AN EXPLORATORY STUDY ON ASSESSING FEASIBILITY OF MASS TIMBER AND ITS ALTERNATIVES IN CONSTRUCTION: TOTAL COST OF OWNERSHIP AND STAKEHOLDER PERSPECTIVES

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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

Recently there has been growing interest for using mass timber as a building material. It has been gaining momentum as an innovative alternative to traditional concrete and steel building methods, finding application in a growing array of construction projects ranging from mid to high rise buildings. Despite these efforts, developers/owners are still reluctant to choose mass timber as mainstream building material for the construction. Various significant barriers are faced by the community in migrating towards mass timber construction which majorly consists, lack of mass timber knowledge and case study projects which makes it difficult for the community to study the overall feasibility of the new construction method. This study aims to mitigate these barriers by conducting holistic exploratory study using total cost of ownership analysis for a 14 story 277749 sq. ft mass timber building to be constructed in Madison. To analyze the financial and economic impact of using mass timber as a building material, this study compares capital cost and total cost of ownership of functionally equivalent building design with alternative materials like hybrid steel/timber, concrete and steel. This would enable owners/developers to realize the impact of using mass timber as a viable construction method. It was realized that front end cost of mass timber was around 10% more costlier than concrete but it saved around 8.4% in longer term. Furthermore, we explore stakeholder interests through a qualitative and quantitative interview tailored to case study buildings, offering valuable insights into their inclinations and priorities. The insights gleaned from this thesis will provide valuable contributions to construction stakeholders, offering fresh perspectives on the use of mass timber building materials.

ACKNOWLEDGEMENTS

I wish to express my deepest gratitude to Dr. George Berghorn, my esteemed advisor, whose unwavering support and exceptional encouragement have been indispensable throughout this research journey. Without his guidance, navigating the complexities of this project and achieving its fruition would have been immensely challenging. His profound expertise continues to serve as a beacon of inspiration for me. Additionally, I extend special recognition to Dr. Matt Syal and acknowledge the ongoing support of the School of Planning, Design, and Construction for their invaluable contribution to my master's education. I am also immensely thankful to Dr. Hongmei Gu and Dr. Raju Pokharel for their invaluable guidance and contributions as committee members, enriching the depth and quality of this research thesis. Their invaluable knowledge regarding mass timber construction data and different cost profile tools for analyzing total cost of ownership of the construction has helped me immensely for conducting this study.

Furthermore, I am deeply grateful to Dr. Hongmei Gu, Josie Duchow, and The Neutral Project Team for their assistance in providing all the necessary data of the Bakers Place Project, without which this endeavor would not have been possible. Lastly, I am profoundly indebted to my family members whose unwavering support and encouragement have served as a constant source of strength throughout my journey.

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CHAPTER 1: INTRODUCTION

1.1 Overview

Over the last century, there has been alarming surge in global greenhouse gas (GHG) emissions and undeniably linked to a rise in the planet's average temperature, leading to the unmistakable phenomenon of global warming (IPCC, 2019). The repercussions of climate change have already begun to manifest, evidenced by an increase in catastrophic events such as severe flooding, extreme heatwaves, and agricultural deterioration, all of which bear witness to the detrimental environmental consequences we face today (WMO, 2023; Diffenbaugh et al., 2018).

Construction, operation, and demolition activities are a significant source of greenhouse gas emissions. A report published by United Nations Environment Program states that construction industry accounts for 38% of CO2 emissions globally (Neill, 2020). Recently, there has been an emphasis on obtaining net-zero energy and zero-carbon emissions for new and old buildings. Various strategies, initiatives and roadmaps are being outlined to make buildings net zero energy and net zero emissions by 2050.

Over last two decades mass timber construction has gained momentum and has significantly lower carbon balance than its alternative concrete, steel, aluminum (Koch, 1992). Mass timber building products are widely utilized in various building types such as residential, commercial, industrial and there is growing interest in U.S construction industry.

This study aims to assess the cost benefits of Mass timber buildings throughout the entire lifecycle of a building. Through a comprehensive total cost of ownership analysis, this research aims to provide valuable insights for investors and stakeholders in making informed decisions regarding building investing strategies.

1.2 Emissions In Construction Industry

Climate change exerts a substantial influence on businesses, society, and individuals, necessitating a collective recognition of the imperative to transition towards a low-carbon economy. At the heart of this transformation lies the building and construction sector, assuming a pivotal role in driving the necessary shift towards sustainable practices and technologies. The construction and use of built environment accounts for 40% of total annual global CO2 emissions (Architecture 2030, 2023). Out of these total emissions, building operations account for 27% annually, and building infrastructure and materials (embodied carbon) are responsible for an additional 14% annually.

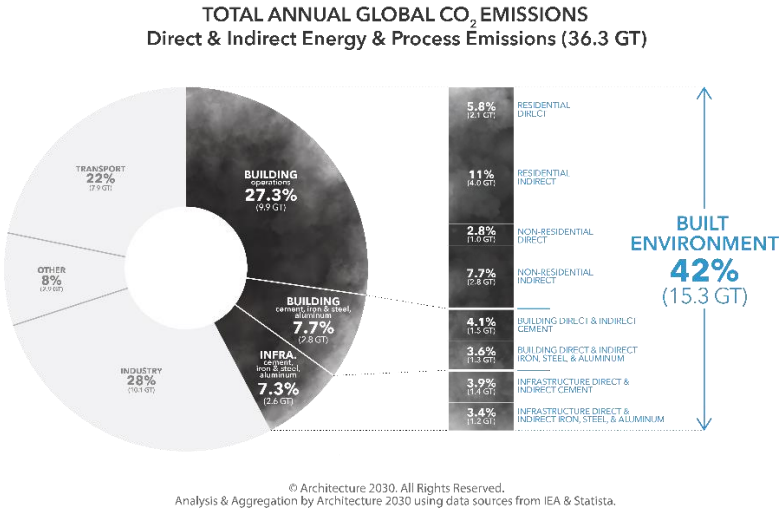

Figure 1.1: Annual total CO2 emissions

Source: Architecture 2030. Data Source: IEA (2022), Buildings, IEA, Paris

In the coming decades, the world's population is projected to reach 10 billion, leading to a significant increase in the global building stock. This growth is expected to double the size of the current building infrastructure. To accommodate the unprecedented wave of building growth projected to occur between 2020 and 2060, an astounding 2.6 trillion ft^2 (240

billion m^2) of new floor area is expected to be added to the global building stock (Architecture 2030, 2023).

However, a concerning issue arises due to the substantial carbon emissions associated with the construction of these buildings, even before they are used. This upfront carbon, which constitutes half of the entire carbon footprint of new construction, poses a severe threat to our remaining carbon budget until 2050.

Given the urgency of the climate emergency, it is imperative for the built environment sector to take a proactive role in addressing this challenge. The impact of upfront carbon in the construction process is immense and demands immediate attention and action. By effectively managing and reducing upfront carbon, the built environment can significantly contribute to mitigating climate change and preserving our carbon budget for a sustainable future (IEA, 2019; WorldGBC, 2019).

To achieve this, the industry is adopting innovative and sustainable building practices that prioritize lower carbon emissions throughout the construction process. This involves employing renewable and low-carbon materials, optimizing energy efficiency in design and operations, and implementing environmentally conscious construction methods (Crawford, 2022).

1.3 Embodied Carbon

Embodied carbon for the construction products refers to all greenhouse gas (GHG) emissions associated with extraction, processing, and manufacturing, transporting, and installing construction materials (Pasternack et al., 2022). This includes emissions generated during various stages such as extraction or harvesting of raw materials, manufacturing processes, transportation of materials to construction sites, the actual

construction phase, and eventual disposal or recycling (Mills, 2023). All greenhouse gas emissions associated with building construction, emissions from extraction, manufacturing, transportation, installation on sites and end of life of building materials, consists of embodied carbon (Pasternack et al., 2022; Wolverton, 2023).

Optimizing the carbon footprint of a building throughout its lifespan involves striking a delicate balance between minimizing embodied carbon and reducing operational emissions. Unlike operational emissions, which occur during the building's in-use phase, embodied carbon is released during construction and renovation and cannot be reduced afterward. Consequently, embodied carbon is projected to account for approximately 50% of emissions in the built environment by 2035 (Eleuterio, 2023). Getting a handle on embodied carbon is critical if we aspire to achieve our ambitious goal of zero emissions by 2050.

In building materials Concrete and steel are carbon intensive materials. They are responsible for 23% of total global emissions and hence there is an incredible opportunity for reducing embodied carbon in these high impact materials through policy, design, material selection, and specifications. To achieve our 2050 target of net zero emissions, government and private sector are making a meaningful stride towards reducing GHG gas emissions, architects are transitioning to lower carbon-intensive materials, all industry professionals are focusing on reducing embodied carbon emissions by choosing lower carbon alternatives (Call for Action: Seizing the Decarbonization Opportunity in Construction, 2021). By replacing carbon intensive materials like concrete and steel with wood, a building embodied energy/emissions can be reduced (Gustavsson et al., 2017; Sathre & O'Connor, 2010).

Research is done by industry professionals to replace these materials with lower carbon intensive building materials such as lumber and engineered wood products along with most recently developed mass timber products (Anderson et al., 2019; Wang et al., 2014). Wood products not only offer carbon storage benefits but also lower carbon footprint during their lifecycle stages (Bergman et al., 2014).

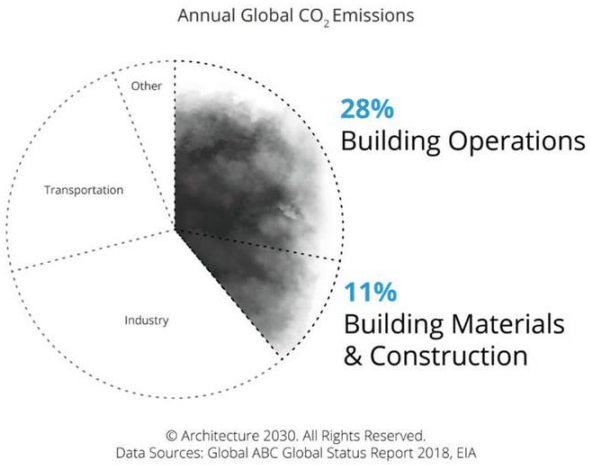

Figure 1.2: Annual CO2 emissions

Source: Architecture 2030. Data Source: Global ABC Global Status Report 2018, IEA

1.4 Mass Timber Construction

Mass timber construction (MTC) is gaining momentum as an innovative alternative to traditional concrete and steel building methods, finding application in a growing array of construction projects. Mass timber buildings are constructed with large pre-manufactured, multilayered, solid wood panels typically ranging from 5 to 12 inches in thickness (Mass Timber, 2023). Mass timber is an engineered wood product and includes glulam, laminated veneer lumber, and cross laminated timber (CLT; American National Standards Institute/APA—The Engineered Wood Association [ANSI/ APA] 2019). CLT is an engineered solid wood panel, fabricated with kiln-dried boards stacked in several odd number layers

usually 3,5,7 or 9, each layer is aligned perpendicular to its adjacent layer and bonded with structural adhesive.

Figure 1.3: Cross Laminated Timber

Source: What Is Cross-Laminated Timber (CLT)? Naturally Wood

These engineered products effectively mitigate the inherent issues of wood, such as expansion and differential shrinkage, while simultaneously enhancing stability and augmenting structural capacity (Gu et al., 2020). Cross-Laminated Timber (CLT) possesses a strength on par with that of steel and concrete, enabling it to serve as a robust structural building material suitable for prefabricated walls and floors within modern building systems (Anderson et al., 2019).

In recent years, the adoption of Mass Timber Construction (MTC) has experienced a remarkable upsurge. To illustrate this growth, consider that in 2003, Europe housed just a single CLT manufacturer, producing approximately 4,000 cubic meters annually. Presently, the global landscape boasts around 50 CLT manufacturers, collectively projecting a production volume of approximately one million cubic meters (Aliento, 2017). Notably, substantial research has been dedicated to investigating the structural, acoustic, moisture, and fire-related attributes of CLT (Oregon BEST, 2017; Zelinka et al., 2019; Scouse et al.,

2020). However, there exists a conspicuous gap in understanding the cost effectiveness of mass timber buildings and has received great attention from academies and industries. The debate surrounding the construction cost disparity between mass timber and traditional building structures is intensifying, with various sources delving into the discussion (Smith et al., 2018). The scarcity of transparent data and comprehensive cost analyses within the market complicates the task of estimating initial expenses for mass timber constructions, preventing easy generalization. Moreover, there exists a notable lack of comprehensive total cost of ownership evaluations to assess the overall economic viability of mass timber buildings.

1.5 Total Cost of Ownership

Traditionally, the concept of Total Cost of Ownership (TCO) has been utilized as a calculation aimed at assisting buyers and owners in evaluating both the apparent and hidden costs associated with acquiring a building (Ellram, 1995). Within the realm of supply chain management, the implementation of vendor managed inventory programs entails the oversight of processes up to and including the point of utilization on an assembly line. In this case, the calculation includes the direct and indirect cost of procuring the building but extends beyond the procurement process to include the costs incurred throughout the supply chain to assure a smooth integration into a final assembly.

1.6 Total Cost of Ownership in Building Construction

Total Cost of Ownership includes the cost of acquiring, maintaining, replacing, and disposing of the system or material (Guhl, 2023). Like an iceberg, the apparent expense of a material upfront is the tip of the iceberg, while the concealed expenses associated with maintenance and eventual replacement remain submerged beneath the surface. Frequently, materials that

come with a lower initial price tag demand more frequent maintenance and replacements. Ultimately, these materials end up being more expensive for building owners compared to a robust alternative that might carry a higher initial cost.

Total cost of ownership is a factor of consideration for nearly every material and system integrated within a building, particularly those susceptible to degradation due to weather conditions or regular occupant utilization. The analysis not only focuses on the cost of acquisition and construction but also on how much it will cost to operate and maintain. In total, life cycle cost analysis looks at the total cost of ownership for a building or a specific item (Figure 1.4).

This study aims to find the Total Cost of Ownership of a mass timber structure and help decision-makers make informed choices by considering the long-term financial implications of different design and material options. Total Cost of Ownership can be particularly useful when evaluating sustainable building materials like mass timber.

Figure 1.4: Life cycle cost analysis

Source: Construction Life-Cycle Cost Analysis, Horst Construction, 2021

1.7 Research Goals and Objectives

The primary objective of this research is to promote the adoption of mass timber buildings which is a sustainable and environmentally friendly alternative to traditional concrete and steel structures. As our global efforts intensify to address climate change and seek lower carbon solutions, the focus is on establishing mass timber as a pivotal choice for constructing buildings.

This research aims to study the owners and developers' perspective on Total Cost of Ownership of a mass timber building at the end of its life based on the general guidelines of ASTM E917-17 and ISO 15686-5 standards (ASTM 2017, ISO 2017). The scope of this building TCO covers building construction cost, operational cost, maintenance and repair cost and residual value and or demolition cost at the end of building life for a period of 75 years for concrete and steel buildings and 100 years for mass timber and hybrid (steel and timber) buildings. Financial variables such as discounts and escalation rates are used in the analysis, whereas the land acquisition, planning and externalities such as management and insurance were excluded.

The objectives of these research are as follows –

- Objective 1 – To develop Comprehensive understanding on tools and techniques for generating cost profiles in construction industry.
    - Task 1: Identify different tools for generating cost profiles
    - Task 2: Conduct an extensive literature review on total cost of ownership and life cycle cost analysis, exploring their advantages and disadvantages.
- Objective 2: Develop cost profiles based upon objective 1 for case study building with its alternative building materials and based on a variety of ownership scenarios.

- Task 1: Conducting data collection on the economic aspects of case study buildings and using TCO to estimate construction costs, operation and maintenance costs, energy costs, and end-of-life costs.
- Task 2: Develop total cost of ownership based on a range of ownership models and scenarios for utility price escalation, variation of discount factors and end-of-ownership scenarios.

- Objective 3: Conduct exploratory study for understanding developer/owners' barriers in adopting mass timber construction and identifying their preferences for alternative building materials.
  - Task 1: Create and distribute developer/owner total cost of ownership interview, with focus on understanding MT-specific building front-end construction and operation & maintenance cost.
  - Task 2: To analyze the influence of total cost of ownership and ownership dynamics of the buildings using qualitative and quantitative interview.

1.8 Research Scope

The primary objective of this study is to assess the cost benefits of mass timber building against its various alternatives through a comprehensive Total Cost of ownership analysis. This research aims to provide valuable insights for investors and stakeholders in making informed decisions regarding building strategies.

Specifically, the research endeavors to quantify the Total cost of ownership of a building using mass timber materials. By conducting this analysis, the aim is to demonstrate that opting for a mass timber construction approach not only yields superior returns for building

owners but also aligns with sustainable practices, thereby showcasing the dual advantages of economic viability and environmental responsibility.

1.9 Summary

The contribution of construction industry towards generation of waste has been at a higher end and harming the environment in many ways. There is a need for development of sustainable processes and methods in construction that will help in preserving natural resources, generate less wastage and emphasize reuse and recycle of materials in the industry, with the aim to achieve reduced greenhouse gas (GHG) emissions.

Through a comprehensive assessment of costs for various building types, this research provides invaluable insights into the financial implications of adopting mass timber as a building material. By accounting for initial construction costs, ongoing operational expenses, maintenance, renovation, and replacement considerations, Total Cost of Ownership illuminates a holistic perspective on the true value of mass timber. By quantifying the long-term financial benefits of mass timber, this research provides a solid foundation for advancing sustainable construction practices and accelerating the adoption of materials that leave a smaller ecological footprint.

As we navigate the global challenges posed by climate change and resource scarcity, understanding the economic benefits of sustainable alternatives like mass timber is paramount.

CHAPTER 2: LITERATURE REVIEW

2.1 Overview

The present chapter provides a contextual overview of the thesis, focusing on three main aspects. Firstly, it examines the significant impact of the building sector on the environment, considering its implications on resource consumption and greenhouse gas emissions. Secondly, the chapter presents an in-depth overview of mass timber construction, highlighting its history, relevance, advantages, and potential as a sustainable building solution. Lastly, it gives glimpse about various cost consideration for mass timber construction and its feasibility in the current market.

2.2 Environmental Effects of Buildings

2.2.1 Climate Change, and Sustainability

The global construction industry plays a significant role in contributing to atmospheric greenhouse gas (GHG) emissions and is a substantial consumer of natural resources in the built environment (IPCC, 2014). Buildings alone account for approximately 40% of worldwide carbon dioxide (CO2) emissions and contribute to around 30% of total energy consumption (Jones et al., 2016; Berardi, 2017). To align with the Paris Agreement's goals, it is essential to reduce global carbon emissions by 50% by 2050 compared to 1990 levels to limit the global average temperature rise to well below 2 degrees Celsius (Paris agreement, 2016). The International Energy Agency (IEA) has proposed a remaining carbon budget of approximately 880 Gt CO2 emissions between 2015 and 2100 to achieve this goal (IEA, 2021). However, the construction industry is estimated to release around 415 Gt of CO_2 over the next 40 years, representing approximately 50% of the recommended carbon budget by the IEA (N. Ahmed et al., 2021).

As the construction industry seeks more sustainable alternatives, mass timber products are gaining traction as a viable and eco-friendly option. Embracing wood-based construction materials can play a crucial role in achieving energy efficiency goals and reducing the overall environmental impact of buildings, thus contributing to a greener and more sustainable future for the construction industry. In response to the growing importance of developing energy-efficient and environmentally friendly buildings, the use of wood as a building material has emerged as a promising solution (Ritter et al., 2011). The adoption of wood-based construction materials can offer substantial economic and environmental benefits. Studies have demonstrated that utilizing mass timber products can contribute to reducing carbon emissions, making it an environmentally responsible choice for sustainable construction practices (Bowers et al., 2017; Gu and Bergman, 2018). In addition to its environmental advantages, wood offers unique architectural and aesthetic possibilities, providing designers and architects with the freedom to create innovative and visually appealing structures. Furthermore, the use of wood in construction can help promote rural economies by supporting the forestry industry and creating job opportunities in areas with abundant timber resources.

2.2.2 Embodied Carbon

The embodied carbon, also known as carbon emissions, of a material refers to the total amount of CO2e (carbon dioxide equivalent) emissions associated with its production, use, and disposal. When considering the embodied carbon at the level of a building structure, it encompasses the overall impact of all materials used, both structural and non-structural.

In the coming decades, understanding the contribution of embodied carbon to the total carbon emissions of a building is of utmost importance. Studies have shown that embodied

carbon can account for up to 20% of the total emissions of a building with standard energy performance. However, in more efficient buildings or net-zero structures with minimal or even negative operational carbon emissions, the embodied carbon can become the primary source of emissions over the building's entire life cycle (IPCC, 2015; Rock et al., 2019). Additionally, in the short-term, the contribution of embodied carbon in a building is particularly significant, as its entire carbon footprint is released during the construction phase.

Embodied carbon is a crucial metric in the context of sustainability and environmental impact assessments, as it provides insights into the environmental burden of different materials and construction practices. By understanding the embodied carbon of a material or building, stakeholders can make informed decisions to reduce carbon emissions, mitigate climate change, and move towards more sustainable construction practices (Cabeza, 2014; Hammond et al., 2011).

Numerous comparative studies (Gorgolewski, 2018) have been conducted to evaluate the embodied carbon of different building materials and systems. These studies often compare the carbon emissions of traditional materials like concrete and steel with emerging sustainable alternatives like timber and CLT.

2.3 Mass Timber

Mass timber structures are a type of construction that utilizes large, prefabricated wood components, primarily composed of solid wood panels. These materials are engineered wood products that offer excellent structural performance and sustainability benefits. Mass timber construction has gained popularity in recent years due to its environmental advantages, aesthetic appeal, and potential to reduce carbon emissions in the building sector.

2.3.1 History of Mass Timber

Mass timber represents an innovative evolution of age-old wood construction techniques that trace back to humanity's earliest endeavors in shelter-building. In contrast, traditional heavy timber structures, distinct from the contemporary mass timber products we'll define later, were crafted using individual tree trunks and have enjoyed widespread use for well over four millennia. This practice took root as humans developed the technological prowess to fashion sharp tools capable of shaping trees into squared timber during the Bronze Age (around 4,000 years ago) (Board Think Wood, 2020).

The concept of heavy timber entails using substantial wooden elements to construct the load-bearing framework of houses or buildings, encompassing vital components like beams and columns. Subsequently, exterior walls and floors are integrated into this skeletal structure. Although present-day applications of this construction approach occasionally showcase its aesthetic appeal, heavy timber construction held sway as the dominant method across Europe, Asia, and North America until the 1850s. It was during this era that the advent of light wood frame manufacturing took shape (Board Think Wood, 2020).

Even in today's landscape, light wood framing remains the predominant choice for residential and low-rise construction, relying on an assembly of lightweight wall constituents, known as studs, which are interconnected through nails or screws. This technique often comes to life in balloon-frame wood structures, where the exterior walls undertake the role of the building's load-bearing support. This style of construction engaged in a rivalry with the traditional heavy timber frame construction until the onset of the 20th century, when the emergence of pioneering structural steel technology took precedence as the preeminent construction method for larger edifices. This technological shift facilitated

longer spans and greater load-bearing capabilities, reshaping the architectural landscape. Mass timber shares a foundational resemblance with heavy timber, yet their divergent construction methods set them apart. While heavy timber originates from single, substantial timber cores, mass timber comes to life through the assembly of laminated or mechanically joined layers of lumber, often drawn from components like the studs found in light wood framing.

This engineered wood product approach heralds a departure from the solid single-piece nature of heavy timber. The inception of mass timber products traces back to the late 19th century, marked by Switzerland's first patent filing in 1901. Regrettably, these pioneering advancements in mass timber coincided with the ascent of steel-framed construction. The ascent of steel construction, expedited by the introduction of elevators toward the close of the 19th century, ushered in the possibility of constructing towering structures that were previously deemed unattainable. This steel-based approach swiftly became the preferred method for high-rise construction, shaping the skylines of major cities throughout the 20th century. Due, in part, to the nascent state of quality control within mass timber at that juncture, steel and concrete emerged as the favored structural systems over the course of the 20th century. Architects, engineers, and builders meticulously honed the design and construction processes to harness the innate structural capacities of steel and concrete. The perception that wood structures were prone to fire further bolstered the appeal of steel, often accompanied by fireproofing measures, as a safer alternative. Consequently, mass timber faced a gradual erosion of its market share and was predominantly confined to specialized building categories.

Figure 2.1: Heavy timber frame, Light wood framing and Steel framing

Source: Timber Saltbox, 2018; Think Wood, 2020; Director Steel Structure

2.3.2 Tree To Lumber

Lumber, also known as timber or wood, is obtained through a process known as sawmilling, which involves cutting logs into various sizes and shapes for use in construction, furniture, and other applications. The process of turning trees into lumber typically involves the following steps (Siau, 1984; Sahin, 2013):

1. **Harvesting**: Trees are harvested from forests or tree plantations using various methods, such as felling or clear-cutting. Responsible and sustainable forestry practices are essential to ensure the long-term health of forests.

2. **Transportation**: Once harvested, the logs are transported to the sawmill. This may involve loading the logs onto trucks or other transportation vehicles.
3. **Debarking**: At the sawmill, the logs are usually debarked to remove the outer layer of bark. This step is not always necessary but can improve the efficiency of the sawing process.
4. **Sawing**: The debarked logs are then sawn into lumber using different sawing techniques. There are two primary sawing methods: plain sawing (also known as flat sawing) and quarter sawing. These methods produce different grain patterns in the lumber.
5. **Drying**: Freshly sawn lumber contains a high amount of moisture. To stabilize the wood and prevent warping or cracking, the lumber is dried in a kiln. Kiln drying reduces the moisture content to a suitable level for its intended use.
6. **Grading and Sorting**: The dried lumber is then graded and sorted based on its quality and characteristics. Grading ensures that the lumber meets specific standards for strength, appearance, and other properties.
7. **Finishing and Treatment (Optional)**: Depending on its intended use, lumber may undergo additional processing, such as planing, to create smooth surfaces. Some lumber may also be treated with preservatives to protect it from decay and insects.

This comprehensive process ensures that lumber emerges as a reliable and versatile material, ready to fulfill a myriad of construction and design needs while upholding quality and sustainability standards. Through responsible harvesting practices, careful transportation, precise sawing techniques, and thorough drying and grading procedures, lumber emerges as a reliable and resilient building material.

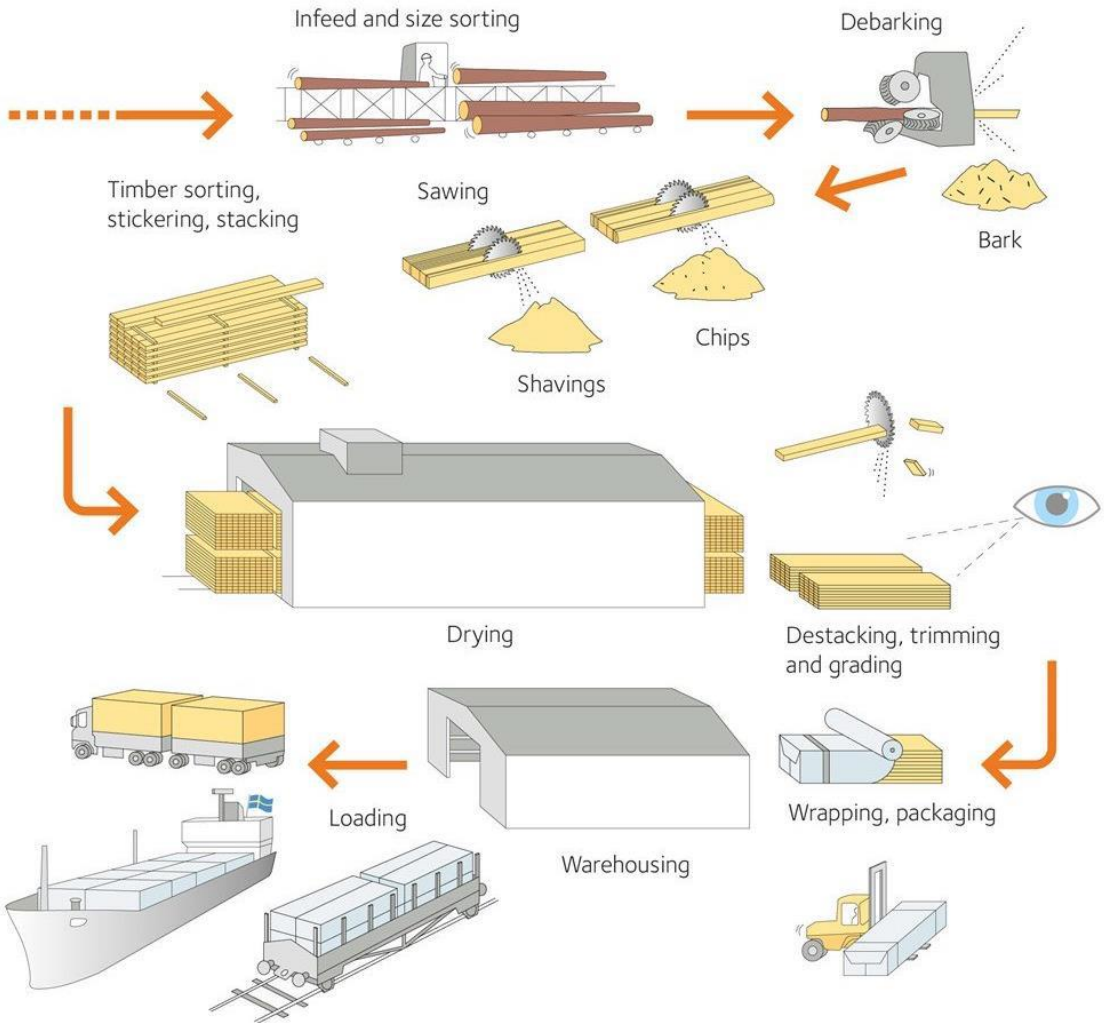

Figure 2.2: Sawmill process from log to dry lumber

Source: Swedishwood.com

2.3.3 Engineered Wood Products

Engineered wood products (EWPs) are a versatile class of wood materials created by assembling smaller pieces of lumber using glue or mechanical fasteners. This transformative process enhances one or more performance metrics or characteristics of the original wood, resulting in products with improved strength, stability, and sustainability. EWPs have found widespread use in the construction industry due to their exceptional properties and eco-friendly attributes.

