Score	-3.34		0.91		0.09		-0.43	
Kurtosis	0.418	0.474	-0.613	1.232	-1.228	0.788	-0.932	1.063
Z Score	0.88		-0.50		-1.56		-0.88	
p- value	<0.001		0.174		0.002		0.091	
Result	Not Normal		Normal		Not Normal		Normal	

Table 4.87: Perception of Curriculum Inclusion test of normality using Shapiro-Wilk

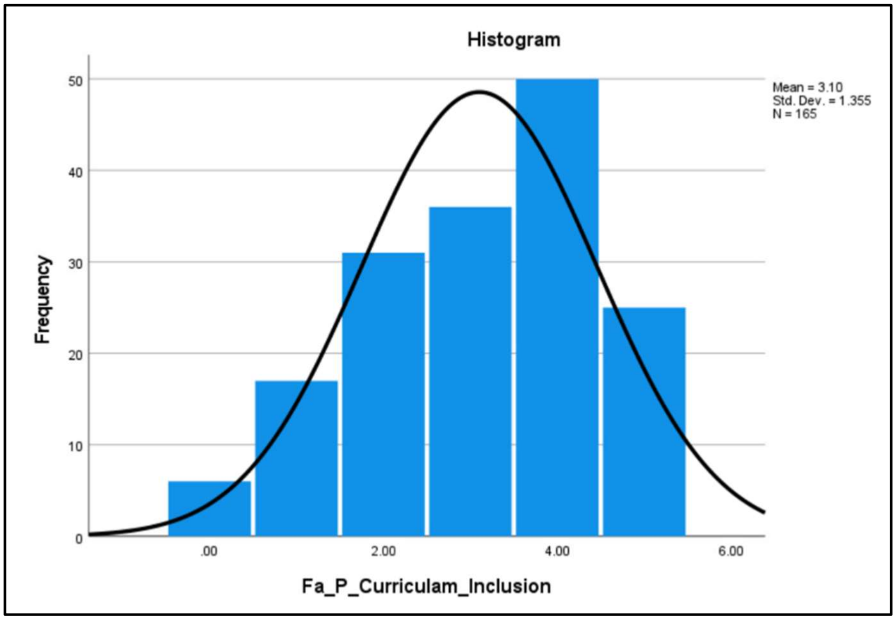


Figure 4.92: Histogram plot for test of normality on Perception of Curriculum Inclusion

To explore potential differences in perceptions based on the curriculum inclusion of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (3, N=165) = 20.847, p = <0.001, leading to the rejection of the null hypothesis. These findings suggest a significant difference in perceptions based on the curriculum inclusion of mass timber among faculty groups. Refer to Figure 4.93 for the box plot illustrating the distribution of the perceptions based on curriculum inclusion across these groups.

Fa_Perception_Curriculam_Inclusion					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.44	4.00	5.12	94.74
Civil Engineering	12	2.50	2.00	1.00	60.83
Construction Management	34	2.29	2.00	1.42	55.74
Others	17	3.11	3.00	2.78	82.74
Total	165				

Table 4.88: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_P_Curriculam_Inclusion is the same across categories of Faculty_Academic_Discipline	Independent-Samples Kruskal-Wallis Test	<.001	Reject the null hypothesis.

Table 4.89: Kruskal-Wallis test results for Perception of Curriculum Inclusion

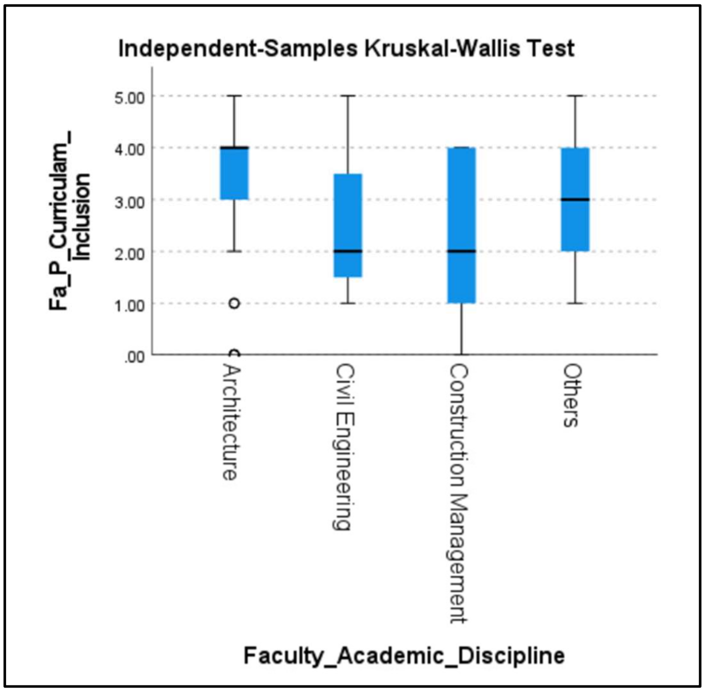


Figure 4.93: Box plot results for Perception of Curriculum Inclusion

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted a significant distinction in perceptions between the construction management and architecture groups, with a significance level of 0.00. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.94, which presents the pairwise comparison of discipline by mean rank.

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Construction Management-Civil Engineering	5.098	15.640	.326	.744	1.000
Construction Management-Others	-27.000	13.836	-1.951	.051	.306
Construction Management-Architecture	39.005	9.224	4.229	<.001	.000
Civil Engineering-Others	-21.902	17.562	-1.247	.212	1.000
Civil Engineering-Architecture	33.907	14.215	2.385	.017	.102
Others-Architecture	12.005	12.202	.984	.325	1.000

Table 4.90: Pairwise test results

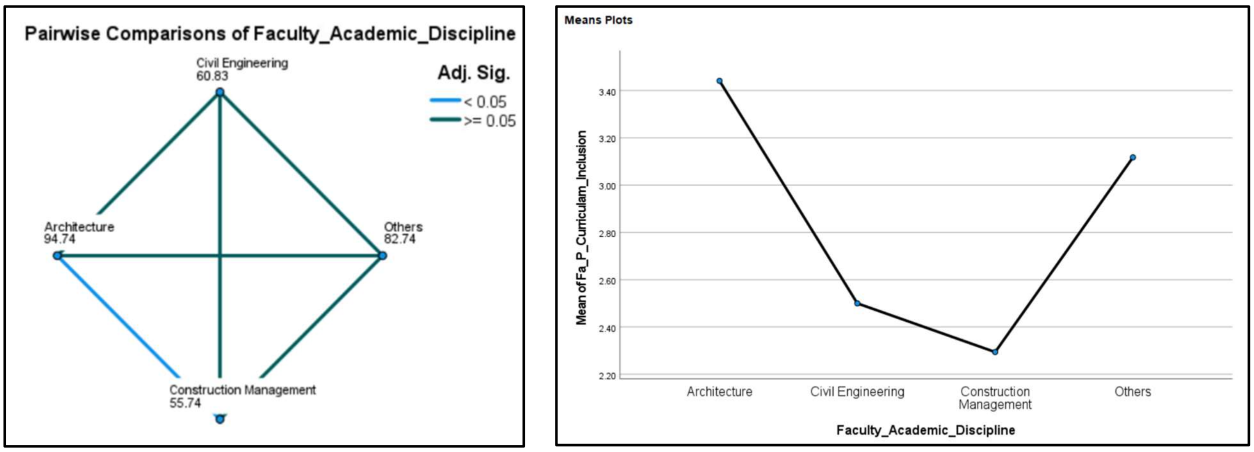


Figure 4.94: Pairwise Comparisons and Means Plot

4.4.5.5 Job Preparation: Faculty

To analyze perception based on the job preparation of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.91, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.097	0.239	0.442	0.637	0.038	0.403	0	0.55
Z Score	-0.41		0.69		0.09		0.00	
Kurtosis	-0.878	0.474	-0.326	1.232	-0.956	0.788	-0.014	1.063
Z Score	-1.85		-0.26		-1.21		-0.01	
p- value	<0.001		0.060		0.005		0.195	
Result	Not Normal		Normal		Not Normal		Normal	

Table 4.91: Perception of Job Preparation data test of normality using Shapiro-Wilk

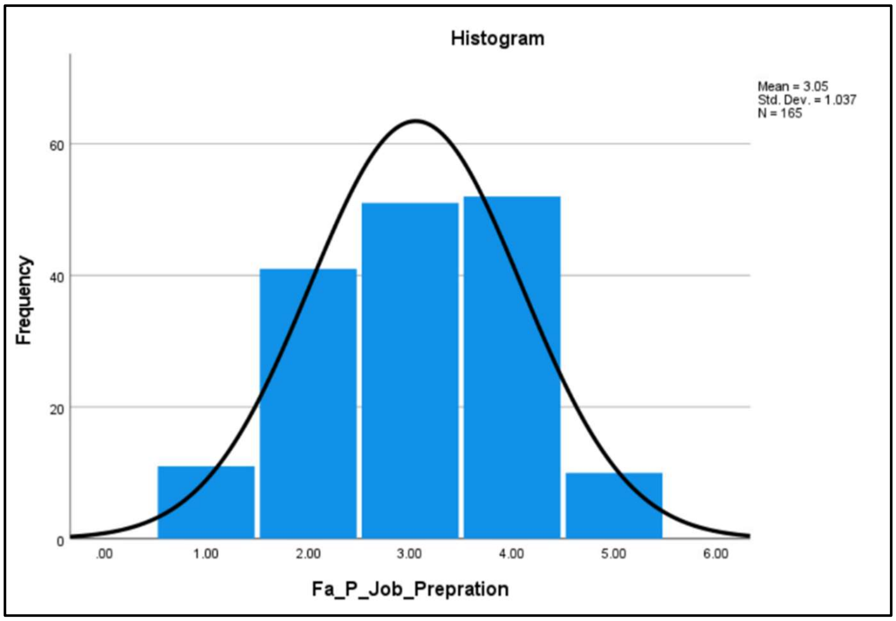


Figure 4.95: Histogram plot for test of normality on Perception of Job Preparation

To explore potential differences in perceptions based on the job preparation of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (3, N=165) = 10.588, p = 0.014, leading to the rejection of the null hypothesis. These findings suggest a significant difference in perceptions based on the job preparation of mass timber among faculty groups. Refer to Figure 4.96 for the box plot illustrating the distribution of the perceptions based on job preparation across these groups.

Fa_Perception_Job_Prepration					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.25	3.00	2.50	91.37
Civil Engineering	12	2.50	2.00	1.00	57.58
Construction Management	34	2.67	3.00	3.66	68.40
Others	17	3.00	3.00	3.00	79.91
Total	165				

Table 4.92: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Fa_P_Job_Prepration is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.014	Reject the null hypothesis.

Table 4.93: Kruskal-Wallis test results for Perception of Job Preparation

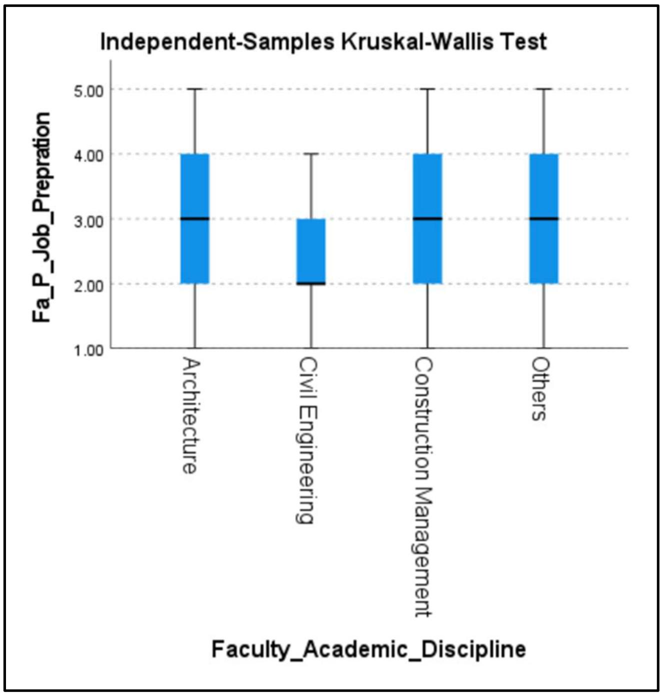


Figure 4.96: Box plot results for Perception of Job Preparation

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted no significant distinction in perceptions. Refer to Figure 4.97, which presents the pairwise comparison of discipline by mean rank.

Pairwise Comparisons of Faculty_Academic_Discipline

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Civil Engineering-Construction Management	-10.814	15.415	-.702	.483	1.000
Civil Engineering-Others	-22.328	17.309	-1.290	.197	1.000
Civil Engineering-Architecture	33.789	14.010	2.412	.016	.095
Construction Management-Others	-11.515	13.637	-.844	.398	1.000
Construction Management-Architecture	22.975	9.091	2.527	.011	.069
Others-Architecture	11.461	12.026	.953	.341	1.000

Table 4.94: Pairwise test results

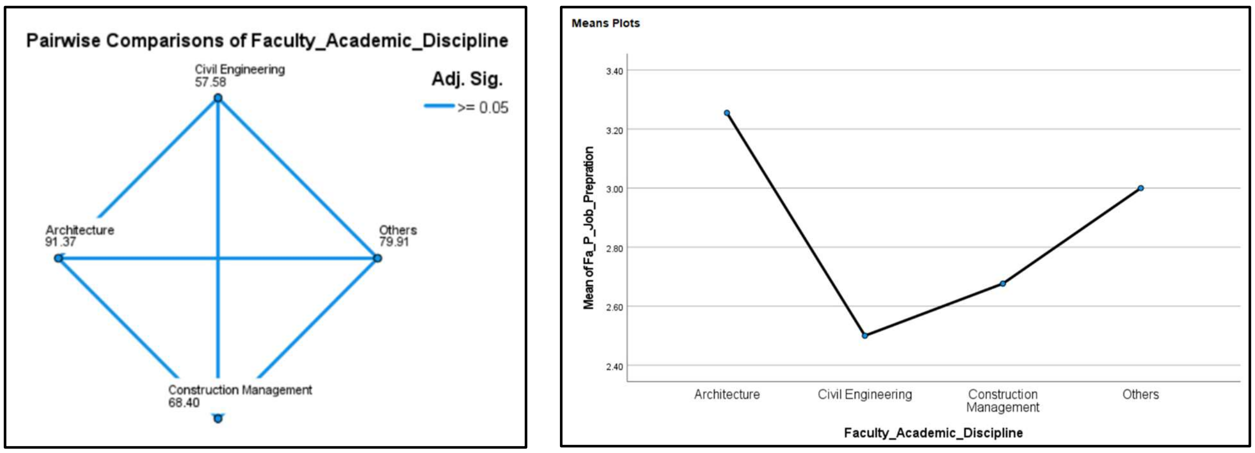


Figure 4.97: Pairwise Comparisons and Means Plot

4.4.5.6 Community Beliefs: Faculty

To analyze perception based on the community beliefs of the mass timber among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.95, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.392	0.239	-1.74	0.637	-0.919	0.403	-1.188	0.55
Z Score	-5.82		-2.73		-2.28		-2.16	
Kurtosis	0.96	0.474	1.911	1.232	-0.563	0.788	-0.164	1.063
Z Score	2.03		1.55		-0.71		-0.15	
p- value	<0.001		<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.95: Community Beliefs data test of normality using Shapiro-Wilk

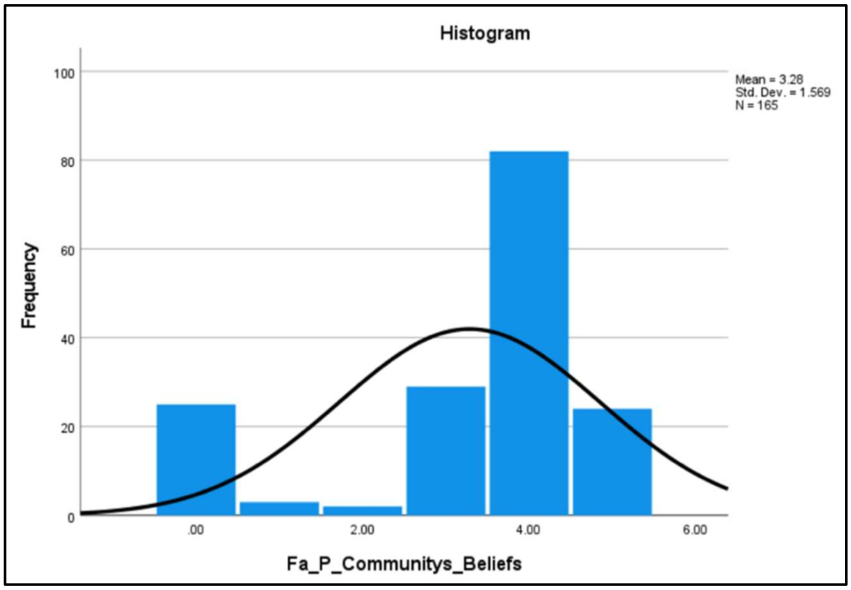


Figure 4.98: Histogram plot for test of normality on Perception of Community Beliefs

To explore potential differences in perceptions based on the community beliefs of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 4.313, p = 0.230, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the community beliefs of mass timber among faculty groups. Refer to Figure 4.99, for the box plot illustrating the distribution of the perceptions based on community beliefs across these groups.

Fa_Perceptions_Communitys_Beliefs					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.44	4.00	5.12	87.86
Civil Engineering	12	3.33	4.00	5.34	85.71
Construction Management	34	2.92	3.50	4.66	70.31
Others	17	3.05	4.00	5.90	77.32
Total	165				

Table 4.96: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_P_Communitys_Beliefs is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.230	Retain the null hypothesis.

Table 4.97: Kruskal-Wallis test results for Perception of Community Beliefs

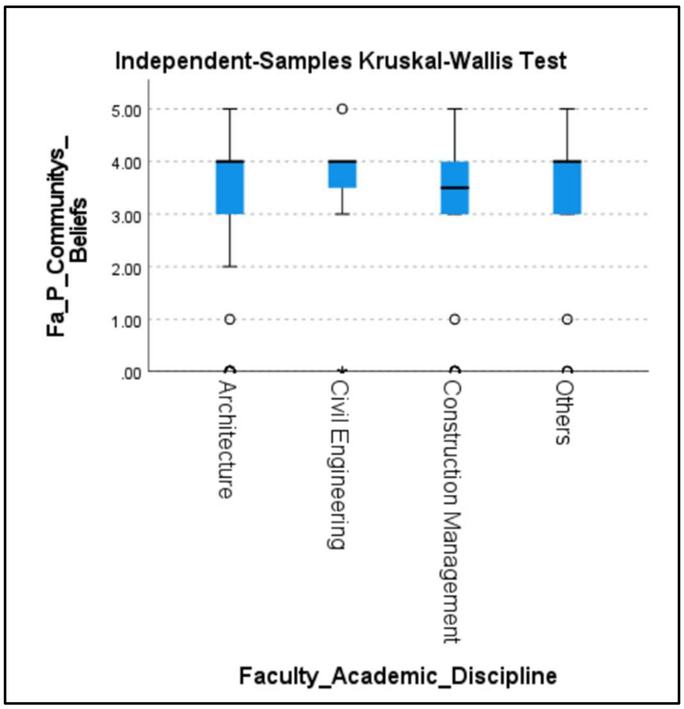


Figure 4.99: Box plot results for Perception of Community Beliefs

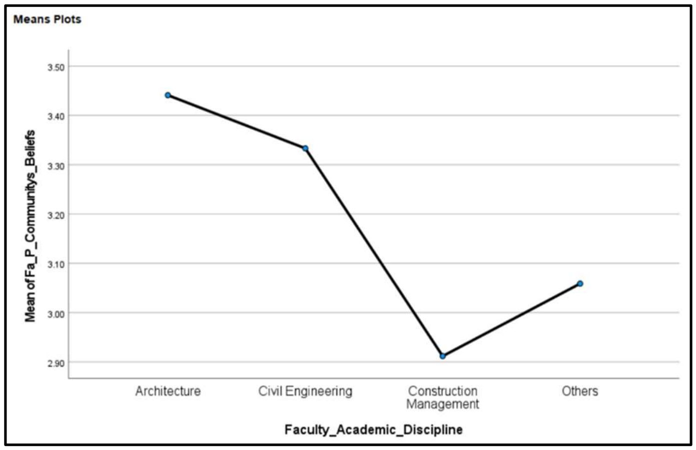


Figure 4.100: Means plot

4.4.6 Adoption of mass timber: Faculty

To explore the key factors influencing the adoption of mass timber among the faculty group in the us construction industry, statistical analysis was conducted.

To delve into the factors impacting adoption, survey questions were further categorized into five distinct areas refer to Table 3.1:

1. Based on regulatory support
2. Based on educational and workforce development
3. Based on collaborative efforts
4. Based on environmental and sustainability factors
5. Based on market perception factors

For each of these subcategories, the data underwent initial normality testing followed by further analysis The results of these are further discussed and illustrated to provide insights into the factors influencing the adoption of mass timber among the faculty group within the US construction industry.

4.4.6.1 Regulatory Support: Faculty

To analyze attitudes towards the adoption of mass timber based on the regulatory support among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.98, the observed significance for the architecture, civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.397	0.239	-2.276	0.637	-1.203	0.403	0.339	0.55
Z Score	-5.85		-3.57		-2.99		0.62	
Kurtosis	1.433	0.474	6.478	1.232	0.541	0.788	-0.58	1.063
Z Score	3.02		5.26		0.69		-0.55	
p- value	<0.001		<0.001		<0.001		0.014	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.98: Regulatory Support data test of normality using Shapiro-Wilk

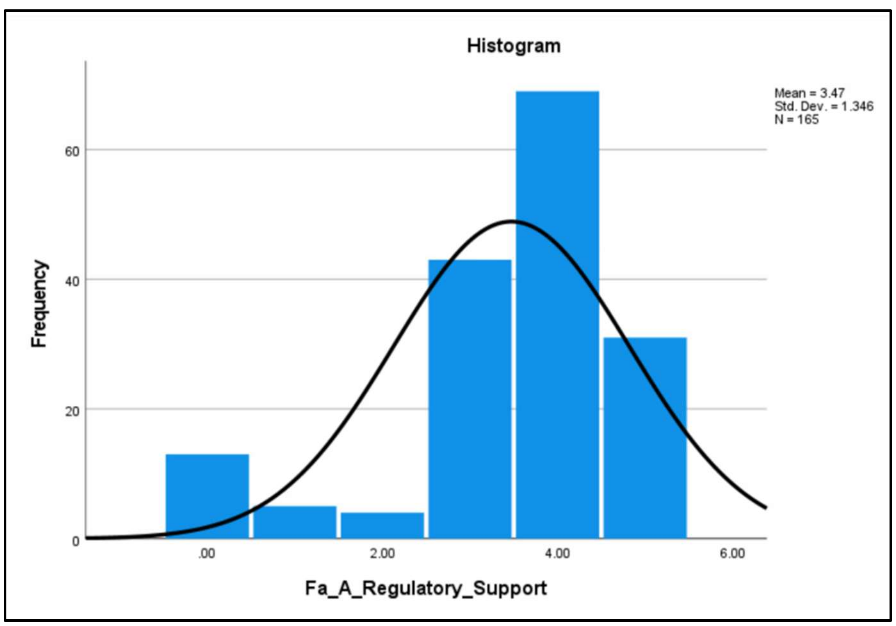


Figure 4.101: Histogram plot for test of normality on Regulatory Support

To explore potential differences in attitude towards adoption based on the regulatory support of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 6.487, p = 0.090, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the regulatory support of mass timber among faculty groups. Refer to Figure 4.102 for the box plot illustrating the distribution of the attitude towards adoption based on regulatory support across these groups.

Fa_Adoption_Regulatory Support					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.59	4.00	4.82	89.72
Civil Engineering	12	3.16	3.00	2.68	64.25
Construction Management	34	3.14	4.00	5.72	72.06
Others	17	3.58	3.00	1.84	77.79
Total	165				

Table 4.99: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Fa_A_Regulatory_Support is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.090	Retain the null hypothesis.

Table 4.100: Kruskal-Wallis test results for Regulatory Support across discipline

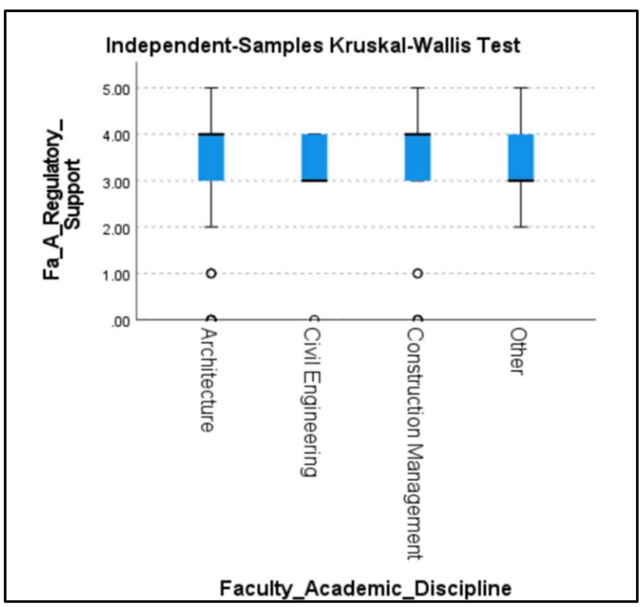


Figure 4.102: Box plot results for Regulatory Support

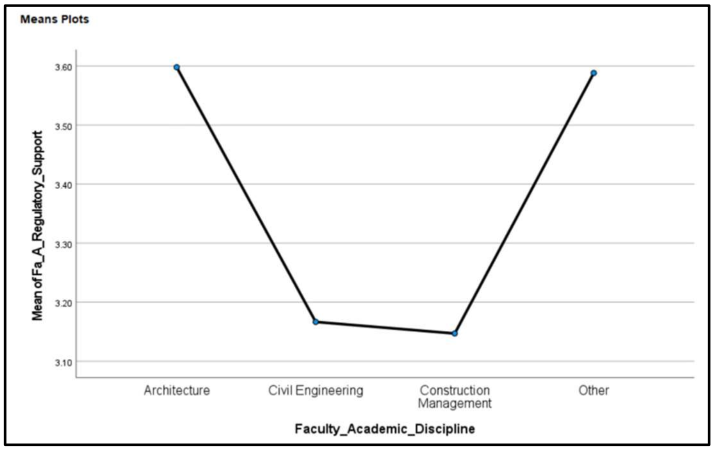


Figure 4.103: Means plot

4.4.6.2 Educational Workforce Development: Faculty

To analyze attitudes towards the adoption of mass timber based on the educational workforce development among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.101, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.459	0.239	-0.299	0.637	0.336	0.403	-0.12	0.55
Z Score	-1.92		-0.47		0.83		-0.22	
Kurtosis	0.341	0.474	-0.857	1.232	1.294	0.788	-0.836	1.063
Z Score	0.72		-0.70		1.64		-0.79	
p- value	<0.001		0.159		0.001		0.090	
Result	Not Normal		Normal		Not Normal		Normal	

Table 4.101: Educational Workforce Development data test of normality using Shapiro-Wilk

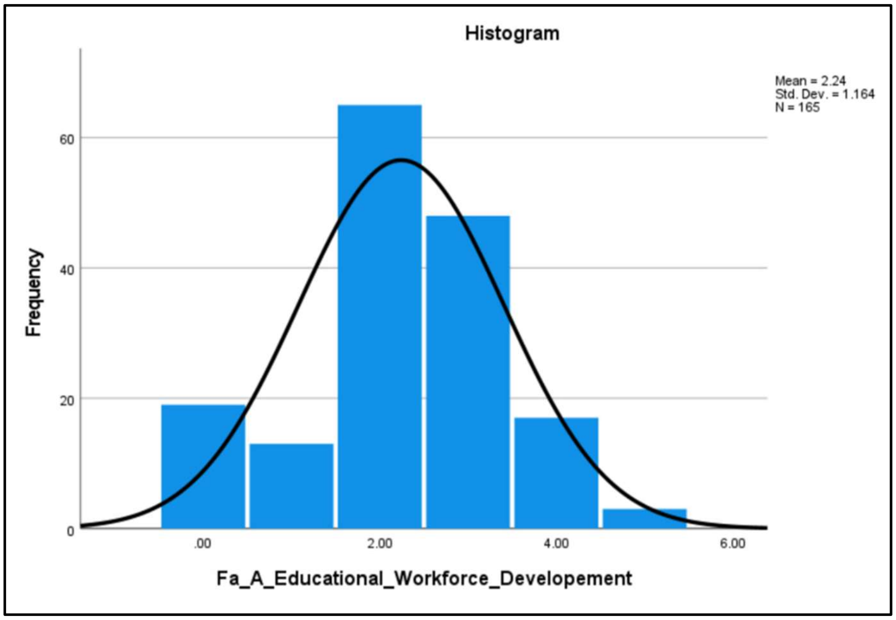


Figure 4.104: Histogram plot for test of normality on adoption of Educational Workforce Development

To explore potential differences in attitude towards adoption based on the educational and workforce development of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 6.763, p = 0.080, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the educational and workforce development of mass timber among faculty groups. Refer to Figure 4.105, for the box plot illustrating the distribution of the attitude towards adoption based on educational and workforce development across these groups.

Fa_Adoption_Educational Workforce Development					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	2.38	2.00	1.24	89.41
Civil Engineering	12	2.25	2.00	1.50	84.25
Construction Management	34	1.91	2.00	2.18	66.63
Others	17	2.05	2.00	1.90	76.38
Total	165				

Table 4.102: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_A_Educational_Workforce_Developement is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.080	Retain the null hypothesis.