Cross-Laminated Timber (CLT): Cross-laminated timber is a versatile and sustainable building material made from layers of dimensioned lumber boards stacked at right angles to each other and bonded with structural adhesives. The alternating grain direction of each layer enhances its strength and stability, allowing CLT panels to be used as load-bearing walls, floors, and roofs. CLT offers excellent fire resistance and seismic performance, making it suitable for a wide range of construction applications (Tannert & Winter, 2011). CLT panels typically exhibit different strengths along two perpendicular directions known as the strong and weak directions. The strong direction represents the orientation in which the panel's resistance and load-carrying capacity are the highest, and it typically corresponds to the larger dimension of the panel. On the other hand, the weak direction refers to the orientation with a lower strength capacity and smaller production dimension. Cross-laminated timber (CLT), first developed in Europe during the early 1990s, has gained widespread popularity and acceptance (Espinoza et al, 2016). Presently, the global CLT industry is flourishing, particularly in Europe, which accounts for approximately 70% of

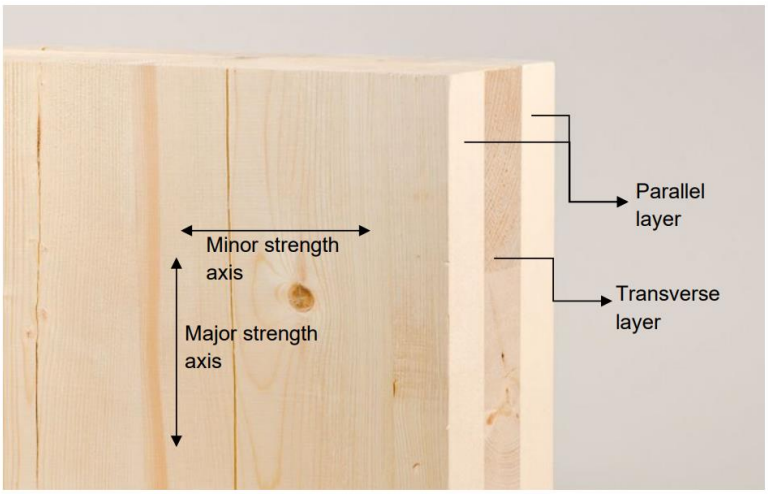

Figure 2.3: CLT panels

Source: Innovations, F.P., 2019

the global CLT production as of 2017 (Muszynski et al., 2017; United Nation Publication, 2017-2019). Recent surveys in the United States targeting the architectural community have revealed that over 50% of the participants (286 respondents) consider CLT as a highly suitable base construction material for multi-family residential buildings, with less than 5% responding otherwise (Ashby, 2016).

The escalating interest in CLT can be attributed to several advantages it offers, including its low environmental impact, particularly in terms of carbon footprint, its high strength-to-weight ratio, ease of installation, and aesthetic features. Emphasizing its sustainability attributes, CLT acts as a carbon sink by storing carbon during its service life, thereby contributing to reduced global warming potential (GWP) during its production compared to steel or concrete structures. Research has shown that CLT buildings have less than half the embodied CO2 of conventional reinforced concrete buildings (Brown, 2016), and their operational energy consumption is relatively low (Block, 2009). Moreover, CLT panels can be reused or recycled, further reducing the carbon footprint of buildings (Ohlbrock et al., 2015). In terms of cost-effectiveness, studies indicate that CLT can reduce construction time by up to 30%, leading to substantial savings in labor costs (Ismail, 2019).

As a result, CLT buildings can be erected at a significantly faster pace, sometimes requiring only 4–7 days per floor, in contrast to 21–30 days for conventional concrete buildings.

Beyond its sustainability attributes and cost benefits, CLT stands out as a competitive construction material in terms of structural capacity, design flexibility, fire resistance, seismic performance, and thermal properties (Beghini et al., 2014; Dangel, 2016).

Figure 2.4: The Smile

Source: Alison Brooks Architects

Advantages of CLT:

- High strength and stiffness: CLT's cross-lamination gives it exceptional strength and stiffness properties, making it comparable to concrete and steel in structural performance.
- Speed of construction: CLT panels are prefabricated off-site, allowing for quicker and more efficient on-site assembly, reducing construction time.
- Sustainability: CLT is made from renewable and sustainable timber resources, offering a lower carbon footprint compared to traditional building materials.
- Fire resistance: The thick layers of wood in CLT provide inherent fire resistance, and CLT can also be engineered with additional fire-resistant treatments.

Glue – Laminated Timber

Glue-Laminated Timber (Glulam): Glue-laminated timber consists of multiple layers of dimensioned lumber glued together with durable adhesives to form large, strong, and stable structural members. Glulam beams and columns are commonly used in commercial and residential construction, offering excellent load-carrying capacity, design flexibility, and aesthetic appeal (Fernández et al., 2019). Glulam is widely used for long-span applications such as roof structures and bridges.

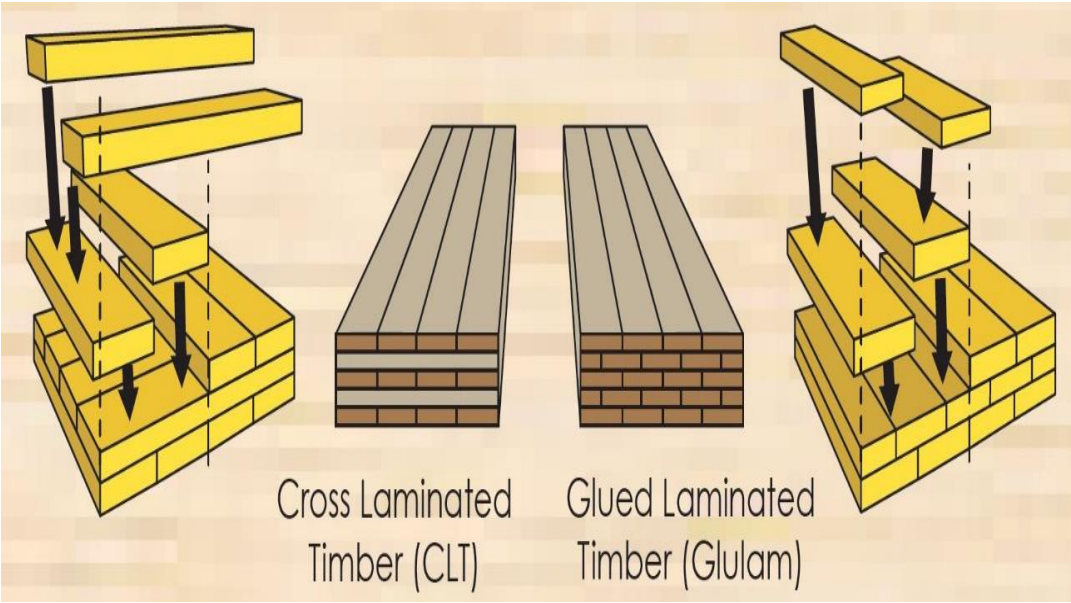

Figure 2.5: Comparison of CLT vs GLT

Source: Building and Construction Authority

Advantages of Glulam:

- Versatility: Glulam can be manufactured in various shapes and sizes, providing design flexibility for architectural creativity.
- Structural performance: Glulam offers high load-carrying capacity, making it suitable for long-span applications such as roofs, bridges, and large buildings.

- Aesthetic appeal: The natural beauty of wood is preserved in glulam, creating warm and inviting spaces in both interior and exterior applications.
- Durability: Properly treated glulam is resistant to decay and insect attack, ensuring long-term durability.

Nail Laminated Timber

Nail-Laminated Timber (NLT): Nail-laminated timber is a traditional and cost-effective mass timber product constructed by simply nailing together layers of solid wood planks (Gagnon & Sathre, 2012). NLT is often used for floors and roof decks, offering similar advantages to other mass timber products, such as strength, durability, and ease of construction. It is a viable option for smaller-scale projects and renovations.

Advantages of NLT:

- Simplicity of construction: NLT does not require specialized equipment or adhesives, making it relatively easy to fabricate and assemble.
- Cost-effectiveness: NLT can be a budget-friendly option for smaller-scale projects or renovations.

Figure 2.6: Nail Laminated Timber

Source: Think Wood, 2020

- Renewable resource: Like other mass timber products, NLT is made from sustainably harvested wood, contributing to its eco-friendly attributes.

Dowel-Laminated Timber (DLT)

Dowel-Laminated Timber (DLT): Dowel-laminated timber is a newer form of mass timber where solid wood boards are connected using hardwood dowels or metal fasteners instead of traditional adhesives. DLT combines the benefits of CLT and glulam, providing a more sustainable and natural alternative to adhesives (World Economic Forum, 2020). It offers high structural performance and ease of assembly, making it suitable for a variety of building applications. Because its grains run in one direction, DLT is best suited for flooring and roofing applications. (Think Wood, 2022).

Advantages of DLT:

- Enhanced sustainability: By eliminating adhesives, DLT minimizes the use of chemicals and enhances the environmental friendliness of the product.

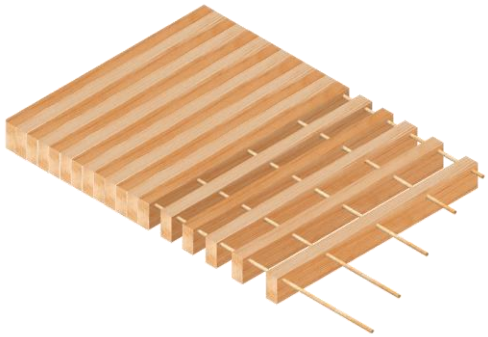

Figure 2.7: Dowel Laminated Timber

Source: Think Wood, 2022

- Ease of assembly: DLT's construction is relatively straightforward, allowing for efficient and quick on-site assembly.

- Structural performance: DLT can provide excellent load-carrying capacity and stability, making it suitable for various building applications.

Laminated Veneer Lumber (LVL)

Laminated Veneer Lumber (LVL): Laminated veneer lumber is a type of engineered wood product made by bonding thin veneers of wood together with adhesives. LVL offers high strength-to-weight ratio and consistent performance, making it suitable for structural beams, headers, and rim boards in construction projects. It is a popular choice for commercial and residential applications due to its dimensional stability and uniformity (He Z et al., 2018).

Furthermore, LVL showcases its efficacy as the flange material for prefabricated wood I-joists, enhancing the strength and stability of these essential load-bearing components. Beyond the realm of construction, LVL exhibits its utility in divergent sectors, serving as an integral material for roadway signposts and proving its mettle as truck bed decking, underscoring its durability even in demanding transportation contexts. The widespread employment of LVL across such a spectrum of applications underscores its significance as a reliable and adaptable choice in the world of structural materials.

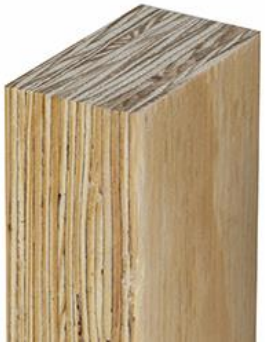

Figure 2.8: Laminated Veneer Lumber

Source: Canadian Wood Council

Advantages of LVL:

- Consistent performance: LVL exhibits uniform strength and stiffness properties, ensuring reliable structural performance.
- Dimensional stability: LVL resists warping, twisting, and shrinking, providing stability over time.
- Renewable resource: LVL is produced from sustainably managed forests, making it an eco-friendly choice.

It is worth noting that these types of mass timber each have their unique strengths and applications, and they all contribute to sustainable construction practices by utilizing renewable resources and reducing the carbon footprint of buildings. The choice of mass timber depends on specific project requirements, design considerations, and sustainability goals. In mass timber construction, glue-laminated timber and cross-laminated timber products are particularly prevalent due to their remarkable strength, sustainability, and design versatility. As the demand for sustainable building materials continues to rise, engineered wood products offer an ideal solution, combining the natural beauty of wood with superior performance for a more eco-conscious and innovative approach to construction.

2.4 Methods and Tools for Estimating Cost Profiles of Construction Projects

2.4.1 Total Cost of Ownership

Total Cost of Ownership (TCO) stands as a pivotal financial metric utilized by asset proprietors to meticulously assess both direct and indirect expenditures across the entire lifespan of an investment. TCO encompasses an array of expenses encompassing construction, ownership, and the ongoing maintenance of structures. The genesis of this

concept can be traced back to its application within the realm of constructed environments, pioneered by professionals affiliated with the Association of Physical Plant Administrators (APPA).

This framework gained prominence particularly within the context of educational institutions and governmental edifices, owing to their enduring ownership and operational responsibilities. Recognizing and comprehending these multifaceted costs assumes paramount significance while contemplating potential real estate investments. This significance is further accentuated in the realm of mass timber buildings. These structures, constructed from innovative timber materials, bring about a unique set of cost uncertainties and a general unfamiliarity with their materials and building systems. Consequently, these challenges have acted as noteworthy obstacles to the wider adoption of mass timber buildings, a trend that has persisted since 2014.

The Total Cost of Ownership (TCO) has long been a recognized cost modeling tool in the field of Supply Chain Management, primarily serving as a purchasing tool for product/system users during vendor selection. Traditionally applied in both Business-to-Consumer (B2C) and Business-to-Business (B2B) settings, it has found notable application in industries such as electronics, the military sector, and heavy equipment (Saccani et. al., 2017).

However, recent years have witnessed a notable transformation in the perception of TCO, evolving from a purchasing tool to a strategic instrument for the lifecycle management of products/systems (Roda et al., 2020). This expanded role encompasses the entire lifecycle of products/systems, supporting various decision-making processes, including both investment and operational decisions (Thiede et al., 2012; Schuman and Brent, 2005; El-Akruti et. al., 2013; Chen et al., 2009). The publication of standards on Asset Management

(ISO 55000:2014(E), 2014) further emphasizes this shift, encouraging the use of TCO methodology for evaluating options related to new or existing assets and operational alternatives.

The evolving landscape prompts a reexamination of TCO to uncover emerging industry needs and a broader understanding, particularly in the context of lifecycle management for industrial assets, with a specific focus on manufacturing assets. Furthermore, TCO is gaining traction as a tool supporting the development of Product-Service Systems (PSSs) through TCO-based contracts. As market dynamics undergo rapid and disruptive changes, asset users increasingly collaborate with Original Equipment Manufacturers (OEMs)/providers. TCO is viewed as a neutral tool for assessing costs and benefits embedded in business-to-business transactions, affirming its relevance and underscoring the necessity to explore its continued development as a lifecycle management support tool (Caniato et al., 2014).

2.4.2 Techno-Economic Analysis

Techno-economic analysis (TEA) is a systematic approach employed to evaluate the economic viability and performance of a given technology. Through TEA, analysts can comprehensively assess the overall value of a technology, enabling an objective comparison of its benefits and costs. It involves a systematic examination of various factors to provide a holistic view of the technology's economic impact. he primary objective of TEA is to assess whether a technology is economically viable by weighing its benefits against its costs.

In techno-economic analysis (TEA), a functional unit is a key concept used to define and standardize the basis for evaluating the economic and environmental performance of a technology or process. It represents a quantifiable measure of the output or service provided by the system under consideration. The functional unit serves as a reference point, allowing

analysts to compare different technologies or processes on a consistent basis. The functional unit clearly defines the output or service that the technology is intended to deliver. This could be expressed in physical units (e.g., megawatt-hours of electricity, kilograms of product) or functional terms (e.g., distance traveled, data processed). The functional unit often involves normalization to a standardized quantity or quality. Total construction cost over the study period can be divided in two categories i.e., Capital expenditure and Operating expenditure.

- Capital expenditure: material, labor and overhead cost.
- Operating expenditure:

1. Utility expenses: electricity, Gas and Water
2. Maintenance, repair and replacement
3. Salvage value/ Cost at End of building service life

TEA provides valuable insights into the economic viability of a technology, helping stakeholders make informed decisions about its development, implementation, or improvement. It serves as a crucial tool in assessing the financial sustainability and competitiveness of technological innovations in various industries.

2.4.3 Life Cycle Cost Analysis

Life Cycle Cost Analysis (LCCA) is an economic methodology employed to assess the comprehensive financial performance of a structure over a predetermined study duration (ASTM, 2017; Dwaikat and Ali, 2018). Within the realm of construction, LCCA serves as a tool to contrast diverse design alternatives for entire buildings, building systems, and construction materials (ASTM, 2017; Tam et al., 2017). Its application extends to gauging the economic viability of building designs, investigating the balance between initial

expenditures and potential long-term cost reductions, and pinpointing cost-efficient systems tailored to specific applications. Life Cycle Costing (LCC) offers a systematic approach to evaluating expenses across a building's entire lifecycle, spanning construction, utilization, maintenance, and eventual decommissioning (Figure 2.9). This method delivers a more comprehensive understanding of enduring costs and potential savings, surpassing the insights provided by Return on Investment (ROI) calculations.

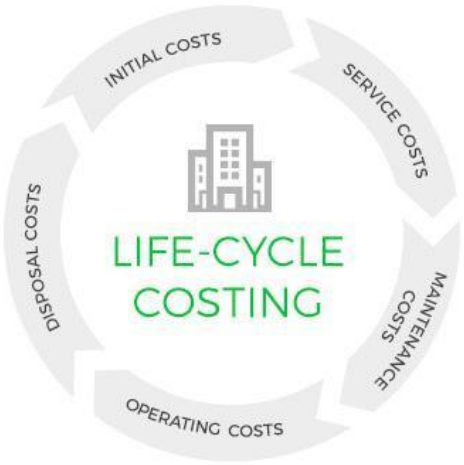

Figure 2.9: Life cycle process

The cost of mass timber construction can vary depending on several factors, including the type of mass timber used, project size, design complexity, regional labor and material costs, and the availability of mass timber in the local market (Smith et al., 2016). While mass timber construction may be competitive with other construction methods, it is essential to consider both upfront costs and long-term benefits to evaluate its overall economic viability.

Here are some key factors that influence the cost of mass timber construction:

1. **Material Costs**: The cost of mass timber materials, such as Cross-Laminated Timber (CLT), Glued Laminated Timber (glulam), and Laminated Veneer Lumber (LVL), can vary depending on the species of wood, manufacturing processes, and market

demand. The availability of locally sourced mass timber can also impact material costs.

2. **Design Complexity**: The complexity of the architectural and structural design plays a significant role in cost. Unique and intricate designs may require additional engineering and fabrication, which can increase construction costs.
3. **Construction Labor**: The availability and cost of skilled labor in the construction industry can impact the overall project cost. Mass timber construction often involves prefabrication, which can help reduce on-site labor costs.
4. **Construction Time**: Mass timber construction is known for its speed and efficiency. Reduced construction time can lead to cost savings due to shorter construction periods and reduced financing costs.
5. **Foundations and Structural Systems**: Mass timber structures typically have lighter foundations compared to traditional concrete and steel structures. The choice of foundation system and overall structural design can affect costs.
6. **Building Height and Regulations**: Building codes and regulations may have specific requirements for mass timber construction, especially for taller buildings. Meeting these requirements can influence costs.
7. **Sustainable Features**: While mass timber construction is inherently sustainable, incorporating additional green building features may affect costs. However, these investments can lead to long-term cost savings through reduced energy consumption and operational expenses.

8. **Market Demand**: As mass timber construction gains popularity, economies of scale and increased market demand may lead to reduced material costs and more competitive pricing.

Performing a life-cycle cost analysis is a critical undertaking in the realm of value engineering. This comprehensive assessment allows for a holistic view of the project, enabling the identification of options that provide optimal value both in the short and long-time frames.

Life cycle cost over building life cycle is given by:

LCC = (Investment Costs + Maintenance/Operational Costs) – Disposal Costs / Residual Value

Consequently, it's important to approach the existing studies with a critical perspective, as some might carry inherent biases or represent a limited subset of successful projects that don't encompass the full spectrum of possibilities.

2.4.4 Discount Rates and Different Valuation Metrics

Collier (Collier et al., 2009) emphasizes the significance of capital investment decision-making in strategy implementation. Capital investment involves spending with the expectation of future cash flows. Lifecycle Costing (LCC) enhances transparency by comparing alternatives based on factors like costs, quality, and comfort. To compare future costs, discount and escalation rates are crucial due to currency value fluctuations. Future costs, like operational costs, must be discounted for fair comparison with investment costs (Kemps et al., 2012). However, literature reveals no universally accepted method for determining discount rates (Dell'Isola and Kirk, 2003). Various evaluation methods exist, including accounting rate of return, payback period, and discounting cash flow. Owners

typically select the discount rate, which includes the basic borrowing cost and an increment reflecting investment risk.

The essence of a discount rate lies in its role of adjusting for societal preferences regarding present versus future income. However, quantifying this preference is complex, as it is contingent on the specific society in question, their perception of income, and the variable quality of income. In cost-benefit analysis, the diversity of outcomes that can be monetized further complicates the assessment of this adjustment.

As previously noted, achieving comparability between future and present costs lacks a universally accepted method. Nevertheless, (Francissen, 2007) suggests several recognized approaches for making Life Cycle Costs of diverse alternatives comparable. These include Net Present Value (NPV), Discounted Payback Period (DPP), and Internal Rate of Return (IRR). Given the array of Discounted Cash Flow (DCF) methods, the frequently utilized NPV and IRR method (Ross et al., 2008; Nábrádi and Szôllôsi, 2007) will be elucidated. NPV involves discounting future cash flows to their present value, enabling a comparison between the present value of future cash flows and the initial investment (Collier, 2009). The formulas applied are sourced from (Geltner et al., 2007).

For discounting a future sum to the present value.

$$PV = \frac{FV}{(1+r)^N}$$

Where, PV = Present value, FV= Future value, r is discount factor and N is the study period

For discounting a present sum forward to its future equivalent.

$$FV = PV(1+r)^N$$

The Net Present Value (NPV) of an investment is calculated as the disparity between the total of discounted cash flows generated by an investment and the initial investment amount.

Net Present Value = Present Value of Future Cash Flows – Investment Costs) + Residual Value

IRR, or internal rate of return, is another metric used in financial analysis to estimate the profitability of potential investments. IRR is a discount rate that makes the NPV of all cash flows equal to zero in a DCF analysis. Internal Rate of Return (IRR) is calculated using the same concept as net present value (NPV), except it sets the NPV equal to zero.

$$0 = \text{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1 + IRR)^t} - C_0$$

where:

C_t = Net cash inflow during the period t

C_0 = Total initial investment costs

IRR = The internal rate of return

t = number of time-periods.

In the realm of construction projects, the Internal Rate of Return serves as a key financial tool, aiding decision-makers in assessing project viability, making investment decisions, and understanding the potential returns and risks associated with the venture.

2.5 Studies On the Cost Implications of Mass Timber

The cost implications of mass timber play a crucial role in its adoption within the U.S. construction industry. However, there remains a notable research gap concerning the cost performance of timber buildings, highlighting a significant area for further investigation in current CLT research. Recent study by (Woodworks, 2024) found that CLT based mass

timber projects can save around 4 months of the scheduled construction duration and better occupancy rates. Moreover, the latest business case studies published by Woodworks council (Woodworks, 2024) indicated that mass timber construction using CLT can yield premium rental rates ranging from 15% to as high as 67% (INTRO Cleveland, 2023). This efficiency can be attributed to the simplified construction process, with fewer, larger elements involved compared to conventional wood-frame solutions.

Venturing to California, a white paper penned by the Central City Association of Los Angeles scrutinized the viability of employing mass timber for affordable housing. In a side-by-side cost analysis, it emerged that a Cross-Laminated Timber (CLT) superstructure could command a premium of up to 37% for buildings spanning 3 to 5 stories. For taller edifices, ranging from 10 to 20 stories, the structural costs exhibited a more moderate increment, hovering around 17% (CCA, 2019). A noteworthy Norwegian study conducted in 2019 offers valuable insights. It highlighted that the mass timber approach incurred a cost roughly 4.6% higher than a comparable steel construction (Tarin et al., 2019). Another noteworthy study, conducted by the Forest & Wood Products in Australia, indicated a cost disparity of about 7% in favor of non-timber alternatives. Yet, the specifics of this comparison and whether the structure comprised solely mass timber components remain ambiguous due to the absence of public project details (CSAW, 2017).

CLT stands as an investment, surpassing the initial cost of materials like steel or concrete on a per-unit basis. However, the allure of CLT's financial benefit lies in a different realm - a reduction in labor expenses (Think Wood, 2020). By virtue of its unique composition and construction process, CLT offers a substantial advantage in terms of on-site labor requirements. The implementation of CLT leads to a remarkable reduction, effectively

halving the number of construction workers needed for the project. This operational efficiency resonates as a pivotal aspect in the overall cost equation, highlighting the intriguing balance between upfront expenditure and long-term savings that CLT brings to the table.

It is crucial for project stakeholders to collaborate closely during the design and planning stages to optimize cost-efficiency without compromising on the quality and performance of the structure. Given the current market, it has been realized that the cost of mass timber is 5-15% expensive, (Bergman et al., 2019). This understanding has been established through consultations with a range of professionals including engineers, timber product manufacturers, and developers within the field. However, obtaining accurate and equitable cost comparison data remains a challenge. This challenge arises partly due to the relative novelty of mass timber construction, coupled with the reluctance of stakeholders to openly share cost-related information.

2.6 Carbon Credits on Mass Timber Construction

Governments worldwide are implementing diverse carbon pricing strategies to align with climate mitigation objectives, aiming to incentivize actions that reduce greenhouse gas (GHG) emissions and enhance carbon removal from the atmosphere through sequestration and storage efforts. Carbon pricing mechanisms serve as vital tools in internalizing the external costs associated with GHG emissions, thereby holding responsible parties accountable. Typically, this involves imposing a price on emitted carbon dioxide (CO_2) to reflect the environmental impacts. The three primary forms of carbon pricing mechanisms are carbon taxes, emissions trading systems (ETS), and carbon offsets, each designed to address specific aspects of carbon emissions management and incentivize sustainable

practices (World Bank, 2021). Policymakers recognize the urgency of addressing climate change and are increasingly turning to carbon pricing to drive emission reductions and foster investments in low-carbon technologies and practices. Carbon pricing mechanisms play a pivotal role in driving the transition towards a low-carbon economy by encouraging innovation, investment in renewable energy sources, and the adoption of cleaner production processes. By internalizing the costs associated with carbon emissions, carbon pricing mechanisms create economic incentives for businesses and individuals to reduce their carbon footprint and transition towards more sustainable practices. As evidenced by data from the World Bank, numerous nations have embraced the concept of carbon taxation, albeit with varying degrees of intensity. In 2021, carbon tax rates exhibit considerable diversity, ranging from the relatively modest figure of $0.08 per ton of CO2 in Poland to a $137.24 in other regions (World Bank, 2021; Taylor et al., 2021).

Recent multipart life cycle assessments (LCAs) on mass timber buildings (Duan et al., 2022; Gu et al., 2021; Puettmann et al., 2021), revealed reductions in embodied carbon emissions ranging from 20% to 45% compared to functionally equivalent alternative building materials. Several countries and governments are making efforts to implement the policies that would recognize mass timber to mitigate carbon emissions. For this effort, Buy Clean California Act ensures that the maximum global warming potential (GWP) is maintained for different construction materials. This policy would reward the stakeholders using wood as building material for reducing carbon emissions (ThinkWood, 2021). Similarly, U.S. government has allocated significant funding, amounting to millions of dollars, to propel climate-smart mass timber construction and broaden wood products markets. This initiative is facilitated through the U.S. Department of Agriculture's Partnership for Climate-Smart

Commodities Program (USDA, 2022; NEFF, 2022). Hence such kind of policies and initiatives may help developers/owners to obtain significant tax credits in the form of subsidies, thus lowering down their total cost of ownership.

2.7 Summary

Several studies have delved into the cost comparisons between timber construction and its alternative counterparts. This discussion focuses on studies centered around realized projects, while excluding those influenced by lobby groups unless the project was actually executed. These diverse studies collectively underscore the intricate and context-dependent nature of cost comparisons between timber construction and its alternatives, emphasizing the importance of scrutinizing each project's specifics to arrive at informed conclusions.

CHAPTER 3: MATERIALS AND METHODS

3.1 Overview

In this chapter, various research methods employed to address the primary research question are delineated. Initially we present the main research objectives and the project work plan to achieve these objectives. Then we give the overview of various methods and tools to identify the cost effectiveness of the construction project during its lifetime. Following this, a comprehensive research framework is presented, offering techno-economical perspective on the study. Finally, we elucidate the way the interview data would be collected and analyzed.

3.2 Objectives

The primary goal of this project is to conduct an exploratory study for identify the obstacles specific to developers and building owners, particularly those related to a limited understanding of the total cost of ownership associated with mass timber buildings. By addressing these barriers, the project aims to identify the feasibility in adoption and development of mass timber structures within the construction industry. This is achieved using following objectives and its work plan to meet these objectives (Figure 3.1):

- Objective 1 – To develop Comprehensive understanding on tools and techniques for generating cost profiles in construction industry.
    - Task 1: Identify different tools for generating cost profiles
    - Task 2: Conduct an extensive literature review on total cost of ownership and life cycle cost analysis, exploring their advantages and disadvantages.
- Objective 2: Develop cost profiles based upon objective 1 for case study building with its alternative building materials and based on a variety of ownership scenarios.

- Task 1: Conducting data collection on the economic aspects of case study buildings and using TCO to estimate construction costs, operation and maintenance costs, energy costs, and end-of-life costs.
- Task 2: Develop total cost of ownership based on a range of ownership models and scenarios for utility price escalation, variation of discount factors and end-of-ownership scenarios.

- Objective 3: Conduct an exploratory study for understanding developer/owners' barriers in adopting mass timber construction and identifying their preferences for alternative building materials.
  - Task 1: Create and distribute developer/owner total cost of ownership interview, with focus on understanding MT-specific building front-end construction and operation & maintenance cost.
  - Task 2: To analyze the influence of total cost of ownership and ownership dynamics of the buildings using qualitative and quantitative interview.

3.3 Total Cost of Ownership

Total Cost of Ownership (TCO) stands as a pivotal financial metric utilized by asset proprietors to meticulously assess both direct and indirect expenditures across the entire lifespan of an investment. TCO encompasses an array of expenses encompassing construction, ownership, and the ongoing maintenance of structures. The genesis of this concept can be traced back to its application within the realm of constructed environments, pioneered by professionals affiliated with the Association of Physical Plant Administrators (APPA).

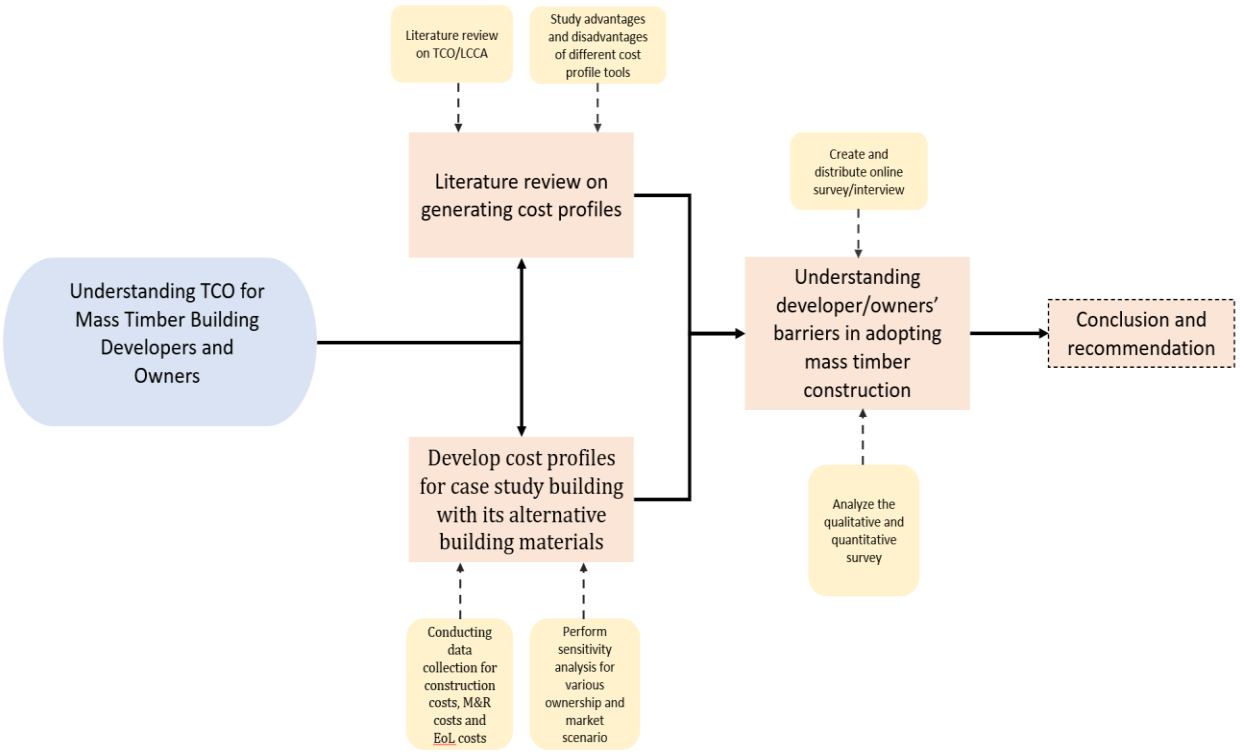

Figure 3.1: Framework for understanding ownership scenarios for mass timber building developers/owners

The total cost of ownership (TCO) stands as a pivotal metric guiding decision-making processes. Conducting a TCO analysis prior to investment or purchase endeavors enhances economic predictability for businesses. The apprehension regarding acquisition expenditures is paramount for companies striving to make prudent and secure investments. Contrary to initial costs, the real challenge often lies in the long-term trajectory of a specific asset's expenses, leading to potential unforeseen financial burdens. Recognizing and addressing this reality is crucial for informed decision-making and sustained financial stability.

3.4 Case Studies, Building Designs and Assumptions

To develop our study, we consider 4 different building designs of the Bakers place project in Madison, Wisconsin. These different building designs were made by Equilibrium consulting, Inc. The Bakers Place project is a 14-story building comprised of a 3-story concrete podium and 11 stories of hybrid steel / timber construction with a primarily residential program above it. In this study they compared 3 different alternatives by which the 11 stories above the concrete podium can be designed. We sincerely thank Equilibrium consulting, Inc for sharing the data related to these different schemes for our study. These alternatives go together with the Revit models developed by Equilibrium. The Revit models and narratives showcased here embody conceptual designs, emphasizing solely the primary structural elements. Fire rating of 2 hrs. for floors and 1 hr. for roof was considered while designing these models and it was based on the International Building Code (IBC) 2021 and its referenced standards. In specific cases, slab toppings are incorporated to ensure functional equivalency, particularly concerning acoustic considerations. In order to better understand the mass timber's influence on a project's genuine time-adjusted returns which optimize the profitability while minimizing the risks, this study will leverage different types of construction scenarios for designing a building. Following are the alternative designs by which 11 stories above the concrete podium were designed.

1. Scheme #1 (Baseline) - Hybrid steel / timber scheme same as actual building design.
2. Scheme #2 - Full Mass Timber scheme with columns aligning as well as possible with current units.
3. Scheme #3 - Concrete scheme.
4. Scheme #4 - Steel scheme.

The podium, encompassing all structural components from the fourth floor down, is consistently constructed as a reinforced concrete structure across various schemes. Element properties, such as rebar intensity and concrete strength, can be ascertained from the Bakers Place Addendum 01 drawings.

Figure 3.2: Different construction schemes for the case study

3.5 Methodology For Estimating TCO

The Total Cost of Ownership (TCO) method offers a comprehensive approach for evaluating the cost-effectiveness of building construction across its entire life cycle. This assessment encompasses three primary phases: initial costs, operational costs during use, and end-of-life costs, including deconstruction and demolition. In terms of the initial construction cost, the evaluation considers permitting, design, material, and construction costs.

To ensure accuracy, industry-averaged cost data specific to the local context is incorporated. This data encompasses various elements, including construction materials, labor expenses, transportation costs, and storage expenditures.

Moving to the operational phase, the methodology includes daily utility expenses, covering electricity, natural gas, and water usage. The determination of utility costs is achieved using energy simulation software and plumbing design systems.

	Hybrid Steel/Timber (Baseline)	Mass timber	Concrete	Steel
Parameters	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Floor area (sq.ft)	277749	277749	277749	277749
# of storey	14	14	14	14
Location	Wisconsin, Madison	Wisconsin, Madison	Wisconsin, Madison	Wisconsin, Madison
Type of building	Mixed office - apartment complex	Mixed office - apartment complex	Mixed office - apartment complex	Mixed office - apartment complex
Constuction code	Type 1 B - Fire resistant	Type 1 B - Fire resistant		
Duration (months)	26.5	25.75	25.5	25.25
# of storey podium	3	3	3	3
Podium Type	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete
Slab assembly	Gypcrete, Sound mat, CLT	Gypcrete, Sound mat, CLT	Concrete, Rebar	Lightweight Concrete
Framing	Braced Steel framing	Glulam and Steel Braced frame	None	Braced Steel framing
Beams	Glulam. Grade 24F-1.8E.	Glulam GL 28h	Concrete, Rebar	Steel Grade ASTM A992
Columns	Glulam GL 28h	Glulam GL 28h	Concrete, Rebar	Steel W12 shape
Fireproofing	Gypsum wallboard for fire protection covers CLT ceiling and Glulam Beams/Columns	Gypsum wallboard for fire protection covers CLT ceiling and Glulam Beams/Columns	No fireproofing	Spray applied fire proofing
Floor height	9-10''	9-10''	7.5-9''	12''
Impact to Podium and Foundation	As per drawing	As per drawing	55% more total gravity load compared to baseline. Design modified accordingly	55% more total gravity load compared to baseline. Design modified accordingly

Table 3.1: Types of buildings

These costs are then calculated by multiplying energy and water usage by the prevailing utility rates. Additionally, building maintenance and repair costs are integral to the TCO assessment. These costs are sourced from reputable commercial databases like RS Means or obtained through professional inputs.

The calculation of the residual value represents another crucial aspect of TCO. The present value (PV) of the residual value at the conclusion of the study period is determined using a linear depreciation model applied to the building's construction cost over its entire lifespan. In essence, this comprehensive TCO methodology ensures a thorough examination of all pertinent cost factors associated with building construction, operation, and eventual decommissioning. By incorporating industry-standard data, simulation tools, and reliable databases, the approach provides a holistic understanding of the financial implications throughout the building's life cycle. To conduct a comprehensive Total Cost of Ownership (TCO) analysis, we categorize ownership into short and long-term scenarios, aligning with our objective of providing an exploratory study tailored to various types of owners. Thus, long-term, and short-term total cost of ownership is given by,

$$Long\ Term\ Cost\ of\ Ownership = PV_{constuction} + PV_{utility} + PV_{MR} + PV_{Residual}$$

$$Short\ Term\ Cost\ of\ Ownership = PV_{constuction} + PV_{utility} + PV_{MR} + PV_{Resale}$$

The construction cost $PV_{construction}$ is the direct building construction cost in the year 0. It includes the cost of building materials, labor, and overhead during the construction process

$$PV_{construction} = PV_{material} + PV_{labour} + PV_{overhead}$$

$$PV_{utility} = PV_{electricity} + PV_{gas} + PV_{water}$$

$$PV_{\text{Electricity}} = \sum_{t=1}^{N} \frac{A_0 \times (1+e)^t}{(1+d)^t}$$

where A_0 is the estimated annual cost ($) in base year 0; e is the price escalation rate; d is the discount rate; and N is the study period (year).

$$PV_{MR} = PV_{\text{Maintenance}} + PV_{\text{Repair}} + PV_{\text{Replacement}}$$

Residual value for long term ownership was estimated in this study with a linear deterioration from original construction cost till the end by considering life span of each scenario. This is based upon the assumption that property becomes depreciating asset in long term ownership.

$$PV_{Residual} = PV_{construction} * \left(1 - \frac{N}{K}\right) \qquad for\ N < K$$

Where K is the lifespan of building and N is the study period (year). On the other hand, we use resale value instead of residual value for short term ownership e.g., 5, 10 or 20 years. This is based upon the assumption that in the short term, owners see marginal appreciation in the prices of real estate. Present value of resale price of the building was estimated using the equation given below,

$$PV_{\text{Resale}} = \sum_{t=1}^{N} \frac{A_0 \times (1+e)^t}{(1+d)^t}$$

Where e is the escalation in market value of the building.

3.6 Assumptions

All the costs were obtained based upon the conceptual designs of the buildings and the materials. It includes various costs such material, labor, transportation, and equipment costs. For estimating operational costs, we assumed maintenance and repair costs same for all the building schemes as the M&R costs for mass timber building is not currently available in any database for US buildings. M&R costs were obtained using per square foot estimator tool in RS Means database. Based on Madison year on year growth of housing value (City of Madison

Housing Report, 2023), we considered the escalation rate of 9.8%. In addition to it, we assumed that mass timber had 7% more value compared to traditional materials based on the study by Woodworks (M Kroskey, 2019; Wingo, 2024). We also assumed total electricity and gas costs for mass timber construction were 10% less than concrete/steel schemes based upon comparative study performed by Khavari for CLT energy consumption (Khavari et al., 2016). To estimate the present value for the long-term ownership costs, we considered discount factor of 3% (Scioto Analysis, 2023) which is one of the widely used discount factors in various studies. For the short-term ownership costs, we assumed discount factor of 10% as base scenario for the study (S & P 500 Data, 2023. We also assumed escalation rate of 1%, 2% and 4.5% for electricity, gas and water respectively were based on US government statistics and the literature (US Department of Energy, 2017). The prices for electricity, natural gas, and water/sewer were obtained from governmental authorities (Madison Gas and Electric, 2023).

3.7 Interview Method and Design

3.6.1 Research Methodology

This research employs an exploratory study approach, a widely adopted strategy for evaluating environments. In this method, a feedback mechanism is developed allowing for the collection of both quantitative and qualitative data through interview and literature review. One of the question this chapter seeks to address the question: How Mixed-Use Tall Buildings designs could affect the total cost of ownership and influence the ownership of the building? To achieve this goal, a comparative interview is conducted as part of this analysis. The literature review uncovered numerous structural and design analyses related to the case studies. Building upon insights from the literature and observations of the selected cases,

this dissertation studies 4 different structural categories by knowing the preferences of owners, developers and construction engineers.

Interview was divided into two parts to perform quantitative and qualitative analysis for mass timber and its various alternative structural design mentioned above. First part included generic qualitative question regarding the experience and knowledge of mass timber building construction of the developers, owners and engineers. It will also try to identify current barriers in adopting mass timber construction and different challenges associated with engineering, procurement and construction of mass timber construction. Second part of the interview include quantitative measures to identify the different ownership scenarios of the mass timber construction using different structural designs used in this study. It will help us to identify what is the current market trend and what are the cost barriers for adopting new structural material compared the traditional ones.

3.6.2 Comparative Methodology

This dissertation employs comparative methodology to identify the advantages and disadvantages of different structural designs. In addition to comparing different structural designs, it will use total cost of ownership analysis for each scenario and identify the owners' preferences in adopting the mass timber construction compared to other structure material. Comprehending these costs is pivotal in assessing any prospective building investment, and this significance is heightened when contemplating mass timber structures. The barriers to the adoption of such buildings since 2014 have been notably attributed to uncertainties surrounding costs and a general lack of familiarity with mass timber materials and building systems.

3.8 Data Collection

We choose participants based upon snowball sampling technique. This was done to limited availability of participants for the study. But using snowball technique, we grew the number of participants increased with the increasing number of interviews. This in turn helped to reduce the biasedness in the study and make it more comprehensive. It also enables us to access the hidden population, mostly included developers, owners and investors. Owners or developers spearhead construction projects, driven by their emphasis on feasibility, financial viability, and goal attainment. Their primary objectives encompass ensuring projects are completed within budget, adhering to timelines, and meeting specified requirements. Additionally, they may factor in considerations such as long-term operational expenses, sustainability, and the project's broader societal impact. In the initial phase, 3 participants were selected based upon their experience. Later, pool of participants was increased to 20 by asking existing participants. This strategy is line with the snowball sampling technique (Figure 3.3) for selecting participants. These participants were scheduled for the interview and their feedback was transcribed.

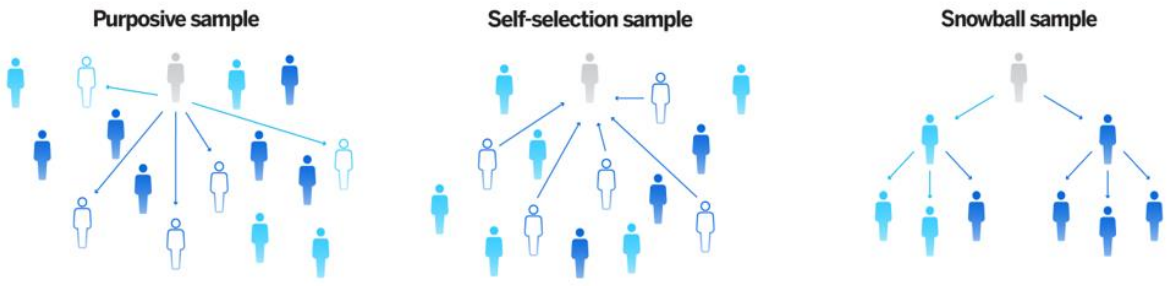

Figure 3.3: Nonprobability sampling techniques

Source: https://www.qualtrics.com/experience-management/research/non-probability-sampling

Detailed outline of the interview questions for the owners/developers can be found in **Appendix A**. All the participants were given in depth details about the building materials and construction scheme before starting the interview. This resource encompasses a curated set of questions designed to understand both qualitative and quantitative aspects of the project. These questions help to extract insightful responses regarding various facets of the endeavor, ranging from overarching goals and strategic objectives to specific performance metrics and technical specifications. By incorporating both qualitative and quantitative inquiries, the interview protocol aims to capture a holistic understanding of the stakeholders' perspectives, preferences, and priorities, thereby helping to understand the preferences and barriers faced by owners' developers in adopting mass timber construction

3.9 Summary

In this chapter, we delved into methodologies for estimating the total cost of ownership (TCO). TCO estimation involves accounting for various market uncertainties and assumptions. Sensitivity analysis emerged as a pivotal tool for gauging the impact of shifting market dynamics and assumptions on the TCO. Such analysis is invaluable for comprehensively studying both short and long-term ownership implications for buildings.

Later in this section, we explored methodologies for conducting interviews among owners and developers to elucidate barriers in adopting mass timber. We designed qualitative and quantitative interviews aimed at comprehensively understanding both physical and cost-related barriers hindering the adoption of mass timber. By leveraging TCO analysis within case studies, we aimed to address these barriers effectively and provide actionable insights for stakeholders.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Overview

We present our results and analysis in two distinct sections. The initial segment focuses on the cost concerning the case study building constructed with various structural materials. We delve into the total cost of ownership across different ownership scenarios, examining the impact of market parameters such as discount factors and escalation rates on these cost profiles. This analysis is categorized into short- and long-term ownership, reflecting varying durations of ownership and their corresponding market parameter considerations.

Subsequently, we analyze the outcomes derived from an interview conducted using the methodology outlined in the preceding section. This interview encapsulates the viewpoints of key stakeholders including contractors, developers, and architects, providing a comprehensive assessment of the pros and cons associated with the adoption of mass timber. Furthermore, we explore stakeholder preferences through a quantitative interview tailored to case study buildings, offering valuable insights into their inclinations and priorities.

4.2 Total Construction Cost

Initial construction cost was obtained from the developer for our case study building in Madison. This cost includes the total construction cost for different case study buildings along with the labor cost and the overhead cost. Labor cost includes construction manager lump, engineer/architects and workers lump sum fee. Overhead costs were also considered and obtained from the developer. It includes extra overhead costs like site management, improvement, different appliances cost etc. Table 4.1 summarizes the total construction cost

for different building materials which includes materials, labor, overhead costs like admin/insurance/construction manager fees etc.

(In Millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	$73.17	$75.30	$68.51	$72.87

Table 4.1: Total construction costs for different schemes

It was found that construction cost with Hybrid Steel/Timber and scheme was more costly compared to concrete and steel by 6.8% and 0.41% whereas full mass timber scheme costlier than concrete by approximately 9.90% and steel by approximately 3.34%. Overall, it was found that having a timber scheme was overall expensive than the concrete and steel scheme. We found that this extra cost was largely attributed to expensive cost for materials like glulam and CLT for mass timber schemes. Below table shows the major factors which contributed to higher material cost for the timber schemes.

MATERIALS	**HYBRID STEEL/TIMBER**	**FULL MASS TIMBER**	**CONCRETE**	**STEEL**
CONCRETE	$6,472,466	$6,952,466	$13,537,486	$7,961,462
GYPCRETE	$947,000	$947,000	-	-
STRUCTURAL STEEL & MISC METALS	$5,202,932	$1,071,607	$1,071,607	$8,954,628
GLUELAM AND CLT FRAMING	$4,171,758	$9,428,000	-	-
Total	**$16,794,156**	**$18,399,073**	**$14,609,093**	**$16,916,090**

Table 4.2: Material costs for different schemes

It was found that material cost for hybrid steel/timber and full mass timber scheme was higher by 15% approx. and 26%. We understand that the increased material costs were partly attributed to supply chain issues within the emerging mass timber market in the USA. As discussed, we divide total cost of ownership for owning these buildings in two different categories based upon years of owning the building. First category is short term of

ownership which include 5 to 20 years of owning the building. Since in short term market parameters varies significantly compared to the long-term ones, we consider different market parameters for short-term ownership. Second is the long-term ownership which includes 40 to 60 years of ownership which mainly includes public institutions, non-profit organizations. Market parameters are usually stabilized for long term ownership and hence remains less aggressive compared to the short-term ownership. In the sections below we would discuss about both short term and long-term ownership of the building by considering different markets parameters influencing total cost of ownership.

4.3 Short-Term Ownership

Short term owners are usually private owners/developers, profit making institutions etc. They generally try to generate the profit from their investment by betting against the market fluctuations. We considered market value of both the buildings increase by 9.8% based on the Madison real estate market statistics (Madison Housing Market, 2024). In addition to this increase, we also assumed that market value of mass timber buildings was 7% more compared to the traditional building material like concrete based upon Woodworks report (Woodworks report, 2018). Various reasons were attributed in the study for higher market rates e.g., aesthetic value, healthy building, environmentally friendly etc. We analyzed the total cost of ownership with discount factors of 7, 10 and 15% for short-term ownership. Our intention behind to use these discount factors was attributed to current short term market fluctuation and yearly returns from the S &P 500 Index (approx. 10%). Considering these market scenarios helped us to estimate the cost of ownership for short term ownership realistically.

4.3.1 10 Years of Ownership

We analyzed short term ownership of 10 years with 10% discount factor as base scenario for the study (S & P 500 Data, 2023). All the future costs are discounted to present to have fair comparison different construction types. Figure 4.1 and 4.2 compares the cost of ownership for 10 years of owning the building with different materials and discount factor of 10%. All the future costs were discounted to present value to consider the time value of money.

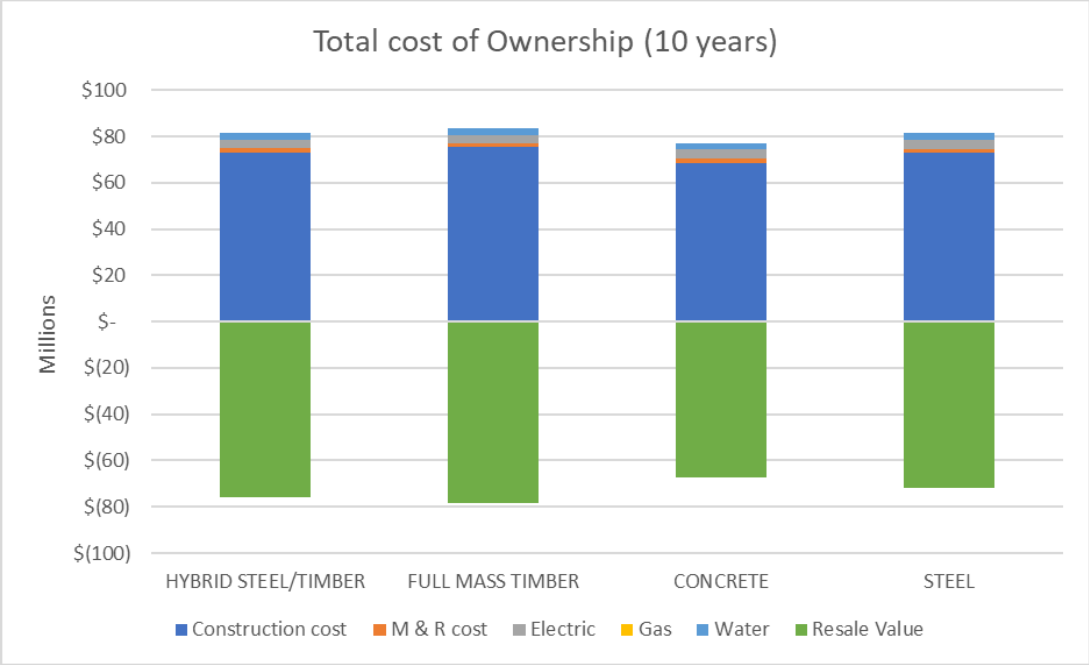

Figure 4.1: Total cost of ownership components (10 years)

It was found that hybrid steel/timber and full mass timber scheme saved around 45% compared to concrete scheme for 10 years owning the building. This saving was largely attributed to high resale value of mass timber building and saving in operation costs compared to concrete and steel scheme (Figure 4.3).

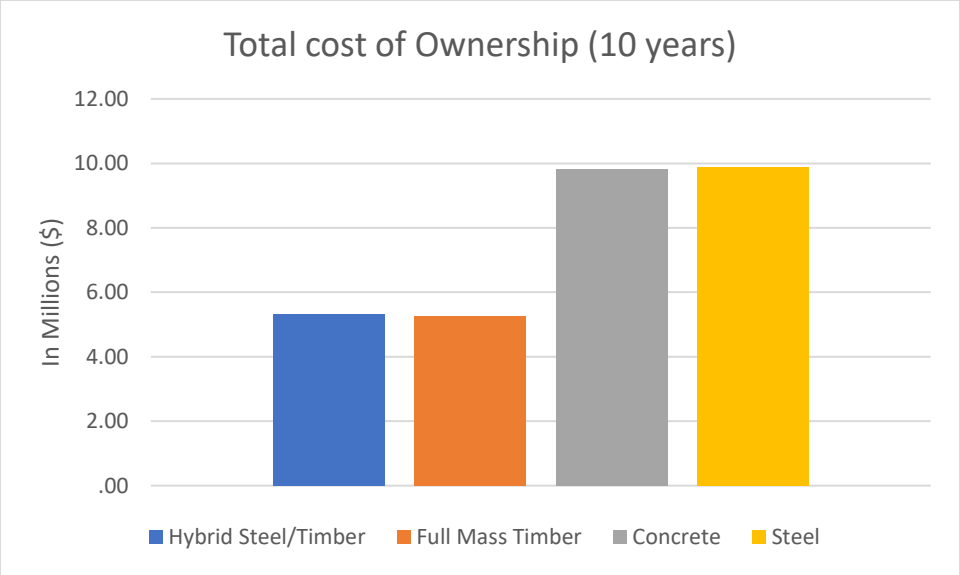

Figure 4.2: Total cost of Ownership (10 years)

4.3.2 Sensitivity Analysis with Different Short-Term Ownership

The analysis presented in Figure 4.4 examines short-term ownership durations spanning 5, 10, and 20 years across various construction types, incorporating a discount factor of 10%.

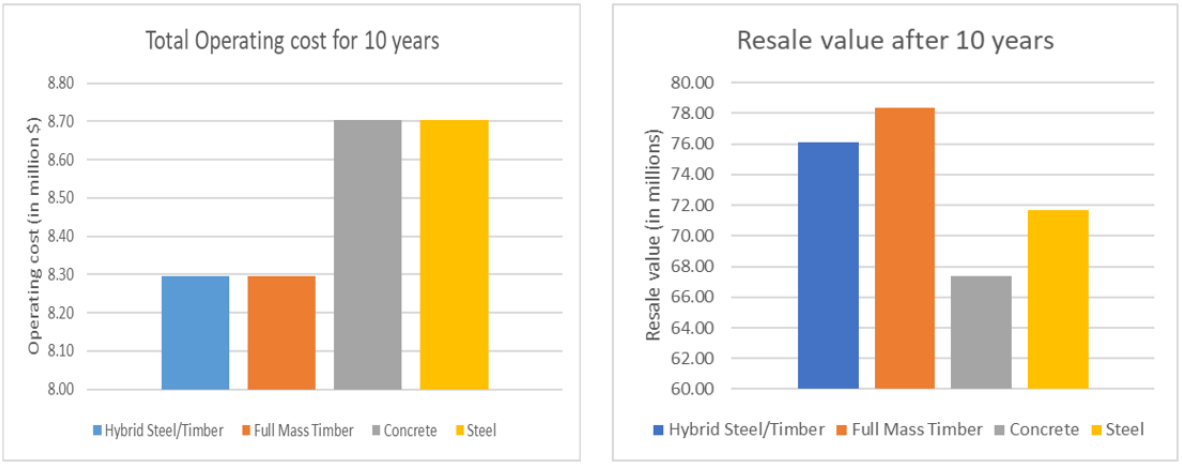

Figure 4.3: Operating Cost and Resale Value for 10 Years Ownership

It is evident that the total cost escalates with the duration of ownership, irrespective of the construction type. Notably, Hybrid steel/timber and full mass timber constructions

consistently exhibit greater cost savings compared to concrete/steel alternatives for all short-term ownership durations.

Two primary factors contribute to this trend: Firstly, mass timber constructions boast a higher resale value relative to concrete, and secondly, timber constructions generally entail lower operating costs. Additionally, a notable observation from Figure 4.4 is the pronounced increase in total ownership costs associated with concrete/steel constructions as the ownership duration extends. This escalation is discernible through the slope of the line corresponding to different ownership durations. Particularly, the slope for a 20-year ownership duration is significantly steeper compared to those for 5 and 10 years, indicating a more rapid increase in costs over time.

This observation underscores the superior cost-saving potential of mass timber constructions compared to concrete counterparts over extended ownership periods. Consequently, such sensitivity analyses are instrumental in guiding decision-making processes regarding preferred ownership types across diverse construction material options.

4.3.3 Sensitivity Analysis with Market Factors for Short-Term Ownership

The analysis depicted in Figure 4.5 sheds light on the fluctuation in total ownership costs over short-term durations, influenced significantly by market factors such as discount rates across different construction materials. Notably, the disparity in total ownership costs between timber/hybrid steel timber and concrete/steel constructions is particularly pronounced at lower discount rates. At reduced discount rates, timber constructions demonstrate a clear advantage over concrete counterparts, especially for a 10-year ownership duration.

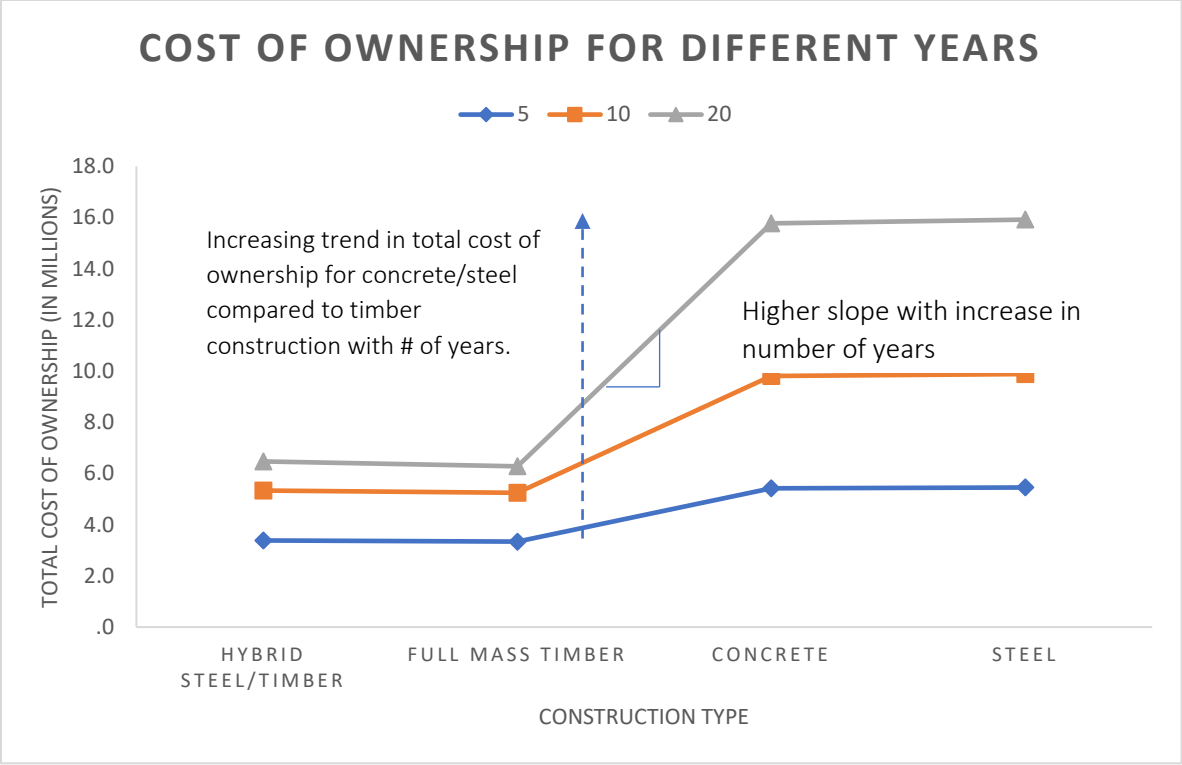

Figure 4.4: Sensitivity analysis for different short-term ownership

When the discount rate falls below approximately 8%, the total ownership costs manifest as negative. This phenomenon is attributable to the context of Madison's real estate market, where properties experience an approximate 10% annual increase in market value for recent years. Consequently, investing in real estate in highly lucrative areas, characterized by rapid growth outpacing the market average, yields negative total ownership costs. This indicates a higher profitability margin for such investments.

Conversely, in riskier markets where higher discount rates prevail, investors demand greater returns from their investments. During such periods, the decision between mass timber and concrete constructions becomes highly competitive. As the discount rate increases, the total ownership costs for concrete constructions decrease relative to full mass timber. With discount rates exceeding 15%, concrete constructions may appear more

favorable for investment due to their lower initial investment costs. This observation is corroborated by Figure 4.5, where at higher discount rates (above 15%), concrete constructions exhibit lower total ownership costs, presenting a more attractive investment opportunity compared to timber alternatives.