Table 4.103: Kruskal-Wallis test results for on adoption of Educational Workforce Development

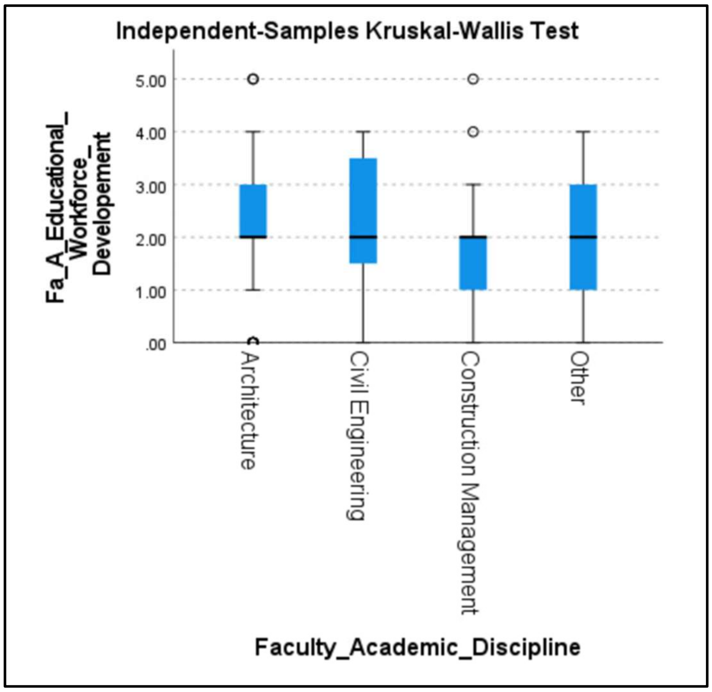


Figure 4.105: Box plot results for adoption of Collaborative Efforts

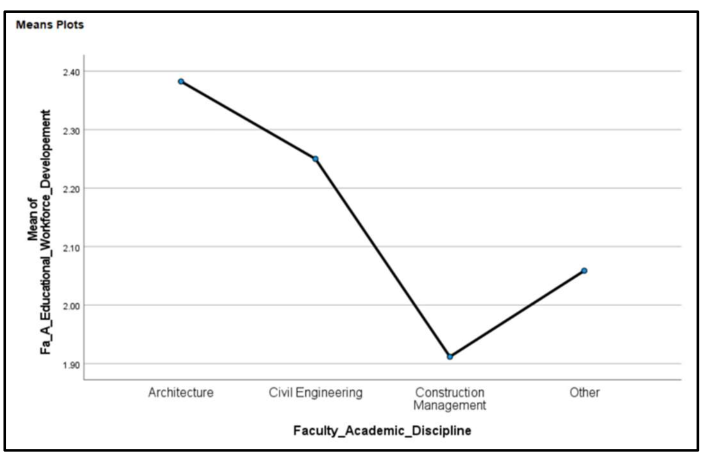


Figure 4.106: Means plot

4.4.6.3 Collaborative Efforts: Faculty

To analyze attitudes towards the adoption of mass timber based on the collaborative efforts among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. Table 4.104, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-2.521	0.239	-1.327	0.637	-2.738	0.403	-2.934	0.55
Z Score	-10.55		-2.08		-6.79		-5.33	
Kurtosis	7.445	0.474	-0.326	1.232	8.017	0.788	10.671	1.063
Z Score	15.71		-0.26		10.17		10.04	
p- value	<0.001		<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.104: Collaborative Efforts data test of normality using Shapiro-Wilk

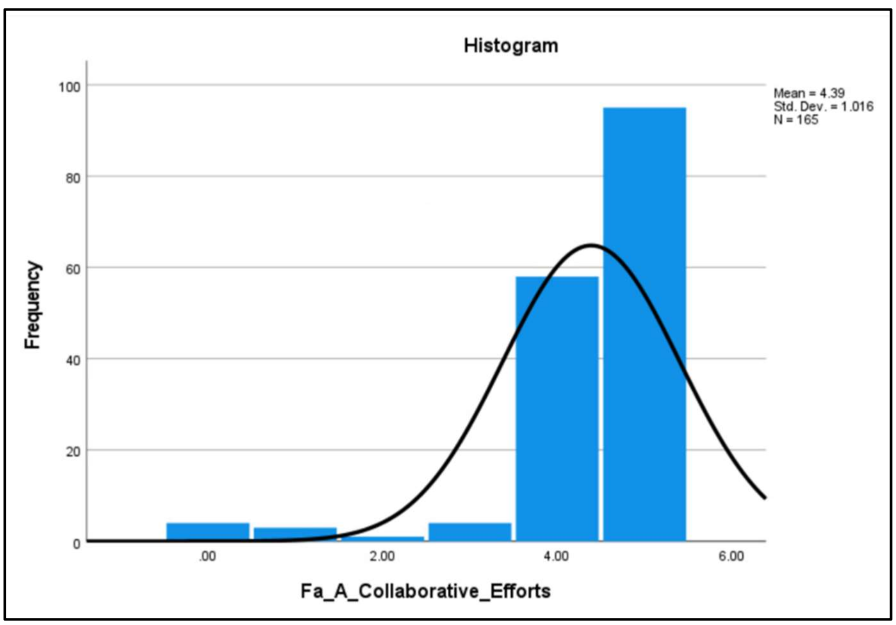


Figure 4.107: Histogram plot for test of normality on Collaborative Efforts

To explore potential differences in attitude towards adoption based on the collaborative efforts of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 4.695, p = 0.196, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the collaborative efforts of mass timber among faculty groups. Refer to Figure 4.108, for the box plot illustrating the distribution of the attitude towards adoption based on collaborative efforts across these groups.

Fa_Adoption_Collaborative Efforts					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	4.42	5.00	6.16	84.58
Civil Engineering	12	4.75	5.00	5.50	98.88
Construction Management	34	4.29	5.00	6.42	81.04
Others	17	4.11	4.00	3.78	66.21
Total	165				

Table 4.105: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Fa_A_Collaborative_Efforts is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.196	Retain the null hypothesis.

Table 4.106: Kruskal-Wallis test results for Collaborative Efforts across discipline

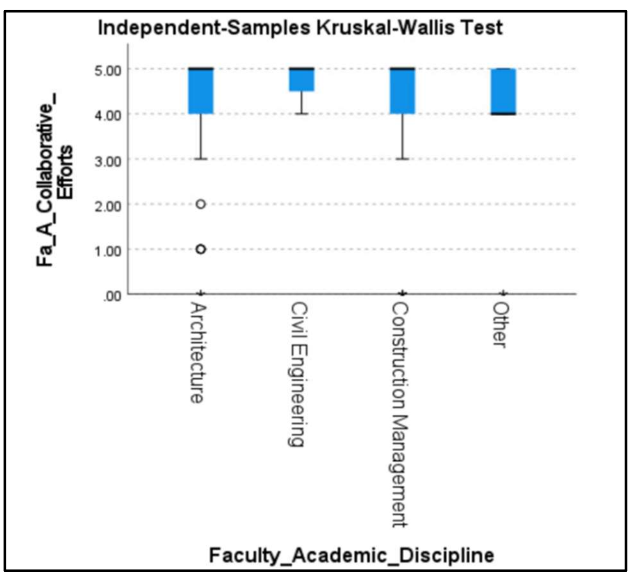


Figure 4.108: Box plot results for adoption of Collaborative Efforts

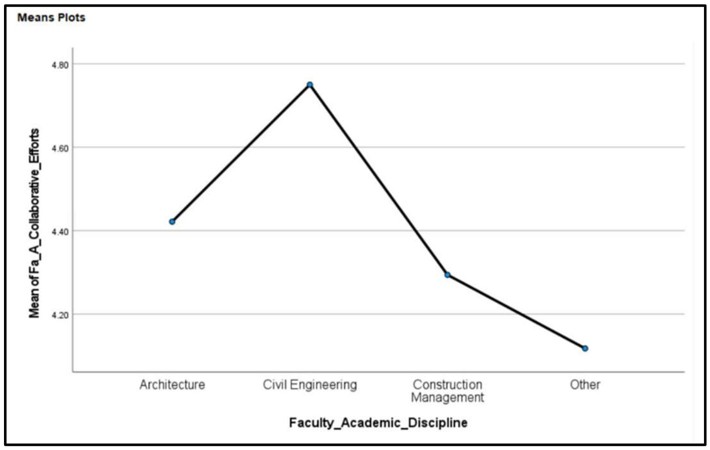


Figure 4.109: Means plot

4.4.6.4 Environmental and Sustainability Factors: Faculty

To analyze attitudes towards the adoption of mass timber based on the environmental and sustainability factors among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.107, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.321	0.239	-0.807	0.637	-0.837	0.403	-0.59	0.55
Z Score	-5.53		-1.27		-2.08		-1.07	
Kurtosis	3.237	0.474	0.009	1.232	-0.21	0.788	-0.732	1.063
Z Score	6.83		0.01		-0.27		-0.69	
p- value	<0.001		0.116		0.005		0.111	
Result	Not Normal		Normal		Not Normal		Normal	

Table 4.107: Environmental and Sustainability Factors data test of normality

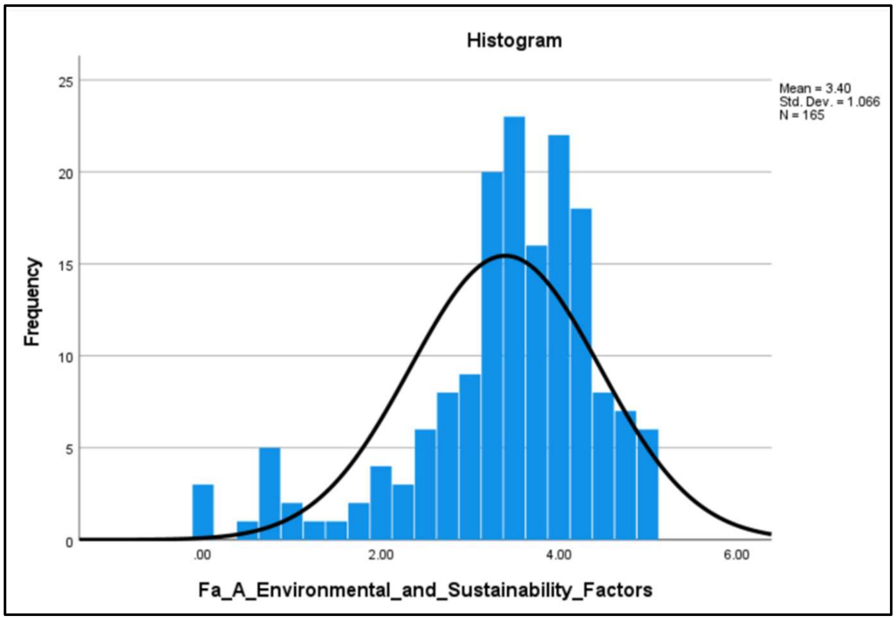


Figure 4.110: Histogram plot for test of normality on Environmental and Sustainability Factors

To explore potential differences in attitude towards adoption based on the environmental and sustainability factors of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 8.800, p = 0.032, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the environmental and sustainability factors of mass timber among faculty groups. Refer to Figure 4.111, for the box plot illustrating the distribution of the attitude towards adoption based on environmental and sustainability factors across these groups.

Fa_Adoption_Environmental and Sustainability Factors					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.61	3.75	4.03	91.54
Civil Engineering	12	3.35	3.37	3.41	72.63
Construction Management	34	2.94	3.25	3.87	66.91
Others	17	3.04	3.25	3.67	71.24
Total	165				

Table 4.108: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_A_Environmental_and_Sustainability_Factors is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.032	Reject the null hypothesis.

Table 4.109: Kruskal-Wallis test results for Adoption of Environmental and Sustainability Factors

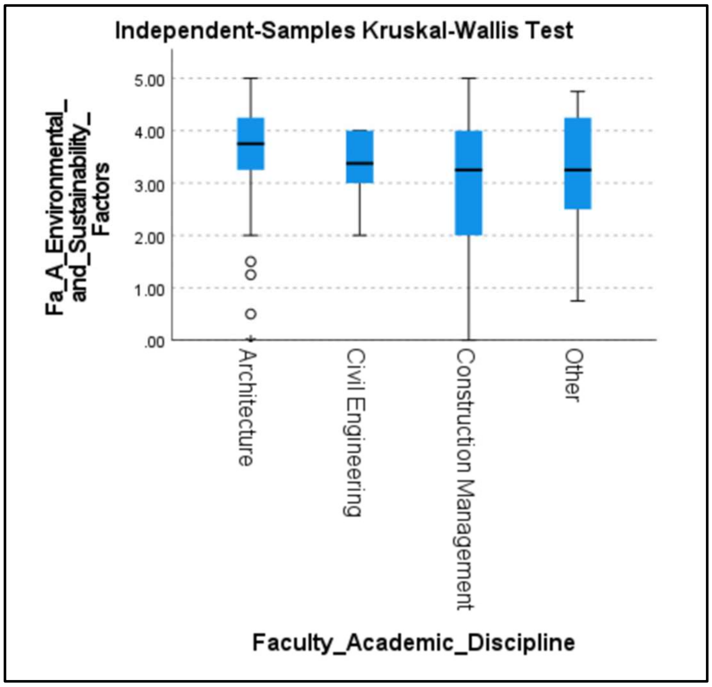


Figure 4.111: Box plot results for Environmental and Sustainability Factors

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted a significant distinction in attitude based on adoption between the construction management and architecture groups, with a significance level of 0.05. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.112, which presents the pairwise comparison of discipline by mean rank.

Pairwise Comparisons of Faculty_Academic_Discipline

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Construction Management-Other	-4.324	14.123	-.306	.759	1.000
Construction Management-Civil Engineering	5.713	15.964	.358	.720	1.000
Construction Management-Architecture	24.632	9.415	2.616	.009	.053
Other-Civil Engineering	1.390	17.926	.078	.938	1.000
Other-Architecture	20.309	12.455	1.631	.103	.618
Civil Engineering-Architecture	18.919	14.510	1.304	.192	1.000

Table 4.110: Pairwise test results

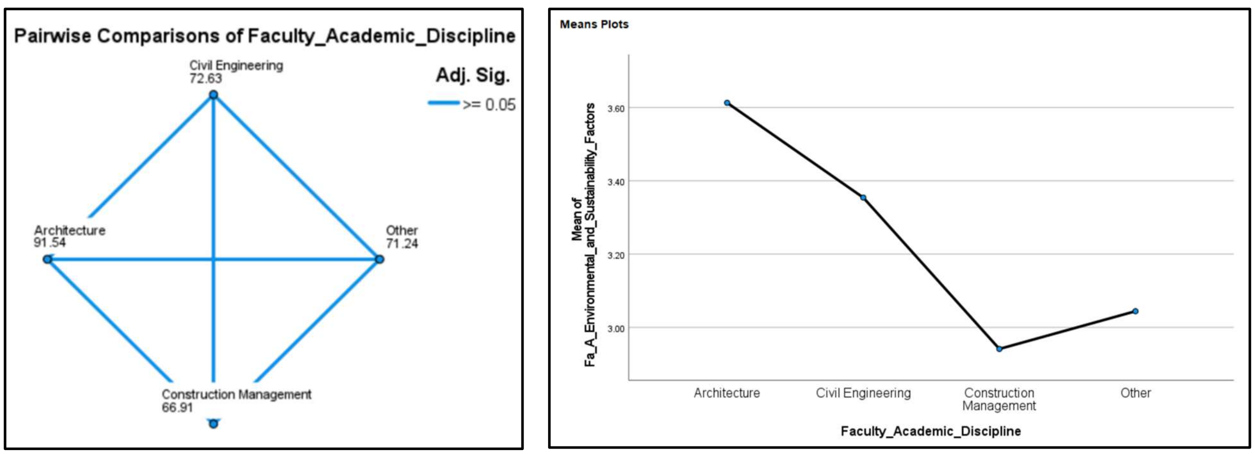


Figure 4.112: Pairwise Comparisons and Means Plot

4.4.6.5 Market Perceptions: Faculty

To analyze attitudes towards the adoption of mass timber based on the market perceptions among the faculty group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.111, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.369	0.239	-1.025	0.637	-0.035	0.403	-0.375	0.55
Z Score	-1.54		-1.61		-0.09		-0.68	
Kurtosis	-0.408	0.474	-0.23	1.232	-0.97	0.788	-0.861	1.063
Z Score	-0.86		-0.19		-1.23		-0.81	
p- value	0.002		0.012		0.191		0.268	
Result	Not Normal		Not Normal		Normal		Normal	

Table 4.111: Market Perceptions data test of normality using Shapiro-Wilk

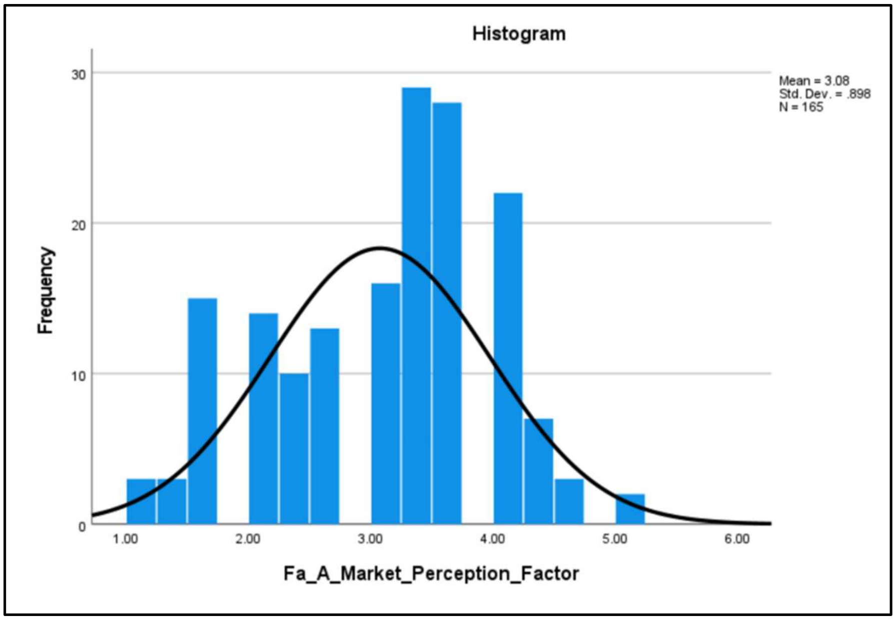


Figure 4.113: Histogram plot for test of normality on Market Perceptions

To explore potential differences in attitude towards adoption based on the market perceptions of mass timber among faculty groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=165) = 6.224, p = 0.101, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the market perceptions of mass timber among faculty groups. Refer to Figure 4.114, for the box plot illustrating the distribution of the attitude towards adoption based on market perceptions across these groups.

Fa_Adoption_Market Perceptions					
Faculty Academic Discipline	N	Mean	Median	Mode	Mean Rank
Architecture	102	3.16	3.33	3.67	86.63
Civil Engineering	12	3.13	3.67	4.75	92.58
Construction Management	34	2.73	2.83	3.03	65.25
Others	17	3.21	3.33	3.57	89.97
Total	165				

Table 4.112: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Fa_A_Market_Perception_Factor is the same across categories of Faculty_Academic_Discipline.	Independent-Samples Kruskal-Wallis Test	.101	Retain the null hypothesis.

Table 4.113: Kruskal-Wallis test results for Market Perceptions across discipline

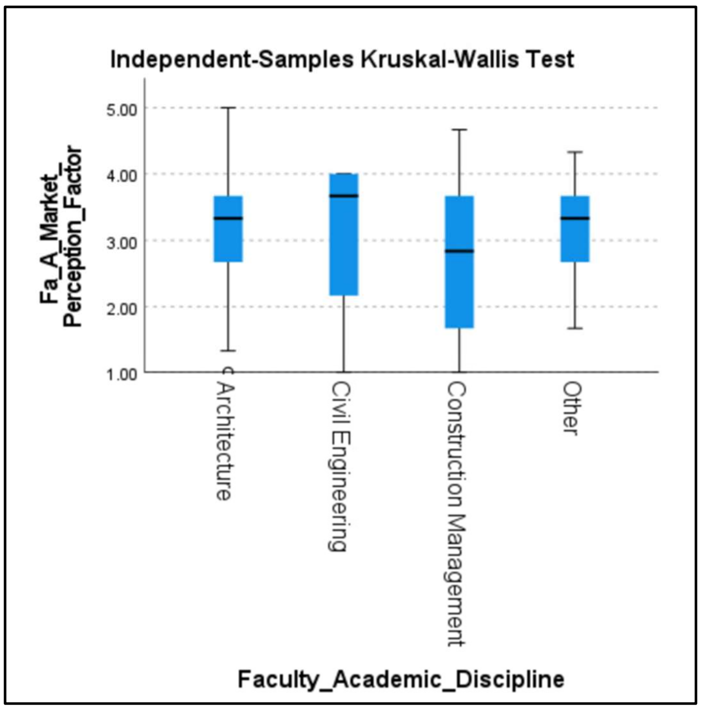


Figure 4.114: Box plot results for Market Perceptions

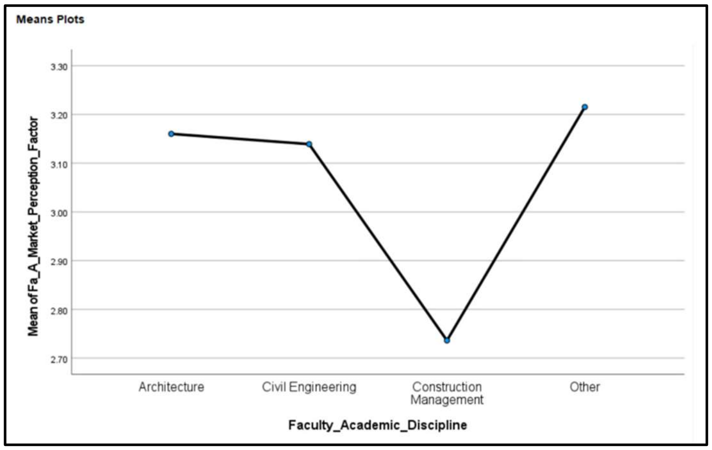


Figure 4.115: Mean plot

4.4.7 Current knowledge about mass timber: Industry

To assess the mean difference based on the current knowledge of mass timber among groups-specifically Industry professionals in architecture, civil engineering, and construction management sectors the following analysis was conducted.

Firstly, the Shapiro-Wilk test was conducted to assess normality for all Industry groups, using a significance level (alpha) of 0.05. Additionally, normality was examined using measures of Skewness and Kurtosis, ensuring the z-scores fell within the range of -1.96 to +1.96, indicative of normal distribution.

Table 4.114 presents the results, indicating that the observed significance (*p*) is more than 0.05 suggesting normal distribution but the Skewness and Kurtosis values don't fall in the specified range making it non-normally distributed. Since the data is not normally distributed, the ANOVA is not applicable, so non-parametric tests were deemed appropriate for analysis.

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.083	0.512	-0.282	0.661	0.322	0.283	0.382	0.501
Z Score	-0.16		-0.43		1.14		0.76	
Kurtosis	-1.959	0.992	0.237	1.279	-0.434	0.559	-1.99	0.972
Z Score	-1.97		0.19		-0.78		-2.05	
p -value	0.668		0.927		0.279		0.172	
Result	Not Normal		Normal		Normal		Not Normal	

Table 4.114: Current knowledge about mass timber data test of normality using Shapiro-Wilk

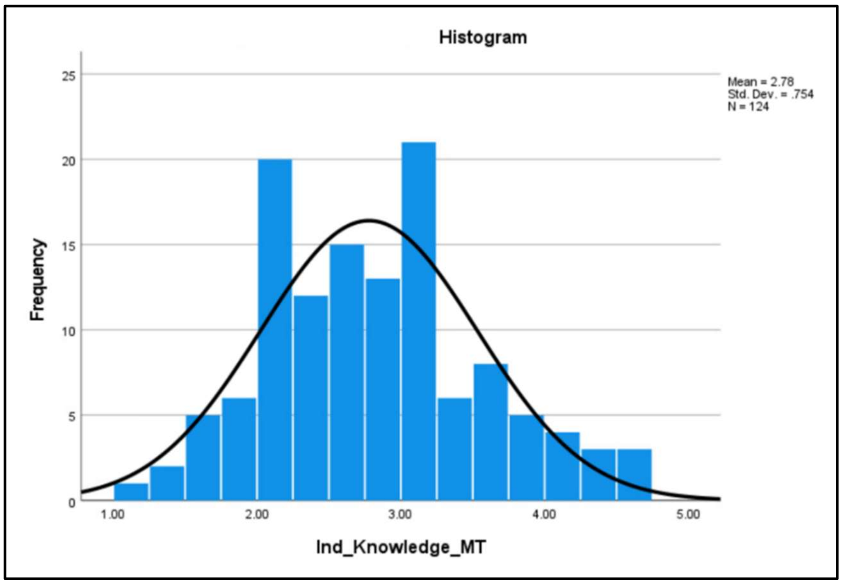


Figure 4.116: Histogram plot for test of normality on Current knowledge about mass timber

To explore potential differences in current knowledge among industry groups, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (3, N=124) = 8.630, *p* = 0.035, leading to the rejection of the null hypothesis. These findings suggest a significant difference in knowledge gaps related to mass timber among industry groups. Refer to Figure 4.117, for the box plot illustrating the distribution of the current knowledge across these groups.

MT_Current Knowledge					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.16	3.17	3.19	82.20
Civil Engineering	11	2.81	2.83	2.87	66.36
Construction Management	72	2.62	2.58	2.50	55.94
Others	21	2.89	2.67	2.23	64.21
Total	124				

Table 4.115: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_Knowledge_MT is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.035	Reject the null hypothesis.

Table 4.116: Kruskal-Wallis test results for Current knowledge about mass timber

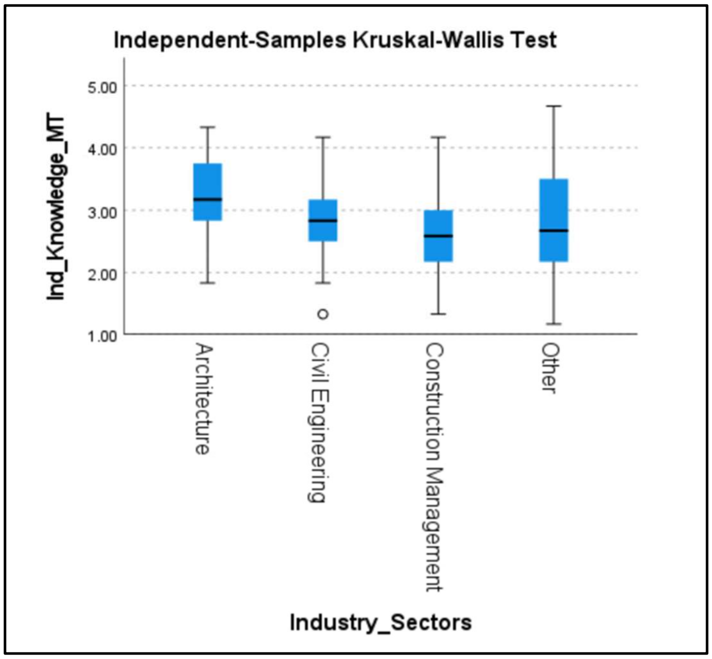
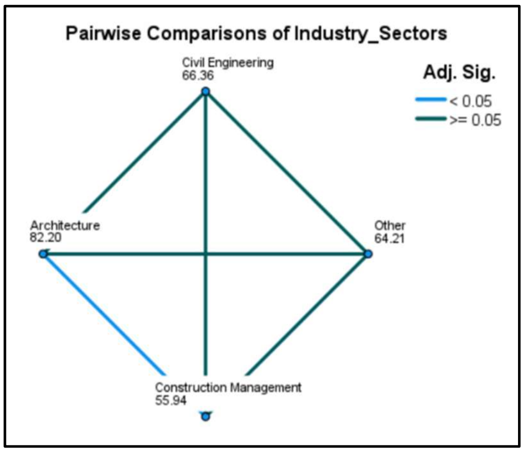


Figure 4.117: Box plot results for Current knowledge about mass timber

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted a significant distinction in perceptions between the construction management and architecture groups, with a significance level of 0.022. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.118, which presents the pairwise comparison of discipline by mean rank.

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Construction Management-Other	-8.277	8.890	-.931	.352	1.000
Construction Management-Civil Engineering	10.426	11.604	.899	.369	1.000
Construction Management-Architecture	26.263	9.060	2.899	.004	.022
Other-Civil Engineering	2.149	13.341	.161	.872	1.000
Other-Architecture	17.986	11.199	1.606	.108	.650
Civil Engineering-Architecture	15.836	13.455	1.177	.239	1.000

Table 4.117: Pairwise test results



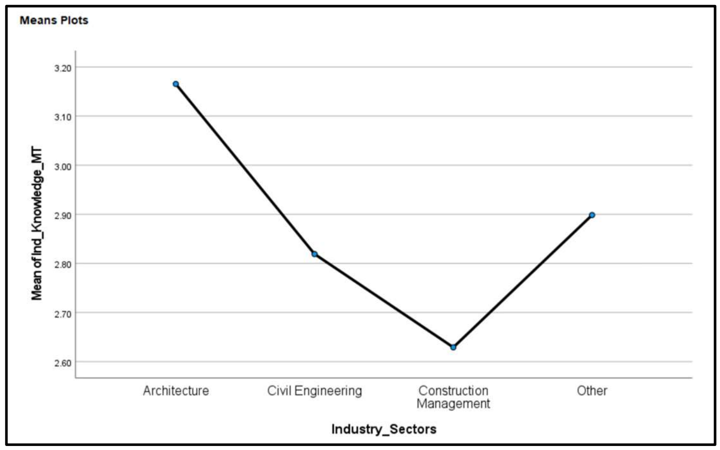


Figure 4.118: Pairwise Comparisons and Means Plot

4.4.8 Perception of mass timber: Industry

To examine perceptions among Industry groups, survey questions were divided further divided into three specific areas:

1. Based on the performance of mass timber
2. Based on sustainability and environmental impact
3. Based on safety and regulatory compliance

Each category was subjected to normality testing followed by further analysis. The findings from these analyses are discussed and illustrated to shed light on the factors influencing perceptions of mass timber among different industry groups within the US construction industry.

4.4.8.1 Based on the performance of mass timber: Industry

To analyze perception based on the performance of the mass timber among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.118, the observed significance for the architecture, civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.95	0.512	-1.181	0.661	-1.126	0.283	-1.176	0.501
Z Score	-3.81		-1.79		-3.98		-2.35	
Kurtosis	3.823	0.992	-0.016	1.279	0.526	0.559	-0.083	0.972
Z Score	3.85		-0.01		0.94		-0.09	
p -value	<0.001		0.011		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.118: performance of mass timber data test of normality using Shapiro-Wilk

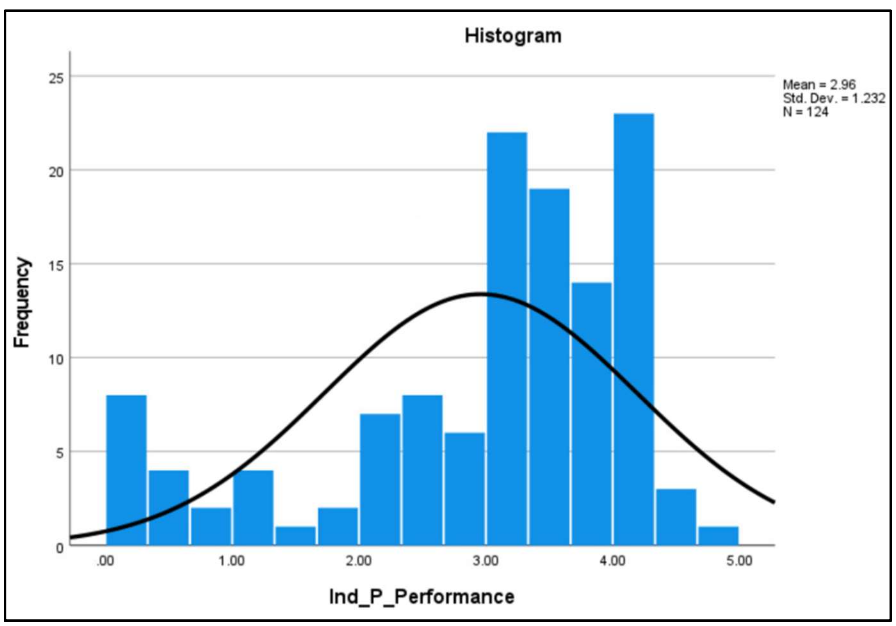


Figure 4.119: Histogram plot for test of normality on performance of mass timber

To explore potential differences in perceptions based on the performance of mass timber among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) 4.873, p = 0.181, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the performance of mass timber among industry groups. Refer to Figure 4.120, for the box plot illustrating the distribution of the perceptions based on the performance across these groups.

Ind_Perception_Performance					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.04	3.31	3.85	61.10
Civil Engineering	11	2.95	3.38	4.24	61.50
Construction Management	72	2.86	3.13	3.67	58.51
Others	21	3.20	3.88	5.24	78.05
Total	124				

Table 4.119: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_P_Performance is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.181	Retain the null hypothesis.

Table 4.120: Kruskal-Wallis test results for performance of mass timber

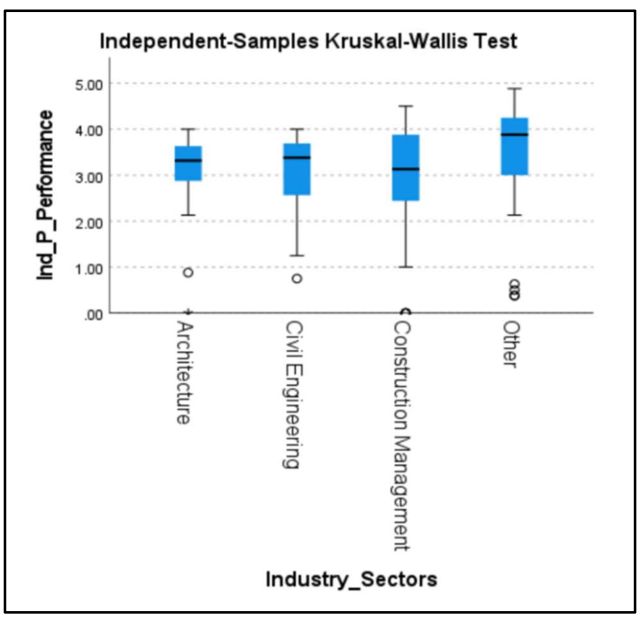


Figure 4.120: Box plot results for performance of mass timber

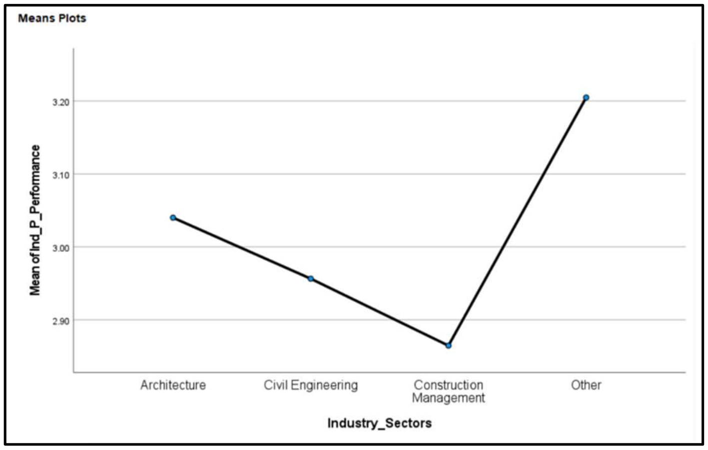


Figure 4.121: Means plot

4.4.8.2 Sustainability and Environmental Impact: Industry

To analyze perception based on the sustainability and environmental impact of the mass timber among the industry groups including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.121, the observed significance for the construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.307	0.512	-0.562	0.661	-1.038	0.283	-1.379	0.501
Z Score	-0.60		-0.85		-3.67		-2.75	
Kurtosis	0.122	0.992	-0.581	1.279	0.26	0.559	1.185	0.972
Z Score	0.12		-0.45		0.47		1.22	
p -value	0.623		0.651		<0.001		0.001	
Result	Normal		Normal		Not Normal		Not Normal	

Table 4.121: Sustainability and Environmental Impact data test of normality

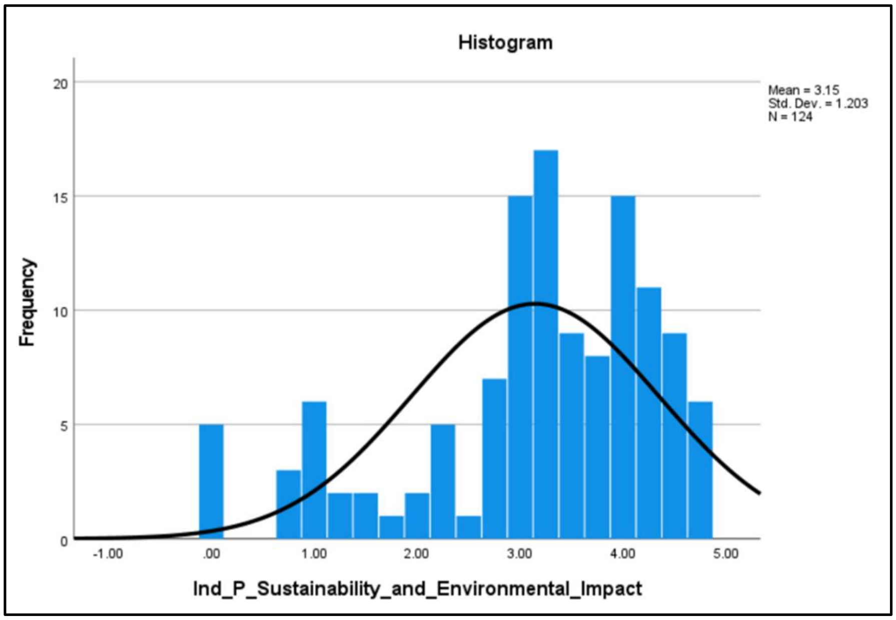


Figure 4.122: Histogram plot for test of normality on Sustainability and Environmental Impact

To explore potential differences in perceptions based on the sustainability and environmental impact of mass timber among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) 6.869, $p = 0.076$, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the sustainability and environmental impact of mass timber among industry groups. Refer to Figure 4.123, for the box plot illustrating the distribution of the perceptions based on the sustainability and environmental impact across these groups

Ind_Perception_Sustainability and Environmental Impact					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.45	3.37	3.21	68.60
Civil Engineering	11	2.86	3.00	3.28	52.50
Construction Management	72	2.98	3.25	3.79	57.70
Others	21	3.53	4.00	4.94	78.38
Total	124				

Table 4.122: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_P_Sustainability_and_Environmental_Impact is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.076	Retain the null hypothesis.

Table 4.123: Kruskal-Wallis test results for Sustainability and Environmental Impact

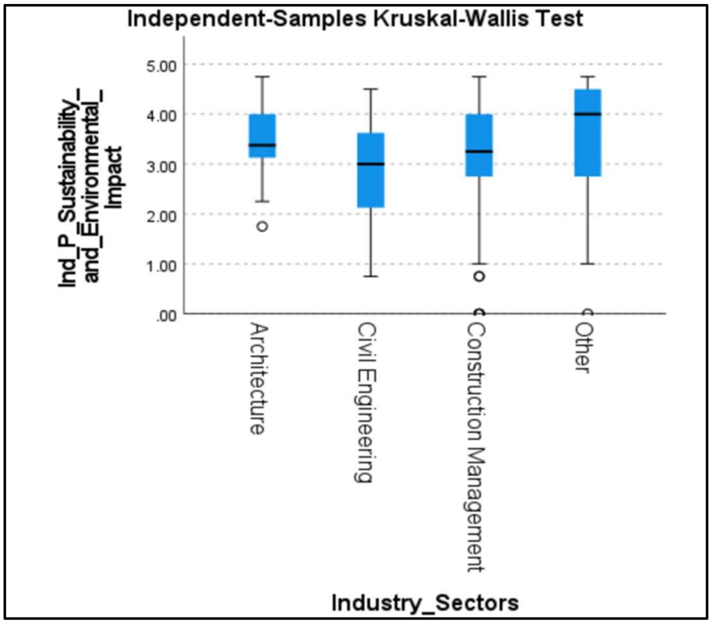


Figure 4.123: Box plot results for Sustainability

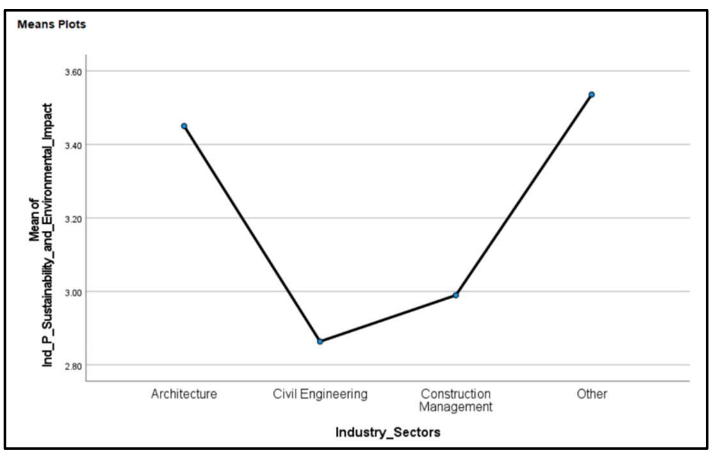


Figure 4.124: Means plot

4.4.8.3 Safety and Regulatory Compliance: Industry

To analyze perception based on the safety and regulatory compliance of the mass timber among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.124, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.682	0.512	-0.714	0.661	-1.118	0.283	-1.116	0.501
Z Score	-1.33		-1.08		-3.95		-2.23	
Kurtosis	0.051	0.992	-0.604	1.279	1.64	0.559	0.409	0.972
Z Score	0.05		-0.47		2.93		0.42	
p -value	0.023		0.062		<0.001		0.001	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.124 Safety and Regulatory Compliance data test of normality using Shapiro-Wilk

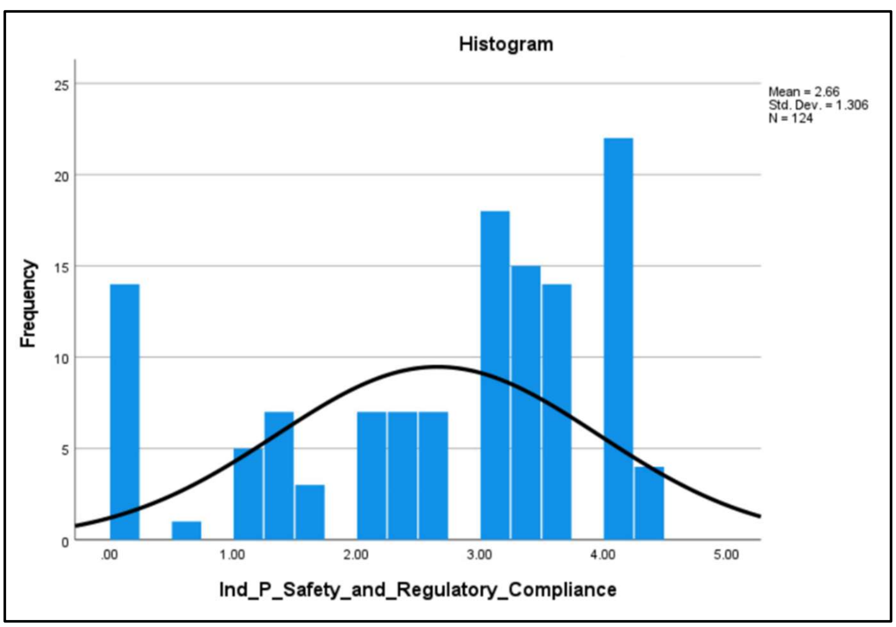


Figure 4.125: Histogram plot for test of normality on Mass Timber Safety and Regulatory Compliance

To explore potential differences in perceptions based on the regulatory compliance of mass timber among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) 0.871, p = 0.832, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the regulatory compliance of mass timber among industry groups. Refer to Figure 4.126, for the box plot illustrating the distribution of the perceptions based on regulatory compliance across these groups.

Ind_Perception_Safety and Regulatory Compliance					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	2.96	3.33	4.07	69.23
Civil Engineering	11	2.51	3.00	3.98	61.23
Construction Management	72	2.59	3.00	3.82	60.90
Others	21	2.65	3.33	4.69	62.26
Total	124				

Table 4.125: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_P_Safety_and_Regulatory_Compliance is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.832	Retain the null hypothesis.

Table 4.126: Kruskal-Wallis test results for Safety and Regulatory Compliance

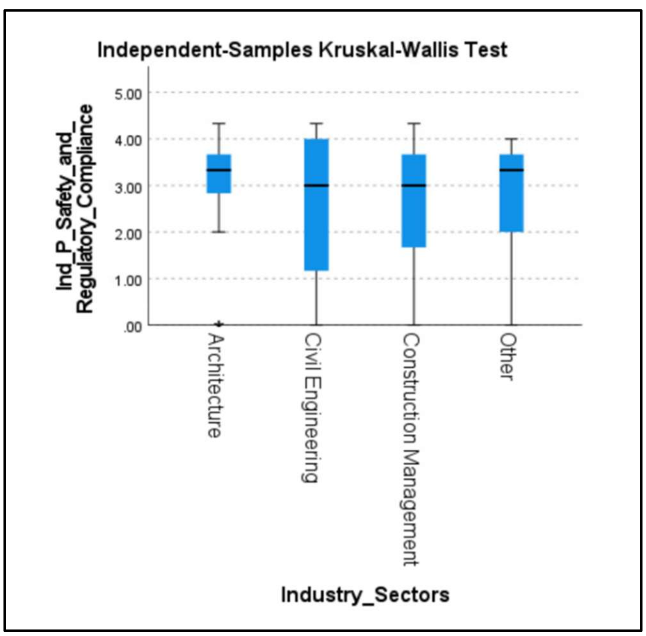


Figure 4.126: Box plot results for Safety and Regulatory Compliance

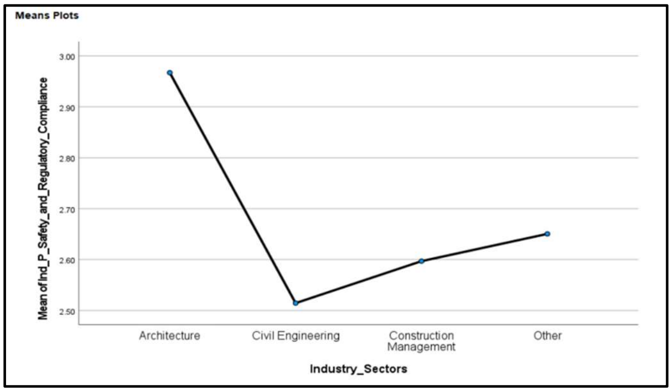


Figure 4.127: Means plot

4.4.9 Adoption of mass timber: Industry

To explore the key factors influencing the adoption of mass timber among the industry group in the us construction industry, statistical analysis was conducted.

To delve into the factors impacting adoption, survey questions were further categorized into six distinct areas refer to Table 3.1:

1. Based on regulatory support
2. Based on educational and workforce development
3. Based on collaborative efforts
4. Based on environmental and sustainability factors
5. Based on market perception factors
6. Based on BIM adoption

For each of these subcategories, the data underwent initial normality testing followed by further analysis The results of these are further discussed and illustrated to provide insights into the factors influencing the adoption of mass timber among the industry group within the US construction industry.

4.4.9.1 Regulatory Support: Industry

To analyze attitudes towards the adoption of mass timber based on the regulatory support among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.127, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.682	0.512	-0.714	0.661	-1.118	0.283	-1.116	0.501
Z Score	-1.33		-1.08		-3.95		-2.23	
Kurtosis	0.051	0.992	-0.604	1.279	1.64	0.559	0.409	0.972
Z Score	0.05		-0.47		2.93		0.42	
p -value	0.023		0.062		<0.001		0.001	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.127: Regulatory Support data test of normality using Shapiro-Wilk

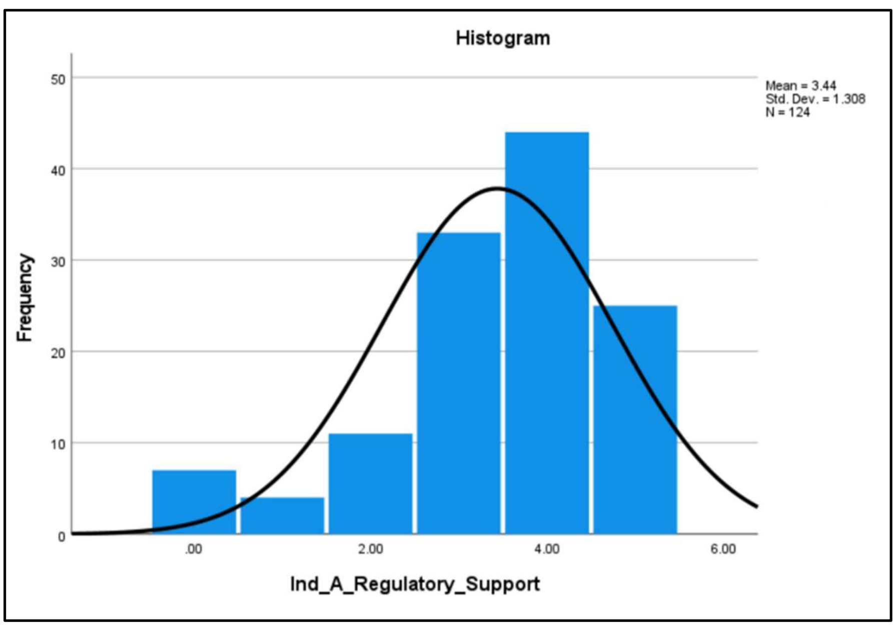


Figure 4.128: Histogram plot for test of normality on Mass Timber Regulatory Support

To explore potential differences in attitude towards adoption based on the regulatory support of mass timber among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 0.547, p = 0.908, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the regulatory support of mass timber among industry groups. Refer to Figure 4.129, for the box plot illustrating the distribution of the attitude towards adoption based on regulatory support across these groups.

Ind_Adoption_Regulatory Support					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.40	4.00	5.20	61.55
Civil Engineering	11	3.18	4.00	5.64	55.77
Construction Management	72	3.50	4.00	5.00	63.12
Others	21	3.38	4.00	5.24	64.81
Total	124				

Table 4.128: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_A_Regulatory_Support is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.908	Retain the null hypothesis.

Table 4.129: Kruskal-Wallis test results for Regulatory Support across discipline

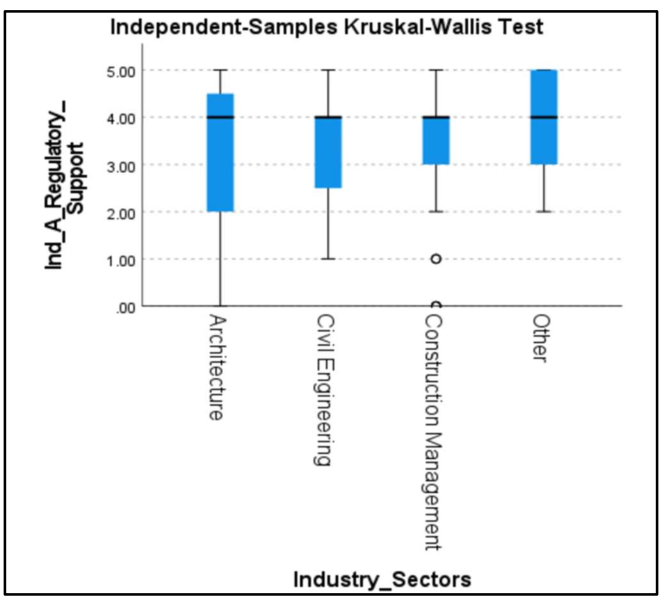


Figure 4.129: Box plot results for Regulatory Support about mass timber

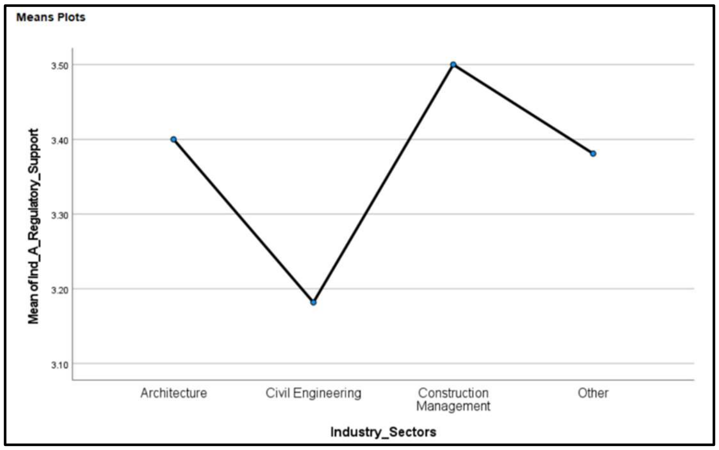


Figure 4.130: Means plot

4.4.9.2 Educational Workforce Development: Industry

To analyze attitudes towards the adoption of mass timber based on the educational workforce development among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.130, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.797	0.512	-0.344	0.661	-0.654	0.283	0.042	0.501
Z Score	-1.56		-0.52		-2.31		0.08	
Kurtosis	1.732	0.992	-1.287	1.279	-0.398	0.559	-0.748	0.972
Z Score	1.75		-1.01		-0.71		-0.77	
p -value	0.005		0.126		<0.001		0.043	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.130: Educational Workforce Development data test of normality using Shapiro-Wilk

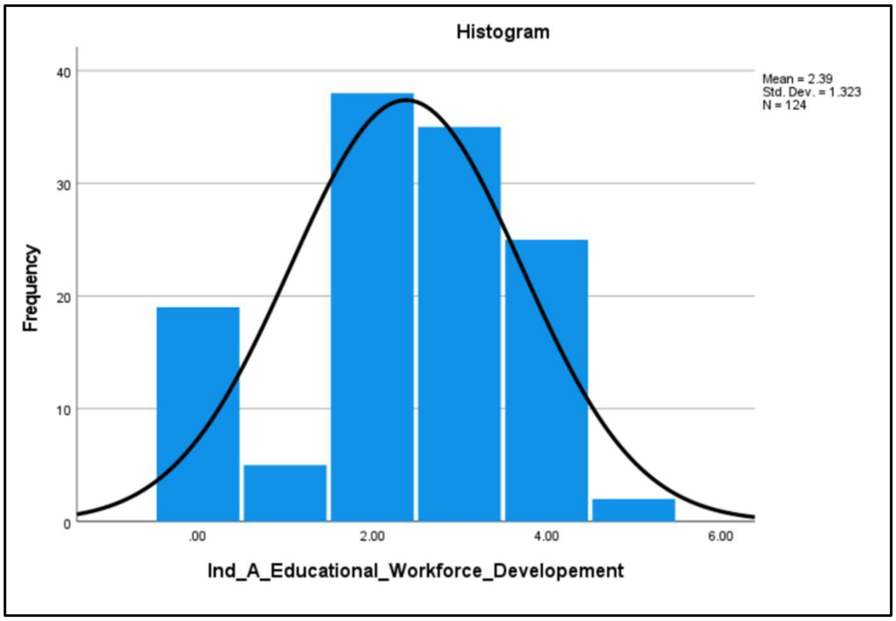


Figure 4.131: Histogram plot for test of normality on Mass Timber

To explore potential differences in attitude towards adoption based on the educational workforce development of mass timber among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 4.846, p = 0.183, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the educational workforce development of mass timber among industry groups. Refer to Figure 4.132, for the box plot illustrating the distribution of the attitude towards adoption based on educational workforce development across these groups.

Ind_Adoption_Educational Workforce Development					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	2.35	2.00	1.30	58.68
Civil Engineering	11	2.45	3.00	4.10	66.41
Construction Management	72	2.52	3.00	3.96	66.97
Others	21	1.90	2.00	2.20	48.76
Total	124				

Table 4.131: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_A_Educational_Workforce_Developement is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.183	Retain the null hypothesis.

Table 4.132: Kruskal-Wallis test results for Educational Workforce Development across discipline

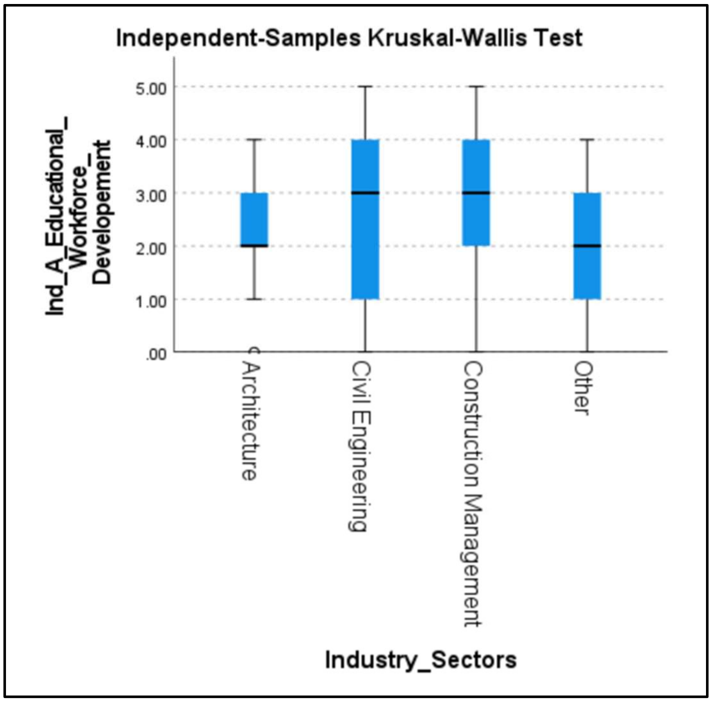


Figure 4.132: Box plot results for Educational Workforce Development about mass timber

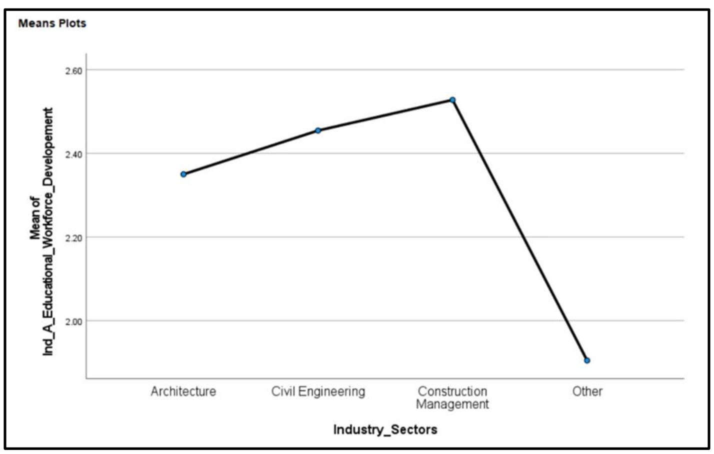


Figure 4.133: Means plot

4.4.9.3 Collaborative Efforts: Industry

To analyze attitudes towards the adoption of mass timber based on the collaborative efforts among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. Table 4.133, the observed significance for the architecture, civil engineering, and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-2.278	0.512	-1.42	0.661	-1.774	0.283	-2.262	0.501
Z Score	-4.45		-2.15		-6.27		-4.51	
Kurtosis	5.487	0.992	2.718	1.279	2.518	0.559	4.615	0.972
Z Score	5.53		2.13		4.50		4.75	
p -value	<0.001		0.020		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.133: Collaborative Efforts data test of normality using Shapiro-Wilk

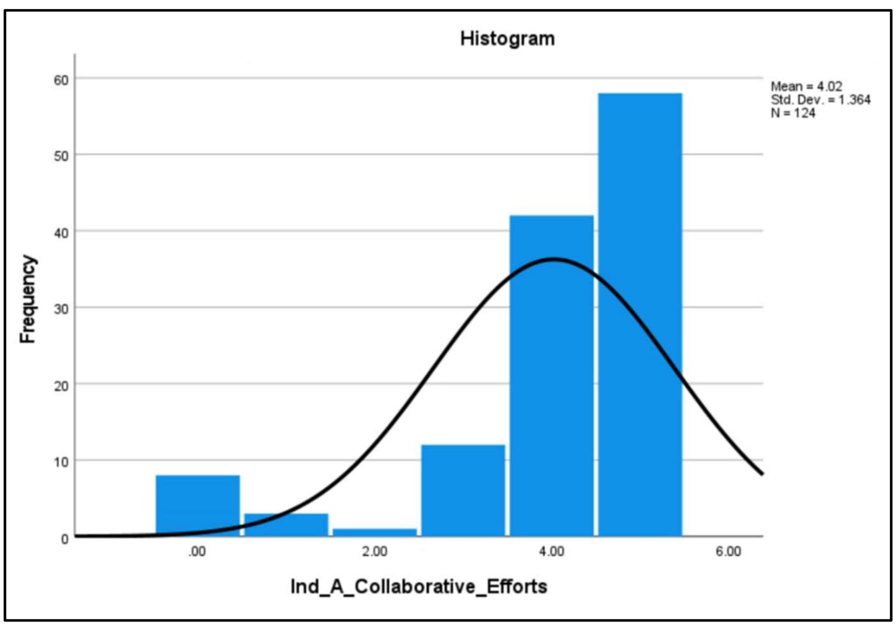


Figure 4.134: Histogram plot for test of normality on Mass Timber Collaborative Efforts

To explore potential differences in attitude towards adoption based on the collaborative efforts among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 6.356, p = 0.096, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the collaborative efforts among industry groups. Refer to Figure 4.135, for the box plot illustrating the distribution of the attitude towards adoption based on collaborative efforts across these groups.

Ind_Adoption_Collaborative Efforts					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	4.45	5.00	6.10	76.03
Civil Engineering	11	3.81	4.00	4.38	51.00
Construction Management	72	3.90	4.00	4.20	58.64
Others	21	4.14	5.00	6.72	68.88
Total	124				

Table 4.134: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_A_Collaborative_Efforts is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.096	Retain the null hypothesis.