4.4 Long-Term Ownership

In contrast to short-term ownership, which typically involves private owners and profit-making institutions seeking to capitalize on market fluctuations for immediate profitability, long-term ownership prioritizes stability and sustained value growth. Institutions engaging in long-term ownership, such as universities and non-profit organizations, emphasize sustainability and the long-term cost benefits of their construction choices. These entities often retain ownership of buildings for extended periods, sometimes until the end of the

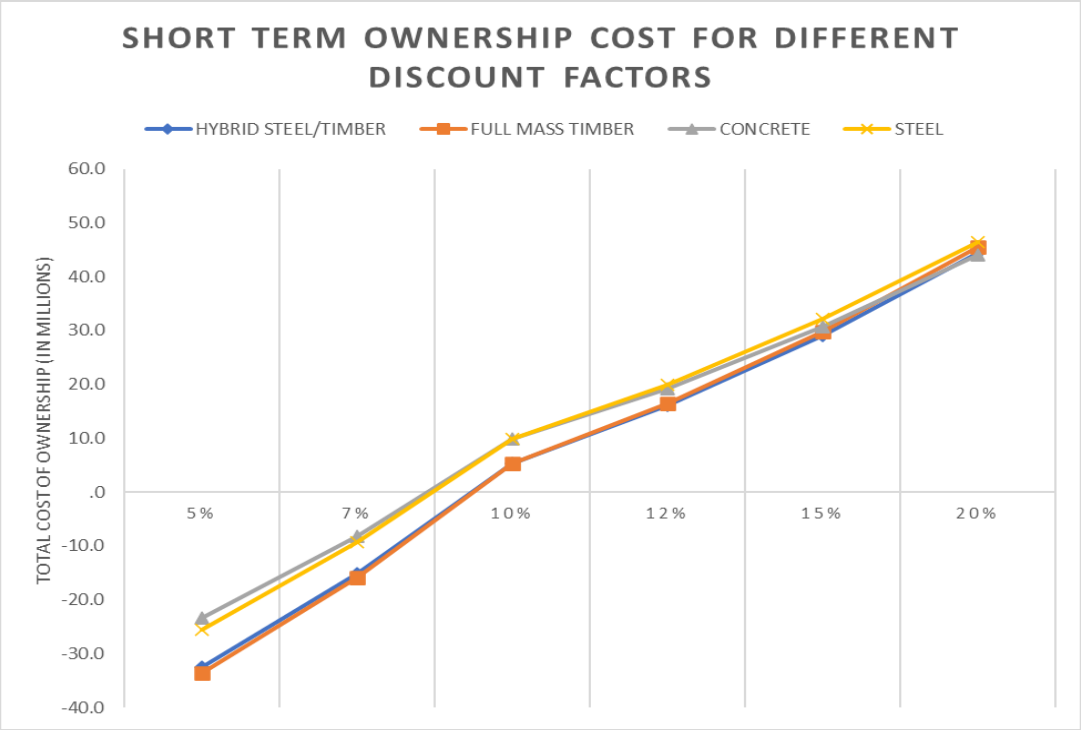

Figure 4.5: Sensitivity analysis for different discount factors (short term ownership)

building's lifecycle. Consequently, their market parameters and investment strategies differ significantly from those observed in short-term ownership scenarios.

To provide insights into long-term ownership comparisons across various construction strategies, we adjust our focus to discount rates ranging from 3% to 7%. These rates align with average US Treasury bond rates and reflect the conservative investment approach typically adopted by institutions involved in long-term ownership. Unlike in short-term ownership analyses, where resale value dominates, we shift our attention to residual value, considering buildings as depreciating assets over the long term. Under this assumption, we model the residual value of the building as linearly deteriorating from its initial construction cost. By incorporating such considerations, we aim to refine our model for total cost of ownership, ensuring its alignment with the realities of long-term investment scenarios. One of the limitations of the current model for long term ownership is factoring in the consideration of increasing market value of building/land over a period of time. We tried to maintain simplicity in the model by considering residual value as linear deterioration of the initial construction cost.

4.4.1 60 years of ownership

We analyzed long term ownership of 60 years with 3% discount factor as base scenario for the study. All the future costs are discounted to present value to factor in the market risk factors for different construction types. Figure 4.6 and 4.7 compares the cost of ownership for 60 years of owning the building with different materials and discount factor of 3% (US Department of the Treasury, 2020). All the future costs were discounted to present value to consider the time value of money.

It was found that long term total cost of ownership for mass timber construction was less than concrete. Compared to concrete, Hybrid steel/timber saved approximately 10 % and Full mass timber saved approximately 8.43%. As discussed earlier this saving was mostly attributed to savings in operating cost and residual value of mass timber building.

4.4.2 Sensitivity Analysis with Type of Long-Term Ownership

The analysis presented in Figure 4.8 examines long-term ownership durations spanning 40, 50 and 60 years across various construction types, incorporating a discount factor of 3% (US Department of the Treasury, 2020).

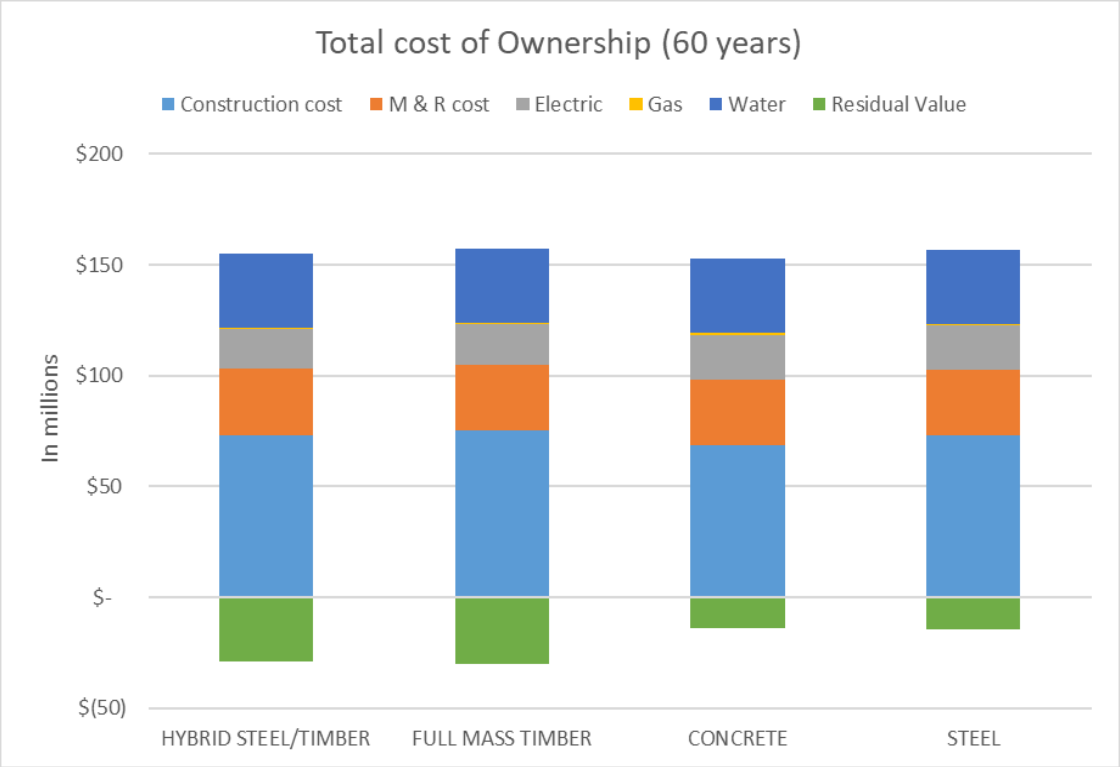

Figure 4.6: Total cost of Ownership (60 years)

It is evident that the total cost escalates with the duration of ownership, irrespective of the construction type. Notably, Hybrid steel/timber and full mass timber constructions

consistently exhibit greater cost savings compared to concrete/steel alternatives for all long-term ownership durations.

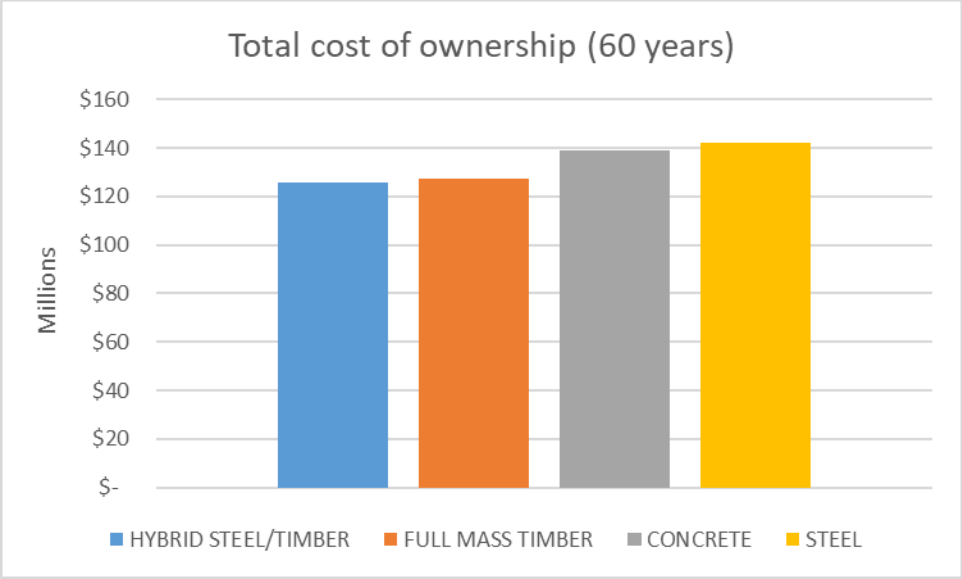

Figure 4.7 Total cost of Ownership (60 years)

Two main drivers are behind this trend: Firstly, mass timber constructions demonstrate favorable residual value compared to concrete, while timber constructions typically come with lower operating costs. Furthermore, an interesting insight from Figure 4.8 is the noticeable rise in total ownership costs linked to concrete/steel constructions as ownership duration increases. This upward trend is evident from the slope of the line representing various ownership durations. Notably, the slope for a 60-year ownership duration exhibits a notable steepness compared to 40 and 50 years, suggesting a swifter escalation in costs over time.

This observation underscores the superior cost-saving potential of mass timber constructions compared to concrete counterparts over extended ownership periods. Consequently, such sensitivity analyses are instrumental in guiding decision-making

processes regarding preferred ownership types across diverse construction material options.

4.5 Interview Outcomes

This section discusses the outcome based upon the methodology discussed in the previous sections. As discussed in the methodology sections we choose participants based upon snowball sampling technique.

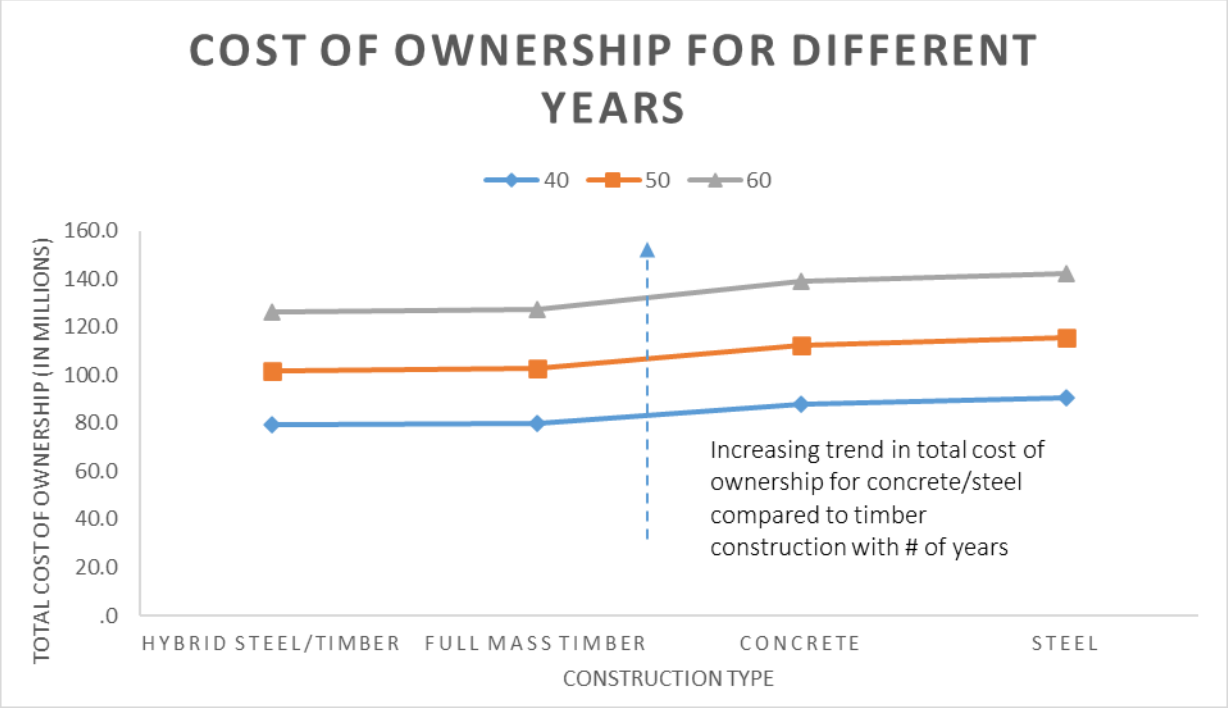

Figure 4.8: Sensitivity analysis for different long-term ownership

This in turn helped to reduce the biasedness in the study and make it more comprehensive. It mostly included developers, owners, and investors. Owners or developers spearhead construction projects, driven by their emphasis on feasibility, financial viability, and goal attainment. Their primary objectives encompass ensuring projects are completed within budget, adhering to timelines, and meeting specified requirements. Additionally, they may

factor in considerations such as long-term operational expenses, sustainability, and the project's broader societal impact.

4.5.1 Owners/ Developers Demographics and Experiences

These participants were scheduled for the interview and their feedback was transcribed. Some of the owner's developer and owners were not having experience with mass timber construction projects. But this in turn would help our study as it would help us know the barriers faced by current concrete/steel/lumber construction owners and developers. 95% of the participants have heard about mass timber as construction material (Figure 4.9). Among all the participants, 60% had experience with mass timber whereas 40% didn't have any experience (Figure 4.10). We also analyzed the developers/owners' demographics based upon their experience in the construction industry and annual budget and type of owners i.e., short/long term or multifamily/retail/industry. Most of the participants had 20 to 40 years of experience.

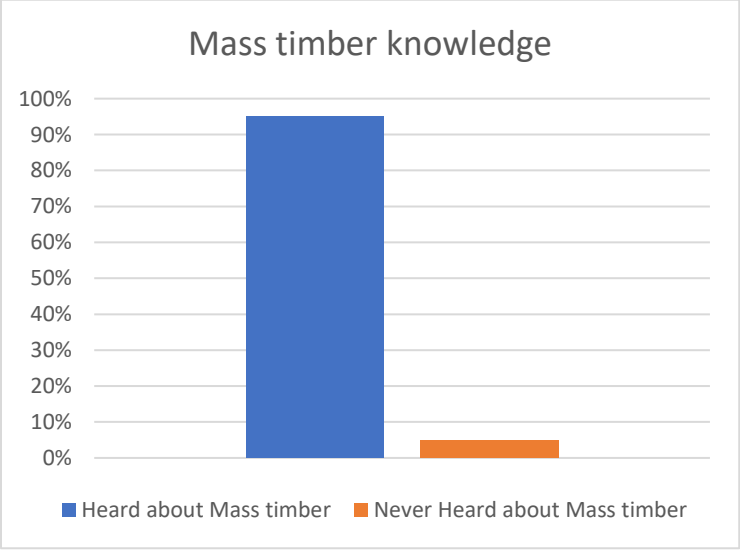

Figure 4.9: Owners/Developers mass timber knowledge

Figure 4.10: Owners/Developers mass timber experience

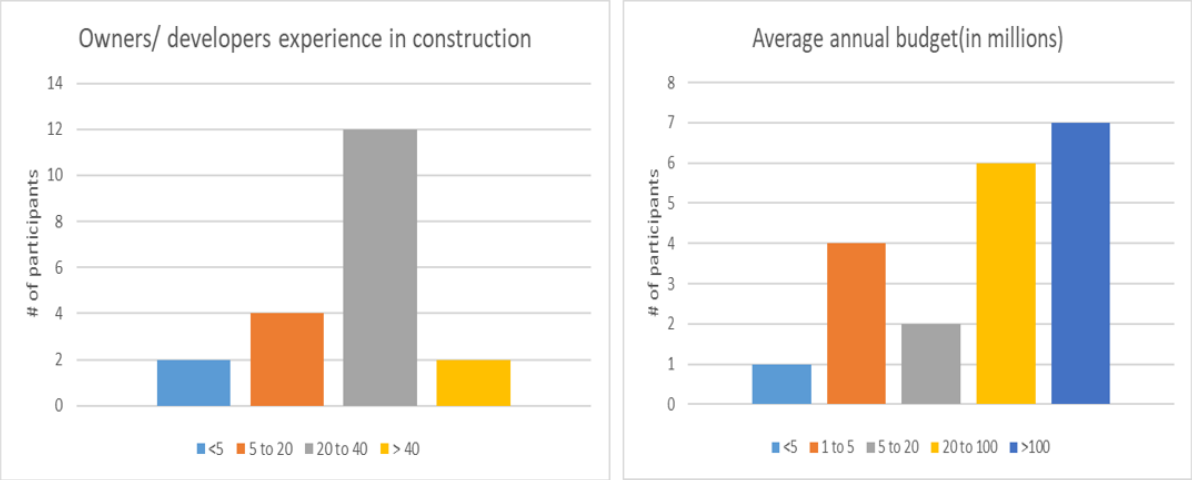

Figure 4.11: Left) Owners/Developers experience in construction. Right) Average annual budget in the construction industry

Annual budget varied between as low as 1 million to as high as 1 billion for few developers/ owners (Figure 11). Apart from these, we also got opportunity to find if they were short- or long-term owners as this would become basis for our study further in the research. Additionally, we categorized owners as short-term, typically owning properties for less than 20 years, or long-term, who typically maintain ownership for 20 years or until the end of the

building's life cycle. This classification serves as a foundation for further investigation in our research. Figure 4.12 shows in detail the years of ownership developers/owners prefer based upon their requirements and project needs.

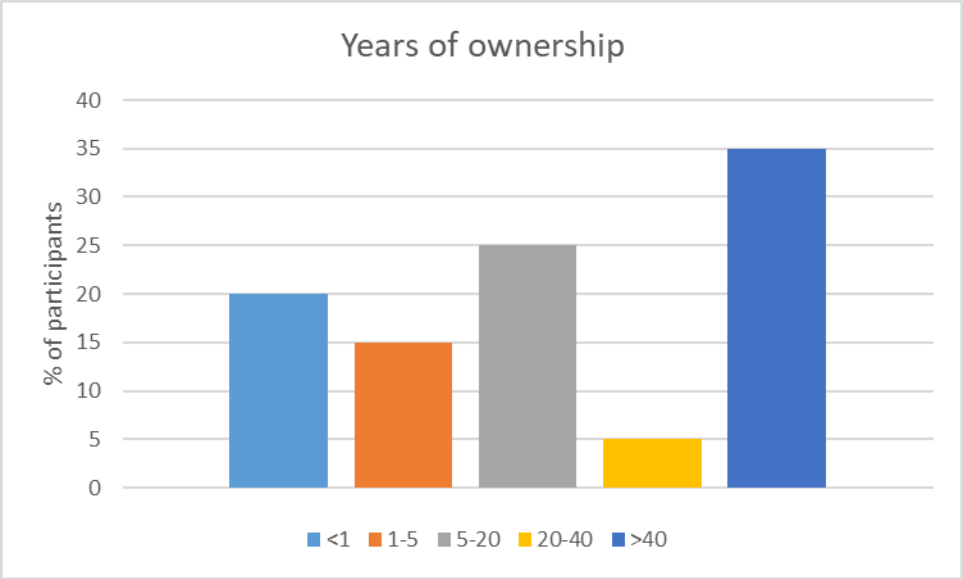

Figure 4.12: Years of ownership

Since the participants contains all types of owners, it helps to make the study more unbiased, thus resulting in fair outcomes and analysis. Additionally, we analyzed the type of owners/developers based upon their investment in different real estate spaces. Figure 4.13 summarizes the percentages of participants in each sector. One participant can invest in different sectors like multi-family housing, single family, retail, non-profit public institutions or industrial space. These can include multifamily (e.g., apartments, condominiums), retail (e.g., shopping centers, malls), and industrial (e.g., warehouses, factories). Majority of the participants were found to be experienced in the categories like multi-family housing and public institutions like universities and non-profit organizations.

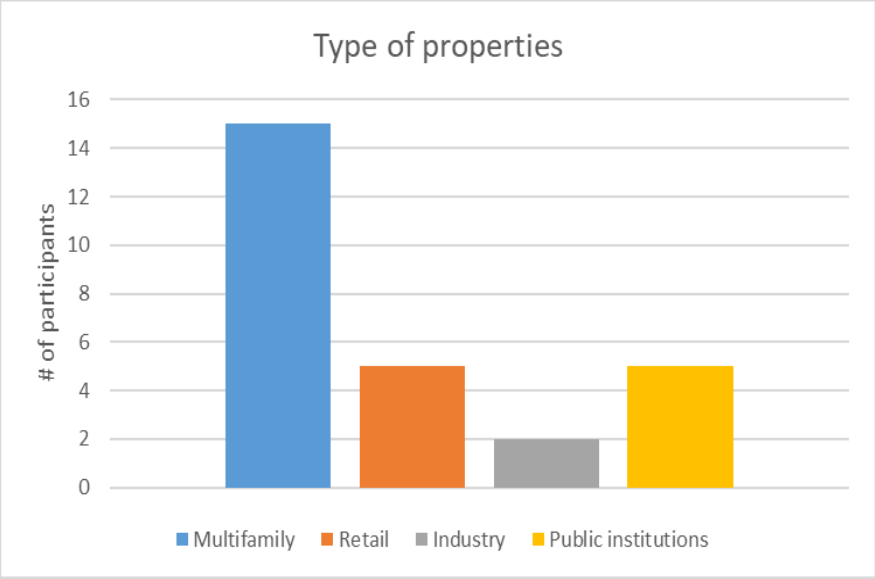

Figure 4.13: Owners/ developers properties of interest

4.5.2 Qualitative Interview Outcomes and Analysis

We did comprehensive analysis for owners/developer's barriers and preferences using the qualitative questionnaire discussed in the methodology section. To analyze the qualitative interview without biasedness, we divided owners/ developers into two categories i.e., one with mass timber experience and another without mass timber experience. We recorded non mass timber owners answers to understand their concerns and barriers of making potential move towards mass timber construction. As we discussed earlier, 40% of the owners/developers were inexperienced with mass timber construction. We found that all these participants faced a common concern about mass timber construction as their future prospect mentioned below:

1. **Perception and Awareness**: Limited familiarity or understanding of mass timber construction methods act as a significant barrier. Concerns regarding its structural integrity, fire resistance, and durability compared to traditional materials like concrete and steel deter its adoption.

2. **Regulatory Challenges**: Building codes and regulations may not adequately address or accommodate mass timber construction, leading to uncertainties or complexities in the permitting process. Additionally, inconsistent regulations across jurisdictions hinder its widespread adoption.
3. **Cost Considerations**: Initial costs associated with mass timber construction, including material procurement, specialized labor, and potentially higher insurance premiums due to fire risks, can be perceived as prohibitive. They may prioritize short-term cost savings over long-term benefits.
4. **Supply Chain Constraints**: Limited availability of mass timber materials, as well as a lack of established supply chains and manufacturing infrastructure, can pose challenges for owners and developers. This scarcity may lead to higher material costs and project delays.
5. **Risk Aversion**: Resistance to adopting new construction methods due to concerns about project risks, including schedule delays, budget overruns, and potential liabilities, can deter owners and developers from embracing mass timber construction.
6. **Insurance and Liability Issues**: Uncertainties surrounding insurance coverage and liability implications, particularly regarding fire safety and structural performance, can raise concerns among owners and developers and influence decision-making.
7. **Market Acceptance**: Perception among potential tenants, buyers, or investors regarding the marketability and resale value of mass timber buildings compared to traditional construction methods can impact the willingness of owners and developers to invest in such projects.

8. **Educational Gap**: Insufficient education and training opportunities for architects, engineers, contractors, and other stakeholders regarding mass timber construction techniques, design principles, and best practices can impede widespread adoption.

Addressing these barriers may require collaborative efforts among industry stakeholders, policymakers, regulatory bodies, and educational institutions to promote awareness, streamline regulations, foster innovation, and mitigate risks associated with mass timber construction.

Apart from above barriers faced by inexperienced mass timber owners, we also analyzed the responses from experienced mass timber owners/ developers. Figure 4.14 shows the number of project experiences for this category of participants. We also discussed about their experience with mass timber projects with respect to cost, construction methodology, financial viability of the overall project, barriers, supply chain issues and their preference for choosing mass timber construction. Figure 4.15 shows the most important criteria for choosing mass timber construction. Although these owners/ developers mentioned multiple reasons, we asked them to choose the most important one among these. None of the participant choose lower cost for adopting mass timber construction. 50% of the mass timber owners' developers choose aesthetic appeal as the most important criteria for choosing mass timber construction. 33% and 17% choose sustainability and higher future returns as the most important factor for choosing mass timber construction. This diversity of perspectives underscores the multifaceted considerations driving the adoption of innovative construction methods in the industry which mostly includes aesthetic appeal as the most important factor for choosing mass timber construction.

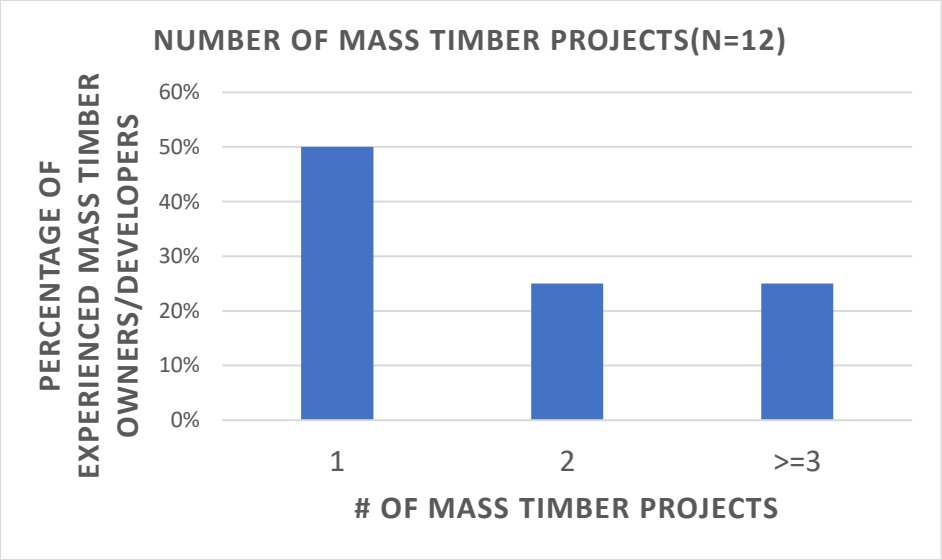

Figure 4.14: Experienced mass timber owner/developers' number of project experiences

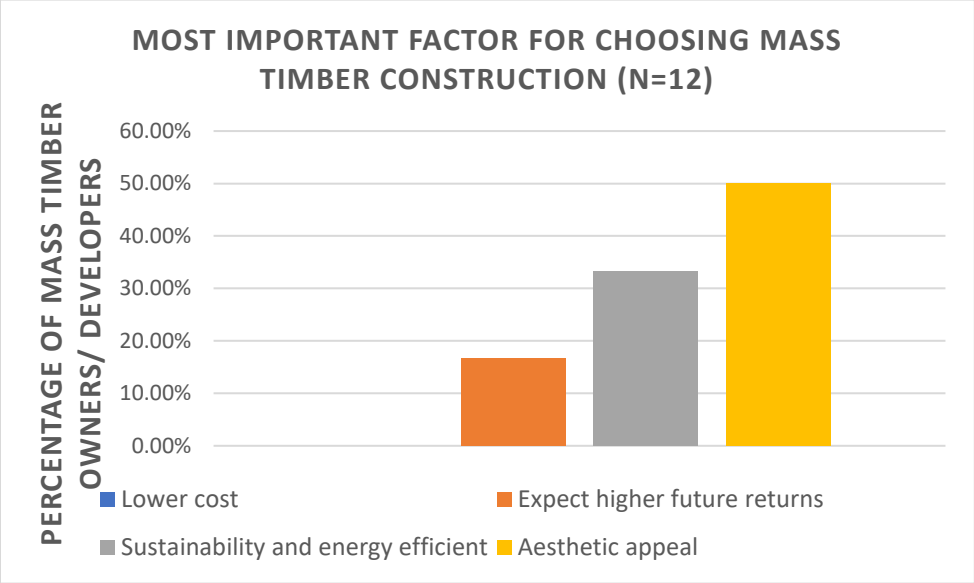

Figure 4.15: Most important factor for choosing mass timber construction

We also divided the barriers faced by the mass timber owners/ developers into distinct groups: a) supply chain barriers b) building codes and zoning regulations c) Inexperienced contractors/ engineers d) Higher premium for labor, material costs. We then systematically recorded the responses of owners and developers within each of these categories to gain insights into the challenges they face when considering mass timber construction (Figure

4.16). Most of the developers faced issues like supply chain constraints where they had to procure materials from the distant places or other countries like Canada/Austria, much higher premium in the form of advanced labor/ machinery like higher cranes and materials costs. Very few of them had issue with following building codes and regulations.

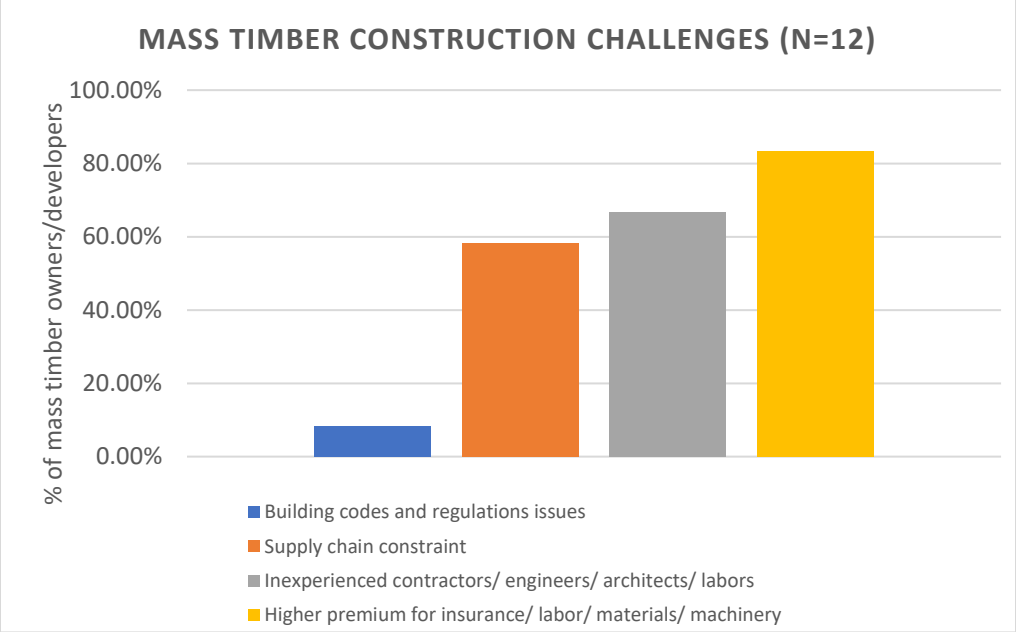

Figure 4.16: Barriers faced in mass timber construction

4.5.3 Case Study Related (Quantitative) Interview Outcomes and Analysis.

In the final stage of comprehensive analysis using this study, we recorded the responses from all kinds of developers/ owners using the total cost of ownership questionnaire developed for the case study buildings. To mitigate and reduce their biasedness for the construction material, we designed the questionnaire in such a way that the type of materials used in construction was hidden from the owners and then revealed to them for rechoosing their strategy. Using this strategy, we insured that participants don't get biased towards certain construction material. When material was not revealed to the participants, based upon the initial construction cost/capital cost, majority of the participants choose the one with lower

costs (concrete/steel). Since they look for profitability, they choose the one with lower cost. But after revealing the materials, 40% of the participants migrated from cheaper construction material like concrete to higher cost materials like hybrid steel timber/ mass timber construction. Figure 4.17 shows the % of participants choosing building materials before and after revealing materials. Major reasons realized for this shift was sustainability and aesthetic appeal for hybrid steel timber/ full mass timber scheme.