Table 4.135: Kruskal-Wallis test results for adoption of Collaborative Efforts

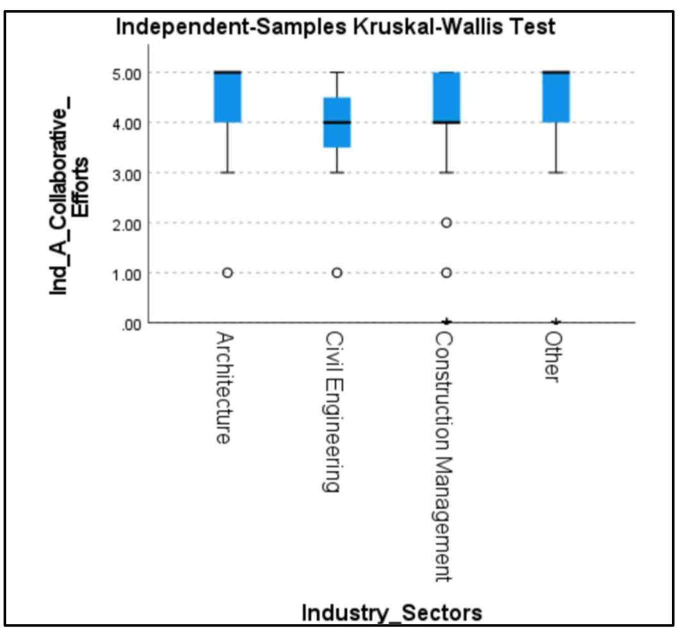


Figure 4.135: Box plot results for Collaborative Efforts about mass timber

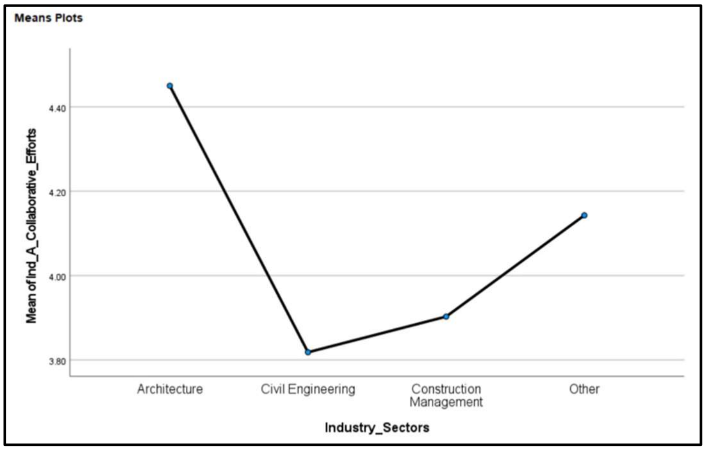


Figure 4.136: Means plot

4.4.9.4 Environmental and Sustainability Factors: Industry

To analyze attitudes towards the adoption of mass timber based on the environmental and sustainability factors among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.136, the observed significance for the architecture and construction management group is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.111	0.512	-0.516	0.661	-0.914	0.283	-1.492	0.501
Z Score	-2.17		-0.78		-3.23		-2.98	
Kurtosis	1.541	0.992	-0.362	1.279	0.087	0.559	2.067	0.972
Z Score	1.55		-0.28		0.16		2.13	
p -value	0.027		0.505		<0.001		0.005	
Result	Not Normal		Normal		Not Normal		Not Normal	

Table 4.136: Environmental and Sustainability Factors data test of normality

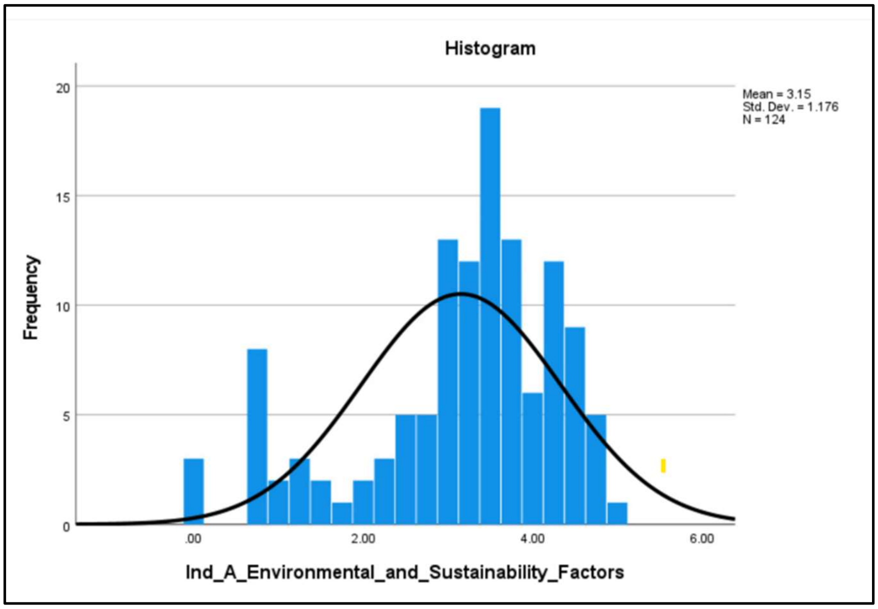


Figure 4.137: Histogram plot for test of normality on adoption of Environmental and Sustainability factors

To explore potential differences in attitude towards adoption based on the environmental and sustainability factors among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 4.913, p = 0.178, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the environmental and sustainability factors among industry groups. Refer to Figure 4.138, for the box plot illustrating the distribution of the attitude towards adoption based on environmental and sustainability factors across these groups.

Ind_Adoption_Environmental and Sustainability Factors					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.33	3.50	3.84	65.45
Civil Engineering	11	2.81	3.25	4.13	49.68
Construction Management	72	3.05	3.37	4.01	59.74
Others	21	3.47	3.75	4.31	75.88
Total	124				

Table 4.137: Mean, Median, Mode and Mean Rank across all disciplines

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_A_Environmental_and_Sustainability_Factors is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.178	Retain the null hypothesis.

Table 4.138: Kruskal-Wallis test results for Environmental and Sustainability Factor across discipline

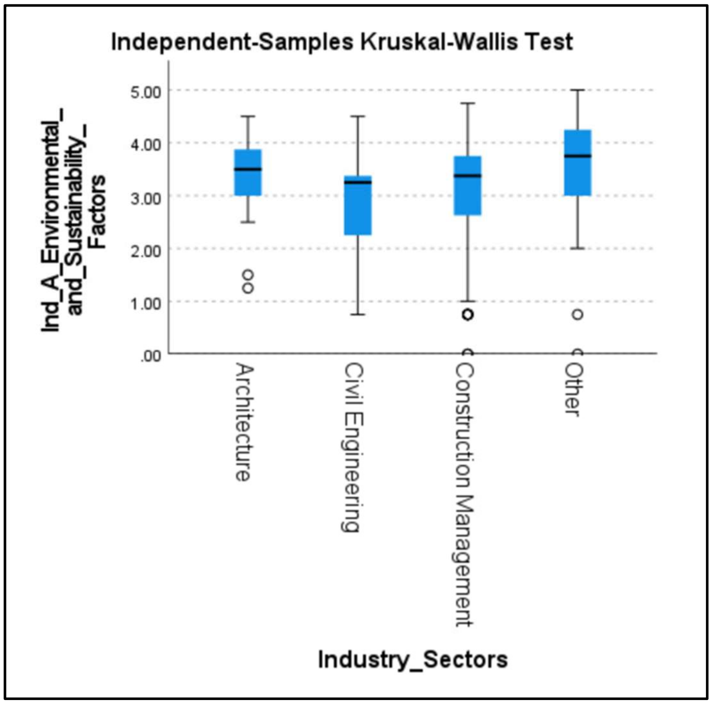


Figure 4.138: Box plot results for Environmental and Sustainability Factors

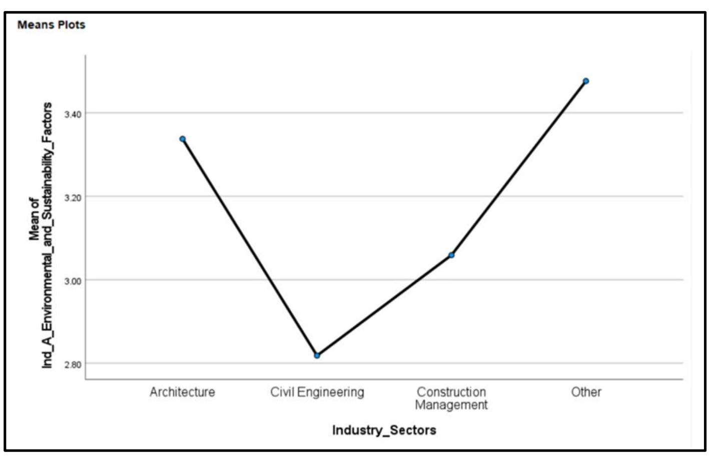


Figure 4.139: Means plot

4.4.9.5 Market Perceptions: Industry

To analyze attitudes towards the adoption of mass timber based on the market perceptions among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.139, the observed significance for the construction management group is less than the assumed alpha of 0.05, indicating that the data

Factors	Architecture		Civil Engg.		Construction Mgm.		Others	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	0.025	0.512	-0.759	0.661	-0.421	0.283	-0.419	0.501
Z Score	0.05		-1.15		-1.49		-0.84	
Kurtosis	-0.947	0.992	-0.675	1.279	-0.735	0.559	-1.483	0.972
Z Score	-0.95		-0.53		-1.31		-1.53	
p -value	0.599		0.122		0.002		0.008	
Result	Normal		Normal		Not Normal		Not Normal	

Table 4.139: Market Perceptions data test of normality using Shapiro-Wilk

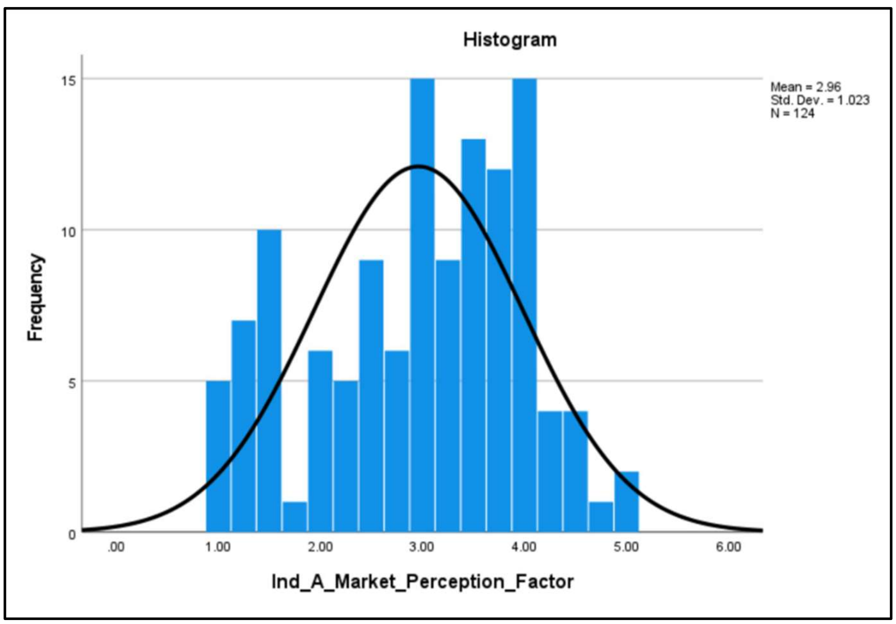


Figure 4.140: Histogram plot for test of normality on Market Perceptions

To explore potential differences in attitude towards adoption based on the market perceptions among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 2.423, p = 0.489, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the market perceptions among industry groups. Refer to Figure 4.141, for the box plot illustrating the distribution of the attitude towards adoption based on market perceptions across these groups.

Ind_Adoption_Market Perceptions					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	2.88	2.87	2.85	56.50
Civil Engineering	11	2.84	3.25	4.07	57.77
Construction Management	72	2.94	3.00	3.12	61.96
Others	21	3.15	4.00	5.70	72.55
Total	124				

Table 4.140: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_A_Market_Perception_Factor is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.489	Retain the null hypothesis.

Table 4.141: Kruskal-Wallis test results for Market Perceptions across discipline

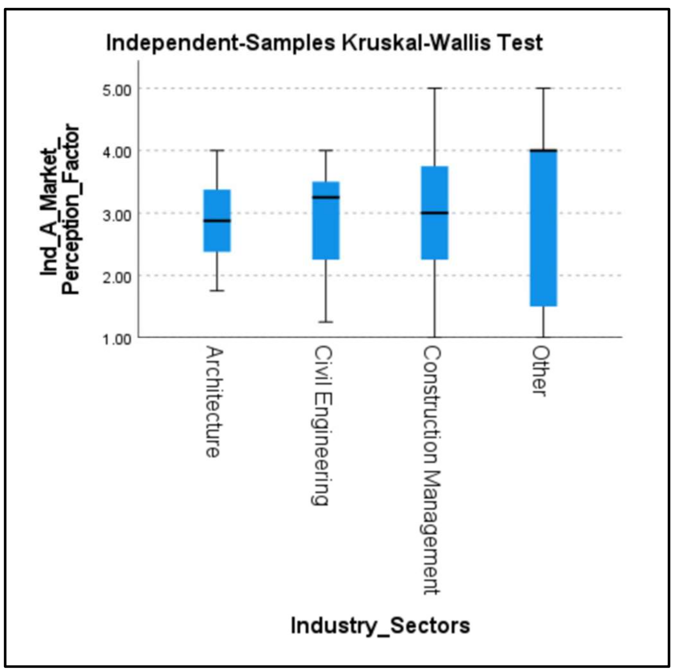


Figure 4.141: Box plot results for Market Perceptions about mass timber

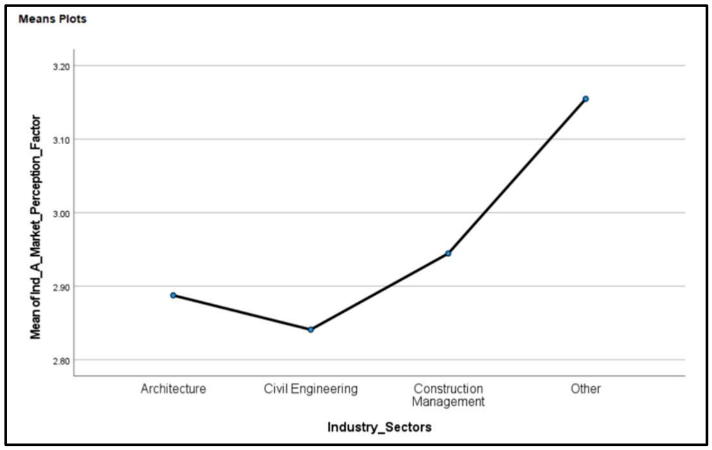


Figure 4.142: Means plot

4.4.9.6 BIM Adoption: Industry

To analyze attitudes towards the adoption of mass timber based on the BIM Adoption among the industry group including Architecture, Civil Engineering, and Construction Management, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.142, the observed significance for the architecture, civil engineering and construction management group is less than the assumed alpha of 0.05, indicating that the data

Factors	**Architecture**		**Civil Engg.**		**Construction Mgm.**		**Others**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.186	0.512	-0.713	0.661	-0.214	0.283	0.996	0.501
Z Score	-0.36		-1.08		-0.76		1.99	
Kurtosis	-0.896	0.992	-1.123	1.279	-0.5	0.559	-0.063	0.972
Z Score	-0.90		-0.88		-0.89		-0.06	
p -value	0.023		0.005		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.142: BIM Adoption data test of normality using Shapiro-Wilk

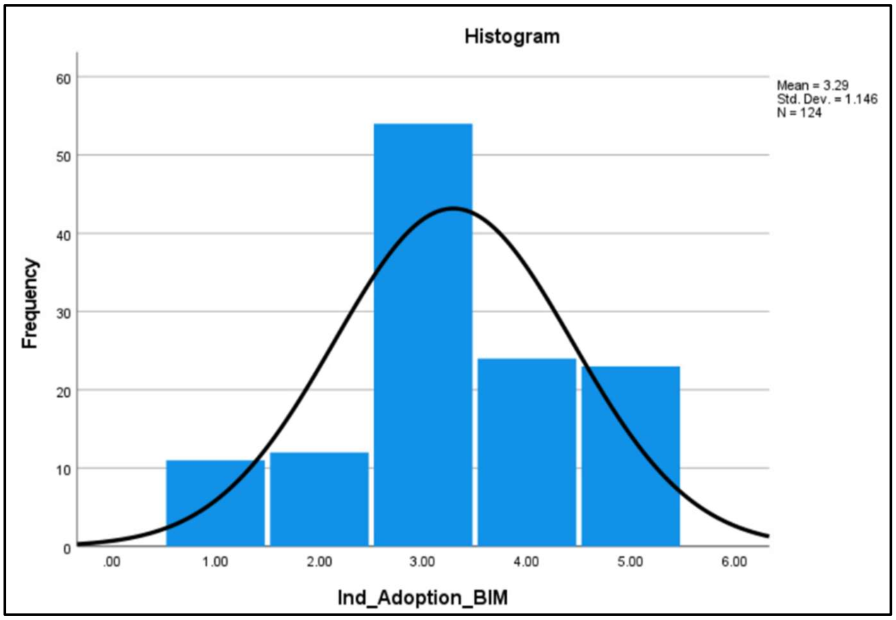


Figure 4.143: Histogram plot for test of normality on BIM Adoption

To explore potential differences in attitude towards adoption based on the BIM Adoption among industry groups, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (3, N=124) = 1.537, $p = 0.674$, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the BIM Adoption among industry groups. Refer to Figure 4.144, for the box plot illustrating the distribution of the attitude towards adoption based on BIM Adoption across these groups.

Ind_Adoption_BIM					
Industry Sectors	N	Mean	Median	Mode	Mean Rank
Architecture	20	3.50	3.00	2.00	67.93
Civil Engineering	11	2.81	3.00	3.38	52.55
Construction Management	72	3.26	3.00	2.48	61.92
Others	21	3.42	3.00	2.16	64.55
Total	124				

Table 4.143: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_Adoption_BIM is the same across categories of Industry_Sectors.	Independent-Samples Kruskal-Wallis Test	.674	Retain the null hypothesis.

Table 4.144: Kruskal-Wallis test results for BIM Adoption across discipline

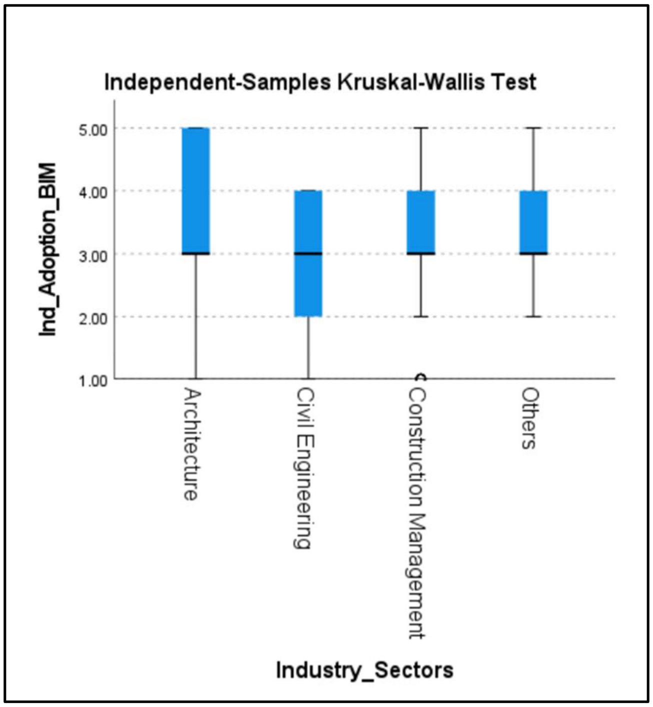


Figure 4.144: Box plot results for BIM Adoption about mass timber

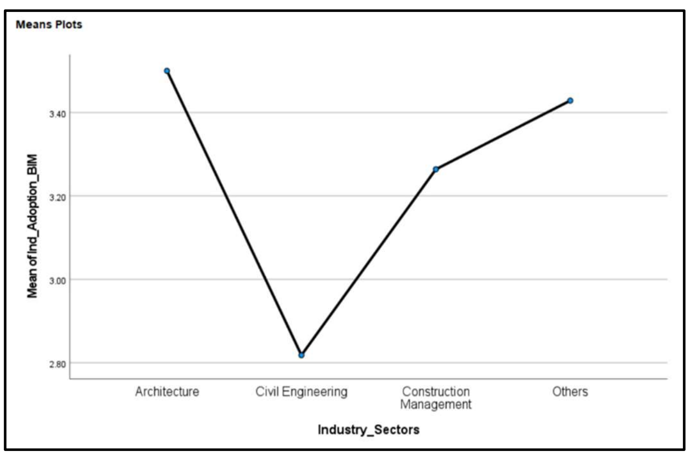


Figure 4.145: Means plot

4.5 EXPLORATORY DATA ANALYSIS: INDUSTRY EXPERIENCE AMONG GROUPS

After conducting the among-group analysis for students, faculty, and industry professionals, the study proceeded to examine among-group comparisons in industry professionals based on their years of experience in the construction industry. This analysis focused on various parameters discussed further to determine significant differences in knowledge, perceptions and attitudes towards mass timber adoption between these groups. The hypothesis was that industry professionals with varying experience levels might have different perspectives, and this analysis was conducted to capture those potential differences.

4.5.1 Current knowledge about mass timber: Industry experience

To assess the mean difference based on the current knowledge of mass timber among groups-specifically based on industry professionals experience following analysis was conducted.

Firstly, the Shapiro-Wilk test was conducted to assess normality for all student groups, using a significance level (alpha) of 0.05. Additionally, normality was examined using measures of Skewness and Kurtosis, ensuring the z-scores fell within the range of -1.96 to +1.96, indicative of normal distribution.

Table 4.145 presents the results, indicating that the observed significance (p) is less than the alpha value of 0.05 for industry professionals with 5-10 and 10-20 years of experience suggesting a non-normal distribution of data Since the data is not completely normally distributed the ANOVA is not applicable and hence non-parametric tests were deemed appropriate for analysis.

Factors	**Less than 1 Year**		**1 - 5 Years**		**5 - 10 Years**		**10 - 20 Years**		**More than 20 Years**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.736	0.752	0.17	0.403	0.674	0.456	0.336	0.58	0.228	0.383
Z Score	-0.98		0.42		1.48		0.58		0.60	
Kurtosis	-0.395	1.481	-0.108	0.788	-0.108	0.887	-0.836	1.121	-0.455	0.75
Z Score	-0.27		-0.14		-0.12		-0.75		-0.61	
p -value	0.466		0.946		0.023		0.423		0.790	
Result	Normal		Normal		Not Normal		Not Normal		Normal	

Table 4.145: Current knowledge about mass timber data test of normality using Shapiro-Wilk

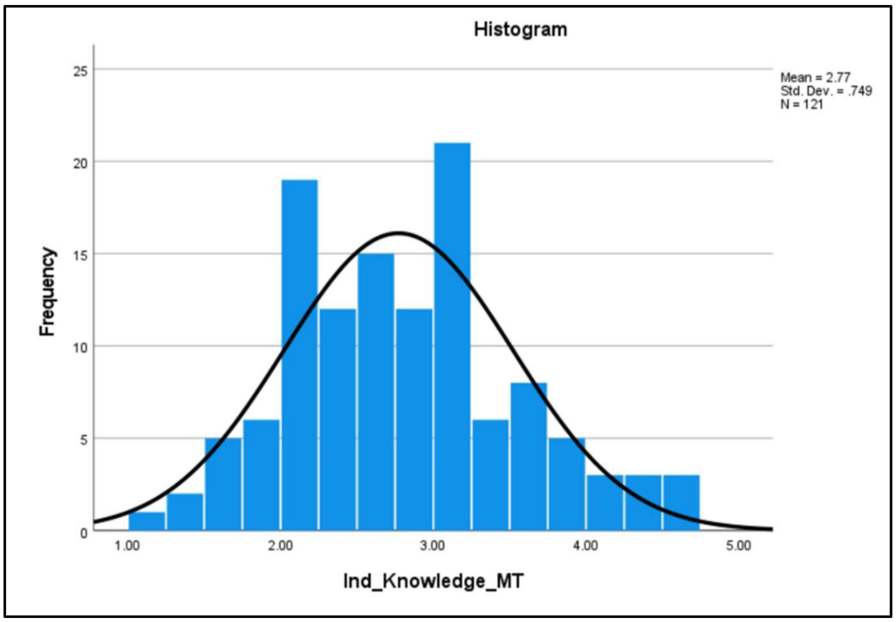


Figure 4.146: Histogram plot for test of normality on Current knowledge

To explore potential differences in current knowledge among industry groups based on their levels of experience, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) = 8.666, p = 0.070, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in knowledge gaps related to mass timber among industry groups based on their levels of experience. Refer to Figure 4.147, for the box plot illustrating the distribution of the current knowledge across these groups.

MT_Current Knowledge Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.25	2.33	2.49	38.94
1 - 5 Years	34	2.83	2.83	2.83	64.85
5 - 10 Years	26	2.72	2.83	3.05	57.62
10 - 20 Years	15	2.47	2.33	2.05	47.20
More than 20 Years	38	2.97	2.83	2.55	69.96
Total	121				

Table 4.146: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_Knowledge_MT is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.070	Retain the null hypothesis.

Table 4.147: Kruskal-Wallis test results for Current knowledge about mass timber across discipline

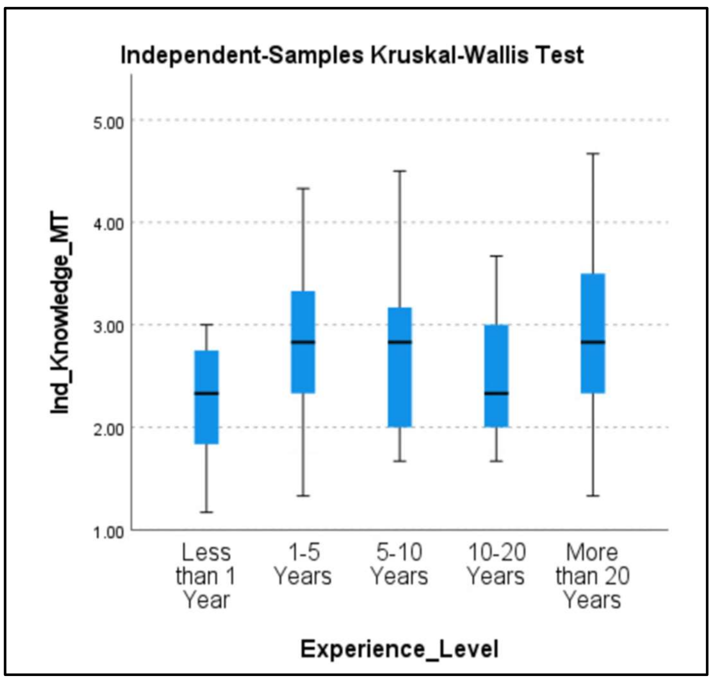


Figure 4.147: Box plot results for Current knowledge about mass timber

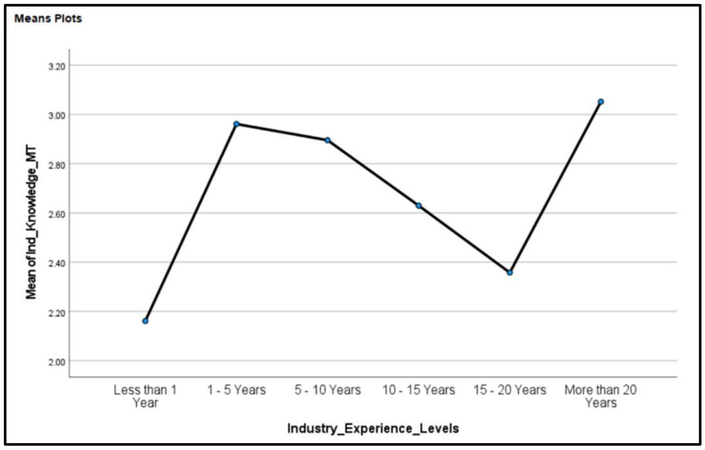


Figure 4.148: Means plot

4.5.2 Perception of mass timber: Industry Experience

To examine perceptions among Industry groups based on their experience in the construction industry, survey questions were divided further divided into three specific areas:

1. Based on the performance of mass timber
2. Based on sustainability and environmental impact
3. Based on safety and regulatory compliance

Each category was subjected to normality testing followed by further analysis. The findings from these analyses are discussed and illustrated to shed light on the factors influencing perceptions of mass timber among different experience levels of industry groups within the US construction industry.

4.5.2.1 Based on the performance of mass timber: Industry Experience

To analyze perception based on the performance of the mass timber among the industry group based on their level of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.148, the observed significance for less than 1 year, 1-5, 5-10 and more than 20 years of experience was less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Less than 1 Year**		**1 - 5 Years**		**5 - 10 Years**		**10 - 20 Years**		**More than 20 Years**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.097	0.752	-1.51	0.403	-1.166	0.456	-0.456	0.58	-1.392	0.383
Z Score	-1.46		-3.75		-2.56		-0.79		-3.63	
Kurtosis	-0.443	1.481	2.393	0.788	0.281	0.887	-1.204	1.121	1.505	0.75
Z Score	-0.30		3.04		0.32		-1.07		2.01	
p -value	0.035		<0.001		0.001		0.139		<0.001	
Result	Not Normal		Not Normal		Not Normal		Normal		Not Normal	

Table 4.148: Performance of mass timber data test of normality using Shapiro-Wilk

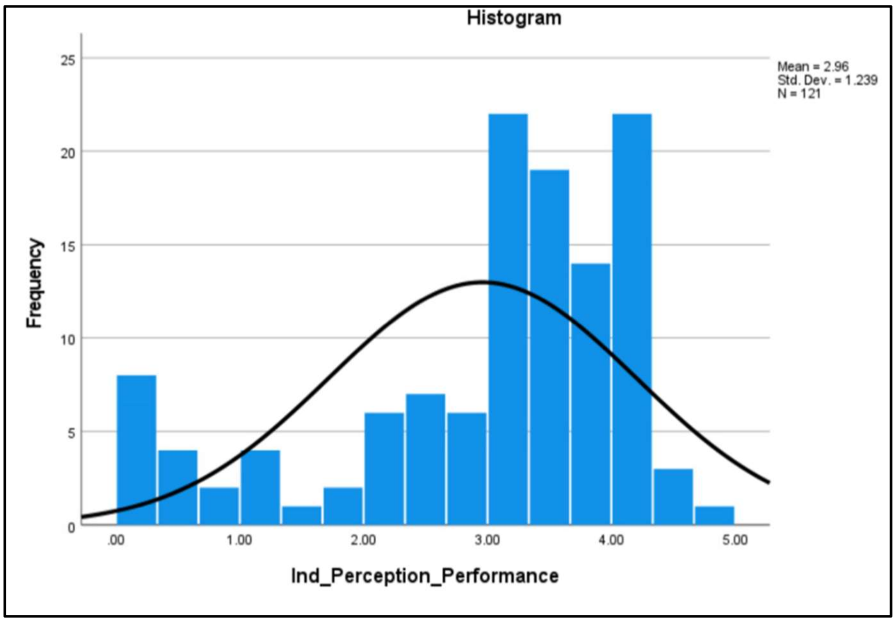


Figure 4.149: Histogram plot for test of normality on performance of mass timber

To explore potential differences in perceptions based on the performance of mass timber among industry groups based on their experience levels, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) 6.514, $p = 0.164$, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the performance of mass timber among industry groups based on their experience levels. Refer to Figure 4.150, for the box plot illustrating the distribution of the perceptions based on the performance across these groups based on their experience levels.

Ind_Perception_Performance Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.62	3.31	4.69	55.13
1 - 5 Years	34	3.09	3.31	3.75	62.68
5 - 10 Years	26	3.06	3.44	4.20	66.44
10 - 20 Years	15	2.23	2.63	3.43	40.63
More than 20 Years	38	3.12	3.44	4.08	65.05
Total	121				

Table 4.149: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_Perception_Performance is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.164	Retain the null hypothesis.