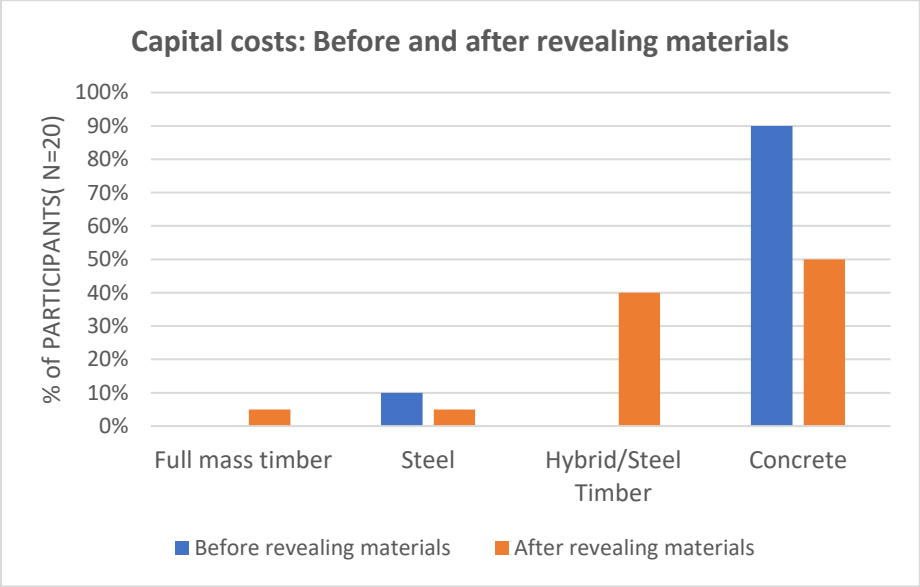

Figure 4.17: Owners/ developers preferences before and after revealing material based upon capital costs

Further to make effective comparison for total cost of ownership, we divided participants in two categories i.e., short-term (0 to 20 years) and long-term ownership (40-end of life). The questionnaire was divided into these two categories so that short term owners did not worry about long term ownership costs and vice versa.

a) Short term owner's questionnaire outcomes

For short term owners, total cost of ownership interview was distributed among them based upon their number of years of ownership preferences. Discount factor was assumed to be

10% as baseline scenario for all the short-term owners. Majority (67%) of the short-term owners selected hybrid/steel timber or timber as their best choice among all of them since they found reduced total cost of ownership. Around (17%) of them selected concrete/steel as their best choice of material because of its low capital cost and their inexperience with mass timber. Majority of them selected timber because of its low operating cost and high resale value compared to concrete/steel.

We have dived further in this comparison, by fluctuating the discount rate from 10% to 15% and 20%. Both the higher discount rates (15% and 20%) had similar kind of preferences. But there was minor shift from mass timber to concrete construction for these higher discount rates. It was realized that for higher discount rates, concrete construction had less total cost of ownership as seen from the below table. Hence it can be hypothesized using this case study that in short term ownership, if the discount rates are higher, concrete construction would be major choice among owners because of lower capital cost and total cost of ownership.

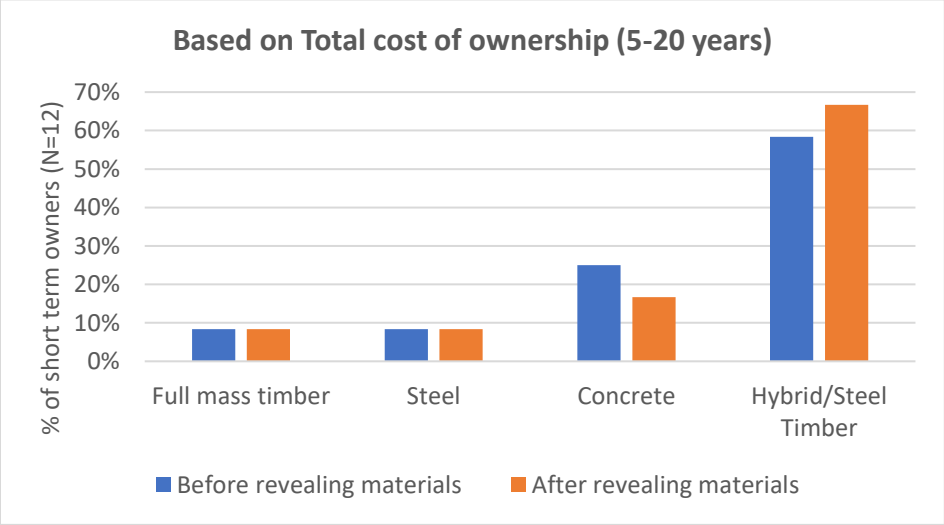

Figure 4.18: Small term owners/ developers' preferences before and after revealing material based upon total cost of ownership

	Total cost of ownership (in millions)			
Discount factor	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
20%	44.4	45.5	44.0	46.4
15%	29.1	29.8	30.6	32.1
10%	5.3	5.2	9.8	9.9

Table 4.3: Sensitivity analysis using different discount factor for short term ownership

b) Long term owner's questionnaire outcomes

Like short term owners, total cost of ownership interview was distributed among long term owners based upon their number of years of ownership preferences (20 to 60 years). Discount factor was assumed to be 3% as baseline scenario for all the long-term owners. 63% of the long-term owners selected hybrid/steel timber or timber as their best choice among all of them because of steep decrease in total cost of ownership compared to concrete/steel material. Majority of them selected timber because of its low operating cost , sustainability and high resale value compared to concrete/steel.

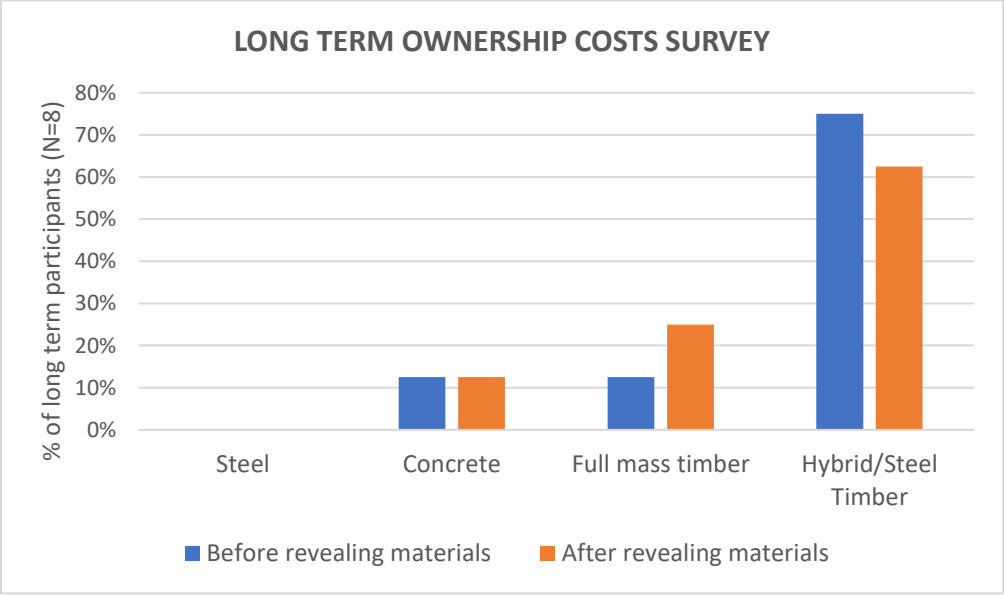

Figure 4.19: Long term owners/ developers' preferences before and after revealing material based upon total cost of ownership

Like short-term ownership, we have dived further in this comparison, by fluctuating the discount rate from 1% to 5%. All the discount rates had similar kind of preferences. It was realized that for higher discount rates, concrete construction had higher total cost of ownership and same was observed in participants choices. For higher discount rates everyone chooses mass timber as their preferred choice. Hence it can be hypothesized using this case study that in long term ownership, if the discount rates are higher, mass timber construction would be major choice among owners because of lower total cost of ownership and more sustainability characteristic of mass timber construction.

Discount factor	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
1%	206.4	207.6	220.8	224.3
2%	157.6	158.9	171.2	174.7
3%	126.0	127.2	138.9	142.4
5%	90.7	92.0	103.0	106.5

Table 4.4: Sensitivity analysis using different discount factor for long term ownership

4.6 Discussions

This section delves into the total cost of ownership for the case study building, comparing various construction materials. We conducted a sensitivity analysis to assess how different market parameters, such as discount rates, influence the overall cost of ownership. Furthermore, we explored the total cost of ownership for different types of owners—short-term and long-term—under varying market conditions. This comprehensive analysis provides insights into different ownership scenarios and their respective cost profiles.

Later in this section, we examined interview outcomes using the methodology outlined in the previous section. This evaluation gauged the current level of awareness among developers and owners regarding mass timber, while also identifying the barriers they

encounter. Additionally, we delved into the preferences and interests of owners when presented with different cost considerations within the case study. Employing a case study approach for the interview allowed us to grasp the biases of owners and developers, thereby enriching our understanding of their perspectives. These results can be used to guage the perspectives of the owners and developers regarding the emerging market of mass timber. It would thus help the stakeholders to guide their investment decision and plan accordingly for their projects.

CHAPTER 5: LIMITATIONS AND CONCLUSIONS

5.1 Limitations

The study had various limitations in estimating capital costs and total cost of ownership. Capital costs was estimated purely based upon conceptual and architectural designs. Thus, actual front-end costs for mass timber might differ after the actual completion of the project. On the other hand, total cost of ownership was estimated using various assumptions. For example, utility costs for mass timber scheme were assumed to be lower than the other schemes discussed in the study. Currently there are not many studies which comparatively analyzes the energy costs for mass timber and its concrete alternative. Because of limited studies, it becomes difficult to substantiate the energy costs for estimating total cost of ownership. Moreover, the maintenance and repair costs for mass timber construction were assumed to be similar as concrete and steel schemes because of lack of availability of necessary data for the mass timber buildings. In addition, the residual value of all the construction schemes was estimated using linear deterioration from the initial costs which factors in the average life of the buildings. Since mass timber is relatively emerging market, it is difficult to compare the building life of mass timber and its concrete alternative.

On the other hand, conducting exploratory study for understanding owners and developers' preferences by conducting interviews has its own limitations. First, there were very few numbers of participants for the interviews. Hence there are large chances of introducing biases in the analyzing the outcomes of the interviews. Second limitation was that study was not able to include all the type of companies based on its experience and size. Future research would consist of involving small, mid-sized and large size companies. Also, current

interviews were only with developers and owners, thus limiting our scope of understanding mass timber awareness, barriers, and perspectives.

5.2 Future Research and Recommendations

To enhance the robustness of the study in comparing the total cost of ownership across various construction schemes, additional efforts are needed to procure comprehensive data pertaining to the emerging market of mass timber construction. In addition to it, developing sophisticated simulation models will be imperative to accurately assess energy costs for mass timber as a building material. This would help in explore the hidden benefits of mass timber by enhancing the operational efficiency of the building. Moreover, there is a need to identify market returns and perform financial analysis for mass timber in comparison to traditional materials. Subsequent research efforts will involve examining cash flow performance and investigating the impact of front-end costs and incentives on owner decision-making processes. As our study analyzes only total cost of mass timber buildings compared to its alternative, more research should be done in analyzing the cash flow in mass timber construction and estimate key financial metrics like internal rate of return or cap rate which could help developers and owners in making key decisions for adopting mass timber as a building material.

Future research endeavors should include a diverse array of stakeholders, encompassing individuals with varying levels of expertise, to garner deeper insights into mass timber materials. Thus, expanding the participant pool will afford a more representative depiction of the actual perception and awareness of mass timber within the US construction market. Our study would help other researchers and owners/developers to assess the drawbacks of

the current situation of mass timber in US and the action plan needed to fill in the existing gaps.

5.3 Summary

This study was structured into two distinct phases.

1) The first phase aims to evaluate the cost profiles of mass timber buildings by conducting a comprehensive Total Cost of Ownership (TCO) analysis, comparing them against various alternative construction materials.
2) The second phase focuses on conducting an exploratory study which understand barriers encountered by developers and owners while also discerning their preferences through case studies based on total cost of ownership.

Through this study, it was realized that traditional construction materials like concrete/steel had lower front-end construction cost or capital cost compared to mass timber. The study revealed that the construction cost with the Hybrid Steel/Timber scheme was slightly higher compared to concrete and steel by 6.8% and 0.41%, respectively. Similarly, the full mass timber scheme was found to be more expensive than concrete by approximately 9.90% and steel by approximately 3.34%. But comprehensive TCO analysis was found to be effective measure to understand the overall cost benefit of mass timber in both short-term and long-term. The findings also indicated that the long-term total cost of ownership for mass timber construction was lower than that of concrete. Specifically, compared to concrete, the Hybrid steel/timber scheme saved approximately 10%, while the Full mass timber scheme saved approximately 8.43%. By sharing the case study with owners/developers participated in this research, we found that in the longer period, their interest grew more in mass timber construction due to its reduced operation/maintenance cost and higher yield in the market

compared to traditional materials. Notably, a stronger inclination towards mass timber construction was observed when the intention of construction was owing it for longer period or till end of life, which usually consist of universities and public institutions. On the other hand, we also found that there was shift in interest from traditional materials to concrete when total cost of ownership analysis was presented to short-term owners whose motive is generally to realize capital gains from owning the building.

To the best of our knowledge, this is the first of its kind comprehensive study which tries to address the cost uncertainties related to mass timber construction among developers/owners. It made sufficient effort to bridge this gap, by sharing these case studies with developers/owners and understand their barriers and interests. Using the interview outcomes, we found following barriers faced by stakeholders in adopting mass timber construction:

1) Higher front-end cost

2) Supply chain constraints like availability of mass timber

3) Higher premiums for material/contractor/labors/machinery etc.

4) Contractors/ designers/ laborer's lack of experience in building mass timber construction.

To address the current challenges associated with mass timber construction, we recommend focusing on developing industry-wide standards, enhancing education, and raising awareness. These efforts will bolster the acceptance of mass timber buildings within the construction sector. Moreover, stakeholders emphasized the necessity of establishing additional timber manufacturing facilities across the country. By expanding manufacturing plants nationwide, material availability can be improved while reducing transportation

costs. This expansion would also contribute to mitigating the prevailing high prices of engineered wood products. Furthermore, enhancing coordination among project stakeholders is essential for effectively addressing the existing challenges in mass timber construction.

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APPENDIX A: Interview Questionnaire

Qualitative Questions

1. Details about company demographics like # of employees, industry experience, mass timber knowledge. What is the preferred # of years of ownership for investing?
2. Do you have any mass timber project experience? If yes, how many?
3. What factors guide your decision-making process when choosing between mass timber, concrete, and steel in construction, and what specific reasons contribute to your selection?
4. What obstacles do you see in adopting mass timber construction?
5. How do environmental attributes like carbon sequestration impact your decision to use mass timber construction?
6. Do zoning regulations hinder the use of Mass timber construction?
7. Do building codes prevent you from using Mass timber construction?
8. Does lack of experience deter you from using Mass timber construction?
9. Does the contractor/designers/architects lack of experience anywhere in project team affect your decision on Mass timber construction?
10. Do supply chain issues for Mass Timber in the US impact the use of mass timber construction projects?
11. Which cost-related decisions and financial impacts are considered when selecting construction projects?

Decision Making Exercise based upon owners:

For all type of owners:

1. Below is the initial investment cost for different building designs. Which building would you prefer and why?

(In Millions)	Building A	Building B	Building C	Building D
Capital Cost	73.17	75.30	68.51	72.87

2. Below is the initial investment cost for different building designs. Which building would you prefer and why?

(In Millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87

Questions for short term owners:

a. 5 years

1. Which building type will you prefer to construct based on total cost of ownership of 5 years with discount factor of 10%? And why?

(In millions)	Building A	Building B	Building C	Building D
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	4.68	4.68	4.93	4.93
Resale Value at 5th year	-74.48	-76.64	-68.02	-72.34
Total cost of Ownership (5 years)	3.38	3.34	5.42	5.45

2. Now if you know the following building materials/types for the above scenario. Which would prefer now and why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	4.68	4.68	4.93	4.93
Resale Value at 5th year	-74.48	-76.64	-68.02	-72.34
Total cost of Ownership (5 years)	3.38	3.34	5.42	5.45

3. Which building type will you prefer to construct based on total cost of ownership of 5 years with discount factor of 7%? And why?

(In millions)	Building A	Building B	Building C	Building D
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	4.94	4.94	5.20	5.20
Resale Value at 5th year	-83.19	-85.61	-75.97	-80.80
Total cost of Ownership (5 years)	-5.07	-5.36	-2.25	-2.73

4. Now if you know the following building materials/types for the above scenario. Which would prefer now and why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	4.94	4.94	5.20	5.20
Resale Value at 5th year	-83.19	-85.61	-75.97	-80.80
Total cost of Ownership (5 years)	-5.07	-5.36	-2.25	-2.73

5. Which building type will you prefer to construct based on total cost of ownership of 5 years with discount factor of 15%? And why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	4.30	4.30	4.53	4.53
Resale Value at 5th year	-62.34	-64.16	-56.94	-60.56
Total cost of Ownership (5 years)	15.13	15.44	16.10	16.84

b. 10 years

1. Which building type will you prefer to construct based on total cost of ownership of 10 years with discount factor of 10%? And why?

(In millions)	Building A	Building B	Building C	Building D
Capital cost	73.17	75.30	68.51	72.87
Operation Cost	8.29	8.29	8.70	8.70
Resale Value at 10th year	-76.14	-78.35	-67.40	-71.68
Total cost of Ownership (10 years)	5.33	5.25	9.82	9.89

2. Now if you know the following building materials/types for the above scenario. Which would prefer now and why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital cost	73.17	75.30	68.51	72.87

Operation Cost	8.29	8.29	8.70	8.70
Resale Value at 10th year	-76.14	-78.35	-67.40	-71.68
Total cost of Ownership (10 years)	5.33	5.25	9.82	9.89

3. Which building type will you prefer to construct based on total cost of ownership of 10 years with discount factor of 7%? And why?

(In millions)	Building A	Building B	Building C	Building D
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (10 years)	9.32	9.32	9.77	9.77
Resale value at 10th year	-97.65	-100.49	-86.44	-91.94
Total cost of Ownership (10 years)	-15.16	-15.87	-8.16	-9.30

4. Now if you know the following building materials/types for the above scenarios Which would prefer for TCO for 10 year with discount factor of 7% and why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (10 years)	9.32	9.32	9.77	9.77
Resale value at 10th year	-97.65	-100.49	-86.44	-91.94
Total cost of Ownership (10 years)	-15.16	-15.87	-8.16	-9.30

5. Which building type will you prefer to construct based on total cost of ownership of 10 years with discount factor of 15%? And why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (10 years)	6.97	6.97	7.31	7.31
Resale value at 10th year	-51.03	-52.52	-45.18	-48.05

Total cost of Ownership (10 years)	29.11	29.75	30.65	32.13

c. 20 years

1. Which building type will you prefer to construct based on total cost of ownership of 20 years with discount factor of 10%? And why?

(In millions)	Building A	Building B	Building C	Building D
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (20 years)	12.86	12.86	13.44	13.44
Resale value at 20 years	-79.57	-81.88	-66.18	-70.39
Total cost of Ownership (20 years)	6.47	6.28	15.77	15.92

2. Now if you know the following building materials/types for the above scenario. Which would prefer now and why?

(In million)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (20 years)	12.86	12.86	13.44	13.44
Resale value at 20 years	-79.57	-81.88	-66.18	-70.39
Total cost of Ownership (20 years)	6.47	6.28	15.77	15.92

3. Which building type will you prefer to construct based on total cost of ownership of 20 years with discount factor of 7%? And why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (20 years)	16.07	16.07	16.78	16.78

Resale value at 20 years	-134.56	-138.47	-111.92	-119.04
Total cost of Ownership (20 years)	-45.32	-47.10	-26.63	-29.39

4. Which building type will you prefer to construct based on total cost of ownership of 20 years with discount factor of 15%? And why?

(In millions)	Hybrid Steel/Timber	Full Mass Timber	Concrete	Steel
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (20 years)	9.43	9.43	9.87	9.87
Resale value at 20 years	-34.19	-35.19	-28.44	-30.25
Total cost of Ownership (20 years)	48.41	49.55	49.95	52.49

Long term owners

a. 40 years

1. Which building type will you prefer to construct based on total cost of ownership of 40 years with discount factor of 3%? And why?

(In millions)	A	B	C	D
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (20 years)	49.89	49.89	51.52	51.52
Residual value at 20 years	-43.90	-45.18	-31.97	-34.01
Total cost of Ownership (20 years)	79.16	80.01	88.06	90.38

2. Now if you know the following building materials/types for the above scenarios Which would prefer for TCO for 40 years with discount factor of 3% and why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87

Operating Cost (20 years)	49.89	49.89	51.52	51.52
Residual value at 20 years	-43.90	-45.18	-31.97	-34.01
Total cost of Ownership (20 years)	79.16	80.01	88.06	90.38

3. Which building type will you prefer to construct based on total cost of ownership of 40 years with discount factor of 5%? And why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (40 years)	34.34	34.34	35.55	35.55
Residual value at 40 years	-43.90	-45.18	-31.97	-34.01
Total cost of Ownership (40 years)	63.61	64.46	72.09	74.41

4. Which building type will you prefer to construct based on total cost of ownership of 40 years with discount factor of 7%? And why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (40 years)	24.96	24.96	25.89	25.89
Residual value at 40 years	-43.90	-45.18	-31.97	-34.01
Total cost of Ownership (40 years)	54.23	55.08	62.43	64.76

60 years

1. Which building type will you prefer to construct based on total cost of ownership of 60 years with discount factor of 3%? And why?

(In millions)	A	B	C	D
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (60 years)	82.06	82.06	84.14	84.14
Residual value at 60 years	-29.27	-30.12	-13.70	-14.57
Total cost of Ownership (60 years)	125.96	127.24	138.95	142.43

2. Now if you know the following building materials/types for the above scenarios Which would prefer for TCO for 60 years with discount factor of 3% and why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (60 years)	82.06	82.06	84.14	84.14
Residual value at 60 years	-29.27	-30.12	-13.70	-14.57
Total cost of Ownership (60 years)	125.96	127.24	138.95	142.43

3. Which building type will you prefer to construct based on total cost of ownership of 60 years with discount factor of 5%? And why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (60 years)	46.77	46.77	48.16	48.16
Residual value at 60 years	-29.27	-30.12	-13.70	-14.57
Total cost of Ownership (60 years)	90.68	91.95	102.97	106.45

4. Which building type will you prefer to construct based on total cost of ownership of 60 years with discount factor of 7%? And why?

(In millions)	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost	73.17	75.30	68.51	72.87
Operating Cost (60 years)	29.90	29.90	30.91	30.91
Residual value at 60 years	-29.27	-30.12	-13.70	-14.57
Total cost of Ownership (60 years)	73.80	75.08	85.72	89.20

5. Which building will you prefer based on life span and front-end construction of the mentioned scenarios?

	HYBRID STEEL/TIMBER	FULL MASS TIMBER	CONCRETE	STEEL
Capital Cost (In millions)	73.17	75.30	68.51	72.87
Life span	100	100	75	75

APPENDIX B: Interview Coded Transcripts

Interview

Interviewee: Hello, hello.
Interviewer: Hi. Thank you for taking time today. So, I will get started. Could you explain what type of your company is and like, do you have employees and how many employees?
Interviewee: I'm over the Planning Design and Construction Department, which is probably about 50 employees within our group.
Interviewer: Oh, that's, that's good to know. Yeah. So have you heard about mass timber buildings? Yes. And so have you like involved in any mass timber projects? And like, Do you have any experience in the mass timber projects?
Interviewee: Yes. So, University has two completed mass timber buildings on campus. We have another building in construction right now that has some mass timber in it. And we're about to start construction on a new forestry building, which will be predominantly mass timber.
Interviewer: Oh, that's great. So from that? So let's suppose if some, so do you invest in the mass timber projects? Or is there someone else? Like who invest in this mass timber project?
Interviewee: No. I mean, it's all university funded. So yeah.
Interviewer: Oh, okay. So all these buildings, like how many years of ownership, they look for, like, how many years they want to own the building, like five years or 10 years? It's, for
Interviewee: us. They're their permanent long-term buildings. So
Interviewer: we need to university granting So 100 years. Oh, okay. You're building? Okay. I see. Probably in that case, I think mass timber makes more sense. Okay. So. Yeah.
Interviewer: Okay. Apart from that, let me ask a few more questions. So let's suppose you do a mass timber construction? Are there any obstacles do you face like, in the mass timber projects?
Interviewee: You know, no, I kind of feel like we're past the major obstacles. I mean, we, you know, the fact that we've got two that are completed already, you know, we don't have any kind of resistance to the concept of it. You know, and, and so now, a lot of the architects and contractors that work with us know that we're pretty comfortable with it. So really, it kind of, you know, just becomes part of the equation that we look at that structurally. And does it make sense? You know, cost wise, schedule wise, etc?
Interviewer: Oh, okay. So are there any, like supply chain issues? For the mass timber projects? Do you face because I know they like in USA, the mass timber haven't been grown properly. So are there any issues like regarding like supply chain or navigating? Who is the suppliers?
Interviewee: I wouldn't say I've noticed that any more than any other supply chain issues that we have, you know, with steel, or HVAC or electrical equipment. And I think the fact, you know, our construction manager at risk that we use are pretty kind of savvy regarding that supply chain, you know, any kind of scheduling delays. So we do kind of early packages to make sure that we can get the material on site when we need it. Oh,
Interviewer: okay. I see. That's good to know. So, I like there are certain building codes, I think, which have been introduced for the master buildings in 2021. So are those like followed during the mass timber projects? Yes. What sort of codes like our safety regulations are followed for this kind of projects.

Interviewee: I mean, South Carolina, we just fall International Building Code. I think it's the 2021 edition. So, um, you know, again, the fact that we've got two completed projects, we haven't run into any major issues we just had. We just did have to go back to our our code official Regarding CLT panel, you know, a two hour rating around an elevator, but they were able to resolve that issue. So, okay,
Interviewer: and what kind of like materials is it, the whole building is just from like using the CLT and glulam? Or is it like a hybrid kind of structures like, where you have steel, and you have mass timber combined both.
Interviewee: So our first two buildings that we did on campus, those are both full mass timber buildings. The one that's in construction right now, which, which is our visitors and Alumni Center, it's a hybrid. So it's kind of more strategically using the mass timber in the lobby, and then on the upper level, and then the, the new forestry building that we're about to break ground on. We basically have kind of a partial basement, that's concrete, and then from there up, it's mass timber.
Interviewer: Oh, okay. So, if I remember correctly, like one of the building has been constructed, and other going on,
Interviewee: yet two are constructed and one is in construction, and we will see for any,
Interviewer: like price difference between, like, the cost of my concrete buildings, compared to the mass timber buildings, is there any gain or like the mass timber buildings are much more pricier than the concrete ones, you
Interviewee: know? Well, and we tend to probably more compare it to steel. So we haven't seen major, it does tend to be a little bit more expensive, but I think, you know, we're kind of on board with kind of leading the way with the mass timber. So especially with a forestry building, where it's worth a little premium to, to, to be able to use that. And we do try and make sure we capture all the costs, that it's not just steel compared to the wood, you know, we're going with the wood, you know, there's acoustical properties of the wood, there's, you know, the fact that, you know, we may not even have any kind of ceiling treatments, we're not doing like lay in ceiling. So we're trying to make sure we capture all of those associated costs, and we're really comparing, you know, apples to apples. Yeah, I
Interviewer: see. So, in the end, like, I can assume like mass timber might be slightly costlier than the concrete ones. Yeah. Okay. So, so during the whole construction projects, like, do the contractors and the other entities like, stakeholders, were they like incapable of? Or did they have any lack of experience while construction constructing these mass timber projects? Um,
Interviewee: I do think on the building, we did have some, some issues with the erection. In fact, I think it was that some of the structure wasn't properly stabilized. So we had some components that fell over. But I think even that, you know, the contractors are getting a lot more savvy with it as they get more experience. So most of the ones that we're using have some experience with mass timber. Oh,
Interviewer: okay. That's good. Let me see more. So, I will be like sharing my screen and asking more like quality quantitative type of questions so that we can go into more depth of this mass timber projects. So, okay, let me share my screen. Let me now explain this data is about 14-story building comprised of a 3-story concrete podium, we have assumed this building is in Madison Wisconsin. It consists of 4 different schemes. The schemes are hybrid steel/timber, full mass timber, concrete, steel. So let me just explain, for hybrid steel timber scheme the beams and column are made of glulam and framing is made up of steel. And for

mass timber the beams and columns are made up of glulam and framing is made of glulam and braced steel framing.
Interviewer: okay, can you see the slide? Like, right now? Just a second.
Interviewee: Now I do. Okay.
Interviewer: That's good. Okay, so let's suppose I give you this for scenarios, like when in each scenario, we use different kinds of building materials. So what would you prefer, like based upon just this capital cost or the initial construction cost for this for buildings?
Interviewee: Well, yeah, I would say it kind of depends on what budget I had established. I certainly would be going for a building See, which is less expensive.
Interviewer: Yeah, okay. So now like, as you have chosen, like building C, which is probably the concrete building, which have like the minimum, less cost. But now like we revealed the materials, like what kind of materials they are. So the first one is like hybrid steel timber, which we have discussed earlier, right. And the full mass timber where the whole construction, it's of CLT and glue lamb. This is concrete, and the fourth one, it's mostly the steel and a little bit of concrete in it. So, based upon this material revealing, which type of building would you prefer them?
Interviewee: You know, if I had a customer on our campus that was really into the mass timber, and we'd accounted for that in our initial, you know, cost estimates, then I would certainly be all for the full mass timber.
Interviewer: Okay, I see. Okay, let's open a different presentation. So just a second.
Interviewer: Okay, I shouldn't have opened this one. Okay. Now, let's suppose we want to analyze my, the whole construction cost, like, let's suppose the building is constructed today, and 40 years from now, what will be my total operation costs and those costs we have considered for our scenario? So ah, here like we are developing models, where we revealed like, my initial capital cost. Sorry, this is 40. Yes, don't, it's written? It's not right. So we have an operating cost, and what is the residual value of the building, which basically means how much value is left in the building? When you are going to sell that building? Probably after 40 years? So this is that value? And we give, what is the total cost of ownership? Like, how much cost you have, how much money you have spent, for the whole 40 years of ownership of this building? And we consider this discount factor of 3%? I'm not sure if you're aware about what is this discount factor? Or do you want me to go into detail about what is yeah, I'm not sure what that discount factor is. So the discount factor basically means it's a basically risk factor of the market. So if you have like, heard about the time value of money, so basically, the money is worth more today than money is worth tomorrow, right? Because there is inflation and the money is less what tomorrow. So we've basically considered different market scenarios where like, if the market is more risky, my discount factor will be much more higher like it can go till 10% or 15%, based on the market risk. So basically, you can think this is a market risk, and we use this market risk and do 40 years of like total cost of ownership analysis on this for buildings. Now, based upon this, which building will you choose among this A, B, C, and D?
Interviewee: I mean, b, And, you know, residual value at a university is less of an issue and less work trying to consider if we're going to, you know, put some more invest more in a building or we're just going to take it down. But operating costs is definitely an important upfront consideration. So I think really B. Okay,