Table 4.150: Kruskal-Wallis test results for performance of mass timber

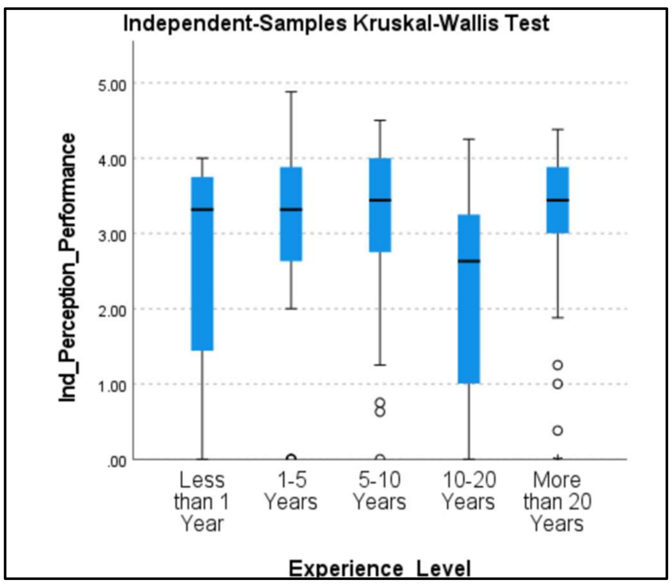


Figure 4.150: Box plot results for performance of mass timber

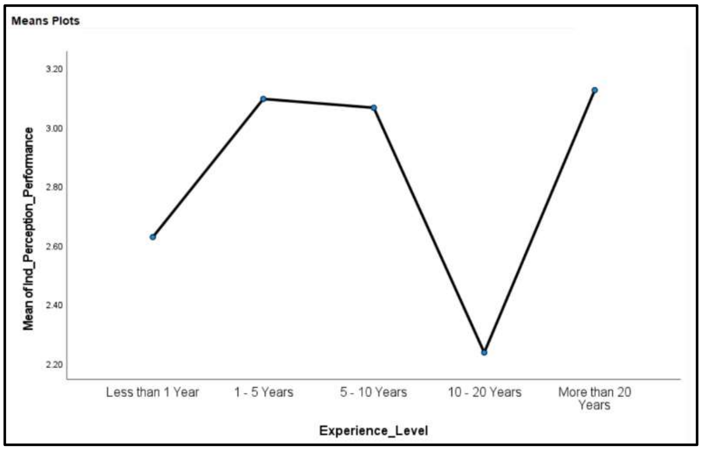


Figure 4.151: Means plot

4.5.2.2 Based on the sustainability and environmental impact of mass timber: Industry Experience

To analyze perception based on the sustainability and environmental impact of the mass timber among the industry group based on their level of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.151, the observed significance for 1-5, 5-10 and more than 20 years of experience was less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Less than 1 Year**		**1 - 5 Years**		**5 - 10 Years**		**10 - 20 Years**		**More than 20 Years**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.654	0.752	-1.811	0.403	-0.934	0.456	-0.497	0.58	-0.792	0.383
Z Score	-0.87		-4.49		-2.05		-0.86		-2.07	
Kurtosis	-1.058	1.481	4.497	0.788	0.042	0.887	-0.893	1.121	-0.269	0.75
Z Score	-0.71		5.71		0.05		-0.80		-0.36	
p -value	0.113		<0.001		0.008		0.337		0.003	
Result	Normal		Not Normal		Not Normal		Normal		Not Normal	

Table 4.151: Sustainability and environmental impact of mass timber data test of normality

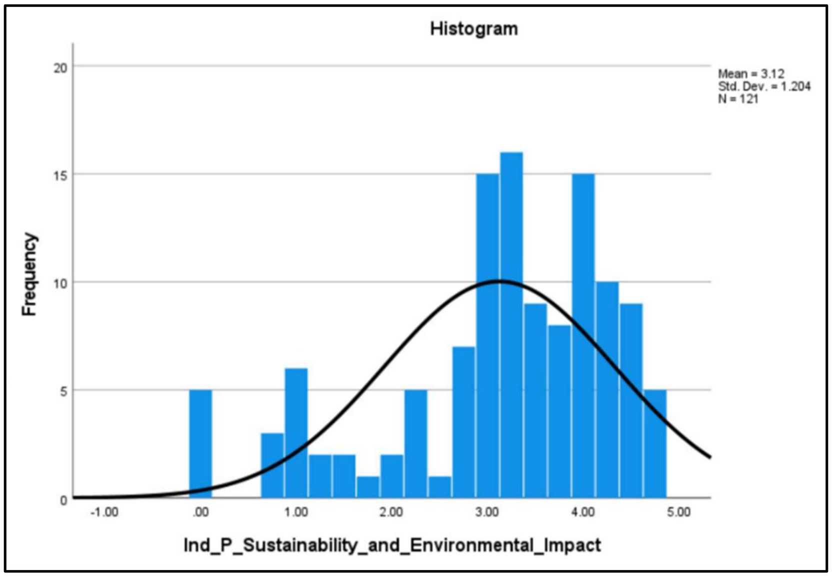


Figure 4.152: Histogram plot for test of normality on sustainability and environmental impact

To explore potential differences in perceptions based on the sustainability and environmental impact of mass timber among industry groups based on their experience levels, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) 7.638, p = 0.106, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the sustainability and environmental impact of mass timber among industry groups based on their experience levels. Refer to Figure 4.153, for the box plot illustrating the distribution of the perceptions based on the sustainability and environmental impact across these groups based on their experience levels.

Ind_Perception_Sustainability and Environmental Impact Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.46	2.62	2.94	47.31
1 - 5 Years	34	3.33	3.25	3.09	65.81
5 - 10 Years	26	3.14	3.37	3.83	61.29
10 - 20 Years	15	2.45	2.75	3.35	41.60
More than 20 Years	38	3.32	3.50	3.86	67.04
Total	121				

Table 4.152: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_P_Sustainability_and_Environmental_Impact is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.106	Retain the null hypothesis.

Table 4.153: Kruskal-Wallis test results for sustainability and environmental impact of mass timber across discipline

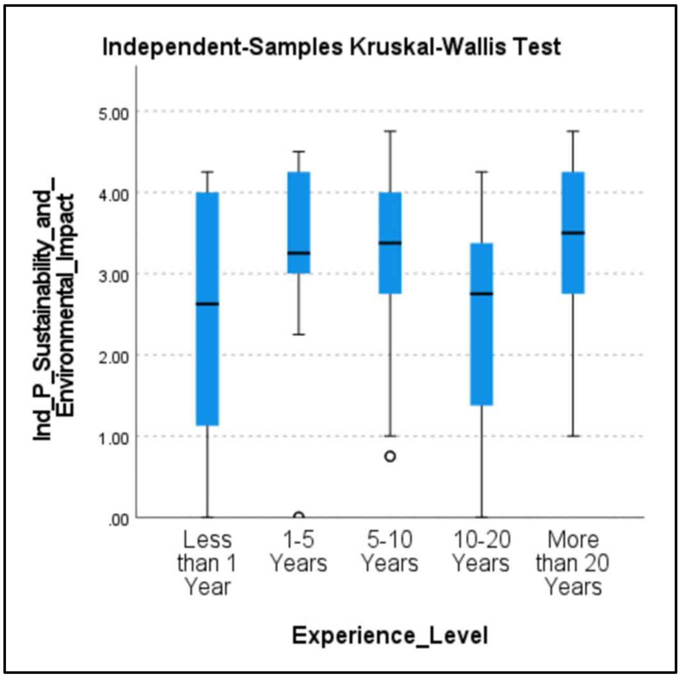


Figure 4.153: Box plot results for sustainability and environmental impact of mass timber

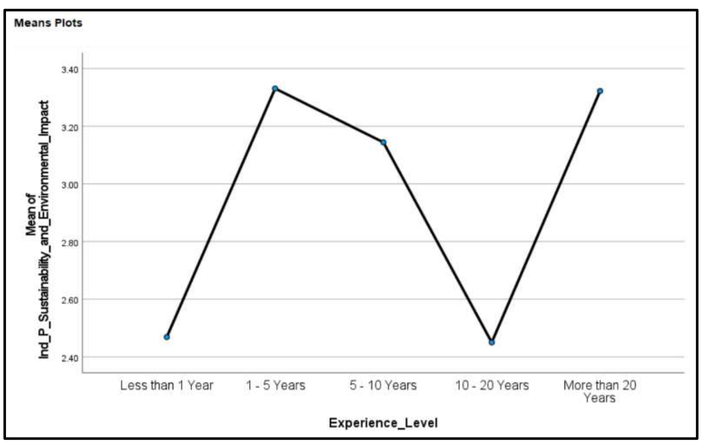


Figure 4.154: Means plot

4.5.2.3 Based on the safety and regulatory compliance of mass timber: Industry Experience

To analyze perception based on the safety and regulatory compliance of the mass timber among the industry group based on their level of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.154, the observed significance for 1-5, 5-10 and more than 20 years of experience was less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Less than 1 Year		1 - 5 Years		5 - 10 Years		10 - 20 Years		More than 20 Years	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.198	0.752	-0.967	0.403	-0.777	0.456	-0.33	0.58	-1.29	0.383
Z Score	-0.26		-2.40		-1.70		-0.57		-3.37	
Kurtosis	-1.963	1.481	-0.275	0.788	-0.496	0.887	-1.206	1.121	1.646	0.75
Z Score	-1.33		-0.35		-0.56		-1.08		2.19	
p -value	0.114		<0.001		0.007		0.136		<0.001	
Result	Normal		Not Normal		Not Normal		Normal		Not Normal	

Table 4.154: Safety and regulatory compliance of mass timber data test of normality using Shapiro-Wilk

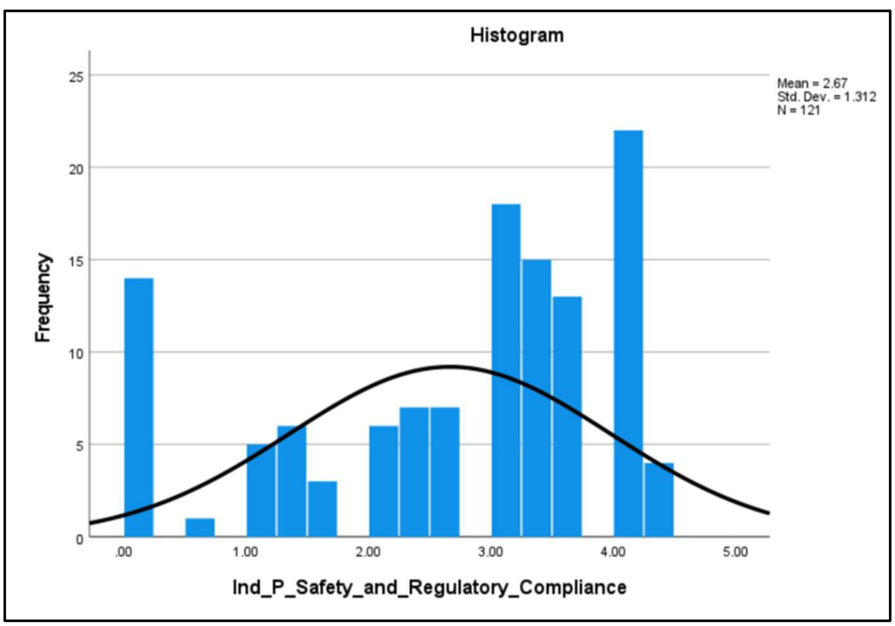


Figure 4.155: Histogram plot for test of normality on safety and regulatory compliance of mass timber

To explore potential differences in perceptions based on the safety and regulatory compliance of mass timber among industry groups based on their experience levels, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) 3.927, p = 0.416, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in perceptions based on the safety and regulatory compliance of mass timber among industry groups based on their experience levels. Refer to Figure 4.156, for the box plot illustrating the distribution of the perceptions based on the safety and regulatory compliance across these groups based on their experience levels.

Ind_Perception_Safety and Regulatory Compliance Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.16	2.16	2.16	52.81
1 - 5 Years	34	2.74	3.33	4.51	64.41
5 - 10 Years	26	2.56	3.00	3.88	57.69
10 - 20 Years	15	2.17	2.33	2.65	48.70
More than 20 Years	38	2.96	3.00	3.08	66.79
Total	121				

Table 4.155: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_P_Safety_and_Regulatory_Compliance is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.416	Retain the null hypothesis.

Table 4.156: Kruskal-Wallis test results for safety and regulatory compliance of mass timber

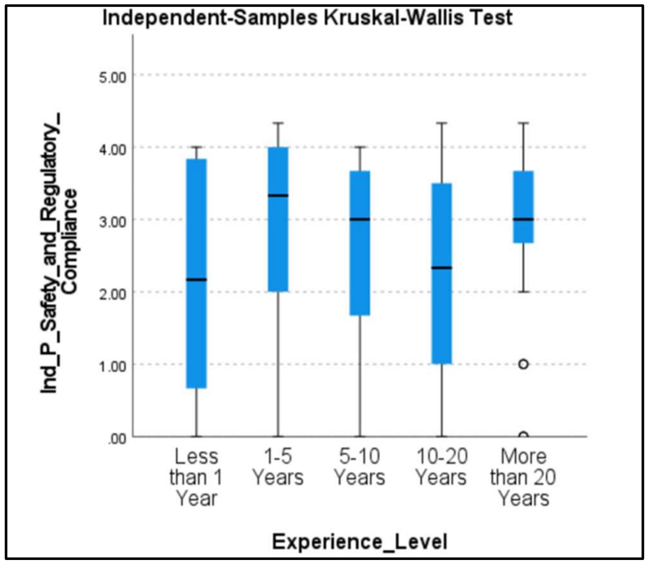


Figure 4.156: Box plot results for safety and regulatory compliance of mass timber

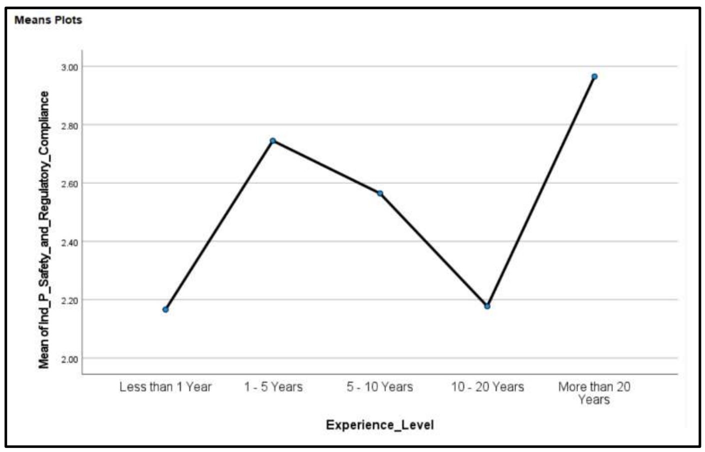


Figure 4.157: Means plot

4.5.3 Adoption of mass timber: Industry Experience

To explore the key factors influencing the adoption of mass timber among the industry group based on their experience levels in the us construction industry, statistical analysis was conducted. To delve into the factors impacting adoption, survey questions were further categorized into five distinct areas refer to Table 3.1:

1. Based on regulatory support
2. Based on educational and workforce development
3. Based on collaborative efforts

4. Based on environmental and sustainability factors
5. Based on market perception factors

For each of these subcategories, the data underwent initial normality testing followed by further analysis The results of these are further discussed and illustrated to provide insights into the factors influencing the adoption of mass timber among the industry group based on their experience level within the US construction industry.

4.5.3.1 Regulatory Support: Industry Experience

To analyze attitudes towards the adoption of mass timber based on the regulatory support among the industry group based on their levels of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.157, the observed significance for less than 1 year, 1-5 years, 5-10 years, 10-20 years and more than 20 years is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Less than 1 Year**		**1 - 5 Years**		**5 - 10 Years**		**10 - 20 Years**		**More than 20 Years**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.835	0.752	-1.134	0.403	-1.415	0.456	1.085	0.58	-0.354	0.383
Z Score	-1.11		-2.81		-3.10		1.87		-0.92	
Kurtosis	-0.875	1.481	0.936	0.788	1.847	0.887	0.398	1.121	-0.704	0.75
Z Score	-0.59		1.19		2.08		0.36		-0.94	
p -value	0.040		<0.001		<0.001		<0.001		0.003	
Result	Not Normal		Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.157: Regulatory Support data test of normality using Shapiro-Wilk

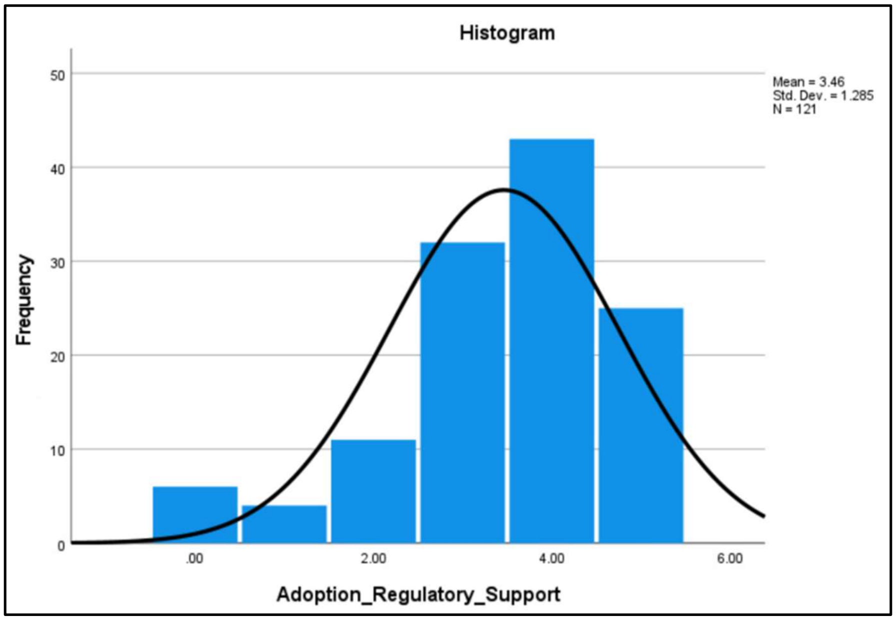


Figure 4.158: Histogram plot for test of normality on Regulatory Support

To explore potential differences in attitude towards adoption based on the regulatory support of mass timber among industry groups considering their level of experience, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) = 2.298, p = 0.681, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the regulatory support of mass timber among industry groups considering their level of experience. Refer to Figure 4.159, for the box plot illustrating the distribution of the attitude towards adoption based on regulatory support across these groups.

Ind_Adoption_Regulatory Support Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	3.12	3.50	4.26	60.50
1 - 5 Years	34	3.41	4.00	5.18	61.03
5 - 10 Years	26	3.69	4.00	4.62	69.08
10 - 20 Years	15	3.46	3.00	2.08	54.77
More than 20 Years	38	3.42	4.00	5.16	58.01
Total	121				

Table 4.158: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Adoption_Regulatory_Support is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.681	Retain the null hypothesis.

Table 4.159: Kruskal-Wallis test results for Regulatory Support of mass timber across discipline

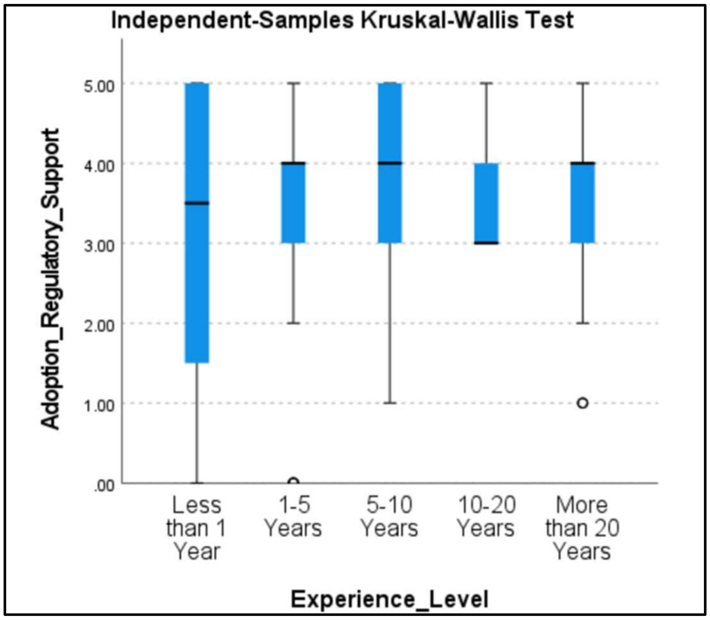


Figure 4.159: Box plot results for Regulatory Support

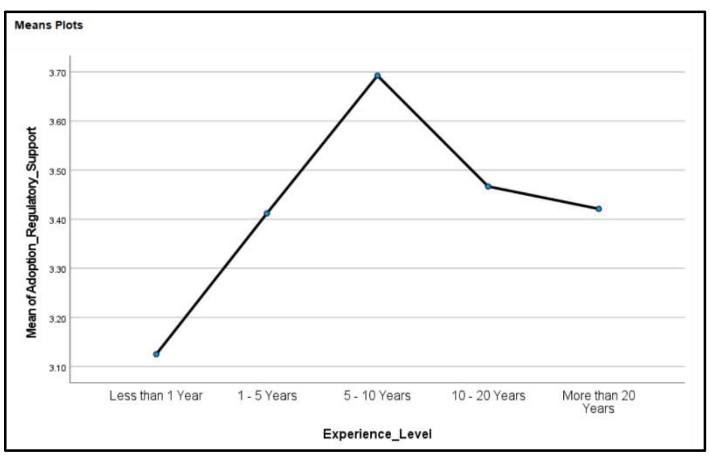


Figure 4.160: Means plot

4.5.3.2 Educational and Workforce Development: Industry Experience

To analyze attitudes towards the adoption of mass timber based on the educational and workforce development among the industry group based on their levels of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.160, the observed significance for 1-5 years, 5-10 years, 10-20 years and more than 20 years is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	**Less than 1 Year**		**1 - 5 Years**		**5 - 10 Years**		**10 - 20 Years**		**More than 20 Years**	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.205	0.752	-0.592	0.403	-0.286	0.456	-1.13	0.58	-0.524	0.383
Z Score	-0.27		-1.47		-0.63		-1.95		-1.37	
Kurtosis	-2.054	1.481	-0.421	0.788	-0.587	0.887	1.137	1.121	-0.295	0.75
Z Score	-1.39		-0.53		-0.66		1.01		-0.39	
p -value	0.056		0.003		0.025		0.006		<0.001	
Result	Normal		Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.160: Educational and Workforce Development data test of normality

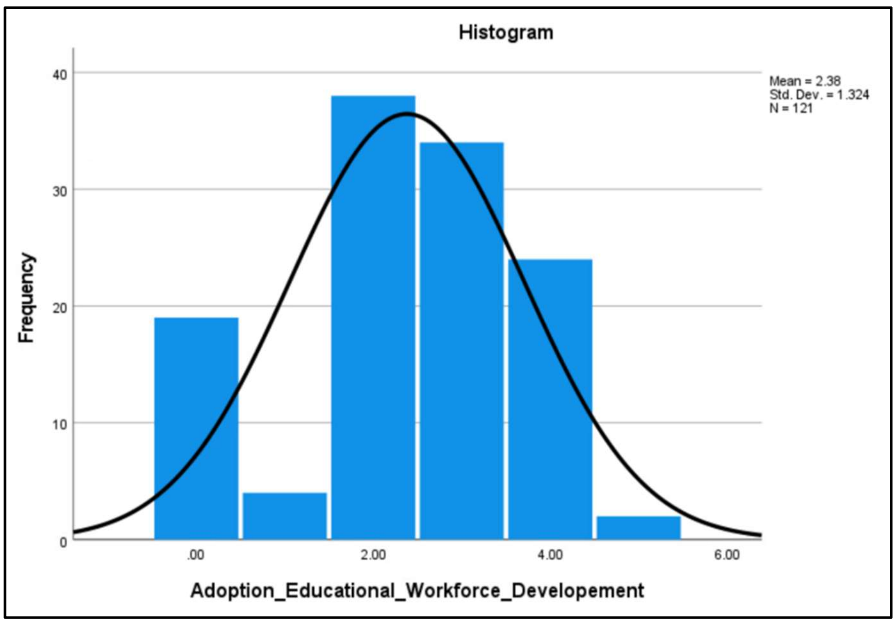


Figure 4.161: Histogram plot for test of normality on Educational and Workforce Development

To explore potential differences in attitude towards adoption based on the educational and workforce development of mass timber among industry groups considering their level of experience, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) = 2.759, p = 0.599, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the educational and workforce development of mass timber among industry groups considering their level of experience. Refer to Figure 4.162, for the box plot illustrating the distribution of the attitude towards adoption based on educational and workforce development across these groups.

Ind_Adoption_Educational Workforce Development Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.00	2.50	3.50	55.56
1 - 5 Years	34	2.64	3.00	3.72	68.38
5 - 10 Years	26	2.42	2.00	1.16	61.62
10 - 20 Years	15	2.33	3.00	4.34	59.30
More than 20 Years	38	2.21	2.00	1.58	55.79
Total	121				

Table 4.161: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Adoption_Educational_Workforce_Developement is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.599	Retain the null hypothesis.

Table 4.162: Kruskal-Wallis test results for Educational and Workforce Development across discipline

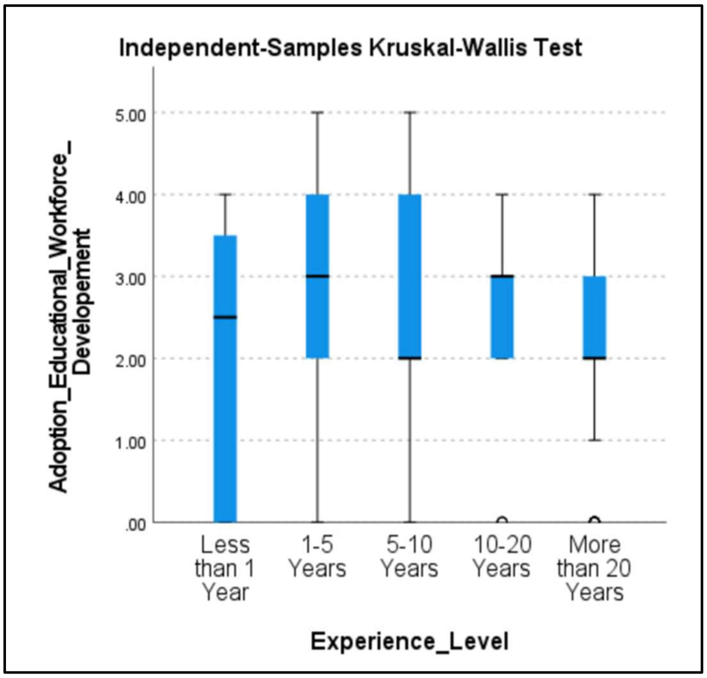


Figure 4.162: Box plot results for Educational and Workforce Development

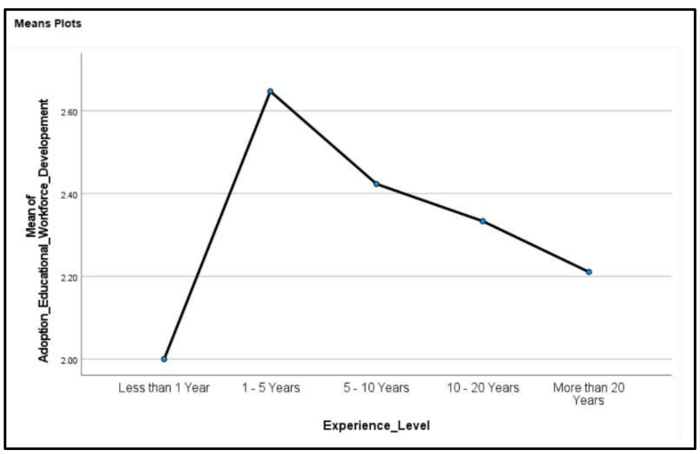


Figure 4.163: Means plot

4.5.3.3 Collaborative efforts: Industry Experience

To analyze attitudes towards the adoption of mass timber based on the collaborative efforts among the industry group based on their levels of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.163, the observed significance for less than 1 year, 1-5 years, 5-10 years, 10-20 years and more than 20 years is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Less than 1 Year		1 - 5 Years		5 - 10 Years		10 - 20 Years		More than 20 Years	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.118	0.752	-1.901	0.403	-0.807	0.456	-1.77	0.58	-1.98	0.383
Z Score	-1.49		-4.72		-1.77		-3.05		-5.17	
Kurtosis	-0.377	1.481	3.57	0.788	-0.272	0.887	2.68	1.121	4.098	0.75
Z Score	-0.25		4.53		-0.31		2.39		5.46	
p -value	0.013		<0.001		<0.001		<0.001		<0.001	
Result	Not Normal		Not Normal		Not Normal		Not Normal		Not Normal	

Table 4.163: Collaborative efforts data test of normality using Shapiro-Wilk

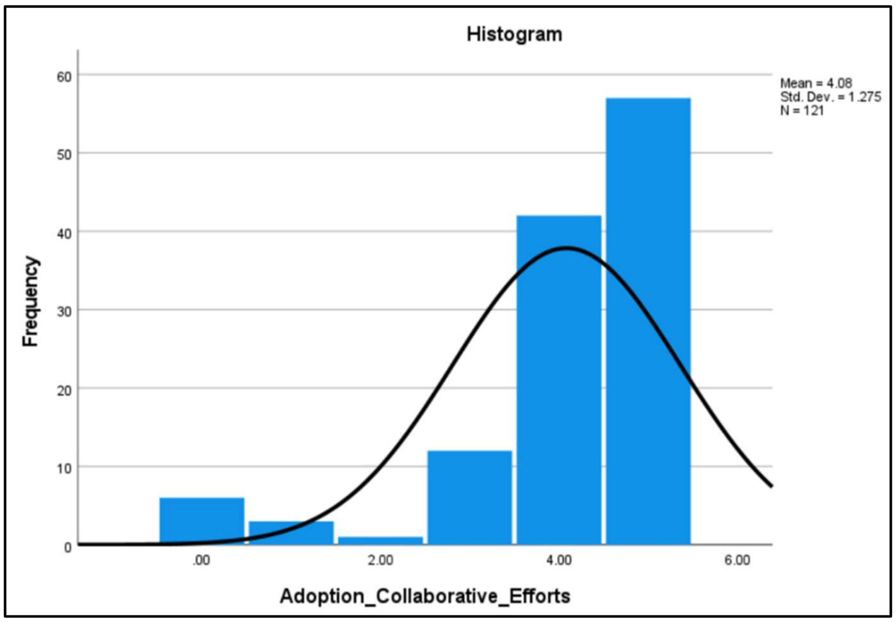


Figure 4.164: Histogram plot for test of normality on Collaborative efforts

To explore potential differences in attitude towards adoption based on the collaborative efforts of mass timber among industry groups considering their level of experience, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) = 6.454, p = 0.168, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the collaborative efforts of mass timber among industry groups considering their level of experience. Refer to Figure 4.165, for the box plot illustrating the distribution of the attitude towards adoption based on collaborative efforts across these groups.

Ind_Adoption_Collaborative Efforts Exp					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	3.00	4.00	6.00	36.31
1 - 5 Years	34	4.11	5.00	6.78	63.85
5 - 10 Years	26	4.46	5.00	6.08	68.08
10 - 20 Years	15	3.86	4.00	4.28	56.47
More than 20 Years	38	4.10	4.00	3.80	60.59
Total	121				

Table 4.164: Mean & Median across groups for current knowledge

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Adoption_Collaborative_Efforts is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.168	Retain the null hypothesis.

Table 4.165: Kruskal-Wallis test results for Collaborative efforts across discipline

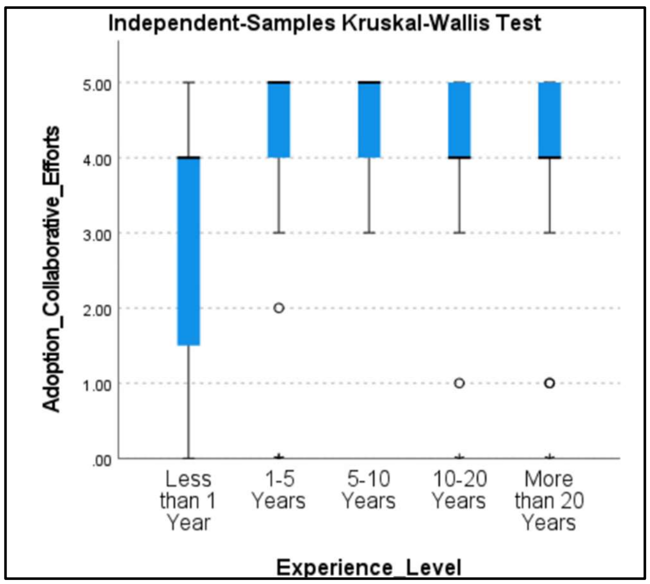


Figure 4.165: Box plot results for Collaborative

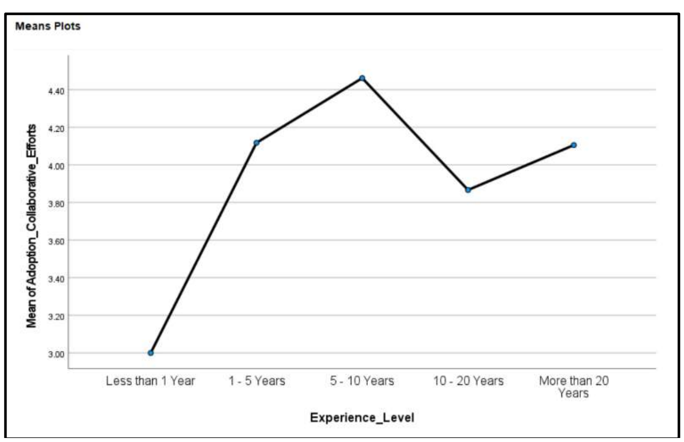


Figure 4.166: Means plot

4.5.3.4 Environmental and Sustainability Factors: Industry Experience

To analyze attitudes towards the adoption of mass timber based on the environmental and sustainability factors among the industry group based on their levels of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.166, the observed significance for less than 1 year, 1-5 years, 5-10 years, and more than 20 years is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Less than 1 Year		1 - 5 Years		5 - 10 Years		10 - 20 Years		More than 20 Years	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-1.213	0.752	-1.43	0.403	-0.974	0.456	-0.156	0.58	-0.918	0.383
Z Score	-1.61		-3.55		-2.14		-0.27		-2.40	
Kurtosis	-0.261	1.481	2.736	0.788	0.228	0.887	-1.515	1.121	0.3	0.75
Z Score	-0.18		3.47		0.26		-1.35		0.40	
p-value	0.011		0.001		0.011		0.074		0.003	
Result	Not Normal		Not Normal		Not Normal		Normal		Not Normal	

Table 4.166: Environmental and Sustainability Factors data test of normality using Shapiro-Wilk

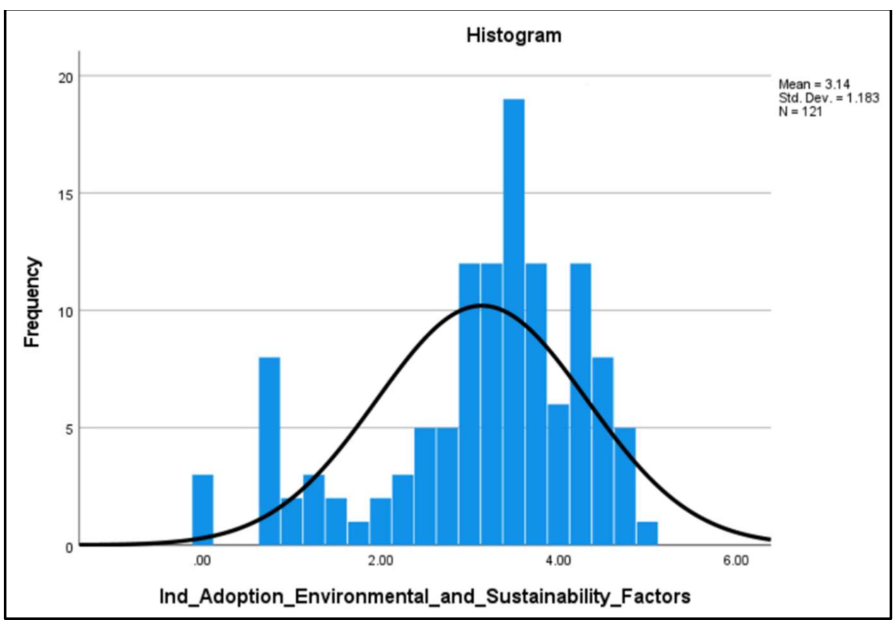


Figure 4.167: Histogram plot for test of normality on Environmental and Sustainability Factors

To explore potential differences in attitude towards adoption based on the environmental and sustainability factors of mass timber among industry groups considering their level of experience, the Kruskal-Wallis test was utilized. The results indicate a significant difference, x^2 (4, N=121) = 12.109, *p* = 0.017, leading to the rejection of the null hypothesis. These findings suggest a significant difference in attitude towards adoption based on the environmental and sustainability factors of mass timber among industry groups considering their level of experience. Refer to Figure 4.168, for the box plot illustrating the distribution of the attitude towards adoption based on environmental and sustainability factors across these groups.

Ind_Adoption_Environmental and Sustainability Factors					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.37	2.87	3.87	39.06
1 - 5 Years	34	3.44	3.62	3.98	70.59
5 - 10 Years	26	3.16	3.50	4.18	61.00
10 - 20 Years	15	2.38	2.50	2.74	39.40
More than 20 Years	38	3.30	3.50	3.90	65.57
Total	121				

Table 4.167: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.[a,b]	Decision
1	The distribution of Ind_Adoption_Environmental_and_Sustainability_Factors is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.017	Reject the null hypothesis.

Table 4.168: Kruskal-Wallis test results for Environmental and Sustainability Factors

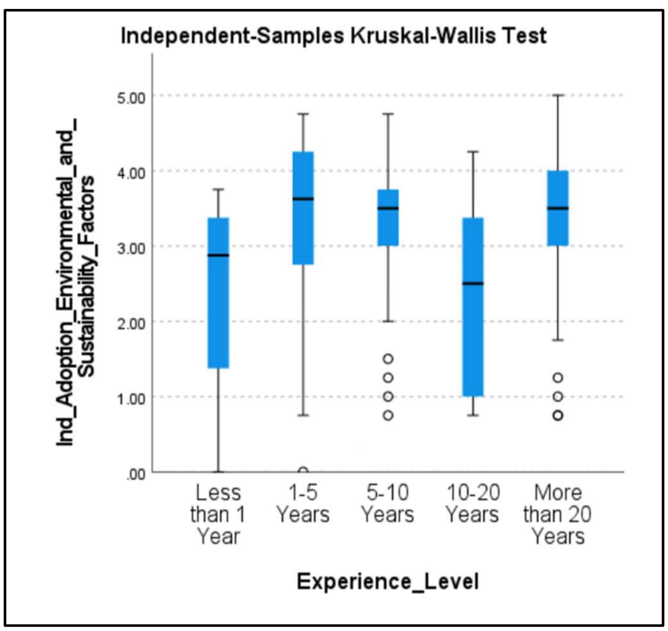


Figure 4.168: Box plot results for Environmental and Sustainability Factors

Additionally, pairwise comparisons were conducted to pinpoint specific differences among groups. The adjusted significance values highlighted a significant distinction in attitude towards adoption between the 10-20 Years and 1-5 Years, with a significance level of 0.40. This significance level falls below our predetermined alpha value of 0.05. Refer to Figure 4.169, which presents the pairwise comparison of discipline by mean rank.

Pairwise Comparisons of Experience_Level

Sample 1-Sample 2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Less than 1 Year-10-20 Years	-.337	15.288	-.022	.982	1.000
Less than 1 Year-5-10 Years	-21.937	14.119	-1.554	.120	1.000
Less than 1 Year-More than 20 Years	-26.503	13.584	-1.951	.051	.511
Less than 1 Year-1-5 Years	-31.526	13.722	-2.297	.022	.216
10-20 Years-5-10 Years	21.600	11.323	1.908	.056	.564
10-20 Years-More than 20 Years	-26.166	10.649	-2.457	.014	.140
10-20 Years-1-5 Years	31.188	10.824	2.881	.004	.040
5-10 Years-More than 20 Years	-4.566	8.888	-.514	.607	1.000
5-10 Years-1-5 Years	9.588	9.098	1.054	.292	1.000
More than 20 Years-1-5 Years	5.022	8.244	.609	.542	1.000

Table 4.169: Pairwise test results

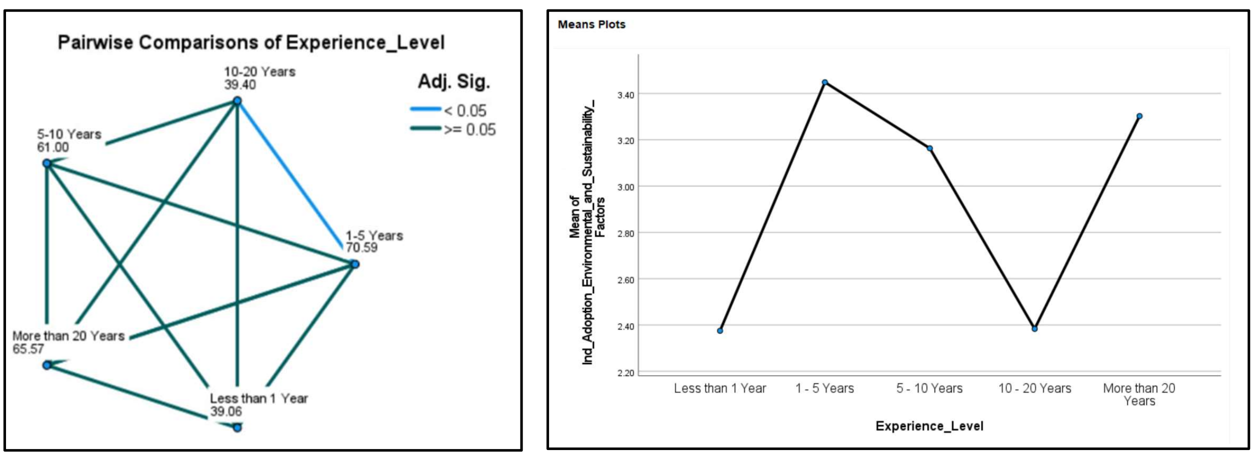


Figure 4.169: Pairwise Comparisons and Means Plot

4.5.3.5 Market Perceptions: Industry Experience

To analyze attitudes towards the adoption of mass timber based on the market perceptions among the industry group based on their levels of experience, first the data was tested for normality, using the Shapiro-Wilk test, along with Skewness and Kurtosis measures. The assumed alpha level was 0.05. As shown in Table 4.170, the observed significance for 1-5 years and 5-10 years, is less than the assumed alpha of 0.05, indicating that the data is not normally distributed. Consequently, non-parametric tests were deemed appropriate for further analysis.

Factors	Less than 1 Year		1 - 5 Years		5 - 10 Years		10 - 20 Years		More than 20 Years	
	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error	Statistic	Std. Error
Skewness	-0.362	0.752	-0.464	0.403	-0.864	0.456	0.45	0.58	-0.156	0.383
Z Score	-0.48		-1.15		-1.89		0.78		-0.41	
Kurtosis	-1.756	1.481	-1.01	0.788	-0.288	0.887	-0.257	1.121	-0.396	0.75
Z Score	-1.19		-1.28		-0.32		-0.23		-0.53	
p -value	0.110		0.022		0.004		0.543		0.140	
Result	Normal		Not Normal		Not Normal		Normal		Normal	

Table 4.170: Market perceptions data test of normality using Shapiro-Wilk

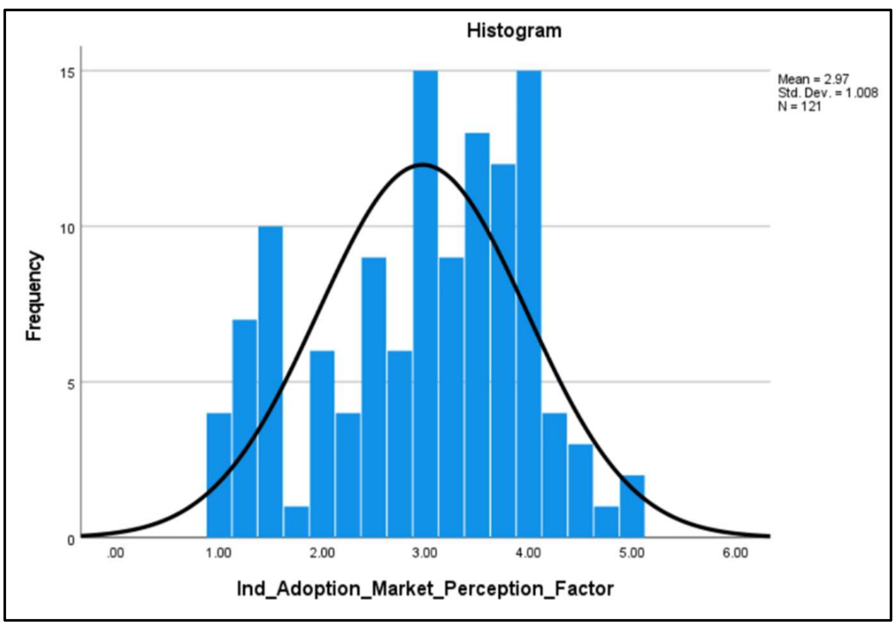


Figure 4.170: Histogram plot for test of normality on Market

To explore potential differences in attitude towards adoption based on the market perceptions of mass timber among industry groups considering their level of experience, the Kruskal-Wallis test was utilized. The results indicate no significant difference, x^2 (4, N=121) = 4.792, p = 0.309, leading to the acceptance of the null hypothesis. These findings suggest no significant difference in attitude towards adoption based on the market perceptions of mass timber among industry groups considering their level of experience. Refer to Figure 4.171, for the box plot illustrating the distribution of the attitude towards adoption based on market perceptions across these groups.

Ind_Adoption_Market Perceptions					
Experience Level	N	Mean	Median	Mode	Mean Rank
Less than 1 Year	8	2.96	3.62	4.94	64.81
1 - 5 Years	34	3.11	3.37	3.89	66.51
5 - 10 Years	26	3.07	3.50	4.36	65.75
10 - 20 Years	15	2.55	2.50	2.40	45.00
More than 20 Years	38	2.93	3.00	3.14	58.33
Total	121				

Table 4.171: Mean, Median, Mode and Mean Rank across all disciplines

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.^{a,b}	Decision
1	The distribution of Ind_Adoption_Market_Perception_Factor is the same across categories of Experience_Level.	Independent-Samples Kruskal-Wallis Test	.309	Retain the null hypothesis.

Table 4.172: Kruskal-Wallis test results for Market perceptions

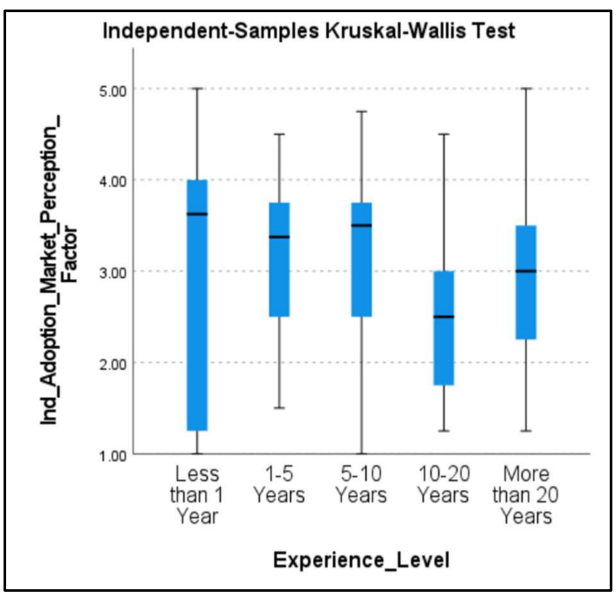


Figure 4.171: Box plot results for Market

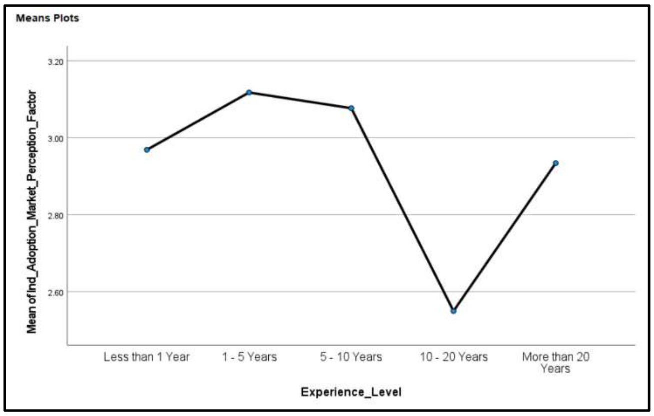


Figure 4.172: Means plot

4.6 Post- Hoc Power Factor Calculation

To ensure the adequacy of the sample size used in this study, a post-hoc power analysis was conducted using G*Power software (G*Power, 2024). The study included three major groups- Students (n = 151), Faculty (n = 165), and Faculty (n = 124)- totaling 440 responses. Given the non-normally distributed data, a Kruskal Wallis test was used to determine the differences among the groups. A subsequent post- hoc power analysis was performed to evaluate whether the sample size was sufficient to detect statistically significant differences.

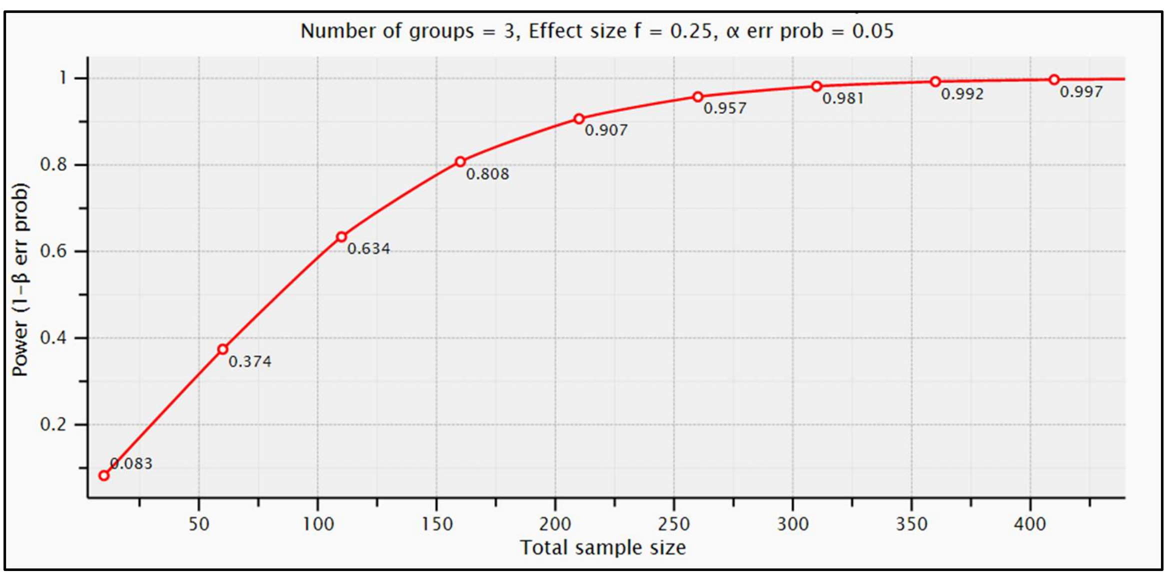


Figure 4.173: Graph Plot Power v/s Total Sample Size

The power analysis indicated a power (1- β) of 0.997, which suggests that the sample size used in this study is highly adequate. A power of 0.997 implies that there is a 99.7% probability of correctly rejecting the null hypothesis when there is a true effect, meaning that the study is very well-powered to detect differences between the groups. This high power is consistent with the sample size determination conducted prior to the study, which suggested a minimum sample size of 384 participants to achieve statistically significant results at a conventional alpha level of 0.05. Therefore, the obtained sample size of 440 not only meets but exceeds the required sample size, further confirming the robustness of the study's findings (Faul, 2007).

4.7 SUMMARY

This chapter details the presentation of results obtained from the study. Analysis of survey responses revealed significant insights into various aspects of mass timber adoption in the US construction industry. Notable differences in knowledge gaps were observed among industry-faculty groups.

Furthermore, perceptions regarding mass timber adoption were examined across different dimensions, including performance, sustainability, safety, and regulatory compliance. This analysis uncovered significant variations in perceptions among industry professionals and students, with significant differences in perception factors: Mass Timber performance and Safety and regulation factors. While there was no significant difference between any of the groups concerning the perceptions regarding sustainability and environmental impact.

The study also investigated factors influencing mass timber adoption, categorized into regulatory and policy factors, educational and workforce development, collaborative efforts, environmental and sustainability factors, and market perception factors. No significant difference was observed for regulatory factors and environmental and sustainability factors. Whereas education and workforce development factors showed a significant difference between industry-student and faculty-student. Similarly for collaborative efforts significant difference was observed between industry-faculty and faculty-student. Finally considering market perception factors industry-student and faculty-student both had a significance <0.05. Hence indicating significant differences in these of the factors.

Apart from the between-group analysis, an among-group analysis was also conducted for students, faculty professionals as well as industry professionals based on their experience levels within the AEC sector. This comprehensive analysis provided key insights into the differences in knowledge, perceptions, and attitudes within these groups.

Further discussions, including the key findings and conclusion, will be presented in the next chapter. Additionally, future research scope and potential avenues for further exploration will also be discussed.

5 CHAPTER: CONCLUSION AND FUTURE SCOPE

In this chapter, the culmination of this research endeavor is presented, offering a synthesis of the findings and achievements. The chapter begins with a summary of the outputs, key contributions, and conclusions derived from the study are then discussed followed by recommendations for future research directions.

The primary objective of this research has been to comprehensively explore and understand the dynamics influencing the adoption of mass timber within the US construction industry, with a specific focus on stakeholders in the Architecture, Engineering, and Construction (AEC) sectors. Through a multifaceted analysis, this study aimed to uncover insights into how knowledge, perceptions, and attitudes towards mass timber vary among academia (students and faculty) and industry professionals, and how these dynamics evolve across different disciplines and levels of professional experience.

The research methodology employed in this study facilitated a robust examination of these issues, involving a detailed survey administered to stakeholders across various segments of the AEC industry. By analyzing the data gathered, this study provides a nuanced understanding of the factors influencing mass timber adoption, offering valuable insights into educational practices, professional development, and industry integration.

This chapter will proceed by summarizing key findings and outlining the significant contributions of the research. Additionally, it will identify areas where further research could deepen understanding and address remaining questions, thus advancing knowledge and practice in sustainable construction technologies.

This section synthesizes the study's outcomes summary by objectives, focusing on addressing three core hypotheses concerning mass timber in the U.S. construction industry. As stated below:

Objective 1: To investigate the knowledge gaps related to mass timber among academia and industry professionals.

- H0: There is no significant difference in the knowledge gaps related to mass timber among academia and industry professionals in the U.S. Construction Industry.
- H1: There are significant differences in knowledge gaps related to mass timber among the academia and industry professionals in the U.S. Construction Industry.

Objective 2: To identify the factors influencing perceptions of mass timber within the U.S. construction industry.

- H0: Perceptions of mass timber in the U.S. construction Industry do not differ between the academic group and the Industry Professionals.
- H1: Perceptions of mass timber in the U.S. Construction Industry differs between academia and Industry professionals.

Objective 3: To analyze the key determinants shaping the adoption of mass timber in the U.S. construction sector.

- H0: Factors influencing the adoption of mass timber are similar among academia and industry professionals.
- H1: Factors influencing the adoption of mass timber vary significantly between academia and industry professionals.

The study utilized between-group analysis to substantiate these hypotheses. Additionally, it conducted among-group analyses within the Architecture, Engineering, and Construction (AEC) sectors, examining differences across disciplines. Furthermore, the study explored variations in perceptions and attitudes among industry professionals based on their experience levels within the construction industry. This section provides a detailed summary of these findings.

To present the findings between among the groups, a heat map approach was employed to highlight the difference in significant values, specifically the p-values, based on the assumed significance threshold of p = 0.05. This visualization displays the comparisons between the main groups- students, faculty, and industry, across the key variables related to knowledge, Perception, and Attitude (KPA). A further detailed explanation of each KPA category is provided below

VARIABLES	I-S	I-F	S-F
Current MT Knowledge	0.206	0.000	0.059
P_Performance	0.009	0.397	0.323
P_Sustainability and Environmental Impact	0.138	0.643	1.000
P_Safety & Regulatory Compliance	0.003	0.158	0.431
A_Regulatory Support	1.000	1.000	1.000
A_Educational & Workforce Development	0.000	0.495	0.000
A_Collaborative Efforts	0.542	0.042	0.000
A_Environmental and Sustainability Factors	0.288	0.235	1.000
A_Market Perceptions	0.000	1.000	0.003

Table 5.1: Between group variables

5.1 Knowledge gaps related to mass timber

The first hypothesis aimed to understand the disparities in the knowledge gaps about mass timber between academia and industry professionals in the U.S. construction industry. To evaluate this hypothesis, the Kruskal-Wallis, a non-parametric statistical approach suitable for non-normally distributed data was employed. The analysis revealed a statistically significant difference in the knowledge gap between academia and industry professionals, thereby validating the hypothesis that significant differences exist between the two groups.

Referring Figure 4.19, which includes detailed pairwise comparison or the heat map presented above table 5.1, it is evident that the most pronounced difference is between the industry and faculty groups, with (p = 0.000). Whereas industry and student is (p = 0.206) and student and faculty is (p = 0.059). Additionally, the difference in their mean values can be observed in table 5.2

Mean	
Students	2.83
Faculty	3.05
Industry	2.67

Table 5.2: Mean- Knowledge gaps

This finding underscores the critical importance of acknowledging and addressing the distinct information needs and perspectives of these stakeholder groups to foster informed decision-making and support the broader adoption of mass timber.

5.2 Factors influencing perceptions of mass timber

The second hypothesis sought to elucidate the factors influencing perceptions of mass timber within the U.S. construction industry, with a specific focus on discerning differences between academia and industry professionals. The perceptions of mass timber were examined based on three parameters:

1. Performance
2. Sustainability and environmental impact
3. Safety and regulatory compliance.

Results from the Kruskal Wallis test showed a significant difference in perception of mass timber based on performance and safety and regulatory compliance, indicating that perceptions of mass timber in the US construction industry differ between academic groups and industry professionals based on these parameters. These findings support the second hypothesis. However, it is noteworthy that only the parameters of sustainability and environmental impact showed no significant difference in perceptions between academia and industry professionals.

In terms of performance, a significant difference was observed between the industry and student groups (p = 0.09), indicating that perceptions regarding the performance of mass timber varied notably between these two groups. Whereas the industry and faculty was (p = 0.397) and faculty and student was (p = 0.323). Ref. Figure 4.22.

Similarly, concerning safety and regulatory compliance, significant differences were noted, particularly between the industry and student groups (p = 0.003). Whereas between industry and faculty, it was (p = 0.158) and between faculty and student it was (p = 0.431). This discrepancy underscores the importance of recognizing and addressing divergent perspectives and concerns regarding the safety and regulatory aspects of mass timber within the U.S. construction industry. Ref. Figure 4.28. The corresponding difference in mean values are also highlighted in table 5.3.

P_Performance

Mean	
Students	3.38
Faculty	3.22
Industry	2.96

P_Safety&Reg

Mean	
Students	3.14
Faculty	2.96
Industry	2.66

Table 5.3: Mean- Perception_Performance & Safety

These results emphasize the intricate nature of the stakeholder perspective, emphasizing the imperative for tailored communication strategies and educational programs to cater the distinct concerns.

5.3 Factors influencing the adoption of mass timber

The third hypothesis aimed to identify the key factors influencing the adoption of Mass Timber in the US construction industry, distinguishing between academia and industry professionals.

The adoption of mass timber was examined based on five parameters:

1. Regulatory support

2. Educational and workforce development
3. Collaborative efforts
4. Environmental and sustainability factors
5. Market perception factors

Results from the Kruskal Wallis test showed a significant difference in the adoption of mass timber based on educational and workforce development, collaborative efforts, and market perception factors, indicating that attitudes towards the adoption of mass timber in the US construction industry vary significantly between academic groups and industry professionals based on these parameters. These findings support the third hypothesis. However, it is noteworthy that the parameters of regulatory support and environmental and sustainability factors showed no significant difference in perceptions between academia and industry professionals.

In terms of educational and workforce development, a significant difference was observed between the industry and student groups (p = 0.000) and faculty and student groups (p = 0.000) whereas between faculty and industry (p = 0.495), indicating that perceptions regarding the adoption of mass timber varied notably between these two groups. Ref. Figure 4.34.

Similarly, in terms of collaborative efforts, a significant difference was observed between industry and faculty (p = 0.042) as well as faculty and students (p = 0.000). Whereas student and industry was (p = 0.542). Ref. Figure 4.37.

Lastly, in terms of market perception factors, a significant difference was observed between Industry and student (p = 0.000) and faculty and student (p = 0.003). Whereas faculty and industry was (p = 1.000). Ref. Figure 4.43. Further details on the differences in mean values are presented below.

A_Edu&Workforce	
Mean	
Students	3.05
Faculty	2.24
Industry	2.38

A_CollabEff	
Mean	
Students	4.00
Faculty	4.38
Industry	4.02

A_MarketPrep	
Mean	
Students	3.41
Faculty	3.08
Industry	2.99

Table 5.4: Mean- Adoption _ Education & Workforce, Collaborative Efforts & Market Perception

In summary, the findings offer valuable insights into the dynamics surrounding mass timber in industry. By employing robust statistical methodologies and analyzing data collected from both groups, the study has contributed to a deeper understanding of the challenges and opportunities associated with the adoption of mass timber. These insights have important implications for policymakers, practitioners, and researchers, informing the development of more effective strategies and interventions aimed at promoting sustainable construction practices and mitigating environmental impacts.

5.4 Among group analysis considering the AEC for Students, Faculty, Industry Professionals, and Industry Professionals based on experience levels

In addition, to the between-group analysis, an among-group analysis was conducted for students, faculty, and industry professionals, as well as industry professionals based on their experience levels considering the AEC sector.