Interviewer: so you said like, residual value is not much of concern for the university. Right. Right. Because they don't sell the building after the years of ownership. Right. Oh, okay. I see. Yeah, but that's good to know, a
Interviewee: permanent asset unless we, we take it down. It's pretty rare for us to be selling selling a building.
Interviewer: Okay, I see. Yeah, probably in this question. It's probably the Same as before, like he revealed the building materials like the first is hybrid steel, the second is full mass timber, concrete and steel. So, I hope your answer would be seem like okay, yeah. So, this is like a 40 years of ownership if you own the building now, let's suppose the market changes like there is a lot of risk in the market. So, instead of 3%, let's suppose the market risk is like 5% or you can say the discount factor is 5%. So, as compared to the 3% like we can see, the prices have changed for this different buildings. Now, probably, which building would you try to choose among these buildings, I
Interviewee: would still kind of be with B.
Interviewer: Yeah, I assume like, the market risk plays an important rule for choosing the buildings, because let's suppose the market risk are higher in the future. Probably it would make more sense to you choose probably mass timber and hybrid steel, timber, right. Okay, because, like, if you see in the previous slide, probably when 3% The cost was around like 80 millions for owning the building for 40 years. And all these values are basically we are considering the present value of the future cost. Basically, that means, like, whatever cost you are incurring in the future, yours, those are discounted, basically means that because those costs would not be in the same amount you're measuring today, because as we have discussed that money today is matters more than money tomorrow, probably. So. Okay, I see in which direction you're trying to go. That's more helpful. Now, let's suppose the market scenarios like it changes by 7%. And we see a quite a difference between my hybrid steel and mass timber. So probably, I think in the same scenario, you would try to choose these two options, right? Yes. Okay.
Interviewee: yeah, I would still kind of be with B as it is more sustainable and aesthetic compared to other options.
Interviewer: Okay, I see. That's it, I think. Okay. Yeah, it was really nice talking to you and you You told your experience with the mastering but it was really helpful. Good.
Interviewee: Well let me know if you have any other questions. Yeah, surely.
Interviewer: Yeah. Okay. Really helpful. Yes. Great. Good luck. Okay. Thank you. Thanks. Bye

Interview

Interviewee: Hello, how are you?
Interviewer: hello. Hi, how are you? Yeah, I'm good. How about you?
Interviewee: I'm good. Happy Friday.
Interviewer: Yeah. Happy Friday. Yes. So yeah, before we get into like the discussion, can you describe? Can you tell us a little bit about, like your company, what you do? And like, how many employees that are working for the company?
Interviewee: Yeah, sure. So my, our, our parent company is called xx. It's a company that my husband and I own. We're a commercial real estate company that we're now you know, foray into development. So this is our first development from scratch. And the development is calledxx. And it's a 30 acre development project. That includes a condo building comprised of mass timber, a multi use building comprised of mass timber. A xx services comprised of mass timber feature hotel comprised of mass, timber, et cetera, et cetera. So

that development is our main project right now. And we have currently, between contractors and straight employees, we have about 100 people working on site.
Interviewer: Oh, that's great. So are you like from the contractor side? Or like, Are you the developer and give the project to the subcontractors for the project?
Interviewee: Yeah, I'm the developer. Oh, okay.
Interviewer: I see. It's good to know. So do you know, like, where these projects are based on like, mostly, are they in Michigan, or so minutes?
Interviewee: They're actually all of our mass timber projects are on one site in Michigan. Oh, okay. I
Interviewer: I see. That's good to know. Okay. So, can I know a little bit about your mass timber projects? Like, how many of them are like, Are you involved in the concrete construction as well? And like, how many years of experience do you have with it?
Interviewee: So now I have three full years of experience. But before we started, we had zero experience with mass timber. We just really were passionate about, you know, using mass timber for the aesthetic and also afford the environmental components. And so, you know, now I have three years working on all parts and pieces of the project. You know, I helped, I helped the architects I worked on the site. I mean, I didn't like pound nails in but, um, I worked. You know, I'm working on site prep and everything I work with and direct all of my contractors. I worked with the city to basically help them get familiar with building codes regarding mass timber. So I've worked in basically every aspect of mass timber at this point. Oh,
Interviewer: okay. That's good. Yeah, actually, there are very few people in the market I think who work on mass timber, but it's good to know like, the couple of them as well. Okay. So so if you like, invest in some properties, or like if you construct some buildings like how many years do you plan to own the building like Good, who keep hold on the building and then sell in the market? So I'm just one I just wanted to understand like, how many years of ownership do you look for? Like, is it a short term? Or like long term?
Interviewee: Yeah, that's a good? That's a good question. Our project lies in a qualified opportunity zone. And so in order for those opportunities and benefits to mature, you need to hold on to the project for at least 10 years. So we'll be holding on to the project for at least 10 years. The only thing that is different from that is that the condos, the kind of building that we have, we're selling unit by unit. So obviously, those we don't retain ownership of.
Interviewer: Okay, so I feel like those condos, like it will be just like to one or two years of ownership and then sell it or like probably after the construction, you sell it, right.
Interviewee: Yeah, we're actually we actually sold some pre construction even.
Interviewer: Oh, okay. Okay. Okay. So, yeah, I will try to get into more like, general more in depth of discussions. So, in this MasterMap construction projects are like, have you faced any difficulties? Like in decision making, like, whether you want to choose mass, timber or concrete? have you faced any dilemma? While doing the project? Was there any specific reason like you chose mass timber projects, rather than the concrete once?
Interviewee: Yeah, that's another good question. You know, we wanted to use mass timber from the start, because we are developing right on the water. And, you know, when we develop a property right on the water from scratch, you want to make sure that, you know, you're, we wanted to increase Commerce on the water. But we also wanted to reduce our environmental impacts as much as possible, because we have, you know, a site that's really

beautiful public access to the waterfront kind of site. So we just really wanted to reduce those environmental impacts as much as possible. And then the secondary benefit for mass timber is that it's really beautiful. Yeah, you know, it's a really beautiful aesthetic. And it kind of fit kind of our Scandinavian sort of design that we had for the project. But I will say it came with its own batch of challenges, you know, it's, our building codes were definitely not up to the standards that they needed to be for mass timber to be built easily. So our building department here in our small town of Muskegon needed to be educated on mass, timber, and all aspects of it. In order for this to happen, I mean, this is a partnership that we've had with the city's building department for going on three years now of education and held hand holding to make sure that you know, that this would actually could actually be executed. We have the first residential mass timber building in the state of Michigan. We also have the first restaurant mass timber restaurant in the state of Michigan. So you can imagine that, you know, these, these things were all challenges that our building department and our city officials had to really overcome. And we had to kind of handhold them through the process. The one thing that helped is that we partnered with an architectural firm and construction firm in Milwaukee, who had just gotten done building ascent, which was, you know, it's the tallest mass timber building in the world. So we actually reached out to the City of Milwaukee and they helped our city actually understand how mass timber works.

Interviewer: Oh, okay. That's, yeah, I think there is a lot of construction going on in mass timber in Milwaukee probably. Okay. Yes. Okay. Yeah, we'll get into like, more specific of these details you have just mentioned, like, the obstacles you faced in the mass timber construction. Sure. I remember you said that the building codes were not available to the contractors or like they were not aware aware of the building codes. So. So other buildings like compliant with this type four be I think, for see if I'm not. Okay. So, other like, during this whole process? Did you find like the contractors were inexperienced with the mass timber construction?

Interviewee: Yeah, that was the other thing I was going to say. So we yeah, we actually we hedge our risk by hiring capitalist construction, who again had just finished constructing the tallest mass timber building in the world at the at a cent. So you know, they're just for us. Just a fairy right away because we live in Muskegon, and there's a ferry that goes from Muskegon to Milwaukee, so we actually hired them to be our general contractor. But of course, they don't self perform needed a lot of subcontractors that are from the area and so you It was really their job to make sure that all of our sub contractors were educated. And what happened was, when we got bids back on, you know, say MEPs, and things for this, these buildings, we found that contractors were bidding these out very, very high. And it was not because mass timber or working with mass timber is more expensive. It's because they weren't experienced with it. And so they over budgeted just to cover their risk, basically. So, you know, we had to work down contractor quotes, I mean, by hundreds and hundreds of 1000s of dollars for each, each quote, and that involves a whole series of educational processes as well, making sure that our subcontractors were also comfortable with what they were bidding.

Interviewer: Okay, I see. Yeah. Okay. So apart from this, like issues with the management, with the construction, like mass timber construction, Did you face any, like supply chain issues with procuring the mass timbers or any sort of like that? Or was it handled by the con subcontractors or contractors? Yes,

Interviewee: so initially, I will say, No, we did not because we were, we worked with element five quite early in the process to try to get a slot, a production slot. But the thing that we ran into is, again, because a lot of our local people are relatively inexperienced, it took a while to get se engineering on board. And of course, you know, that engineering, these buildings need to occur before we can get into production. And so the engineering took far longer than really it should have. And it was because of the inexperience at the firm. So it ended up that we didn't get quite the production slot that we wanted through element five. And I think element five is also very busy, because Michigan has kept them very busy with our explosion and projects. And so I don't think they could quite keep up with with our demand. Of course, we're building multiple mass timber buildings at once. So we did get a little bottleneck and had to think really creatively and outside of the box to make sure that element five could continue procuring the mass timber at the rate that we needed it. Okay,
Interviewer: so most of the procurement, I believe, was done from the Michigan and not like, much from the outside. Is that right? Or was it from like, far away from Michigan?
Interviewee: So they they were, are you asking, like, where we got the timber from? Or you mean, we're
Interviewer: No, I don't want to get more into like, like, who was the one? I just want to know, like, was there like a wrong route for supply chain? Or like, were you able to procure from the local or the regional vendors?
Interviewee: Oh, yeah, we we were able to procure everything from regional vendors. So element five is out of Toronto, not too far away. The only problem was because we were requiring so much mass timber at once. They did have to get some timber from Austria.
Interviewer: Oh, okay. I see. Okay. That's good to know. So yeah, just one last, like, qualitative question I want to ask like, so. What was your experience with overall, like financial and cost impact with the like, for this mass timber projects? Like, what do you believe? Like, how much it was expensive compared to the concrete construction? Or was it better than the concrete ones?
Interviewee: So that's a really interesting question. And this is probably relatively specific to the point in time in which we decided to build when we decided to take on this project, it was right after COVID, where we had wild fluctuations in the market when it came to commodities pricing. So lumber was all over the place, concrete was all over the place. The interesting thing with mass timber is that because it's a completely vertically integrated system, right, they're procuring the timber from their own forests. The price fluctuations actually didn't change, you know, they were not nearly as large as other commodities pricing. So we actually found that, while it was a bit more expensive, maybe 15% More expensive initially than regular concrete construction. By the end, it was actually cheaper, because the very variability was far less. You know, the pricing held firm, from our original quote, where the variability came in, again, is mostly from the engineering firms and experience with bidding out engineering related to mass timber. So it wasn't the timber itself that fluctuated. It was the subcontractors that were going to be doing the work inside the building that fluctuated
Interviewer: Okay, so if we just see, like, if we compare, like the overall footage, like, per square feet, like how much cost? So do you see like around like 10 to 15% more cost compared to the complete ones?

Interviewee: Yes. And I think that if we would have done things correctly from the start, meaning there are a couple of things that we had to redo, I think it would have been come out about the same. But the way our price increase came in was the fact that we needed like brackets remade. Our brackets were, it was either the brackets that weren't made correctly, or the timber was not drilled. Completely correctly, and when we dry fit that timber to the brackets on site, they didn't fit. So we actually needed to purchase new brackets that would fit the timber. And so of course, that added some cost. But I think overall, I don't think I mean, if we didn't have that, I don't think it would have really been that much of a difference just because of the increase in costs for all of these other commodities.
Interviewer: Okay, I see. Yeah, thanks for the great answers from you. Okay, so now probably, So, I will be like sharing my screen and asking more like quality quantitative type of questions so that we can go into more depth of this mass timber projects. So, okay, let me share my screen. Let me now explain this data is about 14-story building comprised of a 3-story concrete podium, we have assumed this building is in Madison Wisconsin. It consists of 4 different schemes. The schemes are hybrid steel/timber, full mass timber, concrete, steel. So let me just explain, for hybrid steel timber scheme the beams and column are made of glulam and framing is made up of steel. And for mass timber the beams and columns are made up of glulam and framing is made of glulam and braced steel framing. And let me share my screen and we can discuss more about the case study. it's the same building, and this is the initial investment cost for different building types. So which building would you prefer from this one? And why? Can you see my screen? Yeah, I
Interviewee: mean, I would prefer the building. That's the cheapest, right? Yeah,
Interviewer: that's right. Okay. Yeah, any would have. And now probably, like, I revealed the building materials, and this was the cost, like we have found for those buildings. Like, they have made an alternative design for concrete, they're made alternative design for mass timber, and this was the initial investment cost they have found for this buildings. So which one would you prefer from this?
Interviewee: These are this is interesting, because now that I see what, what their what their they all are, you know, of course, the cheapest is the best, but yes, you know, I mean, I prefer, I would eat a little bit of cost to go with at least the the hybrid steel building. But you know, cost is, when you're a developer cost is really King, right? So you have to find a way to control these costs. Another thing, another thing that I'll just briefly mention real quick, that added cost was, people don't factor in the fact that, you know, you need cranes, larger cranes in order to produce these hired, you know, mass timber buildings. So, for us, we needed an additional crane that we wouldn't have needed with, with a traditional steel building, just because of the way the mass timber is constructed. So that added, you know, quick $100,000 to our project. And so some of these costs are, you know, not directly related to the mass timber itself, but you find end up slipping into your budget, because you don't know. I mean, for us, we didn't know what we didn't know, you know, we didn't know that we would need an additional crane, we didn't know we would need some specialized brackets. So things like that, that do add cost, but to us, it's worth it.
Interviewer: why do you think like, is it worth it? Even if the costs are higher, like for the most members,
Interviewee: um, for us, it was, again, because of the environmental impacts. And because I think we can sell the units for more than a traditional building, so you have to recoup your costs somehow, right? You're not just going to volunteer to give millions of dollars away just

to build an environmentally sustainable building. That sounds great and altruistic, but it doesn't happen. It's just not the way it works. Um, so for us, we look at the way the mass timber looks and feels and the elegance of it and we say this building is worth more in the and because of it, so we can sell the condos for more, or eventually, you know, we'll be able to sell that building for more. Because it is comprised of mass timber, that's the way that we justified it.
Interviewer: Like, it was easy to sell the mass timber because it was aesthetic, and like, people were looking for employment friendly buildings.
Interviewee: I do, I think, for us, it was mostly the aesthetic. But we are again, right on the water too. So we were able to absorb some of that cost simply because we're waterfront and we can charge more for our units. Um, you know, where it becomes difficult is in an urban setting, you know, where all the buildings are the same, except for the fact that this one has mass timber? Well, I don't know, if you're gonna be able to sell that one for very much more, you know.
Interviewer: Okay, I see. So probably, I think like, in this option, you would try to go for hybrid steel timber, because, you know, like, it have much more impact in the future, right?
Interviewee: Yeah. But I would also really try to lobby my local and state government to give me some additional funds or tax credits, to incentivize me to make up that difference.
Interviewer: This government gave like, tax, I just wanted to know, like, out of the question, like do government gives tax credit, if you have enrollment friendly materials for building
Interviewee: I currently not for mass timber, I know that we have some people that are actively lobbying for those tax credits, my lobbyist included. So you know, that's something that I think for the future, if we really want mass timber to take off in the state of Michigan, we're going to need to provide those tax credits again, because we're right on the waterfront, we have a great location, we were able to sell our units for more and recoup those costs. But, you know, a lot of people aren't able to do that.
Interviewer: Okay. Okay, now, probably like that was just for initial cost associated with the buildings. Now probably like we have analyzed the cost for five years of owning the building, and what will be the total cost associated with the five years of ownership of the buildings. So here is the scenario like where we consider capital costs, operating costs include, like, all the other costs, like repair, maintenance, electricity, water, and all those things, and the resale value is at the fifth year, but all these prices are discounted to the present value. So have you heard about, like this discount factors? Or do you want me to explain a little bit about it?
Interviewee: Hello, hey, sorry, I just switched you over to my air pods. So
Interviewer: Oh, it's okay. So, maybe I will repeat this question again. So, yeah, this is the scenario for like, five years of fully like ownership of the building and then selling it. So, here we have like initial investment costs and the operating costs for five years of ownership and the resale value at the 5 year, but all these costs are discounted to the present value, like all the future costs are discounted to the present. So, are you aware about this discount factor or do you want me to explain a little bit about this discount factors? No, no, this makes sense. Okay. So, yeah, these are like the total cost and of ownership like for five years. So, based upon this total cost of ownership for the five years, which building would you prefer?
Interviewee: Whatever costs the least that is hybrid steel.

Interviewer: Yeah, when which caused the lease okay. So now, like probably we revealed the materials and we have observed like mass timber and concrete, so mass timber or hybrid steam, timber, they gain like lot more market rates compared to the concrete like around 10%. More Oh, that's interesting. Yeah, for this kind of study, it may be like region dependent as well, but for this region, we have realized this and we have considered that fact in consideration. So we see like, by using 10% discount factor, which basically means like, each year, my inflation is basically 10% Or you want a 10% return from the project. So based upon all those things, we have revised the cost. And this is the building materials. So now probably which building would you choose among this one?
Interviewee: Yeah would go with hybrid steel timber.
Interviewer: so can I know the reason like is it just because of the cost or anything else? Yes. Okay, so I see. Yeah, probably here. Yeah, it's in negative. Maybe I won't go into this part because it gets a little bit tricky. I'm here, because we see that the discount factors matters a lot more in the so here, we initially considered a 10% discount factor, which basically means that the market fluctuate, Shin is too high, and you expect more return from the market as well. But in this study, we considered like 7%. Probably I won't go into this example, I will let me go to another example like 15%. So, and these are the total costs associated with different buildings with five years of ownership. So which building will you choose among this one? So all these costs are like discounted to the present value.
Interviewee: So I mean, yeah, go with one of the hybrid steel timbers. Okay. All right. That's the least cost.
Interviewer: Yes. So probably, I get the intuition that based upon the initial investment cost, like you would prefer concrete. But, like, four or five or 10 years of ownership, you believe that most numbers make more sense, right? Yes. Okay. That sounds good to know. Yeah, this is like another for 10 years of ownership, how the building cost will look like. So now, probably, if you see for 10 years, and you see the difference between these building prices, like after 10 minutes or so, which building would you prefer? I think probably Building A or B, because they haven't. Okay, so I just revealed the material like for those buildings, they are probably like hybrid steel or timber. So. So we can see probably, basically, to this case study that. If you like, have more like years of ownership of the mass timber, we see a lot more benefit compared to the concrete buildings, because they have less operation cost, and the resale value is more compared to the concrete buildings.
Interviewee: So yeah, this is yeah, this is exactly what I was saying with, you know, being able to sell them at a higher price. We could do that at the outset. But it's, you know, good to know that you can do that later on as well. That's great.
Interviewer: Yeah, right. So yeah, this is basically the conclusion we have found from study and probably we will take your input consideration as well. So apart from this, maybe you are not a long term like owner, but it just wanted to ask one last one or two more questions. So based upon this initial investment costs, and the life of mass timber legs full life of mass timber, I don't like. So this is the life of mass timber, which is 100 years and the concrete steel were opposite to be like 75 years. This is just a guess, like, based upon the studies, which was like, low initial investment costs are like, which lasts longer? Definitely one. Okay, I see. Okay, just one last question. Like, actually, we are doing this survey to know, like, what are the difficulties which mass timber developers owners face? And like, what, how we can proceed the research in this domain to help out all the developers? So is it possible to, like get more contacts of the developers owners from you, because we have very limited

people for the survey, if we can get more and we can realize like, what difficulties they face and we can conduct the study in a more appropriate way based upon their inputs. So do you have Yeah, sure.
Interviewee: I can I can reach out to some other contacts that I have. Did I have to be within the state of Michigan?
Interviewer: No, it can be anywhere like Michigan or anywhere in the US? Yes. All right. Great.
Interviewee: I mean, you can Yeah, I mean, I'm the we're the sole owners of of our buildings, but definitely I have other contacts. They just are another states, because we've consulted with a lot of people from a lot of other states. I'm used for mass timber just because we were the first to do this year. Yeah. As far as residential goes, so I think those contacts,
Interviewer: okay. Yeah, if you can share those contacts, like later on the email, that will be really helpful, because we don't have much now for this. So we just want to discuss with other people and see how we can help it. Okay,
Interviewee: I think I think this is this is great research that, you know, that we're doing and great, but we'll be able to share. I do know, you know, cost is king when it comes to these things. So when it comes to especially developer minded people, right, they're gonna look at At the initial costs, but I think sharing what this, you know, the overall lifespan of these buildings are and what the resale value is. People will take that into consideration as well. So it's great.
Interviewer: Yeah, that's right. Because most of the people like they think, okay, concrete, we have a lot more market, it's easy to handle things and they go for concrete, but they don't think about the long term cost, like with the mass timbers, like in the market price they capture later on years. So I
Interviewee: also think that the more experience that we get into Michigan market with subcontractors, the the more the class will be go down. Yeah.
Interviewer: Yes. Okay. Yeah. It was a great discussion with you. And, yeah, thank you. Thank you very much. Yeah. Thank you. Yeah, just you can share me the context later on the email on trajectories email. So I hope that is fine.
Interviewer: All right. Sounds good. Thanks. Thank you. Yep, yep.

Interview

Interviewer: Hello. Hey, guys. Good afternoon.
Interviewee: And I was actually going to ask you the same if you can pop in the chat, the spelling of your name and then say it again for me. Okay,
Interviewer: the spell is like, god of G Oh, you are a we gotta go. Yeah, that's right. Got it?
Unknown Speaker: Yes. Okay, thank you for sharing.
Interviewer: Okay, yeah, I will probably try to keep it short and finish it soon. So can you tell a little bit about yourself, the company you work for, and like the kind of organization is it is? Absolutely.
Interviewee: And I've been in the real estate industry for about 20 years now. And that's been as a realtor as an investor, as you know, an emerging developer and then I also am a licensed builder. So connecting all those dots within real estate. And that's led me today to work with xx. Seven Planning and Development Organization, which that is how we came to meet. And to talk about mass timber and those pieces. Were planning and development organization doing mission based work. And we are headquartered in Ypsilanti, Michigan. So we are local, we're not that far. And we are doing some good development and planning

work and I believe you have a meeting with Mark gets Huff just just soon after this one. And he'll be, he'll definitely be able to take a deep dive into the company. But I've been on board with participating in the acquisition, the asset management and the a bit of the construction management and development roles.
Interviewer: Oh, yeah, that sounds amazing. Okay, so my next question would be like, so have you heard about like, mass timber buildings? And like, if yes, have you involved in any mass timber construction project?
Interviewee: We have learned of it we again, we learned of it through Sandra with the Well, we learned about it and just doing some research about how to value engineer some projects, and what are other building materials, and what are ways that there can be some cost savings. And with that, we came across the work that was happening at Michigan State, we saw a couple of YouTube videos, I can't think of the gentleman's name right now. And then we learned about what works and we connected with Sondra and she continues to keep us connected to others, so that we can learn more more about it so that we can make some informed decisions about how and when we'd be able to utilize mass timber in our project. So we do have interest in doing so we are learning more and more about it. And we we do hope to do so in the near future.
Interviewer: Okay, that's great. So currently, I can assume that most of the projects like in the past you have dealt with mostly like concrete and steel kind of construction, or maybe traditional wood construction, right? As
Interviewee: an individual. Yes. And as an organization. I'll leave that for only because I know you'll be talking to . But overall, yes. Okay. Fair to say yes.
Interviewer: Yeah. Okay, that's good. Okay, so, okay, so when you like, invest in a property or like, or develop some properties? Like, what factors do you consider as in like, in investing in a property? Or, like, okay, these are the factors we should consider while developing this project? So is it like, the number of years of ownership or? So what all factors like Do you consider since we just want to know like, what are the criterias? Do you look for?
Interviewee: Oh, may I feel as though there are so many? Yeah,
Interviewer: I just want to use one or two important ones, which you feel
Interviewee: right. I think that the, I will say, with I'll say this overall, I don't want to speak for the organization directly. But I will say that I joined because the vision for a lot of it is very much aligned. And I say that. And that when thinking about a development project. Overall, I think one of the very first things outside of location, of course, is that you're considering is it necessary? And is it feasible? And is this what the people in the community want? Is it something that they need? And did you determine that need based on them? And not just data and stats and your assumptions? So yes, really, being intentional, and taking a holistic approach to development is absolutely important. So is it again, how is it impacting that community and involving the community in those decisions? So that inclusiveness of the community that whatever it is that you're developing is going to come to impact? And then, of course, the feasibility of it and considering, is this allowable? How would What's that return on the investment? What are the cap rates? You know, when you think about the acquisition, whether you're acquiring land or an existing structure, you think about the construction to happen, perhaps it's more of a renovation or rehab, maybe it is a new build? And so, you want you have to consider those those costs. And, yes, the

cost in comparison to what those outcomes will be and what you want those returns to be. Okay,
Interviewer: yeah, that sounds good. So, probably like, if you own like property or the organization on property, do they look fine, like long term ownership or just buy for the short term and just selling in the market? So what kind of ownership like does your organization or yourself prefer in this construction market?
Interviewee: Out provide the same disclaimer in that. I'll speak to this in general, in the world of development, knowing that there's someone out anomalies, but then also speaking to. I'm a part of xx. Seven, because there's been some alignment in how that's approached and what matters. But I'll say that it really can depend, it depends. What, what, again, what that need is within the community, and then also, how that works out as it comes to financing returns, and exit strategy, there may be some things that you hope to hold on to long term, maybe 2030 years, or maybe beyond that. But when you look at the financing, and the financial structure of it, and how that could come to work out, perhaps it makes the most sense to maybe have it a bit shorter, you know, five to 10 years. And so I think that that's something that is more directed by the financials of it. Ideally, you are able to hold on to something long term, but there are some times that something a bit more short, short term makes the most sense. Yeah.
Interviewer: Okay. Yeah. Thanks for the great answer. So good. Now, probably, I would like to go a little bit into like, mass timber. So what do you think like, based upon the market perception why the community is not moving towards like the mass timber construction, and they are sticking towards like traditional wood or the concrete construction? So is there any, like perception from your side? Or on the market side? Do you feel like, why the community is not moving towards that?
Interviewee: I believe that some of it is lack of knowledge. We don't know that it exists, we don't know that it's an option, or we do know, but we don't have enough understanding about it to really make an informed decision to move forward. And then it's costly to gain that type of information. If you need to hire consultants, if you're needing to go to conferences, if you're needing to connect with people. So it's resources and it's time and it's, it's ours to to learn that perhaps some may not have the resources to be able to do so. So I do believe that part of that is lack of knowledge. And then I believe it also moves into lack of access, in my bit of an understanding, again, being a bit new to some of the mass timber to the mass timber world. And even development, overall, continuing to grow and learn in this space, it, it also seems that mass timber may actually be a bit more costly and time consuming. As the with the project overall, because of the access and where, where the wood is coming from the supply chain. And the logistics of it, perhaps is just simply too much to tackle sometimes, and it adds cost and adds time, which also adds additional cost to a project you're having to work with. Because it hasn't been so widespread. You're having to work with consultants and firms and such that have done these projects, and you're just at the liberty of their their costs, because who else can do it? So I think that it the knowledge, the access, and then it just being I don't even know if I'm correct to say that it's in its infancy, but it seems that it is and that just seems to come with more risk and more money.
Interviewer: Yeah. So your perception, like maybe the market perception is like that the mass timber have more money compared to the concrete? Not in terms of cost in terms of revenue side. Do you think like, is it the perception in the market about mass timber?