Sr. No.	Category	Method	*p* - Value	Findings	Details
Students Group					
1	Current knowledge	Kruskal Wallis	0.282	No significant difference	Refer Table 4.38
2	Perceptions				
	Performance	Kruskal Wallis	0.399	No significant difference	Refer Table 4.41
	Sustainability and environmental impact	Kruskal Wallis	0.694	No significant difference	Refer Table 4.44
	Safety and regulatory compliance	Kruskal Wallis	0.821	No significant difference	Refer Table 4.47
	Curriculum inclusion	Kruskal Wallis	0.660	No significant difference	Refer Table 4.50
	Job preparation	Kruskal Wallis	0.353	No significant difference	Refer Table 4.53
	Community beliefs	Kruskal Wallis	0.765	No significant difference	Refer Table 4.56
3	Attitude towards adoption				
	Regulatory support	Kruskal Wallis	0.557	No significant difference	Refer Table 4.59
	Educational and workforce development	Kruskal Wallis	0.073	No significant difference	Refer Table 4.62
	Collaborative efforts	Kruskal Wallis	0.102	No significant difference	Refer Table 4.65
	Environmental and sustainability factors	Kruskal Wallis	0.822	No significant difference	Refer Table 4.68
	Market Perception factors	Kruskal Wallis	0.282	No significant difference	Refer Table 4.71
Faculty Group					
1	Current knowledge	Kruskal Wallis	0.131	No significant difference	Refer Table 4.74
2	Perceptions				
	Performance	Kruskal Wallis	0.050	There is a significant difference	Refer Table 4.77 and Figure 4.84 for pairwise comparisons
	Sustainability and environmental impact	Kruskal Wallis	0.034	There is a significant difference	Refer Table 4.81 and Figure 4.87 for pairwise comparisons
	Safety and regulatory compliance	Kruskal Wallis	0.090	No significant difference	Refer Table 4.84
	Curriculum inclusion	Kruskal Wallis	<0.001	There is a significant difference	Refer Table 4.88 and Figure 4.93 for pairwise comparisons
	Job preparation	Kruskal Wallis	0.014	There is a significant difference	Refer Table 4.92 and Figure 4.96 for pairwise comparisons
	Community beliefs	Kruskal Wallis	0.230	No significant difference	Refer Table 4.96
3	Attitude towards adoption				
	Regulatory support	Kruskal Wallis	0.090	No significant difference	Refer Table 4.99
	Educational and workforce development	Kruskal Wallis	0.080	No significant difference	Refer Table 4.102
	Collaborative efforts	Kruskal Wallis	0.196	No significant difference	Refer Table 4.105
	Environmental and sustainability factors	Kruskal Wallis	0.032	There is a significant difference	Refer Table 4.108 and Figure 4.111 for pairwise comparisons
	Market Perception factors	Kruskal Wallis	0.101	No significant difference	Refer Table 4.112
Industry Group					
1	Current knowledge	Kruskal Wallis	0.035	There is a significant difference	Refer Table 4.115 and Figure 4.117 for pairwise comparisons
2	Perceptions				
	Performance	Kruskal Wallis	0.181	No significant difference	Refer Table 4.119
	Sustainability and environmental impact	Kruskal Wallis	0.076	No significant difference	Refer Table 4.122
	Safety and regulatory compliance	Kruskal Wallis	0.832	No significant difference	Refer Table 4.125
3	Attitude towards adoption				
	Regulatory support	Kruskal Wallis	0.908	No significant difference	Refer Table 4.128
	Educational and workforce development	Kruskal Wallis	0.183	No significant difference	Refer Table 4.131
	Collaborative efforts	Kruskal Wallis	0.096	No significant difference	Refer Table 4.134
	Environmental and sustainability factors	Kruskal Wallis	0.178	No significant difference	Refer Table 4.137
	Market Perception factors	Kruskal Wallis	0.489	No significant difference	Refer Table 4.139
	BIM Adoption	Kruskal Wallis	0.674	No significant difference	Refer Table 4.143
Industry Group_Experience levels					
1	Current knowledge	Kruskal Wallis	0.07	No significant difference	Refer Table 4.146
2	Perceptions				
	Performance	Kruskal Wallis	0.164	No significant difference	Refer Table 4.149
	Sustainability and environmental impact	Kruskal Wallis	0.106	No significant difference	Refer Table 4.152
	Safety and regulatory compliance	Kruskal Wallis	0.416	No significant difference	Refer Table 4.155
3	Attitude towards adoption				
	Regulatory support	Kruskal Wallis	0.681	No significant difference	Refer Table 4.158
	Educational and workforce development	Kruskal Wallis	0.599	No significant difference	Refer Table 4.161
	Collaborative efforts	Kruskal Wallis	0.168	No significant difference	Refer Table 4.164
	Environmental and sustainability factors	Kruskal Wallis	0.017	There is a significant difference	Refer Table 4.167 and Figure 4.168 for pairwise comparisons
	Market Perception factors	Kruskal Wallis	0.309	No significant difference	Refer Table 4.171

Table 5.5: Among-groups within AEC key findings

This comprehensive analysis aimed to identify the differences in means regarding knowledge, perceptions, and attitudes towards mass timber among these various groups, refer the table 5.1 to note the key findings. A heat map approach was used to clearly illustrate the difference in significance values and their corresponding means, helping to better understand the variations between these groups.

VARIABLES	CE-CM	CE-OT	CE-AR	CM-OT	CM-AR	OT-AR
Current MT Knowledge	0.304	1.000	1.000	1.000	1.000	1.000
P_Performance	1.000	1.000	1.000	1.000	0.532	1.000
P_Sustainability and Environmental Impact	1.000	1.000	1.000	1.000	1.000	1.000
P_Safety & Regulatory Compliance	1.000	1.000	1.000	1.000	1.000	1.000
P_Curriculam Inclusion	1.000	1.000	1.000	1.000	1.000	1.000
P_Job Prepration	1.000	1.000	1.000	1.000	0.467	1.000
P_Community Beliefs	1.000	1.000	1.000	1.000	1.000	1.000
A_Regulatory Support	1.000	1.000	1.000	1.000	1.000	1.000
A_Educational & Workforce Development	1.000	1.000	0.223	1.000	0.064	1.000
A_Collaborative Efforts	1.000	1.000	1.000	1.000	1.000	1.000
A_Environmental and Sustainability Factors	1.000	1.000	1.000	1.000	1.000	1.000
A_Market Perceptions	1.000	1.000	0.934	1.000	0.421	1.000

Table 5.6: Among Group- Students

5.4.1 Among group analysis- Student

As observed, we can see there is no significant difference in among AEC groups considering the students.

5.4.2 Among group analysis- Faculty

VARIABLES	CE-CM	CE-OT	CE-AR	CM-OT	CM-AR	OT-AR
Current MT Knowledge	1.000	1.000	1.000	1.000	0.282	1.000
P_Performance	1.000	0.843	0.090	1.000	0.487	1.000
P_Sustainability and Environmental Impact	1.000	1.000	1.000	1.000	0.022	1.000
P_Safety & Regulatory Compliance	1.000	0.880	1.000	1.000	0.380	0.293
P_Curriculam Inclusion	1.000	1.000	0.102	0.306	0.000	1.000
P_Job Prepration	1.000	1.000	0.095	1.000	0.069	1.000
P_Community Beliefs	1.000	1.000	1.000	1.000	0.277	1.000
A_Regulatory Support	1.000	1.000	0.395	1.000	0.296	1.000
A_Educational & Workforce Development	1.000	1.000	1.000	1.000	0.070	1.000
A_Collaborative Efforts	1.000	0.299	1.000	1.000	1.000	0.560
A_Environmental and Sustainability Factors	1.000	1.000	1.000	1.000	0.053	0.618
A_Market Perceptions	0.515	1.000	1.000	0.475	0.137	1.000

Table 5.7: Among Group- Faculty

As observed, we can see there is a significant difference among AEC groups considering the faculty between the Construction management and the Architecture groups. Where the Perception based on Sustainability and Environmental Impact and the Perception based on Curriculum Inclusion have a significance value less than the assumed significance of 0.05. Additionally, the difference in their mean values can be observed in the table 5.9

P_Sust&Env	
Mean	
Architecture	3.56
Civil Eng.	3.33
Construction Mgmt.	2.83
Other	3.16

P_CurrivulamInc	
Mean	
Architecture	3.44
Civil Eng.	2.50
Construction Mgmt.	2.29
Other	3.11

Table 5.8: Mean - Perceptions_Sustainability & Environmental Impact , Curriculum Inclusion

5.4.3 Among group analysis- Industry

VARIABLES	CE-CM	CE-OT	CE-AR	CM-OT	CM-AR	OT-AR
Current MT Knowledge	1.000	1.000	1.000	1.000	0.022	0.650
P_Performance	1.000	1.000	1.000	0.169	1.000	0.784
P_Sustainability and Environmental Impact	1.000	0.312	1.000	0.119	1.000	1.000
P_Safety & Regulatory Compliance	1.000	1.000	1.000	1.000	1.000	1.000
A_Regulatory Support	1.000	1.000	1.000	1.000	1.000	1.000
A_Educational & Workforce Development	1.000	1.000	1.000	0.209	1.000	1.000
A_Collaborative Efforts	1.000	0.893	0.271	1.000	0.233	1.000
A_Environmental and Sustainability Factors	1.000	0.295	1.000	0.413	1.000	1.000
A_Market Perceptions	1.000	1.000	1.000	1.000	1.000	0.909
A_BIM	1.000	1.000	1.000	1.000	1.000	1.000

Table 5.9: Among group - Industry

As observed, here again, there is a significant difference between the Construction management and the Architecture groups regarding their current knowledge of mass timber. This difference is reflected in a significance value below the assumed significance of 0.05. For a detailed comparison of their mean values, refer to table 5.10.

Knowledge	
Mean	
Architecture	3.16
Civil Eng.	2.81
Construction Mgmt.	2.62
Other	2.89

Table 5.10: Mean- Current Knowledge

As observed, the most significant difference is observed among the Construction Management and Architecture for both the among groups based on Faculty and Industry group. Where the Architecture group exhibits a higher mean value, exceeding 3 on our standard survey scale. One possible reason for this could be that architects are naturally more inclined towards wood due to its aesthetic appeal.

5.4.4 Among group analysis- Industry Experience

VARIABLES	Current MT Knowledge	P_Performance	P_Sustainability & Environmental Impact	P_Safety & Regulatory Compliance	A_Regulatory Support	A_Educational & Workforce Development	A_Collaborative Efforts	A_Environmental & Sustainability Factors	A_Market Perceptions
1Y_1-5Y	0.594	1.000	1.000	1.000	1.000	1.000	0.305	0.216	1.000
1Y_5-10Y	1.000	1.000	1.000	1.000	1.000	1.000	0.153	1.000	1.000
1Y_10-20Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1Y_20+Y	0.226	1.000	1.000	1.000	1.000	1.000	0.539	0.511	1.000
1-5Y_20+Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5-10Y_1-5Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5-10Y_20+Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5-10Y_10-20Y	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.564	1.000
1-5Y_10-20Y	1.000	0.423	0.253	1.000	1.000	1.000	1.000	1.000	0.469
5-10Y_10-20Y	1.000	0.230	0.821	1.000	1.000	1.000	1.000	1.000	0.670

Table 5.11: Among Group - Industry Experience

Considering the industry experience levels among the AEC groups, there is no significant difference observed among the groups.

Hence, upon examining the data across subgroups, it is evident that future research should focus on these specific areas and subgroups to gain more understanding of the differences. By addressing these specific aspects, future studies can provide more precise insights and develop tailored strategies for promoting mass timber adoption. This focused approach will be instrumental in bridging knowledge gaps and addressing barriers effectively, thereby contributing to more informed decision-making and advancement in the field.

5.5 RESEARCH CONTRIBUTIONS

This study contributes significantly to the body of knowledge on mass timber adoption in the US construction industry, with a particular focus on the Architecture, Engineering, and Construction (AEC) sectors. The primary contributions are as follows:

5.5.1 Comprehensive survey scope and methodology

The study employed an extensive survey methodology encompassing students, faculty, and industry professionals within the AEC sectors. Unlike the existing research that predominantly focused on architects' perspectives, this study broadens the scope to include a diverse range of stakeholders, thereby providing a more holistic understanding of mass timber adoption.

By capturing insights from these varied groups, the research acknowledges the continuous educational and professional cycle within the AEC industry. Students educated by faculty members transition into the industry, where they encounter new challenges that subsequently inform academic research and innovations.

5.5.2 Integrated Stakeholder Analysis

The inclusion of students, faculty, and industry professionals is based on the premise that the flow of knowledge and innovation in the AEC industry is cyclical. Students, once educated, move into the industry, where they encounter practical challenges and often become the focus of academic research, leading to new knowledge and innovations that are fed back into the educational system. By integrating perspectives from all three groups, the study provides a holistic view of the current state of mass timber adoption and the factors influencing it. This comprehensive analysis is crucial for understanding how educational practices, industry experience, and ongoing professional development interact to shape attitudes toward mass timber.

5.5.3 Between-Group Comparisons

The study conducted detailed between-group comparisons of means between students, faculty, and industry professionals. This analysis aimed to identify significant differences in knowledge, perceptions, and attitudes towards mass timber across these distinct groups.

The findings revealed notable differences, offering critical insights into how various stakeholder groups perceive mass timber. These insights are instrumental in developing targeted strategies to address specific knowledge gaps and misconceptions within each group, thereby promoting a more cohesive approach to mass timber adoption.

5.5.4 Among-Group Comparisons

Beyond the between-group analysis, the research also conducted among-group comparisons to explore variations within each stakeholder category. For the student group, comparisons were made considering architecture, civil engineering, and construction management disciplines. Similar analyses were performed for faculty and industry professionals.

Furthermore, the study examined differences in attitudes, perceptions, and knowledge considering industry professionals based on their experience levels. This detailed analysis provided insights into how experience in the industry influences industry professional's perceptions of mass timber, highlighting the intra-group dynamics that impact the adoption rate.

5.5.5 Pioneering Comprehensive Approach

This study is pioneering in its comprehensive approach, as no previous studies have conducted such an extensive survey across multiple AEC stakeholder groups and performed detailed comparisons both between and among these groups. This novel methodology sets a new standard for future research in the field.

The study's innovative design and thorough analysis contribute to a deeper understanding of the multifaceted dynamics influencing mass timber adoption. This approach not only enriches the academic discourse but also provides practical insights that can be leveraged by educators, industry leaders, and policymakers.

5.6 OUTREACH STRATEGIES- ADVANCE MASS TIMBER CONSTRUCTION

The findings of this research offer valuable insights that can be leveraged to enhance outreach strategies and advance the adoption of mass timber in the construction industry. By examining the varying knowledge levels, perceptions, and attitude towards adoption across different groups, this study provides a foundation for developing targeted approaches to promote mass timber more effectively. The following points outline how these findings can be utilized to address current challenges and drive progress in the field.

5.6.1 Targeted Educational Campaigns

Example: Develop educational material and workshops specifically tailored for architects, engineers, and construction managers. These materials could highlight the benefits of mass timber in areas where the research identified gaps. For example, if the research found that sustainability aspects are not well understood, create content that emphasizes the environmental advantages of mass timber.

5.6.2 Industry -Academia Collaborative Workshops

Example: Organize workshops where students, faculty, and industry professionals come together. These workshops should include interactive activities that encourage participants to work in mixed groups, fostering collaboration and the exchange of ideas. This approach will help bridge the gap between academic research and industry practices.

5.6.3 Leverage the Power of Social Media

Example: Utilize platforms like LinkedIn to start conversations and raise awareness. Series of posts each focusing on different aspects of mass timber, such as its environmental benefits, architectural appeal, or knowledge gaps identified in the research. Engaging visuals like infographics and jpegs to capture attention and using compelling captions to spark interest and encourage discussion can be done. Additionally, polls can be created that start with general questions about mass timber and gradually delves into more specific topics. This approach not only educates but also engages a broader audience, potentially influencing stakeholders perceptions and increasing mass timber adoption.

5.7 FUTURE RESEARCH

While the study has provided valuable insights into the knowledge gaps, perceptions, and factors influencing the adoption of mass timber within the U.S. construction industry, there are several avenues for future exploration and enhancement of the existing knowledge base. The following are the potential areas for future research:

5.7.1 Enhancing Participant Involvement

This research utilized questionnaire surveys to gather data on knowledge, perceptions, and attitude towards mass timber adoption. Achieving a high participant rate is crucial for accurately projecting findings and ensuring statistical analysis and validation. Although this research has a sufficient number of responses for statistical analysis and validation. Increasing the number of participants in future research could yield more accurate and generalizable results.

A larger sample size would enhance the understanding of mass timber adoption across various demographics and regions. It would allow for more detailed analyses, potentially revealing subtle differences and trends not detectable with a smaller sample. This can be achieved by extending the survey reach to include a wider range of geographic locations, industries, and educational institutions. Utilizing various recruitment strategies, such as online platforms, professional networks, and academic partnerships, can help achieve this goal.

5.7.2 Potential for future analysis and exploration

In this study, the researcher collected and reviewed extensive data that holds significant potential for further analysis. While the research question directed the scope of the current analysis, it is important to acknowledge the limitations that were present. These limitations, however, do not diminish the value of the data set but rather highlight the opportunities for additional research.

The data gathered provides a rich foundation for exploring various parameters that were not fully addressed in this study. Future research can delve into these aspects to gain a more comprehensive understanding of mass timber adoption in the US Construction industry. For instance, future researchers could examine correlations between different variables to uncover relationships that may influence attitudes and perceptions towards mass timber. Further analysis could include exploring demographic factors such as age, gender, and educational background to see how these variables impact knowledge and attitudes towards mass timber. Additionally, investigating regional differences in greater detail could provide insights into how local policies, climate conditions, and economic factors affect the adoption of mass timber.

5.7.3 Qualitative research to enhance understanding of mass timber adoption

Future research should complement quantitative analysis with qualitative methods to gain deeper insights into the factors influencing mass timber adoption. While quantitative data reveals trends and correlations, quantitative techniques like interviews, focus groups, and case studies can uncover the underlying motivations, barriers, and decision-making processes.

Interviews with key stakeholders, such as architects, builders, policymakers, and educators, can provide detailed personal experiences and perspectives. These conversations can highlight specific challenges and benefits perceived by those directly involved in mass timber projects, offering a richer context to the quantitative findings.

Focus groups can facilitate dynamic discussions among diverse participants, revealing collective attitudes and beliefs. These discussions can illuminate contrasting viewpoints and common concerns, providing a comprehensive understanding of how various factors influence mass timber adoption. Focus groups can also identify perceived gaps in knowledge and training, guiding future educational initiatives.

Case studies of successful mass timber projects can showcase best practices and strategies for overcoming obstacles. By examining specific projects, researchers can extract lessons applicable to future endeavors, highlighting the roles of local policies, community engagement, and industry collaboration.

Incorporating qualitative research will enrich the overall analysis, providing a more nuanced understanding of mass timber adoption. This approach will enrich researchers to offer more informed and actionable recommendations for industry professionals, policymakers, and educators promoting more effective strategies for sustainable building practices.

5.7.4 Longitudinal studies to track the evolution of mass timber adoption

Longitudinal studies present a valuable opportunity to track changes in knowledge, perceptions, and adoption of mass timber over an extended period. By repeatedly surveying the same group of stakeholders such as architects, builders, and educators longitudinal research can reveal how attitudes and behaviors evolve in response to new information, technological advancements, regulatory changes, and market dynamics.

One of the key advantages of longitudinal studies is their ability to identify trends and patterns that might not be apparent in cross-sectional research. For example, tracking changes in perceptions of mass timber environmental benefits over several years can provide insights into how increased awareness of climate change and sustainability influences the acceptance of this building material. Similarly, observing shifts in knowledge advancements in mass timber technology.

Longitudinal research can also shed light on the sustainability and long-term viability of mass timber solutions. By examining how mass timber projects perform over time, researchers can assess factors such as durability, maintenance requirements, and lifecycle costs. This information is crucial for understanding the practical benefits and challenges of mass timber in real-world applications, informing both industry practices and policy decisions.

These studies will enable a deeper understanding of how various factors influence the acceptance and integration of mass timber, ultimately supporting the development of more effective policies, educational programs, and industry practices.

5.7.5 Annual State of the Industry Survey

As the industry evolves, it is crucial to regularly access the state of mass timber adoption through longitudinal studies. One suggested approach is to implement an annual "State of the Industry" survey. This survey would capture year-on-year changes in perceptions, market trends and policy developments about mass timber. By consistently tracking these factors, researchers can identify emerging patterns, monitor the impact of previous interventions, and adjust strategies accordingly. This ongoing data collection would be invaluable in guiding future research and outreach efforts, Helping keep the momentum for mass timber adoption strong and informed by the latest industry insights.

5.7.6 Surveying Subgroup to Delve into Differences

As part of future research, it is essential to conduct more detailed surveys targeting specific subgroups within the construction industry and academia to better understand the variations in Knowledge, Perception, and attitude towards the adoption of mass timber. While the current study provided a broad overview, focusing on subgroups can reveal subtle differences that may not be apparent in the aggregate data.

For Example, as observed in the among-groups analysis a significant difference was observed in the construction management and architecture among the Faculty and Industry groups hence the next focus can be shifted towards these groups to gather in-depth details.

Surveying these subgroups will allow for a deeper exploration of how different variables influence mass timber adoption, leading to more informed recommendations and strategies that are responsive to specific needs and concerns of diverse stakeholders. This approach is crucial for advancing the understanding and broader acceptance of mass timber in the U.S construction industry.

5.7.7 Detailed Analysis of Individual Survey Questions

To gain a more nuanced understanding of the factors influencing mass timber adoption, future research should consider conducting in-depth analyses of individual survey questions within specific categories, such as sustainability, safety, or market availability. By breaking down responses at this granular level, researchers can uncover specific areas of concern or opportunities that might be masked in broader analysis. This approach would allow for a more targeted understanding of the key issues, enabling more effective communication and intervention strategies.

5.7.8 Follow-up Surveys on Required Resources

A key area for future research involves conducting follow-up surveys aimed at identifying the specific resources necessary for advancing mass timber adoption. This could include gathering insights from industry professionals, educators, and policymakers about the tools, material or training needed to support the widespread integration of mass timber in construction practices. Another researcher could design a questionnaire to explore these needs in detail, providing a roadmap for targeted interventions that address the identified gaps. Such a survey would help tailor resource allocation to meet the stakeholder's demands, ensuring that the support provided is both relevant and effective.

5.7.9 Educational initiatives to promote mass timber adoption

Educational initiatives play a crucial role in facilitating the wider adoption and integration of mass timber into mainstream construction practices. By developing comprehensive educational programs, training modules, and professional certificates, awareness, knowledge and skills related to mass timber can be enhanced among the key stakeholders, including architects, engineers, builders, and policymakers.

These educational programs should be designed to cover various aspects of mass timber construction, from fundamental principles and design techniques to advanced engineering methods and sustainability benefits. By offering structured courses and workshops, educational institutes and industry organizations can provide both theoretical knowledge and practical skills necessary for implementing mass timber projects successfully.

Training modules tailored for different professional groups can address specific needs and challenges faced by each sector. For architects, modules could focus on design flexibility, aesthetics considerations, and integration with other building systems. For engineers, the emphasis could be on structural performance, load calculations, and material properties. Builders might benefit from hands-on training in construction techniques site and the economic benefits of mass timber helping them to develop supportive regulations and incentives.

Professional certifications can further validate the expertise of individuals in mass timber construction, in addition to formal education and training, ongoing professional development opportunities such as seminars, webinars, and conferences can keep stakeholders updated on the latest advancements in mass timber technologies and practices. Networking events can also facilitate knowledge exchange and collaboration among professionals from different fields.

These efforts will not only improve the competency of industry professionals but also foster a culture of innovation and sustainability within the construction sector, driving the industry towards more environmentally responsible practices.

In conclusion, future research directions in the adoption of mass timber should prioritize longitudinal studies to track evolving perceptions and trends, complemented by qualitative research to deepen understanding of stakeholder motivations and barriers. Educational initiatives, including comprehensive programs and professional certifications, are essential for equipping architects, engineers, builders, and policymakers with the knowledge and skills needed to integrate mass timber into mainstream construction practices. These approaches will collectively advance sustainability and widespread adoption of mass timber in construction, fostering a more resilient and environmentally conscious built environment.

5.8 FINAL REMARK

This study has explored the multifaceted aspects of mass timber adoption in the US construction industry, analyzing knowledge, perceptions, and attitudes towards mass timber adoption among various stakeholder groups. Through comprehensive data collection and analysis, significant insights have been gained into the factors influencing the acceptance and implementation of this sustainable building material.

The findings underscore the importance of addressing both technical and perceptual barriers to facilitate the wider adoption of mass timber. By integrating educational initiatives, promoting awareness, and providing targeted training, stakeholders can be empowered to embrace mass timber more confidently. Additionally, longitudinal and qualitative research can further enrich our understanding of how attitudes and practices evolve over time, providing a robust foundation for future advancement.

As the construction industry continues to seek sustainable solutions, mass timber presents a viable and environmentally friendly option. By leveraging the insights from this research, industry professionals, policymakers, and educators can work collaboratively to overcome challenges and promote mass timber as a mainstream building material. This will not only enhance the sustainability of the built environment but also contribute to the global efforts of combating climate change.

In conclusion, the journey towards widespread mass timber adoption requires concerted efforts in education, policy, and research. The potential benefits of mass timber are substantial, and with the right strategies in place, it can play a pivotal role in shaping a more sustainable and resilient construction industry.

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APPENDIX A: SURVEY QUESTIONNAIRE

SURVEY QUESTIONNAIRE

Survey Flow

Block: Default Question Block (19 Questions)
Standard: Mass Timber Knowledge & Awareness (13 Questions)
Standard: Mass Timber Perceptions and Attitudes (18 Questions)
Standard: Academic Perspective (9 Questions)
Standard: Industry Perspective (9 Questions)
Standard: Future Expectations (4 Questions)
Standard: Thank You! (1 Question)

Dear Participant,

I am Hemangi Chavan, a Construction Management graduate student at Michigan State University, conducting research for my Master's Thesis. Your insights are invaluable.

I am inviting you to participate in a research study regarding your opinions and knowledge of mass timber materials and construction. Your participation is estimated to take approximately 15 minutes. Please note that you have the option to skip any questions and, if you choose, you may also decide not to participate in the research study by skipping the survey entirely.

Purpose: This study explores academic practitioners' and industry professionals' attitudes toward and knowledge about mass timber materials and construction.

Voluntary Participation: Participation is voluntary, and your decision not to participate has no consequences.

Ethical Considerations: Your responses will be kept confidential, and there are no foreseeable risks to participating in this study.

Institutional Review Board (IRB) Approval: This study has been thoroughly reviewed and approved by the Institutional Review Board at Michigan State University to ensure the protection of participants' rights and welfare.

Benefits: You will not directly benefit from your participation in this study. However, your participation in this study will contribute to the understanding of how information about mass timber can be better shared and included in formal and informal learning opportunities in the United States.

Please note: This is not a test of your knowledge but just to understand what you know; hence, there's no right or wrong answer.

Contact: If you have concerns or questions about this study, such as scientific issues, how to do any part of it, or to report an injury, please contact the researcher, George Berghorn, PhD at 552 W. Circle Dr. East Lansing, MI 48824, berghorn@msu.edu, 517-862-7821.

Thank you for your participation.

Sincerely,

Hemangi Chavan,

Michigan State University,

Grad Student, Construction Management.

To start the survey, please click the "Arrow" button below.

Demographic Information

1. Please enter the year you were born:

____

2. Please select the category that best fits your primary role:

- ○ Student (1)
- ○ Faculty (2)
- ○ Industry Professional (3)

3. What is the highest level of education you have completed?

- ○ High School (1)
- ○ Associate's or other 2-year degree (2)
- ○ Bachelor's degree (3)
- ○ Master's Degree (4)
- ○ Ph.D / Doctorate (5)
- ○ Other (Please Specify) (6) ____

4. Which field or department best fits your current educational program or profession?

- ○ Architecture (1)
- ○ Construction Management (2)
- ○ Civil Engineering (3)
- ○ Interior Designing (4)
- ○ Other (Please Specify) (5) ____

5. Please select the states in the United States where your school is located or company works or operates.

You can choose multiple states from the list below:

- ▢ Alabama (189)
- ▢ Alaska (190)
- ▢ Arizona (191)
- ▢ Arkansas (192)
- ▢ California (193)
- ▢ Colorado (194)
- ▢ Connecticut (195)
- ▢ Delaware (196)
- ▢ Florida (197)

- [ ] Georgia (198)
- [ ] Hawaii (199)
- [ ] Idaho (200)
- [ ] Illinois (201)
- [ ] Indiana (202)
- [ ] Iowa (203)
- [ ] Kansas (204)
- [ ] Kentucky (205)
- [ ] Louisiana (206)
- [ ] Maine (207)
- [ ] Maryland (208)
- [ ] Massachusetts (209)
- [ ] Michigan (210)
- [ ] Minnesota (211)
- [ ] Mississippi (212)
- [ ] Missouri (213)
- [ ] Montana (214)

- ☐ Nebraska (215)
- ☐ Nevada (216)
- ☐ New Hampshire (217)
- ☐ New Jersey (218)
- ☐ New Mexico (219)
- ☐ New York (220)
- ☐ North Carolina (221)
- ☐ North Dakota (222)
- ☐ Ohio (223)
- ☐ Oklahoma (224)
- ☐ Oregon (225)
- ☐ Pennsylvania (226)
- ☐ Rhode Island (227)
- ☐ South Carolina (228)
- ☐ South Dakota (229)
- ☐ Tennessee (230)
- ☐ Texas (231)

- ☐ Utah (232)
- ☐ Vermont (233)
- ☐ Virginia (234)
- ☐ Washington (235)
- ☐ West Virginia (236)
- ☐ Wisconsin (237)
- ☐ Wyoming (238)

---

6. Please select the option that best describes your professional journey:

- ○ I have primarily worked in the industry and then transitioned to a role as a professor at a university (1)
- ○ I have primarily worked as a professor at a university and then transitioned to a role in the industry (2)
- ○ I have worked in both industry and academia nearly the same amount of time throughout my career (3)
- ○ I have exclusively worked as a professor or academic staff at a university (4)
- ○ I have exclusively worked in various roles within the private sector (5)
- ○ Other (Please Specify) (6) ____

Display This Question:

If 2. Please select the category that best fits your primary role: = Faculty

Demographic Information

Display This Question:

If 2. Please select the category that best fits your primary role: = Faculty

1. How many years of experience do you have working in academia?

- ○ Less than 1 year (4)
- ○ 1 - 5 Years (5)
- ○ 5 - 10 Years (6)
- ○ 10 - 15 Years (7)
- ○ 15 - 20 Years (8)
- ○ More than 20 Years (9)
- ○ Other (Please Specify) (10) ____

Display This Question:

If 2. Please select the category that best fits your primary role: = Faculty

2. What is your current position/ job title?:

____

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

Demographic Information

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

1. Please select the category that best describes your company's primary role:

○ General Contractor / Construction Management (1)

○ Specialty Subcontractor (2)

○ Engineering Firm (3)

○ Architecture Firm (4)

○ Consultant (5)

○ Other (Please Specify) (6) ____

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

2. How many employees does your company currently have?

- ◯ <50 (1)
- ◯ 50 - 250 (2)
- ◯ 250 - 500 (3)
- ◯ 500 - 1000 (4)
- ◯ >1000 (5)
- ◯ Other (Please Specify) (6) ____

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

3. How many years of experience do you have in the AEC (Architecture, Engineering, and Construction) industry?

- ◯ Less than 1 Year (4)
- ◯ 1 - 5 Years (5)
- ◯ 5 - 10 Years (6)
- ◯ 1 - 15 Years (7)
- ◯ 15 - 20 Years (8)
- ◯ More than 20 Years (9)
- ◯ Other (Please Specify) (10)

____

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

4. Mass Timber is a modern construction material made by layering and bonding wood together to create strong and large panels. It's a sustainable alternative to traditional building materials and includes types like Glue-Laminated Timber (Glulam) and Cross-Laminated Timber (CLT). Have you worked with Mass Timber in your construction projects? If yes, please indicate your level of experience:

- ○ No experience with Mass Timber (4)
- ○ 1 Mass Timber Project (5)
- ○ 2 - 5 Mass Timber Projects (6)
- ○ 6 - 10 Mass Timber Projects (7)
- ○ 11 - 15 Mass Timber Projects (8)
- ○ 16 - 20 Mass Timber Projects (9)
- ○ More than 20 Mass Timber Projects (10)
- ○ Other (Please Specify) (11) ____

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

5. Please enter your current job title within the company.

____

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Demographic Information

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

1. What level of study are you in currently?

◯ First two years of Bachelor's Degree (1)

◯ Second two years of Bachelor's Degree (2)

◯ Master's Degree (3)

◯ Ph.D. (4)

◯ Other (Please Specify) (5) ____

Mass Timber Knowledge & Awareness

1. How familiar are you with the concept of mass timber construction?

○ Not familiar at all (1)

○ Slightly familiar (2)

○ Moderately familiar (3)

○ Very familiar (4)

○ Extremely familiar (5)

○ I don't know (6)

---

2. The general public in the United States is increasingly accepting and embracing mass timber construction as a viable and sustainable building method.

○ Strongly disagree (6)

○ Disagree (7)

○ Neither agree nor disagree (9)

○ Agree (11)

○ Strongly agree (12)

○ I don't know (13)

---

3. How likely are you to recommend mass timber construction for sustainable building projects?

- Extremely unlikely (1)
- Somewhat unlikely (2)
- Neither likely nor unlikely (3)
- Somewhat likely (4)
- Extremely likely (5)

4. How confident are you in your knowledge of mass timber construction techniques and benefits?

- Not Confident (1)
- Somewhat Confident (2)
- Unsure (3)
- Confident (4)
- Very Confident (5)

5. Educational and workforce development programs adequately prepare professionals and workers for careers in mass timber construction.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

---

6. Current fire safety measures and regulations adequately address potential fire risks in mass timber construction.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

Mass Timber Knowledge & Awareness

7. Do you believe that mass timber construction is an affordable housing solution compared to traditional concrete/steel construction?

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

8. Mass timber construction contributes to improved acoustic insulation in buildings.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

9. Mass Timber construction exhibits commendable thermal insulation properties.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

10. How familiar are you with the latest developments in modular mass timber construction techniques and their potential applications?

- Not familiar at all (1)
- Slightly familiar (2)
- Moderately familiar (3)
- Very familiar (4)
- Extremely familiar (5)

11. Regulatory support and incentives such as tax credits and zoning accommodations are essential for promoting the growth of mass timber construction.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

Mass Timber Perceptions and Attitudes

1. How familiar are you with the latest advancements in mass timber construction materials, such as CLT, Glulam, NLT, etc., and adhesives?

- ○ Not familiar at all (1)
- ○ Slightly familiar (2)
- ○ Moderately familiar (3)
- ○ Very familiar (4)
- ○ Extremely familiar (5)

---

2. The principles of the circular economy can significantly reduce waste and promote sustainable practices in the mass timber construction industry.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

---

3. Mass timber construction promotes sustainable forestry practices.

- ◯ Strongly disagree (6)
- ◯ Disagree (7)
- ◯ Neither agree nor disagree (9)
- ◯ Agree (11)
- ◯ Strongly agree (12)
- ◯ I don't know (13)

---

4. Mass timber construction reduces the carbon footprint of a building throughout its entire life cycle.

- ◯ Strongly disagree (6)
- ◯ Disagree (7)
- ◯ Neither agree nor disagree (9)
- ◯ Agree (11)
- ◯ Strongly agree (12)
- ◯ I don't know (13)

---

5. Mass Timber construction contributes to improved energy efficiency throughout the life cycle of buildings and structures.

- ◯ Strongly disagree (6)
- ◯ Disagree (7)
- ◯ Neither agree nor disagree (9)
- ◯ Agree (11)
- ◯ Strongly agree (12)
- ◯ I don't know (13)

Page Break

Mass Timber Perceptions and Attitudes

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6. The mass timber construction methods offer architectural aesthetics and design possibilities that are valuable for the United States built environment.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

---

7. Mass timber construction meets the safety standards required for building in the United States..

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

8. The cost-effectiveness and affordability of mass timber construction methods make them a viable option for a wide range of construction projects.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

9. The existing building codes and standards effectively accommodate the unique requirements and details of mass timber construction.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

---

10. You are confident in the ability of mass timber construction to create strong and resilient building structures that can withstand natural disasters and enhance overall resilience.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

Page Break

Mass Timber Perceptions and Attitudes

11. Mass timber construction makes the on site construction process faster as compared to that of traditional concrete and steel construction.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

12. How important do you believe sustainable certification programs such as FSC (Forest Stewardship Council) or LEED (Leadership in Energy and Environmental Design) are for ensuring the environmental sustainability of mass timber construction projects?

- ◯ Extremely important (6)
- ◯ Moderately important (7)
- ◯ Slightly important (9)
- ◯ Not important (11)
- ◯ I don't know (13)

---

13. Mass Timber construction is gaining market acceptance and consumers in the United States increasingly prefer mass timber as a building material.

- ◯ Strongly disagree (6)
- ◯ Disagree (7)
- ◯ Neither agree nor disagree (9)
- ◯ Agree (11)
- ◯ Strongly agree (12)
- ◯ I don't know (13)

---

14. You are open to change and innovation in construction methods, including mass timber.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (8)
- Agree (9)
- Strongly agree (10)

---

15. Collaborative efforts between Academia, Industry, and the government are important for advancing research and development in mass timber construction.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

End of Block: Mass Timber Perceptions and Attitudes

Start of Block: Academic Perspective

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

Academic Perspective

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

1. Your academic institution adequately include mass timber construction in its curriculum.

- ◯ Strongly disagree (1)
- ◯ Disagree (2)
- ◯ Neither agree nor disagree (3)
- ◯ Agree (4)
- ◯ Strongly agree (5)
- ◯ I don't know (6)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

2. Your institution is preparing students for jobs related to mass timber construction projects.

- ◯ Strongly disagree (1)
- ◯ Disagree (2)
- ◯ Neither agree nor disagree (3)
- ◯ Agree (4)
- ◯ Strongly agree (5)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

3. Your faculty members are up to date with the latest trends and developments in mass timber construction.

- ◯ Strongly disagree (1)
- ◯ Disagree (2)
- ◯ Neither agree nor disagree (3)
- ◯ Agree (4)
- ◯ Strongly agree (5)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

4. How often do academia and industry professionals collaborate to integrate real-world insights into research or teaching on mass timber, specifically within your institution?

- ○ Never (1)
- ○ Sometimes (2)
- ○ About half the time (3)
- ○ Most of the time (4)
- ○ Always (5)
- ○ I don't know (6)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

5. How often are discussions about the environmental benefits of mass timber construction, including the potential for carbon sequestration, incorporated into the curriculum within your department or institution?

- Never (1)
- Sometimes (2)
- About half the time (3)
- Most of the time (4)
- Always (5)
- I don't know (6)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

6. The expansion of mass timber construction in the U.S. has the potential to bring new life to the existing community's beliefs of mass timber construction and have a positive influence on the timber and forestry industry.

- ◯ Strongly disagree (6)
- ◯ Disagree (7)
- ◯ Neither agree nor disagree (9)
- ◯ Agree (11)
- ◯ Strongly agree (12)
- ◯ I don't know (13)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

7. The education and training programs in your academic institution address the challenges related to mass timber structural performance.

- ◯ Strongly disagree (1)
- ◯ Disagree (2)
- ◯ Neither agree nor disagree (3)
- ◯ Agree (4)
- ◯ Strongly agree (5)

Display This Question:

If 2. Please select the category that best fits your primary role: = Student

Or 2. Please select the category that best fits your primary role: = Faculty

8. You are well-informed about the challenges and opportunities associated with mass timber construction techniques, especially in the context of academia and research.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (8)
- ○ Agree (9)
- ○ Strongly agree (10)

End of Block: Academic Perspective

Start of Block: Industry Perspective

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

Industry Perspective

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

1. Mass Timber material is readily available in the United States market.

- ○ Strongly disagree (11)
- ○ Disagree (12)
- ○ Neither agree nor disagree (14)
- ○ Agree (16)
- ○ Strongly agree (17)
- ○ I don't know (18)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

2. You are actively involved in adopting sustainable practices within mass timber construction projects, such as sourcing locally and responsibly.

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Neither agree nor disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

3. You are confident in overcoming regulatory hurdles associated with mass timber construction.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (8)
- ○ Agree (9)
- ○ Strongly agree (10)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

4. How important is it for your organization to invest in ongoing training and education programs to ensure your future workforce is well-equipped to handle mass timber construction projects effectively?

- ○ Not at all important (1)
- ○ Slightly important (2)
- ○ Moderately important (3)
- ○ Very important (4)
- ○ Extremely important (5)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

5. You incorporate Building Information Modeling (BIM) into your mass timber projects for efficiency and accuracy.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (8)
- ○ Agree (9)
- ○ Strongly agree (10)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

6. The Mass Timber construction industry contributes significantly to the local and national economy in the United States, including job opportunities and economic growth.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

7. Your organization is open to exploring innovative construction methods and materials, including mass timber, to meet modern construction challenges.

- Strongly disagree (6)
- Disagree (7)
- Neither agree nor disagree (9)
- Agree (11)
- Strongly agree (12)
- I don't know (13)

Display This Question:

If 2. Please select the category that best fits your primary role: = Industry Professional

8. The United States Construction industry is willing to adopt mass timber methods in the near future.

- ◯ Strongly disagree (11)
- ◯ Disagree (12)
- ◯ Neither agree nor disagree (14)
- ◯ Agree (16)
- ◯ Strongly agree (17)
- ◯ I don't know (18)

End of Block: Industry Perspective

Start of Block: Future Expectations

Future Expectations

1. The mass timber construction market is experiencing substantial growth leading to a promising future.

- ○ Strongly disagree (6)
- ○ Disagree (7)
- ○ Neither agree nor disagree (9)
- ○ Agree (11)
- ○ Strongly agree (12)
- ○ I don't know (13)

---

2. Mass Timber construction will become a standard practice in the United States.

- ○ Strongly disagree (1)
- ○ Disagree (2)
- ○ Neither agree nor disagree (3)
- ○ Agree (4)
- ○ Strongly agree (5)

---

3. To what extent do you believe that mass timber construction will revolutionize the construction industry?

- ◯ Not at all (24)
- ◯ Slightly (25)
- ◯ Moderately (26)
- ◯ Significantly (27)
- ◯ Completely (28)

End of Block: Future Expectations

Start of Block: Thank You!

Dear Participant,

Your participation is greatly appreciated. In the bustling world of construction and design, you took precious time out to contribute to my research. Your insights are valuable.

If you're further interested in this research and would like to be contacted for a quick 1-on-1 interview, kindly share your details below:

Name:

Email Id:

Contact No:

Rest assured, the information provided will be confidential and will only be used for this research.

Best Regards,

- [ ] Name (4) ____
- [ ] Email ID (5) ____
- [ ] Contact No (6) ____

End of Block: Thank You!

APPENDIX B: PILOT TESTING RESPONSES

1. Shafayet Ahmed

Chavan, Hemangi

From:	Shafayet Ahmed <shafayet.ahmed@wmich.edu>
Sent:	Thursday, February 1, 2024 12:22 PM
To:	Berghorn, George; Chavan, Hemangi
Subject:	Re: Assistance with a student survey
Follow Up Flag:	Follow up
Flag Status:	Flagged

George,

Thanks for sharing the survey. I just submitted my responses. A quick follow-up regarding one of the questions I found a bit complicated to answer:

"Mass timber construction can address the need for sustainable and affordable housing in the United States."

Sustainability and affordability could be two separate constructs. Mass timber construction is sustainable in many ways. However, I am unsure about its affordability part, which I found somewhat expensive than the traditional concrete/steel construction. Providing one answer for two different domains might confuse the participants.

Good luck with the research!

Shafayet Ahmed, Ph.D. (he, him, his)
Assistant Professor
Department of Civil and Construction Engineering
College of Engineering and Applied Sciences
Western Michigan University
Kalamazoo, MI 49008-5316
Email: shafayet.ahmed@wmich.edu

Figure B.1: Pilot testing feedback Email Support

2. Prof. Matt Syal

Chavan, Hemangi

From:	Syal, M.G. Matt
Sent:	Wednesday, January 31, 2024 2:44 PM
To:	Berghorn, George; Chavan, Hemangi
Subject:	RE: Assistance with a student survey

Hemangi

I just took the survey and it took me 10-11 minutes.
Just two comments:

1. Why use “in the United States” in many questions?
2. Have you thought of grouping questions in categories and assign a page to each category, e.g., Environmental/sustainability aspects, Curriculum, Training, Projection. Right now many similar theme questions show up on different places.

Overall, good questions.

Thanks
MS

Prof. M.G. Matt Syal, Ph.D., CPC, LEED®AP
Professor, Construction Management
School of Planning, Design and Construction
MICHIGAN STATE UNIVERSITY
www.canr.msu.edu/people/matt_syal

Figure B.2: Pilot testing feedback Email Support

3. Kristen Cetin

From: Cetin, Kristen
Sent: Friday, February 2, 2024 12:12 PM
To: Berghorn, George <berghorn@msu.edu>; Chavan, Hemangi <chavanhe@msu.edu>
Subject: RE: Assistance with a student survey

Hemangi,

I just completed your survey. A few comments/suggestions since you asked for them. Hope this helps. (Note I did pause to write down comments so my time for taking this will be longer in your records),

- For "Mass Timber Construction makes the construction process faster as compared to that of traditional concrete and steel construction" – might want to clarify the bounds of this time – just on site or the entire process from start to finish
- "Mass Timber construction contributes to improved energy efficiency in buildings and structures in the United States" – do you mean operational efficiency only – i.e when the building is built and being used or more of an LCA type thing where we're taking into account energy associated with things that happen before the use phase of the building
- "Mass timber construction contributes to improved building performance, such as acoustic insulation, in the United States" – seems this is just referring to acoustics – so I would just say this rather than the broader building performance term
- "Mass timber construction can reduce the carbon footprint of a building" – suggest defining the boundary conditions of this question – do you mean use phase? Entire life cycle?
- "The presence of sustainable certification programs such as FSC (Forest Stewardship Council) or LEED (Leadership in Energy and Environmental Design) is essential for ensuring the environmental sustainability of mass timber construction projects in the United States." – I found this question a bit confusing, perhaps reword to clarify what you mean
- "How often is there a collaboration of academia with industry professionals to integrate real-world insights into research or teaching on mass timber" – where? At my institution?
- "How often do you incorporate discussions about the environmental benefits of mass timber construction, including the potential for carbon sequestration, into your curriculum?" when you say "you" do you mean me, the survey taker, or my department or institution? Also suggest adding a "I don't know" for this question

Regards,

Figure B.3: Pilot testing feedback Email Support

APPENDIX C: IRB APPROVAL

MICHIGAN STATE
UNIVERSITY

EXEMPT DETERMINATION
Revised Common Rule

October 27, 2023

To: George H Berghorn

Re: **MSU Study ID:** STUDY00009868
Principal Investigator: George H Berghorn
Category: Exempt 2(i)
Exempt Determination Date: 10/27/2023
Limited IRB Review: Not Required.

Title: Industry and Academic Attitudes Towards and Beliefs About Mass Timber

This study has been determined to be exempt under 45 CFR 46.104(d) 2(i).

Principal Investigator (PI) Responsibilities: The PI assumes the responsibilities for the protection of human subjects in this study as outlined in Human Research Protection Program (HRPP) Manual Section 8-1, Exemptions.

Continuing Review: Exempt studies do not need to be renewed.

Modifications: In general, investigators are not required to submit changes to the Michigan State University (MSU) Institutional Review Board (IRB) once a research study is designated as exempt as long as those changes do not affect the exempt category or criteria for exempt determination (changing from exempt status to expedited or full review, changing exempt category) or that may substantially change the focus of the research study such as a change in hypothesis or study design. See HRPP Manual Section 8-1, Exemptions, for examples. If the study is modified to add additional sites for the research, please note that you may not begin the research at those sites until you receive the appropriate approvals/permissions from the sites.

Please contact the HRPP office if you have any questions about whether a change must be submitted for IRB review and approval.

New Funding: If new external funding is obtained for an active study that had been determined exempt, a new initial IRB submission will be required, with limited exceptions. If you are unsure if a new initial IRB submission is required, contact the HRPP office. IRB review of the new submission must be completed before new funds can be spent on human research activities, as the new funding source may have additional or different requirements.

Reportable Events: If issues should arise during the conduct of the research, such as unanticipated problems that may involve risks to subjects or others, or any

Office of Regulatory Affairs
Human Research Protection Program

4000 Collins Road
Suite 136
Lansing, MI 48910

517-355-2180
Fax: 517-432-4503
Email: irb@msu.edu
www.hrpp.msu.edu

problem that may increase the risk to the human subjects and change the category of review, notify the IRB office promptly. Any complaints from participants that may change the level of review from exempt to expedited or full review must be reported to the IRB. Please report new information through the study's workspace and contact the IRB office with any urgent events. Please visit the Human Research Protection Program (HRPP) website to obtain more information, including reporting timelines.

Personnel Changes: After determination of the exempt status, the PI is responsible for maintaining records of personnel changes and appropriate training. The PI is not required to notify the IRB of personnel changes on exempt research. However, he or she may wish to submit personnel changes to the IRB for recordkeeping purposes (e.g. communication with the Graduate School) and may submit such requests by submitting a Modification request. If there is a change in PI, the new PI must confirm acceptance of the PI Assurance form and the previous PI must submit the Supplemental Form to Change the Principal Investigator with the Modification request (available at hrpp.msu.edu).

Closure: Investigators are not required to notify the IRB when the research study can be closed. However, the PI can choose to notify the IRB when the study can be closed and is especially recommended when the PI leaves the university. Closure indicates that research activities with human subjects are no longer ongoing, have stopped, and are complete. Human research activities are complete when investigators are no longer obtaining information or biospecimens about a living person through interaction or intervention with the individual, obtaining identifiable private information or identifiable biospecimens about a living person, and/or using, studying, analyzing, or generating identifiable private information or identifiable biospecimens about a living person.

For More Information: See HRPP Manual, including Section 8-1, Exemptions (available at hrpp.msu.edu).

Contact Information: If we can be of further assistance or if you have questions, please contact us at 517-355-2180 or via email at IRB@msu.edu. Please visit hrpp.msu.edu to access the HRPP Manual, templates, etc.

Exemption Category. The full regulatory text from 45 CFR 46.104(d) for the exempt research categories is included below. [1234]

Exempt 1. Research, conducted in established or commonly accepted educational settings, that specifically involves normal educational practices that are not likely to adversely impact students' opportunity to learn required educational content or the assessment of educators who provide instruction. This includes most research on regular and special education instructional strategies, and research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

Exempt 2. Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording) if at least one of the following criteria is met:

(i) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects;

(ii) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or

(iii) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

Exempt 3. (i) Research involving benign behavioral interventions in conjunction with the collection of information from an adult subject through verbal or written responses (including data entry) or audiovisual recording if the subject prospectively agrees to the intervention and information collection and at least one of the following criteria is met:

(A) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects;

(B) Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation; or

(C) The information obtained is recorded by the investigator in such a manner that the identity of the human subjects can readily be ascertained, directly or through identifiers linked to the subjects, and an IRB conducts a limited IRB review to make the determination required by 45 CFR 46.111(a)(7).

(ii) For the purpose of this provision, benign behavioral interventions are brief in duration, harmless, painless, not physically invasive, not likely to have a significant adverse lasting impact on the subjects, and the investigator has no reason to think the subjects will find the interventions offensive or embarrassing. Provided all such criteria are met, examples of such benign behavioral interventions would include having the subjects play an online game, having them solve puzzles under various noise conditions, or having them decide how to allocate a nominal amount of received cash between themselves and someone else.

(iii) If the research involves deceiving the subjects regarding the nature or purposes of the research, this exemption is not applicable unless the subject authorizes the deception through a prospective agreement to participate in research in circumstances in which the subject is informed that he or she will be unaware of or misled regarding the nature or purposes of the research.

Exempt 4. Secondary research for which consent is not required: Secondary research uses of identifiable private information or identifiable biospecimens, if at least one of the following criteria is met:

(i) The identifiable private information or identifiable biospecimens are publicly available;

(ii) Information, which may include information about biospecimens, is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained directly or through identifiers linked to the subjects, the investigator does not contact the subjects, and the investigator will not re-identify subjects;

(iii) The research involves only information collection and analysis involving the investigator's use of identifiable health information when that use is regulated under 45 CFR parts 160 and 164, subparts A and E, for the purposes of ``health care operations'' or ``research'' as those terms are defined at 45 CFR 164.501 or for ``public health activities and purposes'' as described under 45 CFR 164.512(b); or

(iv) The research is conducted by, or on behalf of, a Federal department or agency using government-generated or government-collected information obtained for nonresearch activities, if the research generates identifiable private information that is or will be maintained on information technology that is subject to and in compliance with section 208(b) of the E-Government Act of 2002, 44 U.S.C. 3501 note, if all of the identifiable private information collected, used, or generated as part of the activity will be maintained in systems of records subject to the Privacy Act of 1974, 5 U.S.C. 552a, and, if applicable, the information used in the research was collected subject to the Paperwork Reduction Act of 1995, 44 U.S.C. 3501 et seq.

Exempt 5. Research and demonstration projects that are conducted or supported by a Federal department or agency, or otherwise subject to the approval of department or agency heads (or the approval of the heads of bureaus or other subordinate agencies that have been delegated authority to conduct the research and demonstration projects), and that are designed to study, evaluate, improve, or otherwise examine public benefit or service programs, including procedures for obtaining benefits or services under those programs, possible changes in or alternatives to those programs or procedures, or possible changes in methods or levels of payment for benefits or services under those programs. Such projects include, but are not limited to, internal studies by Federal employees, and studies under contracts or consulting arrangements, cooperative agreements, or grants. Exempt projects also include waivers of otherwise mandatory requirements using authorities such as sections 1115 and 1115A of the Social Security Act, as amended. (i) Each Federal department or agency conducting or supporting the research and demonstration projects must establish, on a publicly accessible Federal Web site or in such other manner as the department or agency head may determine, a list of the research and demonstration projects that the Federal department or agency conducts or supports under this provision. The research or demonstration project must be published on this list prior to commencing the research involving human subjects.

Exempt 6. Taste and food quality evaluation and consumer acceptance studies: (i) If wholesome foods without additives are consumed, or (ii) If a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration or approved by the Environmental Protection Agency or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

Exempt 7. Storage or maintenance for secondary research for which broad consent is required: Storage or maintenance of identifiable private information or identifiable biospecimens for potential secondary research use if an IRB conducts a limited IRB review and makes the determinations required by 45 CFR 46.111(a)(8).

Exempt 8. Secondary research for which broad consent is required: Research involving the use of identifiable private information or identifiable biospecimens for secondary research use, if the following criteria are met:

> (i) Broad consent for the storage, maintenance, and secondary research use of the identifiable private information or identifiable biospecimens was obtained in accordance with 45 CFR 46.116(a)(1) through (4), (a)(6), and (d);
>
> (ii) Documentation of informed consent or waiver of documentation of consent was obtained in accordance with 45 CFR 46.117;
>
> (iii) An IRB conducts a limited IRB review and makes the determination required by 45 CFR 46.111(a)(7) and makes the determination that the research to be conducted is within the scope of the broad consent referenced in paragraph (d)(8)(i) of this section; and
>
> (iv) The investigator does not include returning individual research results to subjects as part of the study plan. This provision does not prevent an investigator from abiding by any legal requirements to return individual research results.

[1]Exempt categories (1), (2), (3), (4), (5), (7), and (8) cannot be applied to activities that are FDA-regulated.

[2] Each of the exemptions at this section may be applied to research subject to subpart B (Additional Protections for Pregnant Women, Human Fetuses and Neonates Involved in Research) if the conditions of the exemption are met.

[3] The exemptions at this section do not apply to research subject to subpart C (Additional Protections for Research Involving Prisoners), except for research aimed at involving a broader subject population that only incidentally includes prisoners.

[4] Exemptions (1), (4), (5), (6), (7), and (8) of this section may be applied to research subject to subpart D (Additional Protections for Children Involved as Subjects in Research) if the conditions of the exemption are met. Exempt (2)(i) and (ii) only may apply to research subject to subpart D involving educational tests or the observation of public behavior when the investigator(s) do not participate in the activities being observed. Exempt (2)(iii) may not be applied to research subject to subpart D.

APPENDIX D: EMAIL SUPPORT BY TOEBE CONST. AND COTY FOURNIER

Mass Timber Survey

Shae Raines <sraines@toebe-construction.com>

Tue 2/20/2024 11:15 AM

To:Tyler Bassinger <tbassinger@toebe-construction.com>;Jace Bearden <jbearden@toebe-construction.com>;Zach Birchmeier <zbirchmeier@toebe-construction.com>;Kurt Daavettila <kdaavettila@toebe-construction.com>;Adam Dillon <adillon@toebe-construction.com>;Dave Fischer <dfischer@toebe-construction.com>;Jason Fowler <jfowler@toebe-construction.com>;Tony Knutson <tknutson@toebe-construction.com>;Dan Kroll <dkroll@toebe-construction.com>;David Kruse <dkruse@toebe-construction.com>;Logan McClatchey <lmcclatchey@toebe-construction.com>;Craig Minkler <cminkler@toebe-construction.com>;Kevin Mullins <kmullins@toebe-construction.com>;Tim Mulvihill <tmulvihill@toebe-construction.com>;Steve Funck <sfunck@toebe-construction.com>;Satyam Karnati <skarnati@toebe-construction.com>; Noah Pio <npio@toebe-construction.com>;Andrew Standhardt <astandhardt@toebe-construction.com>;Tom Stover <tstover@toebe-construction.com>;Rodney Will <rwill@toebe-construction.com>;Chris Taylor <ctaylor@toebe-construction.com>;Dave Ruhle Jr. <druhle@toebe-construction.com>;Terry Holley <tholley@toebe-construction.com>; Jeremy Johnson <jjohnson@toebe-construction.com>;Heath Peterson <hpeterson@toebe-construction.com>;James Weber <jweber@toebe-construction.com>;Don Langworthy <dlangworthy@toebe-construction.com>;Brandon Beemer <bbeemer@toebe-construction.com>;Greg Adelberg <gadelberg@toebe-construction.com>;Armando Cantu <acantu@toebe-construction.com>;Wally Bard <wbard@toebe-construction.com>;Josh Bashaw <jbashaw@toebe-construction.com>;Brandon Williams <bwilliams@toebe-construction.com>;Brian Adelberg <badelberg@toebe-construction.com>;Jose Calzada <jcalzada@toebe-construction.com>;Denny D'Epifanio <ddepifanio@toebe-construction.com>;Chris Freeman <cfreeman@toebe-construction.com>;Gerry Saavedra <gsaavedra@toebe-construction.com>;Jorge Gonzalez <jgonzalez@toebe-construction.com>;Edmundo Guzman <eguzman@toebe-construction.com>;Dan Hart <dhart@toebe-construction.com>;Jody Holley <jholley@toebe-construction.com>;Bryan Hufnagel <BHufnagel@toebe-construction.com>;Fabian Melendez <fmelendez@toebe-construction.com>;Kyle Joseph <kjoseph@toebe-construction.com>;Juan Salinas <jsalinas@toebe-construction.com>;Adam Kovar <akovar@toebe-construction.com>;Ed Leddy <eleddy@toebe-construction.com>;Joe Martinez <jmartinez@toebe-construction.com>; Jordan Drouillard <jdrouillard@toebe-construction.com>;Gerald Newby <gnewby@toebe-construction.com>;Tom Payne <tpayne@toebe-construction.com>;Alan Payne <apayne@toebe-construction.com>;Tony Ruhle <truhle@toebe-construction.com>;Robert Schmidt <rschmidt@toebe-construction.com>;Ludwig Schulz <lschulz@toebe-construction.com>;Terry Wingert <twingert@toebe-construction.com>

Hello All,

I am writing to you on behalf of our current intern, Hemangi Chavan, a Construction Management graduate student at Michigan State University, who is conducting research for her Master's Thesis.

The study aims to explore the attitudes and knowledge of academic practitioners and industry professionals regarding mass timber materials and construction. Your valuable insights will contribute to a better understanding of how information about mass timber can be effectively shared and integrated into learning opportunities in the United States. The survey will take approximately 15 minutes to complete, and your participation is entirely voluntary and confidential. We kindly request that you complete the survey by **Friday, March 1st**.

Please find the survey link attached:
https://msu.co1.qualtrics.com/jfe/form/SV_em7FGOOEqu83KHc

If you have any questions or concerns about the study, please feel free to connect. Your participation in this study would be greatly appreciated.

Thank you!

Shae Raines
Toebe Construction LLC
28990 S Wixom Rd
P.O. Box 930129
Wixom, MI 48393

Ph: 248.349.7500
Fax: 248.349.4870

TOEBE
EST. 1922

Figure D.1: Email snapshot

Chavan, Hemangi

From:	Coty Fournier <coty@cotyfournier.com>
Sent:	Tuesday, February 27, 2024 9:31 AM
To:	Goerke, Melanie G; aholman@christmanconstructors.com; amanda.allen@whiting-turner.com; Arthur Theusch; Aaron Walsh; Bora, Mohak; Brian Conklin; carsoncl@hotmail.com; cbohm@acceldevgroup.com; Dehaven, Chris; Chase Huston; dagostinodevelopment@gmail.com; Dan Hamilton; Dwight.hooks@merck.com; Grant Malone; james.kramek@bartonmalow.com; Jeremy Gershonowicz; Barnes, Justin; Kent Jackson; Foucher Kevin; Honaman, Lisa; Makan, Kelsey E; Mark Ireland; mhouston@bowaconstruction.com; Michael Prochazka; Mrozowski, Timothy; Nick Kuelske; Rob Train; ryan@guardianlp.com; srewold@frankrewold.com; Stacey Nellis; tim.prochko@gmail.com; Tweedy, Adam; wygnaled@gmail.com
Cc:	Chavan, Hemangi
Subject:	5-minute survey to assist one of our CM grad students

Hello CM IAB members:

I have copied the email I received below from one of our CM grad students – Chavan Hemangi. Please give 5 minutes to help gather data for her master thesis by taking a super easy survey on your experiences and knowledge of mass timber construction methods. Please generously share the survey link with friends and colleagues in the industry so she can maximize her data set.

The survey link is embedded in her email below – and Chavan is copied above if you have any questions for her.

Thanks for your time to help her.

Coty

Figure D.2: Email Support

APPENDIX E: REACH VIA NEWSLETTER AGC AND MASS TIMBER @MSU


March 6, 2024
www.agcmichigan.org

ASSOCIATED GENERAL CONTRACTORS

The Midweek Briefing

Alert on Critical Tax Relief

The U.S. Senate is sitting on immediate tax relief legislation that can put more money into your pockets, instead of the IRS's. We need you to take action! >> Read more

Companies Thrive on 4-Day Workweek

Companies that have tried it are reporting happier workers, lower turnover and greater efficiency. Now, there's evidence that those effects are long lasting. >> Read more

Award Winning Team Photos

The professional photos of all award winners from the Annual Meeting are now available. >>See the photos

If You Missed It...Highlights from Annual Meeting

The chapter's Annual Meeting, held February 23, 2024, was a resounding success, highlighting achievements in innovation, honoring apprentices of the year, and emphasizing excellence in construction education and safety. It was a celebration of hard work, dedication, and the relentless pursuit of excellence in the industry. >> Read more & see photos

Survey for Attitudes Towards Mass Timber Materials & Construction

A construction management graduate student at MSU is conducting research for his Master's Thesis and has asked our membership for input . You are invited to participate in his research study regarding your opinions and knowledge of mass timber materials and construction. >> Learn more & take the survey

Figure E.1: AGC Newsletter

MassTimber@MSU News

MassTimber@MSU leverages research, education, outreach, communications, policy, and partnerships to advance sustainable mass timber construction and manufacture in Michigan and the surrounding region.

Website

Attention Mass Timber Professionals, we need your feedback

Hemangi Chavan, a Construction Management graduate student at Michigan State University, is looking for your opinions and knowledge of mass timber materials and construction. Your involvement in this study will help improve how information on mass timber is shared in US learning settings! Click the link below to access the survey.

Survey

Figure E.2: Mass Timber @MSU Newsletter

APPENDIX F: SURVEY QR CODE SCANNER

Figure F.1: QR Code scanner prepared to circulate at NAHB Builders show 2024