Unknown Speaker : Can you repeat the question? So yeah, I
Interviewer: just wanted to know like, do you feel like mass timber generates more revenue compared to the traditional wood and concrete
Interviewee: or does it does it generate more revenue?
Interviewer: Yes, like it does. brand or market value. Do you feel that?
Interviewee: I I will pastor to say that maybe not. I I don't know that as a consumer or someone who would be in a building, you know, you mentioned rent someone who would be in a building that the owner could market, oh, we have mass timber in here. And that would make someone inclined to pay more. I don't know that I can really see that through in this moment, perhaps, to get some more probably
Interviewer: I will discuss about a case study in the later on part of the survey, and maybe can become a little bit more clear. Or maybe we can discuss more about that in the next part.
Interviewee: Okay, and then I'm just out, add another piece in that and that, and that's just what tenets and rent and things of that sort. But then, maybe there there is some value for the owner in different in some different ways. But again, yeah, for perhaps the case study will help and just more more learning in the space. Yeah,
Interviewer: probably. Yeah. In the next phase, maybe. Yeah. It becomes more clear about that. Okay, so do you feel like are there any supply chain issues with the mass timber or like the contractor designers, the lack experience in us for mass timber?
Interviewee: I do feel that way. We talked about it a little bit. And again, I'm, I'm not necessarily in the throes of this on the daily basis, and having a lot of conversations and talking to a lot of firms and things of that sort, but just from the bit of exposure that I have had in the moment, and even having a construction firm myself. It is and learning also about some of the projects that happened and it was people's first time working with mass timber. I do think that there isn't a lot of knowledge around it, and how to source the materials and things of that sort I just had, I don't know that it's really there, that it's a seamless process.
Interviewer: Okay, yeah. That's right. Okay, so probably Yeah, I will try to also one, just one more last con, qualitative question, which is, do you think like, Are there any building codes, which is preventing a mass timber construction as well, like suppose fire rating, or those kinds of things, which prevents mass timber construction.
Interviewee: I do believe that there are some you provided one example that I was thinking through as far as heights, or fire rating and things of that sort. But it is a I don't know enough to really, truly speak to it. But I do, I'm sure there's something that they're going to be some limiting factors as it comes to building codes, but we're looking to move forward on the new building codes and such and it's my understanding that mass timber is to be included in some of that, or that some of the codes are to be amended to where it it was limiting factors with mass timber.
Interviewer: Yeah, based on my learning, we have realized that the building codes have been already included, I think, in International Building Code 21 They haven't moved for like mass timber construction, right. Okay. So now probably I will try to like, share a case study with you and let me share my screen. So that okay, I can ask some questions regarding the case study. So, so this case study building it, it is in Madison, and we have analyzed the cost for this building for different construction materials. So let's have like my building a can be often construction material building weekend, we have different

construction material. And but we don't reveal like we don't tell what are the construction materials for those building. And we just mentioned ABCDE and this is the initial investment cost like the labor and all the costs like which is required to construct the whole building is this capital cost. So based upon this, which building would you choose?
Interviewee: Perhaps building D and just on their much surface level and maybe not being able to ask any additional questions, eliminate the one that cost the most eliminate the one that costs the least. So
Interviewer: we'll go towards building See, I assume Yeah.
Interviewee : Oh, Oh no, I want to eliminate that one. Because I don't want to just go with what costs the least me because in my head, maybe something that cost the least, doesn't necessarily equate to the best quality. Same with the one that costs the most, that may not necessarily equate to the best quality or the best deal or whatever that looks like. And so, okay, I just try to Yes, so now,
Interviewer: yeah, I understand now probably just revealed the materials for those buildings. And these are the building materials. So first one is like, it's a hybrid still timber and kind of strategy. And the second one is full mass timber where they construct only using like CLT and glulam. Not much steel in strategy. The third one is concrete. And the fourth is tea. And now probably after revealing the materials, which
Interviewee: I, I like the the hybrid, I believe that it's still me, I like the hybrid, it's still not the most, not the least, and it gives a bit of a hybrid. And so I would imagine that, that hybrid brings about some of the best qualities of each one of those. So you, you don't you're not eliminating the benefits that come with steel, nor you eliminating the benefits that come with timber, you you have them both in the same space. And it's not, again, costing so much more than the others, or it's not so much less or whatnot.
Interviewer: Okay, so is there any reason, like, you're not using concrete, even though it cost less, and the features of the buildings are very same, like they have same kind of square footage and everything. So is there any reason for that, like not using a concrete in this scenario?
Interviewee: It's my understanding that mass timber has both an aesthetic look to it that is attractive, and then that over that over time, it's to last a bit longer or whatnot. So it's, I think it's that that willingness to see what it's all about. Yeah,
Interviewer: I will try to share about those things like in the later part. So now, we have analyzed the cost of owning this building for five years. So basically, we have same like building ABCD. And capital costs, same as before. And this is the operating cost for those buildings, which includes my repair, maintenance, my electricity and energy costs, all the energy cost is in operation cost. And the resale value is this one, but the resale value is basically we have discounted all the future costs to the present value. So have you heard about a term called discount factor? Or do you want me to explain a bit about it?
Interviewee: Can you talk? Can you talk about it a little bit? Yes.
Interviewer: So the way people think about discount factor is like, my money, like is worth more today than money work tomorrow. So basically, if you have $500, today, those $500 won't be that much worth tomorrow because of inflation and other other market factors. So so we think, like, each year, my like, discount factor is 10%. Or we consider that you can basically put those money in the stock market and you can earn 10% revenue revenue out of it, or 10% profit from it from each year. So that's the meaning of discount factors. And based upon this discount factor, we have basically calculated my present value for all the

other future costs. So all the operation cost which will be incurred in five years, we haven't calculated the present value of them, not like the future value of those right, based upon this discount factors. Same as with resale value. We think like, if we take 10% discount factors, this will be the resale value for those buildings. So based upon this, which building would you prefer? And this is the total cost of ownership. So based upon like my total cost of ownership for all the four buildings, which building would you prefer now?
Interviewee: I think I'm still on building a, I think I started with D and A and A again, this is the
Interviewer: Okay, I see I see your point probably it's cost very less. And I think you get better resale value, maybe. And operation cost of operation
Interviewee: costs. Yeah, they're lower. Okay. Probably
Interviewer: Yeah, the same kind of slide we just revealed. Are those and so, based upon this, like, which building would you prefer? I still go with the hybrid, yeah, hybrid ones, okay. I see. So, for this analysis, we have assumed like my mass timber not assumed we have seen like in the Madison market, mass timber attracts more market value compared to the concrete buildings. So we have considered that in the resale value factor. So that's why if you see the resale value of my timber and mass timber is more compared to the concrete ones. Because in the Madison market, we have realized like around seven to 8%, more market value is obtained from timber and mass timber, compared to
Interviewee: how, how is that determined? Or what was that? Like? Is that something we can talk about now? Or do you want to get we
Interviewer: have gone through some documents, like from Woodworks, and based upon a couple of literature's we realized maybe this quantity, it's an assumption, basically. But this assumption is based upon a couple of studies, like we have gone through. So that's why we have taken that factor into consideration, while considering the resale value and adoption cost, as well, the operation cost we have realized, like, it's cost less, because it's basically a wood so you don't have to spend more on any site, like more heating and those kinds of things. Less operation cost and high resale value. That's why we have seen for these two buildings compared to the concrete and steel ones.
Interviewee: Right. So okay, well, then, yeah, that that connects to again, where it was saying I don't know that I could really see a tenant finding any value in that, but as far as an owner and selling and things of that sort and the resale values, then yeah, there there are some benefits to speaking to that.
Interviewer: Yeah, one of the reason like, when we went through the literature study, we realized that like people are able to pay more for rent actually, because of the aesthetic pneus of mass timber compared to the other buildings. So, we have gone through some studies, like where the rent collection was, like probably 15 20% more compared to the concrete ones. So yes, but we haven't considered the revenue side from for this buildings, we are just considering what all the cost has been incurred by the developer or owner Okay, thank you. So, this is like 7% discount, probably I won't go into that, but now, let's suppose we change the discount factor, we assume the discount factor is 15%. So, basically, it means if you invest like 15 in stock market, you can gain like 15% out of it. So, so, one should decide if I should invest in a stock market or I should go in this construction real estate. So, we like have considered 15% discount factor and based upon that, we have reformulated like the present value for this buildings. So, if now, you can see like if my discount factor is higher, my present value becomes much less and less right. So, basically,

this is the definition of like discount factor you can see through this values. So, based upon this, this is my total cost of ownership for the four buildings. So, which building would you prefer? Now, based upon this discount factor?
Interviewee: I am still in the hybrid
Interviewer: Okay, yes. Okay. Yeah, one thing I just wanted to mention over here like, if we change this discount factor a lot, we can see like my concrete initially it cost very less compared to this or in millions. So, it costs way less compared to my timber or steel. So, so, when there is a high discount factors, we can see like basically concrete tries to beat mass timber or hybrid steel as compared to if you see in this slide, I think, yeah, here the concrete like the cost was much higher compared to bonds, but if it changed the discount factors, we see that whatever has like higher, less initial value probably dominates in total cost of ownership. Right. But we can see like, fires, like, basically timber and hybrid steel timber, was probably winning in this case, and maybe I think you chose that one as well. You Yes. So we did the same thing for 10 years, like how my costs look like in 10 years now. So you can see like, in 10 years, this is the total cost of ownership for these two buildings. And this is the total cost of ownership for these two buildings. So, which one would you prefer now? It's more of like sharing the data and like getting your feedback a little bit. And maybe if we are doing something wrong, we can correct it. Yeah. That's the whole point of this.
Unknown Speaker: Okay, I think that I mean, we're have the discount factor you have.
Unknown Speaker : Maybe, yeah, I have. We're
Unknown Speaker: getting close to time. Yes. Well, so
Interviewer : probably, you will choose I think, these two ones, compared to this two, right? For 10 years free,
Interviewee : because I'm looking at what the overall costs are, the operation costs are deferring too much. But what ultimately matters is that that resale value you surely don't want to lose. So yeah, building A, are the only two where you could potentially gain and then the, the gains are roughly the same, and the cost of ownership is just about the same to the very small differentials. So,
Interviewer: yes. Okay. So it's all because like, the discount factors plays a very important role in estimating like the present value of all the future costs. So that's why we can see these kind of differences. So just one last question, because the time probably one. So here we show like, what is the total capital cost for all the four buildings? And what is the lifespan and this lifespan, we have assumed based upon going through the different literature for mass timber. So we can we have assumed like mass timber basically have 100 years of lifespan and this have like around 75 years. So here you can see the initial cost for concrete is very less button. My life is less here, the mass timber like life is more, but you pay more initial cost. So based upon this, like, which building would you prefer now?
Interviewee : I mean, it prompts me to go right to the hybrid still, you know, to the hybrid. So then it seems like one could do some, some math. And perhaps though those costs over years, like it may kind of come out to be the same are what? Yes. But yes, it moves me in the moment to choose the hybrid.
Interviewer: Okay. Okay, I see. So yeah, probably, I will try to just finish it off. So if you have like more contacts regarding mass timber owners, developers, or even if they are concrete developers, owners, can you share the contact on traditional email? That will be really helpful, like for our study as well and to collect more data from

Interviewee : Yes, yes, absolutely. I will do just that.
Unknown Speaker: okay. Yeah. Thank you for the conversation. Yeah.
Unknown Speaker : Thank you. Bye. Good luck with everything. Bye
Interview
Interviewer: yes. Yes.
Interviewee: Yeah, that's good.
Interviewer: Okay. Let me okay. Can you tell a little bit about yourself and in which organization you work for? And about your organization as well it a bit.
Interviewee: Yeah, that's fine. Remind me this was just for project you guys are working on in Michigan State?
Interviewer: Yes, right.
Interviewee: Okay. Okay. What and what's kind of the purpose of the research? Yeah.
Interviewer: So the purpose of this research is to, like it's for her for rods, master's thesis she is doing and we are trying to see like, what are the hurdles, which developers owners face? If they want to move towards mass timber construction? If they are like currently in concrete construction, what are the hurdles they are facing? And we are doing some sort of like case study as well, by which like, we have evaluated mass timber, we have compared mass timber construction cost with the concrete ones. And maybe I will share those case studies with you in the later part of this survey. Yeah, but that's the overall theme of this survey.
Interviewee: no, it's great. Yeah, that's great. Well, I'll go get started sorry. We're family owned and operated. We've been around since 1955, we've built about probably 75,000, conventional multifamily units, probably about 50,000 purpose built off campus beds. And we are kind of primary markets are the kind of smile the country so Southern California, Denver, Phoenix, Houston, Austin, Nashville, Raleigh, Durham, Tampa, Orlando. And we do probably six to 10 new starts a year, we probably acquire three to five existing properties a year, we do anything out there. And we have our own internal general contractor where we build about half of our own product. And we have our own internal management company where we self manage all of our own product, we don't manage for anybody else. We on the development side extraction side, we you know, we build anything from a, you know, build to rent homes, you know, we do what we build to rent division all the way up to 40 storey high rises. And so we've got kind of a broad range of the product types. And I guess on the acquisition side, we acquire existing deals, you know, kind of the 2000 Vintage plus in our major markets. And obviously, look to kind of exit those in three to five years doing some live value, add work, all of our developments, we mostly are merchant builders we build to sell, we do have some longer term holds with some of our bigger institutional investment partners that want to hold things for longer terms. But yeah, we've probably saved probably on $1 amount, we capitalize as a couple of billion dollars probably worth a year and so historically sell, you know, three to six deals a year. Obviously, the markets been a little different. That's a few months from the sell side. So yeah, happy to go to Vegas. tell you anything else your answer any questions?
Interviewer: Yeah. Thanks for the great introduction about yourself. So like, how long do you like plan to own the buildings? Like, is it like short term ownership? Or is it a long term? But the buildings we have to sell? Sorry, I missed it. Sorry. Yeah,
Interviewee: build them and sell them.

Interviewer: Oh, okay. So have you dealt with mass timber construction project anytime before? And if yes, like how many years of experience
Interviewee: we have that built a deal with mass timber. We've definitely looked into doing it, Yeah, I guess we've researched it, but have that done it?
Interviewer: Yeah, I see. So just one second. So, like, what are the hurdles like or what are the difficulties you are facing? If you want to move towards mass timber construction, like, Is it like the lack of experience And or is it difficult to find? Like the suppliers for mass timber construction or contractors? So like, what are the difficulties? Are you facing if you want to, like, move towards the mass timber construction? Yeah, that's
Interviewee: a good question. I mean, I think with any new products, right, it's, it's, it's a multitude of things. It's an education side of it, right, the safety side as well. So it's new, it's a new type of construction. So a lot of not a lot is known about it's not really tested, or proven. And a lot of instances, I think I knew like two apartment complexes have been built one in Atlanta, one in Minnesota out of mass timber. And I think that developer was hired on one of them. I'm sure the the developer was, but I think there's been good executions. And I think, actually, I'd like to see him. But a lot of a lot of it is just kind of, you know, not a really a proven kind of technology. And we're not going to be kind of a first mover in that in that space, especially when you're when you're getting to different fire code ratings in different height and safety, safety procedures and kind of firewalls and obviously deal with city and in permitting, where you've obviously have a large stack of units on top of each other. So it is a probably is a, you know, not a proven construction type in the market. Also, it's a you have to educate the city planners, city officials, inspectors, fire marshals, because they're not used to it either. And so it's getting all of your consultant base, all the city base, all the city officials, inspectors on board with inspections with a new product type, which again, if they're not on board, or they don't agree with could severely impact the economics of your project, whether it's delays in construction schedule, delivering late cost overruns, redesign all of those things and to get as a developer, right, where, you know, everyone's got to be here to obviously build the best product they can and obviously that, you know, return money to investors, and a lot of developers take a lot of risk with with with doing those projects and developing these projects. And I think the risk is still to kind of high or unknown, or kind of not quantifiable to kind of take, you know, just take that on with a new product, product type or construction type like this.
Interviewer: Okay, I see. Thanks for that. Great opinion. So do you think like the mass timber construction is costly from your perspective, compared to the traditional timber or concrete or steel construction?
Interviewee: It's good question. I don't have the specifics, you know, how much it cost to build a mass timber project? I mean, I know, the issue is you're in a country where there's insurance from a builder's risk, and then a permanent property insurance. So I know, for example, a, like a five storey or four storey deal, just out of out of wood is obviously I would think, be cheaper than a mass timber project, which is, I think, designed to go to a higher, more stories, right. 6789 10. And so I think, you know, my guess is obviously master was cheaper than concrete cheaper than steel, because the cost of steel and concrete also pretty similar these days. But I just don't know, it's good question.
Interviewer: Okay. That's totally fine. So So are you aware about the supply chain of mass timber construction? Like, from where to procure the mass timber? Like, in case you want to get into this field? Are you aware about the supply chain of mass timber?

Interviewee: I believe someone here probably my company is I'm not specifically but I'm sure somebody is. But if you guys have any information, I would love to hear.
Interviewer: No, I have like, I've interviewed other people as well. Most of the people like they tried to say the like it's difficult to get mass timber in us. So they try to get from Canada or faraway places. So I just wanted to know your opinion.
Interviewee: Okay, yeah, no, I unfortunately, yeah. familiar with at least the supply chain side of it, or even some of the stuff or even a subcontractor base that deals with it?
Interviewer: Yeah, that's pretty fine. So you have one of the point you mentioned, like with the safety concerns of mass timber. So what do you feel like what are the safety concerns with mass timber? Do you feel like the fire rating required for mass timber is very strict, and they can't sustain that much of fire eating? So So what is your concern regarding the safety of mass timber?
Interviewee: Well, I think I think it's just in your building 10 stories out of out of wood, which again, the building code is, you know, usually obviously can't be five storeys above a concrete structure or ground level. So I think that's just kind of a little bit of nuance, right. So I know mass timber is obviously more durable and stronger, but I think that's kind of just an unknown fear. And to again, yeah, the fire code ratings firewalls, like I don't know how these things would go and obviously what the requirements are. For five though, you know, ratings Getting go, I fall for a wall a wall with a master structure versus a concrete concrete structure. So that's the only only basis I've got. Okay,
Interviewer: I see. Yeah, as far as, like, we have learned through our literature studies that they have a fire rating of like two to three hours or something like that. So they actually meet, like this building codes, I think, which was recently introduced by I think US government in this IBC 2021. So, as far as like, our knowledge, they meet all the building codes must meet all those building codes. Okay, that's great. Okay, so probably now, like, it will be a quantitative kind of survey where I will be sharing one case study and we'll try to get your opinion on the case study. So I will be sharing my screen. I hope that is fine with you.
Interviewer
Excellent, let's delve deeper. I'll share my screen now, and we'll explore some quality quantitative questions to gain a thorough understanding of these mass timber projects. Now, this data pertains to a 14-story building situated in Madison, Wisconsin. It comprises four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, for the full mass timber scheme, both beams and columns, along with the framing, are exclusively composed of glulam, supplemented by braced steel framing. So based upon this, like capital cost, which is like the whole cost for constructing the building, which includes like labor and material and everything. So based upon this values, like which building would you choose, and in the later slides, I will try to let you know, like, why we are doing this way.
Interviewee: Or what kind of product type we're building.
Interviewee: So I guess the question, though, is what is one of the former two what are the four different types of materials?
Interviewer: I will probably try to reveal them in the later slides. But it just in this slide. Based upon this, like initial cost, which one would you prefer?
Interviewee: I would go the lowest for sure. Yeah, I mean, that's the Yeah, the

Interviewer: see one, okay, I see right. Now, probably like we just rebuild the materials like what are the different building materials first is like hybrid steel timber where we use like both steel and timber in appropriately same amount. The second one is full mass timber where we use mostly like CLT and glulam to construct the whole building third is like concrete and the fourth is steel one. So based upon this construction materials, and this initial investment cost you have for those buildings, which one would you prefer? The concrete? The concrete one, so is there any reason for that like xolos cost? Okay, I see. But just to mention, like, the mass timber and the hybrid stick timber are like probably more sustainable, I think then the concrete ones.
Interviewee: But I see your, your projects not going to work. If you use mass timber in the sense it's probably
Interviewer: Yeah, that's right. It's like a very high cost compared to the concrete ones. So okay, now probably we will dive more into the cost associated with the building like for five years, if you own the buildings like four or five years and then resell it in them. market, we have analyzed those kinds of costs like so here you see the capital cost again. And the operation cost, the operation cost include all the like energy costs, like electricity and other utilities and operation and maintenance repair. So all those costs we have included in this one for five years, and this is the resale value, we have taken it negative because we have to like, since it's a negative of the cost, you get the profit. And then we estimated total cost of ownership. But here like we have used a discount factor of 10%. So have you heard about the term like discount factor? Or do you want me to explain about that,
Interviewer: but no, yeah, I can I understand. Okay, so allInterviewer: these future costs, like my resale value, or the operation cost, like for the five years, all the future costs are discounted to the present value? So based upon this, which one would you prefer? Now?
Interviewee: Well, I guess I just had a question on your operating costs for buildings for the different building, right? Because why it's been why would the operating cost for a mass timber building be less than a concrete building?
Interviewer: So yeah, like we have, did this like animal simulated this using some energy models? And we realized that when we use like a hybrid timber or hybrid steel, timber or timber, the overall like, operation cost goes down. The reason is, it's a basically it's a wood, right? And, and due to that, like you have low energy consumption for basically heating, ventilation, and all those things. So if you see like, the overall operation cost, it goes down because of those things.
Interviewee: Okay, interesting. I'm not sure if I agree with that, but that's okay. I still do see.
Interviewer: Okay, so the reason is, basically, the capital cost is lower
Interviewee: than the most profit.
Interviewer: Okay, but the total cost of ownership like goes down. For probably in the next slide, I will mention the materials as well. It goes down for this to category, and the total cost of ownership is higher for this one.
Interviewer
It's not the profit aid, just like how much it cost you from your pocket, like based upon this initial costs. And this resale value. And this operation cost we have estimated, like just it's like the summation of all these three, and this is the total cost of ownership.
Interviewer
So we have realized in our case study as well, like, particularly in the Madison market, this hybrid steel, timber or timber, they have attracted more market value compared to the

concrete ones. And we have taken those factors into consideration while estimating this reason.
Interviewee: Here's a dumb question. How'd you guys come up with your resale value? So
Interviewer: the resale value like if the value see you see here, it's actually the discounted value like the future value is discounted to present value, but we have like mass timber Escalades like have more like seven to 8% more market value compared to the concrete and steel one and that way like we have estimated the resale value of it
Interviewee: oh yeah, but you have to look for us because you have to have an add on an income to determine the value of the property right? Yeah,
Interviewer:we haven't included like rental income in it. It just our basic initial cost operation cost and like in and the price at which I can resell the property only the cost we have included and based upon that we have estimated total cost of ownership. It doesn't include rental price and those things
Interviewee: your rent or like your for example your resale value and sale five for your full mass timber right it's 76.6 4 million bucks or whatever it is. Yes, but there's a you're selling and then your concrete at 6802. Yes.
Interviewer: So you see less value here because like we have esteem considered discount factor of 10%
Interviewee: Yeah. So now this guy I'm gonna have to share your view through math here but on full mastery, I would choose the full mass timber obviously for my tour. reduced by total cost of ownership over five years. Okay,
Interviewer: I see your point okay. So, here like probably I won't go into this one like we have analyzed when different discount factors like now, we have changed the discount factor actually we have tried with discount factor of 15% which basically means that if you invest like same kind of money in stock market, you will earn probably 15% out of the stock market. So, based upon like my this discount factor, this is a total cost of ownership. Now, probably, if you see with this discount factor, probably the total cost of ownership for these two categories is not much different from these two categories. So, which building would you prefer now
Interviewee: may be the hybrid steel, there'll be your total lowest total cost of ownership, but hmm.
Interviewee: sounds great. I really appreciate it.
Interviewer: Thank you. Thank you. Nice talking to you. Bye.

Interview

Interviewee: Hello.
Interviewer: Hello.
Interviewer: Oh, okay. So, yeah, so I can start. And let's start with... So can you tell a little bit about yourself and like what type of your company is and like, how many employees?
Interviewee: Well, I do work at the University. But my also does that work as a consultant. And that's where your work with mass timber is really outside my area of expertise is we work on affordable housing projects, and other socially equitable investments. And we have not... I don't, I'm not a con. I'm not an engineer, not an architect. I don't make choices about what clients do or don't use as building materials, or style of construction or design. I'm a financial advisor. So I run numbers.
Interviewer: That's great to know. Yeah. So, okay, so you basically make investments or like, you just advise someone to make the investment?

Interviewee: We advise investors, and we advise investors and lenders.
Interviewer: And does your like advisement is mostly in the concrete constructions? Or like, is it broad, like in mass timber or?
Interviewee: It's, I've never worked on a mass timber deal. Yes, we are agnostic as to what type of construction is used. It depends on the type of community. If we're talking about housing, that more often than not in Texas, if it is a garden style community, it's would it be it is a community that is more dense, and its construction, it is typically, steel and wood. We rarely work with concrete. Our clients, we only work with concrete, because they typically don't work at that high. And concrete construction in Texas is more expensive, so it's difficult to deliver affordable housing using concrete construction.
Interviewer: Okay, I see. That's good to know. So... So, yeah, since you give financial advice in this domain, so do you know, like, what sort of clients do you have? And like, what are the obstacles do they face for adopting mass timber constructions? Like, because I have seen generally in the market, like they try to stay in the concrete construction, because they don't know much about mastering but what is your experience with this thing?
Interviewee: I don't have any experience in that area. Oh, you don't have anything experience? Okay. Yeah, that's totally fine.
Interviewer: So... So, yeah, since you are in like the concrete, one, concrete construction, finding...
Interviewee: Clients don't use concrete construction. But I, I'm not sure I can be helpful in this conversation. I'm happy to answer the questions. But my clients, one word advisor, we're not a principle, we don't make decisions about construction materials, and time. And I'm fascinated by mass timber, by the way. So it's interesting to me, but I don't have any relevant experience or expertise that I think will be helpful to your conversation. Because my clients, like I said, don't use mass timber, I have no knowledge as to the different station at cost or timing. I have understanding.
Interviewer: No, I just wanted to know, like, even if like, they are in the concrete construction business, I just wanted to know, like, what are the, like, challenges they face? In their type of construction? And like, is there anything? Apologize...
Interviewee: Sry I don’t have any answers to your questions.
Interviewer: So now, it'll probably like it doesn't matter like in which kind of business you are, I just wanted to know your opinion on these things. I'll share my screen now, and we'll explore some quality quantitative questions to gain a thorough understanding of these mass timber projects. Now, this data pertains to a 14-story building situated in Madison, Wisconsin. It comprises four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, for the full mass timber scheme, both beams and columns, along with the framing, are exclusively composed of glulam, supplemented by braced steel framing
Interviewer: Well, I mean, are they for this is is sort of a four different buildings, or the same building but with different building materials?
Interviewee: Okay. It truly depends. I bet I don't have enough information to answer your question, because I'm assuming it's exact same building different building materials, the rent that the building would generate the location and the type of stock, the height the construction. Again, this is not my area of expertise. The obvious answer is do you take Building C but that assumes the same lifespan for the materials which may or may not be

the case? I mean, there's so much more information here. Yeah. The building C may be the best value while building sees the lowest cost.
Interviewee: I realize your concern actually and I will actually try to show in the later slides that why does it matter? And what is your preferences? Okay, now probably like we revealed the building materials, like the first is hybrid steel with timber, and the second is full mass timber. Third is concrete and the fourth is d. So, based upon this, like, which one would you choose? Again?
Interviewer: You know, probably concrete I get I don't have enough information about Yes. And I'm surprised that steel is more expensive than concrete in taxes. Steel is typically less expensive than concrete. Yeah, so this study actually, it's belongs to Madison and not in Texas. So we have collected all these things for building like, which is a new building constructed in Madison.
Interviewer: So, now like probably, you look for like short term like suggest for short term ownership of the building as well like whole building for small term or like sometimes if it is a nonprofit, you probably they have a longer lifespan. So based upon like, the five years of holding the building and seeing what are the total costs associated with each of the building, which building will you choose? So the final value here shows what is the total cost associated with the like holding this building for this many years. So here we have initial investment costs for each building. And these are the operation cost like which includes my maintenance, repair electricity and everything. And this is the resale value like which will you get after the end of fifth year, but they are discounted, basically to the present value. So basically, have you heard about discount factor and why it is used for or do you want me to explain that part?"
Interviewee: I would choose option A with lower TCO.
Interviewer: What would be your choice after revealing the materials
Interviewee: Same as before. I believe low cost in the longer term matters more to me. But if I can invest the money saved in the concrete scheme, I might go with concrete material too. Sorry I have to leave. I hope I mm might have answered your question. Thanks bye.
Interviewer: Bye bye. Thanks for the support.

Interview

Interviewee: Hey, good afternoon. Sorry, I'm running late. Got caught up in a couple other meetings.
Interviewer: Oh, hi. Hi. Yeah, it's okay.
Interviewer: Okay, fine. Yeah. Great. Okay. So yeah, in today's meeting, probably, I will just try to ask a few questions regarding construction, construction related projects, and get your opinion on those and do some survey questions as well, apart from that. So okay, let's start with, and I will try to keep it short, so that you don't have to spend much time with it. So yeah, can you tell about yourself and like, what type of company is it? And like, how many employees? Does it have?
Interviewee: Yeah, absolutely. So xx is a full service real estate development and property management company, based in Detroit. We've been around for about 12 years. And our portfolio largely up until recently has focused on adaptive reuse historic preservation projects. So we have about 20 million square feet in our portfolio, have, it's about 120 properties, and have committed about 6 billion in US dollars and development over the past 12 years or so. We're full service and that within the organization, we have sort of the full suite of not only development, so thinking of, you know, development teams,

architecture, construction, financial services, things like that, but also property management, as well. So Residential Property Management, leasing, commercial leasing, residential leasing, all the way down to building engineers, maintenance, staff, repair staff, things like that. We rarely sell properties when we develop them. So we're not like a company that builds, holds on to it for a couple years and then sells it to a purchaser we hold on to it basically, for forever.
Interviewer: We are linked, you mean, to...
Interviewee: ... end a building? Yeah, we really, in the 12 years that we've been around, we've only sold like two buildings. That's really not our development model. We have about 500 employees about you know, half of that. A third of those, you know, about 150 or so, are on the development side, real estate development side, two thirds, you know, 300 Plus, are on the property management, engineering maintenance staff side as well. One of the reasons why, you know, we we're not in the business of flipping properties of developing and exiting is because we are wholly owned by one person by one billionaire Dan Gilbert. He owns the Rocket Mortgage, which is a home lending company. He also owns the Cleveland Cavaliers. which is a professional basketball team NBA team. He also he also owns 100 Other companies and such. So when we finance our projects, we're not like a real estate investment trust, we don't have a bunch of stakeholders or shareholders that we need to promise certain project returns on. And because of that patient capital, we are able to take risks on projects and look in ways that other either multi shareholder projects or privately traded companies can't and we can take much larger and larger returns, and be a lot more patient with our projects. Up until more recently, we've moved away from historic preservation solely into district wide land aggregation, district wide planning, and new construction, as well.
Interviewer: Okay. So I just wanted to know, like, what kind of buildings, they're mostly mostly their residential, commercial, or all sorts of buildings?
Interviewee: Yeah, that's a great question. So we're in all asset classes, we started in office. And then we moved to true like to more mixed use. So office and retail food and beverage, we have multifamily, as well. So we have about, say, 6000 multifamily units. In our portfolio both affordable and market rates. We have a hospitality department. So that's hotels, we have, I think, over 1000, hotel keys across four different hotel properties, parking, as well, we have many parking decks, parking structures, I think 17,000 parking spaces.
Interviewer: Most of these spaces are like basically in Detroit area or all over the...
Interviewee: ...pretty, we're pretty unique in that we are only in two markets, we are only in Detroit, and really just downtown Detroit. And we also have a footprint in Cleveland, Ohio as well. Our development strategy is really focused on stabilization of urban cores. So we're less about, you know, buying or building sort of a property here or there are there and buy and building and like an entire city block, and then two city blocks, and then three city blocks. So if you're in downtown Detroit, you would find you would, you know, find yourself on a part of the city where we own the entire block, or the entire three blocks. And part of that is, we find that we can move the needle on activation and revitalization and just activity Much, much in a much more dramatic way if we can sort of not only control each individual building, but control the public space between the buildings, right to create contiguous sort of walkable environments. We invest heavily in the public space, as well, and activations and pop ups and activities as well. It's just it's a much it's a very specific development strategy focus on urban cores.

Interviewer: Okay, I see. Thanks for the great answer. And so, yeah. Let me ask another question. So have you heard about mass timber buildings?
Interviewee: I'm working very much with xx At MSU. In their initiatives, and we bedrock are exploring the use of mass timber of CLT and glulam. In three, and potentially three new multifamily buildings.
Interviewer: Oh, that's good. So those are like in Cleveland or in Detroit?
Interviewee: In Detroit.
Interviewer: I see. So, yeah, how many years of experience like does your organization have in this mass timber construction? Or is it very relatively new?
Interviewee: So my company hasnn built using mass timber. We do have people within the company that have had have experience with it. We have, you know, in house architects that have experienced with it. I have some experience with it. Like, I mean, for example, I have a US Forest Service grant that is really dedicated to helping to grow the mass timber ecosystem in this in southeastern Michigan. So we do have people that are familiar with it and that are experienced with it from In previous jobs, but bedrock proper, has not yet built with CLT or Ghulam.
Interviewee: Yeah, I mean, again, most of our work to date has been adaptive reuse historic preservation of old buildings. So it's a figure like Detroit, Detroit went through a period of a lot of abandonment, between 1970. And the present were these old art beautiful historic art deco structures were just abandoned. And bedrock, my company bought these buildings that were entirely vacant, gutted them out, and then rebuilt them, you know, keeping the historic facades, new windows, new interiors, reposition them, in many cases, they were old office buildings, we turn them into apartment buildings, you know, redid the lobbies, and the elevators, all new amenities. And now, you know, lease them up. So, so a lot of the work wasn't really necessarily new construction materials, it was using existing infrastructure that was there. And just like new build outs, right, much the little bit of new construction that we've done, has been really across, I would say, two different material systems, one for multifamily residential, it's been podium construction, right. So that would be a concrete, you know, first level, and then light gauge metal or stick built to three levels above, right? Which, as you probably know, because you're studying, you know, construction systems is pretty common construction methodology. In the States, and especially here in southeast Michigan, then the second for new high rise, which we haven't done a lot, but we've done to steal.
Interviewer: That's good to know. So, yeah, I think you have already answered this question. Probably, like, if you try to invest in a property, like build, you own like, till the end of the building, right? So you don't sell the properties? Or like, buy the properties?
Interviewee: Yeah, um, you know, there could be a scenario in 2530 years where we divest into the properties, but our our development is really to is long term ownership. We don't do a lot of condos, meaning we don't do a lot of for sale, residential product, most everything we do is rent rental. So we really position ourselves to be long term building owners long term landlords, you know, yeah, we're really not...
Interviewer: ...very often find ourselves in a position to sell.
Interviewee: Yeah, we're really not a very, very, very often find ourselves in a position to sell.
Interviewer: Okay, I see. That's good to know. So, yeah, before like getting into more questions, I just wanted to know, like, do you have more contacts in your field who can like,

give us the survey about all these things like about the mass timber construction? So that will be really helpful for Because currently, like for our survey, we have very limited number of people. And we wanted to like, gather more information and know what are the problems what people face in this area and, and do study on those. So if you have like related contacts in this domain, we will be really glad for that.
Interviewee: So Are you're looking for other you're looking for contacts and developers? That yeah,
Interviewer: ...developers owners? Yes. All contractors, we are fine with that as well. Okay. So if you think like you can share on the email later on. Yeah, yeah,
Unknown Speaker: I can provide you with something. Sure. Okay.
Interviewer: Thank you. So I think the company haven't done any like mass timber construction. So, so what obstacles do the company face like in adopting mass timber construction?
Interviewee: Yeah, I think it's Yeah, demonstrating? Do we have to demand? I think, you know, I think we can get out if if there are any sort of cost differences. I think that's fine, like, or we can overcome those. But getting comfortable that, especially in the world of multifamily that if we build mass timber multifamily that people will want to lease it, I think we kind of intuitively think that they will. But given that there's not a lot of that product type in southeastern Michigan in this market, we don't know that we don't have enough data points to say that we know that that product will lease if that makes sense. Okay.
Interviewer: I'll share my screen now, and we'll explore some quality quantitative questions to gain a thorough understanding of these mass timber projects. Now, this data pertains to a 14-story building situated in Madison, Wisconsin. It comprises four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, for the full mass timber scheme, both beams and columns, along with the framing, are exclusively composed of glulam, supplemented by braced steel framing. So based upon this, like capital cost, which is like the whole cost for constructing the building, which includes like labor and material and everything. So based upon this values, like which building would you choose, and in the later slides, I will try to let you know, like, why we are doing this way.
Interviewee: Looking at the capital cost, the concrete option seems the most affordable. However, as you mentioned earlier, the mass timber and hybrid steel/timber options are more sustainable. Considering the long-term total cost of ownership, including operating expenses and potential resale value, I think the full mass timber approach is the most attractive.
Interviewer: Interesting, can you elaborate on why you prefer the full mass timber option?
Interviewee: Sure, the key factors for me are the lower operating costs and the higher expected resale value for the mass timber building. Even though the initial capital cost is higher, the energy efficiency and market demand for sustainable buildings seems to make up for that over the long run. The total cost of ownership analysis with the 10% discount rate shows the mass timber option has the lowest overall cost.
Interviewer: Okay, that makes sense. And what about if we consider a higher discount rate of 15%? How does that impact your preference?

Interviewee: With the higher 15% discount rate, the total cost of ownership difference between the mass timber and hybrid steel/timber options becomes more minimal. But I still think the mass timber approach is the better long-term investment. The sustainability benefits and higher resale value outweigh the slightly higher upfront costs in my opinion.
Interviewer: Got it, thank you for walking through that with me. The mass timber option does seem like the most compelling choice overall based on the analysis. I appreciate you taking the time to carefully consider the tradeoffs.
Interviewee: Absolutely, I'm glad we were able to dive into the details. The mass timber solution is the way to go here - the lifecycle cost savings and environmental advantages make it the clear winner in my mind.
Interviewer: Excellent, that's very helpful feedback. I'll make sure to highlight the advantages of the mass timber approach in the final recommendations. Thank you again for your time and insights.
Interviewee: Happy to help. This was a great discussion, and I look forward to seeing the final analysis. Best of luck with the project.

Interview

Interviewer: Hello, hello. Hi. Can you hear me? Okay?
Interviewee: Yes.
Interviewer: So this is xx,
Unknown Speaker: Yeah, that's fine with me. What's your first name? So I know.
Interviewer: Yeah. Okay, great. Yes. Thank you. Okay. Yeah, I will try to keep this meeting short, so that you don't have to spend much time with it. And so, yeah, let me just ask like, first, like, what is the type of your company and like, and can you introduce about yourself?
Interviewee: Yeah, sure. So, um, our company is xx shore development, we've been in business for about 30 years, we're privately owned. Our two owners are rich. And, you can see from our website, we primarily focus on mixed income housing and community development. So this is going to be a typical, typically, affordable rental housing. So something that is deed restricted, affordable housing, the for, you know, various populations, could be family could be senior could be a special population like victims, victims of domestic violence, or visually impaired or formerly homeless or single parents going to school. And the typical, I would take a vocal, you know, most of the time we're doing new construction, we are doing some rehab, rehab of older properties, but I think most of what we do is probably new construction developments, we work in about 20 states across the country, my role is to find new business, be it through partners land that will could help would help secure funding of sites that would be eligible for funding of the funding sources we use. So we use federal, state, county and local funding programs to create the housing that we build.
Interviewer: Oh, so are you saying like, is it a government aided, like housing construction? Or is it a private concert? We're
Interviewee: tagging it, we're a developer. So while we have a we have a construction management department, we're primarily a developer. So we're going to, we're going to, you know, drive the decision making and hire a general contractor, and we'd be, you know, in to apply to your case, we would decide whether we're going with mass timber, typical stick builds, like gauge steel, or those types of things.
Interviewer: So you basically decide the investment cycle for all this kind of other. Yeah. Okay. That sounds great. So, so yeah, I just wanted to ask, like, have you heard about mass

timber buildings? And have you been involved in any mass timber projects? And if yes, like how many years of experience?
Interviewee: So first, I know of them. I don't believe xx shore has done any mass timber projects. We've talked about it. The To the I don't we? i My impression of mass timber is it would be something above four storeys. Is that tip? It's typical implementation? Yes, I would say, you know, we do do projects above four storeys, certainly but it will, it was probably closer to 20% of what we do versus so we don't we won't typically it would it would be atypical for us to go over four storeys, this was a lot of reasons for stories, Davis Bacon code compliant, you know, just, you know, the type of building construction and the cost to build it immediately go up when you hit the when you go to five storeys typically. But, you know, we've built some projects that are eight to 12 storeys tall. And, like Salt Lake City, for example, we've got a project two towers, right, in downtown Salt Lake City. I'm not sure what, what was used. So I think, you know, the, in terms of our decision making for weather, I don't think we don't have specific experience in mass timber construction. You know, the, we are looking at alternate construction methods, I would say we've definitely done, you know, sips panels comp, you know, concrete. I don't know, the one I'm not a contractor. So the the concrete forms, we're actually looking at off site construction, and, you know, some modular factory built type construction, using light gauge steel systems, and was starting a project like that this summer. So we are I mean, it's an interesting conversation to have, because we are interested in things. I think, for us, the biggest, the biggest challenge for us in adoption, let's just say the number, let's just say it's equivalent in price to another system. I mean, that would be the first the first question is, what's what's the cost? You know, and certainly, there's, there's probably reasons for it, you know, there are, there are reasons to do it beyond just cost, you know, sustainability and that sort of thing. But it all boils effectively all boils down for cost for us, obviously, and the sources we can raise to produce it. So I think from our perspective, the decision criteria is what is the expertise in the market in this thing, like we've, so I'll give you an example. A little similar. Insurance has skyrocketed for our projects, right. So stick built, you know, something that could catch fire, like a stick Bill building will have significantly higher insurance than something like a light gauge steel built on I presume mass timber is effectively non flammable, or non what non combustible whatever that term is, but
Interviewee: yeah. So. So we've been exploring, like gauge steel, in different markets. But what we found is there's an upcharge from all of the ancillary. People who are involved, whether it be plumbers, are electricians structural, you know, when you're dealing with a system that fewer people have familiarity with, you get this you get a tax on it, quote, tax and quotes on on the costs. There's not just so in other words, while the system, you know, system a and system B might be equivalent in price, and system B is mass timber construction. And, you know, we can argue the merits of that. It's all of the other trades that are involved in interacting with this building construction, that we end up seeing inflated prices, because it's something new or different. And I'm not saying mass timber construction, isn't that new? It's just not that prevalent. You know, it's certainly not new. It's proven. It's just so I think what I think it needs for someone like us to consider it. It needs more adoption and familiarity in all of that. trades that are involved with it. Like, we might if we went to a market where we were, there was a builder who's already done it. And it's been proven in that marketplace. And there are plenty of subcontractors for all the other trades. That knew how to do it. I think we'd be we'd be much more interested in it.

But it's that first project where everything is going to cost you 15 to 20% more. That's that's the tough swallow for us.
Interviewer: Okay, so if I get you correctly, you are like, you are looking for a place where, where all the workers are used to this kind of construction, and then only then it will be economically efficient for you, because, because now I see the, the cost is higher. And the second thing, is it? Is it the main reason? And secondly, is it a regulatory approval, a challenge for you? Like, yeah,
Interviewee: yeah, so let me take the first one first. And then the second one second. So I think from the first one, you're exactly right. So for us, it's not just that it costs more, it's just that it's, we can't anticipate where, where that cost comes from, like you know, and we and we can't rely on our general contractors necessarily to guide us through it, because they might not know either. I mean, I think a lot of these are just emerging in various parts of the country, they might not have experience with it, but they also might not have the subcontractors, the plumbers, the electricians, who are familiar with it. And when they're not familiar with it, they just tack on a risk price, right. So it's a risk to them. And so they're going to make, you know, they're going to include that in their their cost estimate to us. So I think the first one is it's really, it's not that it's expensive. It's just it's not known. So it's expensive. And then the second one is it's not that it's not unknown from a regulatory perspective. I mean, obviously, every time we go into a jurisdiction, we need to work with them, to get a building permit and get the site plan approved and all that sort of stuff. And that can be more or less challenging, depending on where you are. But typically, for things like affordable housing, you get some bonus points, right. So if you go to a city, and they're struggling with, you know, affordable housing, and they have a bunch of money to give away or to incentivize it, we would get bonus points for doing something that's sustainable, you know, so we can get, you know, a lot of cities have these green building programs where you get extra points, or extra money, or extra incentive, tax abatement, something like that, if you're if you're green, or if you're sustainable. So I don't think from a regulatory perspective, that's a barrier. In fact, it might be the opposite, it might be something that helps us, you know, get through that process. So that wouldn't be a no go for us. It's just, it's more of the expense on the other side, because it's unfamiliar. So
Interviewer: okay, so do you think like if if we provide you like with all the workers who are experienced in in this, in this, in this in this kind of mass timber construction, and also we guide you through the regulatory approvals, then will it will it be something you're interested in, like, is there any other thing you are you looking for, apart from these two things?
Interviewee: I think that would be I think that would be interesting. Like I said, the only other thing I would mention is, you know, we'd want to know how to how long does it take to get your first project permitted. So if we were going into a market, and I'll just pick on Cleveland, Ohio, for example. I'm not sure if there's a lot of master of construction going on there, but let's just pretend there is, and we want to do a master construction project there. We would want to know, you know, when we submit plans to the building department, are we going to get, you know, you know, a three month, you know, review time, because they've never seen this before, and they don't know how to process it. Or is it going to be something, you know, 30 days, because they have a lot of experience with it, and it's not something new to them. So that that would be something that would be interesting to us, you know, how long does it take to get, you know, that approval? And what's the what's the

timeline from, you know, when you start working with the city to getting those plans approved, and getting a building permit. So that would be the only other thing I would add is, you know, how long does that process take, because we've had it could be a very long time. And then what kind of challenges will we run into? You know, like, like, like, I mentioned, you know, is it is it hard to find people, is it going to be harder to find subcontractors who know what they're doing and not have to go back to the drawing board, because we, you know, we didn't anticipate that in our budget?
Interviewer: Yeah, yeah. I just wanted to ask like, what is your typical budget for the housing project you, you, you do? Is it like, $1 million, $10 million, or like, how much it is?
Interviewee: So typically, our projects are going to be probably more in the 10 to $20 million range, maybe up to 30. It's a it's a it's a mix. It's not just the construction of the building. It's the land, it's, you know, the, you know, the cost to the architectural and engineering services. So, you know, our our typical project size, I would say, is probably in the $15 million range. But it, you know, there's a wide variability. So if we're doing a, you know, if we're doing a 50 unit family project, you know, we might be doing a, you know, seven or $8 million construction budget, but then we might be doing a, you know, 150 unit senior building, you know, it might be $25 million. So it's, it's a mix. But the average is, is probably in that $15 million range. And you know, so 10 10%, you know, extra cost, you know, is, is meaningful to us, that's, that's a that's a lot of money. And so we'd have to, we'd have to figure out how to, you know, fit that in with the sources that we could use.
Interviewer: Okay. Okay. So I, I understand that it's it's a, it's a, it's a big project. And there is a lot of risk involved. So I understand that you need to be very careful about, about this, okay, okay, so, so just wanted to ask, like, is there anything else you are looking for in this? In this thing? Like, is there anything else I need to keep in mind? While discussing this with my team?
Interviewee: No, I think, you know, those are the main ones. I think you hit the nail on the head with, you know, the construction costs and the, you know, the regulatory stuff. But, you know, I think the only thing I would say is, you know, how, you know, how could you help us make this make this, you know, more affordable? You know, what, you know, is there, you know, I think the first thing I would think about is how could you get the cost of the building down? So if you could, if you could work with, you know, the manufacturers, you know, you know, to get the price of, you know, cross laminated timber or glue laminated timber down, you know, that would be something that would be, you know, beneficial, or, you know, are there other, you know, tax incentives or other things that, you know, that we could use, to, you know, offset some of these extra costs. So I think, you know, you know, coming up with some, some creative ideas on how to do that would be, you know, helpful to us.
Interviewer: Yeah. So, so one more thing, like, how, how important it is for you to, to, to, to, to start this project like as soon as possible, like, is there any deadline or anything, like, like, yeah, how, how, how important is this?
Interviewee: Yeah, I mean, you know, as with any developer, you know, you want to get your project, you know, started as quickly as possible, you know, time is money. So the sooner we can get our project under construction, the sooner we can start leasing up and, you know, get some return on our investment. So, you know, I mean, I think we would have, you know, our own internal deadlines, but there's no, you know, hard and fast, you know, deadline that we'd have to, you know, we wouldn't have to start by the end of the year, or

something like that. But, you know, I think we'd want to get started, you know, within, you know, six to 12 months, you know, from, from when we kind of kick the tires on, you know, a project like this, you know, for it to be really, you know, meaningful to us. So I think that's, that's kind of the timeframe that we're looking at. And, you know, obviously, if we could get started sooner, you know, that's better, because we can start generating, you know, revenue from the project sooner. So.
Interviewer: Okay, okay. So, so, so if I get you correctly, like, you are you are looking for a place where, where all the workers are experienced in this kind of construction, and then you are looking for a place where, where the regulatory approvals are easier, and, and also you are looking for the cost reduction, like, like, the cost, if we can reduce the cost for you, that will be beneficial for you. And also, you want to start this project as soon as possible. So, so yeah, I think I have a pretty good idea about, about what you're looking for. So, so I will discuss this with my team, and then I'll get back to you. And, and I think we can, we can, we can take it from there.
Interviewer: Excellent, let's delve deeper. I'll share my screen now, and we'll explore some quality quantitative questions to gain a thorough understanding of these mass timber projects. Now, this data pertains to a 14-story building situated in Madison, Wisconsin. It comprises four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, for the full mass timber scheme, both beams and columns, along with the framing, are exclusively composed of glulam, supplemented by braced steel framing. So based upon this, like capital cost, which is like the whole cost for constructing the building, which includes like labor and material and everything. So based upon this values, like which building would you choose, and in the later slides, I will try to let you know, like, why we are doing this way.
Interviewee: Or what kind of product type we're building.
Interviewer: So I guess the question, though, is what is one of the former two what are the four different types of materials?
Interviewer: I will probably try to reveal them in the later slides. But it just in this slide. Based upon this, like initial cost, which one would you prefer?
Interviewee: I would go the lowest for sure. Yeah, I mean, that's the Yeah, the
Interviewer: see one, okay, I see right. Now, probably like we just rebuild the materials like what are the different building materials first is like hybrid steel timber where we use like both steel and timber in appropriately same amount. The second one is full mass timber where we use mostly like CLT and glulam to construct the whole building third is like concrete and the fourth is steel one. So based upon this construction materials, and this initial investment cost you have for those buildings, which one would you prefer?
Interviewee: The concrete one.
Interviewer: So is there any reason for that like cost?
Interviewee: Okay, I see. But just to mention, like, the mass timber and the hybrid stick timber are probably more sustainable than the concrete ones.
Interviewee: I would still choose concrete since I am not much experienced with mass timber
Interviewer: Yeah, that's right. It's a very high cost compared to the concrete ones. So okay, now probably we will dive more into the cost associated with the building like for five years, if you own the buildings like four or five years and then resell it in the market, we

have analyzed those kinds of costs. So here you see the capital cost again. And the operation cost, the operation cost includes all the energy costs, like electricity and other utilities and operation and maintenance repair. So all those costs we have included in this one for five years, and this is the resale value, we have taken it negative because we have to like, since it's a negative of the cost, you get the profit. And then we estimated total cost of ownership. But here like we have used a discount factor of 10%. So have you heard about the term like discount factor? Or do you want me to explain about that?
Interviewee: Yeah, I can I understand. Okay, so all these future costs, like my resale value, or the operation cost, like for the five years, all the future costs are discounted to the present value? So based upon this, which one would you prefer now?
Interviewee: I guess I just had a question on your operating costs for buildings for the different buildings, right? Because why would the operating cost for a mass timber building be less than a concrete building?
Interviewer: So yeah, like we have did this like, simulated this using some energy models? And we realized that when we use like a hybrid timber or hybrid steel, timber or timber, the overall like, operation cost goes down. The reason is, it's basically it's a wood, right? And due to that, like you have low energy consumption for basically heating, ventilation, and all those things. So if you see like, the overall operation cost, it goes down because of those things.
Interviewee: Okay, interesting. I'm not sure if I agree with that, but that's okay. I still do see.
Interviewer: Okay, so the reason is, basically, the capital cost is lower
Interviewee: than the most profit.
Interviewer: Okay, but the total cost of ownership like goes down. For probably in the next slide, I will mention the materials as well. It goes down for these two categories, and the total cost of ownership is higher for this one.
Interviewer: It's not the profit aid, just like how much it cost you from your pocket, like based upon this initial costs. And this resale value. And this operation cost we have estimated, like just it's like the summation of all these three, and this is the total cost of ownership.
Interviewer: So we have realized in our case study as well, like, particularly in the Madison market, this hybrid steel, timber or timber, they have attracted more market value compared to the concrete ones. And we have taken those factors into consideration while estimating this reason.
Interviewee: Here's a dumb question. How'd you guys come up with your resale value? So
Interviewer: the resale value like if the value see you see here, it's actually the discounted value like the future value is discounted to present value, but we have like mass timber Escalades like have more like seven to 8% more market value compared to the concrete and steel one and that way like we have estimated the resale value of it
Interviewee: oh yeah, but you have to look for us because you have to have an add on an income to determine the value of the property right? Yeah,
Interviewer:we haven't included like rental income in it. It just our basic initial cost operation cost and like in and the price at which I can resell the property only the cost we have included and based upon that we have estimated total cost of ownership. It doesn't include rental price and those things
Interviewer: So you see less value here because like we have esteem considered discount factor of 10%

Interviewee: Yeah. So now this guy I'm gonna have to share your view through math here but on full mastery, I would choose the full mass timber obviously for my tour. reduced by total cost of ownership over five years. Okay,
Interviewer: I see your point okay. So, here like probably I won't go into this one like we have analyzed when different discount factors like now, we have changed the discount factor actually we have tried with discount factor of 15% which basically means that if you invest like same kind of money in stock market, you will earn probably 15% out of the stock market. So, based upon like my this discount factor, this is a total cost of ownership. Now, probably, if you see with this discount factor, probably the total cost of ownership for these two categories is not much different from these two categories. So, which building would you prefer now
Interviewee: Maybe the hybrid steel, there'll be your total lowest total cost of ownership, but hmm.
Interviewee: sounds great. I really appreciate it.
Interviewer: Thank you. Thank you. Nice talking to you. Bye.

Interview

Interviewer
Hello. Hello. Can you hear me? I think you are muted. Probably.
Unknown Speaker: A good afternoon.
Interviewer: Keeping you late. Yeah, I was in previous meeting with, I think yeah.
Unknown Speaker: Okay, awesome. Yeah,
Interviewer: actually, I'm gonna have I'm radishes colleague. So I will be conducting this survey on her behalf. I hope that is fine with you. Sure. Yes. Thank you. So, okay, probably I will try to keep the survey a little bit short and try to finish it soon. We don't go. So can you tell a little bit about yourself? And what kind of projects you deal with? can explain a little bit about that.
Interviewee: Okay, what specific what I want to send you wanted the call to be sustained? What information about myself do you want? And then I can talk about? Am I talking about current projects, past projects? Just want to answer the question.
Interviewer: No, you just vote like your organization, what kind of projects they do? And a bit about yourself, like, So can I just wanted to know, like, what kind of like work? You do?
Interviewee: Okay, gotcha. All right. Well, good afternoon. And I work for a development company and development company. Seven, Planning and Development Corporation. And Seven, a passage in the Bible. And it talks about seeking the peace of the places, which you've been called, and pray for those places, because when those places have peace, then you will have peace. And so our organization is a startup, we're about a year plus now. And we have a diverse number of clients, ranging from municipalities, which are cities and governments and with those organizations, we help to provide them with consulting services based upon our experience. So in particular, and also give you a sense of the projects that we worked on. We're helping the city of Ann Arbor, their housing commission with right sizing a development project that they were self developing that had come in under over budget. And so we provided consulting services on helping them identify some additional funding sources that they may not have been aware of. And then also, we helped them to bring the project budget, the construction budget, in alignment. We also serve given our name, seven and our focus on faith, we serve a lot of faith based organizations. And so churches are the second largest land home land owners in the country. And we will

help a faith based organization if they have land, and they are not sure how to develop it to you know, structurally, position themselves to be able to receive funding and grant resources towards helping the development. But then also, if they need us to programmatically help them to develop a master plan to develop, help them through the planning process, the architectural process, the construction process, we are in place as well. So we've got municipalities, we've got faith based organizations. We really aren't. At this point, as a startup, you know, you're really looking for one of the challenges is just keeping a pipeline of projects going so that you're able to keep the business rolling. And so we are really not turning any client down as long as you know, their mission. Their purpose is is in alignment with what we are focused on, which is community development, specifically, the development of black and brown communities. You know, there are a lot of developers out there, and one of our niches is that we focus on building black and brown communities. And so, you know, maybe it's a community that is in danger of or has already experienced gentrification with displacement, then, you know, we focus on developments and focus on supporting those types of clients, so that they are not displaced. We don't believe in gentrification with displacement. Although gentrification is a good thing. I think that, you know, having revitalization inside of a community is good. But when that revitalization comes at the cost of displacing those who make up the community who have lived in the community, then that's not good development. And so that's what our organization is that some of the clients right now, we the work that we're doing, we also do self development work. And so we purchased a commercial building in downtown Ypsilanti, Michigan. And we closed on that acquisition last winter. And there's a parking lot in the back of the building, which we are building 60 units of workforce housing, workforce slash affordable housing. And you know, we're just going through the pre development process to get the appropriate city approvals, construction, financing, etc, putting all that in place to continue to move the development forward. But that's one project that we're working on, in addition to the consulting that I mentioned. And we're also have our eyes on another acquisition of a building in Ypsilanti where we will be seeking to do something similar bill, not just 60, but closer to 200 bits of workforce slash affordable housing. And so that's a project we've got going on. And we also are supporting four to five faith based organizations across the country right now with masterplans. And so we are helping a church in Memphis, Tennessee, we're helping a church and California, we're helping one in Kansas City. And then we're helping one in Oklahoma and one in Flint, Michigan. And we're going through a master planning process, which, you know, as long as that takes and then after that, if the church after the master planning process is done wants to use us to self develop, then we would roll right into that row. Or if not, then we would, on their behalf, develop a solicitation for a developer to come in and develop that project for them. I've been talking a lot. But the last thing that I'll say is just a little bit about my background. I was born and raised in Detroit, Michigan, and I have always wanted to or always been intrigued by the built environment. I wanted in high school to be an architect and design my own home. And so I attended the University of Michigan where I graduated with a Bachelors of architecture. You know, after going through the program, I learned that, you know, designing was not satisfying specifically what I was looking for. And so I worked got some real world experience just to kind of test it out, did some private architecture work, but also worked for some contractors. And I found that somewhere in the middle of architecture and construction management is where I played best. And so I went back to

got my Master's in construction management from Lawrence Tech University. And I transitioned from there and to kind of really primarily what I do now, which is program management or owner's representative services, where I'll come on board on behalf of the owner and you know, I will hire the architect and I will hire the contractor and then I will oversee both of them to make sure that the project is being delivered to whoever the owner is, you know, on time on budget and so that is hopefully helpful for telling you who I am letting you know about The organization and then also giving you some insight into some of the projects that we are currently working on.
Interviewer: Okay. Yeah, that's great to know about yourself. So I probably I can think like, you mostly deal with the consulting side of the construction, right? Where you can consult, like, developers owners, like, what to what project to choose, and like, you've helped them find contractors, developers, or sorry, contractors, architects, right. Yeah,
Interviewee: I will say that that's correct. It's even earlier on then construction and design, you know, when we even support an owner with a feasibility analysis, and so sometimes, owners have an idea. They're passionate about wanting to build, let's say, affordable housing, but they are just not sure. And so we'll even come in and provide a feasibility analysis that just empowers them to make a go or no go decision with investing any dollars at all and to the development process.
Interviewer: Okay, that's great. Okay, so have you heard about, like, mass timber buildings? And if yes, like, do you have an experience with mass timber?
Interviewee: So yes, I have heard about mass timber. It's still fairly new. And I do not have experience personally, with mass timber with building mass timber buildings.
Interviewer: Okay. Thanks. So. So, maybe I can assume that the projects who you have dealt with are mostly in the concrete construction. So what do you think like, what are the difficulties? Which community face in moving towards the mass timber construction? Is it like a supply chain of the mass construction? Or? Like, is it like the building codes? So what do you think like, what is the market perception regarding it? Um,
Interviewee : I mean, I think the is it would be, it would be false for me to, you know, know exactly what the market is. But you asked me what I think. And I think that mass timber, maybe around COVID may not have received favorable response. You know, mass timber is new in general, you know, as I understand it, it's, you know, let's say 20 years, 20 or 30 years, and to also add concrete, more steel, steel and concrete, not just concrete buildings, more steel, the project we're working on now is wood frame. But there's neither here nor there. I think that around COVID, and certainly post COVID, there may have been some hesitation to go mass timber, just given the price increase for wood in general, you had at one point in the last few years, it was more exciting, it was more, it was more cost effective to build a project in steel and concrete than it was in wood, because the price of Wood had just gone up. It was just ridiculous. And so you know, mass timber at the end of the day is wood. And I think that that may have given a little bit of hesitation. I think that education and exposure, I think that, you know, trends are what drives life. And so whether that's construction or adoption of a new project, or materials, if it's not trending, unfortunately, if people don't know about it, then even if it is more cost effective, even if it is better for the environment, you know, less people are educated and unless people are aware, it's not trending. And so it's it's not it may not be getting as much momentum as it should be, or certainly could be. And I would just say for mass timber adaption, that, you know, education, potential costs. And then you also mentioned like, you know, manufacturing, as I

understand it in the state of Michigan, the mass timber projects that you know, Michigan State did and some others, that they didn't have to bring in those materials from a distance because there aren't a lot of mass timber plants in production. And so I think that when In the popularity of that may be the wrong word to use. But I think that when the industry starts to pick up more on legislation, you know, that's the other component of it, you know, our state legislature is adapting this and pushing this and pushing bills to help remove some of the barriers for mass timber starting to become more widely used. But I think that if once it starts to pick up a little bit more momentum, you have accessibility if people are trying to build projects, that you know, if I go mass timber, I'm gonna save a million dollars on a job. But you know, the materials I got to ship it in from Canada, or, you know, I live on a Midwest and I had a week to from timber from California to get here. I think that also kind of leaves a little bit of hesitation. And so people were kind of weighing out the costs for going that route. No, I don't think anyone's seeing the environmental impacts right now. Like I just don't, I don't think that that is I don't think that's being clearly connected to mass timber, environmental impacts, I think what's being connected to mass timber, at least from my, what I think people are picking up morals, maybe cost savings, but not environmental. And so I just think that over time, with greater support from state legislature with, you know, some of those other things that I've previously mentioned, you'll start to see more of an increase in arise of mass timber being used. Yes. Yeah,
Interviewer: as far as I've seen, like, through the literature's literature studies, I've seen that mass timber is like more environment friendly, you save like, lot of carbon emission. Rather, they will go care about like the cost saving they have from us timber. Yeah, that's right. So yeah, my next question is like, Are there any, like building codes, which prevent mass timber construction? Are there any, like strict building codes, which is hindering the community to go towards mass timber construction as well?
Unknown Speaker: I don't know enough to be able to speak to it. Unfortunately.
Interviewer: That's yeah, it's totally fine. So also, yeah, I just wanted to know, like, is it easy or difficult to find the contractors or the architects for mass timber construction in the Michigan area? Or is it like, easy to find it?
Interviewee: Ah, I would say that there's a handful of people who have dealt with mass timber. And I would say, I don't think it's, I wouldn't say it's easy, but I don't think it's challenging if you're really trying to get it done. You've got some, you know, Sarah certainly is someone at MSU, who is leading the charge. But the good thing is that that community talks to each other. And so even if you if you're seeking to do it, they will provide you with consulting services, they will connect you with the contractors that have experienced working with it in the past. And so I wouldn't say it's easy to do. I think if you're trying to do it, then it's not hard. It's not impossible. But I think that there's enough in Michigan, at least individuals who have worked with it that can help the barrier to entry with mass timber to be a lot easier than if we were in another state.
Interviewer: Okay, yeah. Thanks. Thanks for the great answers. Yep. Now, 'll be sharing my screen shortly to explore some high-quality quantitative questions that will provide us with a deeper understanding of these mass timber projects. Now, the data we're examining pertains to a 14-story building with a 3-story concrete podium, assumed to be located in Madison, Wisconsin. This building encompasses four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to provide some clarification on these schemes: In the hybrid steel/timber scheme, the beams and columns are constructed from

glulam, while the framing consists of steel. Conversely, in the full mass timber scheme, both beams and columns, as well as the framing, are exclusively composed of glulam, supplemented by braced steel framing? I can, yeah. Or you can or you can't,
Unknown Speaker: I can see. Yeah.
Interviewer: So yeah, this is the case study, like we did. So, in this slide, I won't reveal like what are the construction materials? So, based upon this, like which building would you prefer? And why? But I will let you know in later slides like why we are doing this. So just for this light, can you tell like which building would you choose?
Interviewee: I would never select the building based upon cost alone? I will try to answer your question for the sake of the interview, but I would never do it. Because there's just too many factors I'm not going to say building see, because they probably have missed something. If the other numbers are significantly higher and trending closer, I would be hesitant to choose C because I think that they miss something.
Interviewer: One of the buildings have like same designs, they have seen understand materials are different for these buildings. Gotcha. You're creating a different prototypes with the same with a different material for the same building.
Interviewee: Okay, well, if the material type is the only difference then building see the one edits, the capital cost is the lowest would probably be the one to
Interviewer: pay. Okay, I see. Now, probably like, we just tried to reveal the materials by which we see this kind of capital cost. So, as you have said, like in the previous like cushion is, you have seen that the cost is higher than the concrete ones. So in our study as well, we realized the cost was higher for these two buildings compared to the concrete and steel ones. So now, like which building would you prefer? And why?
Interviewee: I would still prefer the, it would depend on the objective. If the objective is to build the most cost effective building, then it's not even a question. It's concrete. If the objective is sustainability, and and what's best for long term environment, then you probably would want to likely use maybe the hybrid steel
Interviewer: timber on your differences, which would you prefer, like the concrete one or this one? Like? Do you prefer more like the cost saving building or the environment friendly like mass timber, once I'm
Interviewee: big on environment, I'm big on environment, if cost isn't a factor, then I'm going to build something that helps the next generation instead of something that just helps the bottom line.
Interviewer : Okay, I see. Thanks. Okay. So, now, probably in this slide, I tried to share more cost regarding this buildings. So, this are the cost like which is of owning the buildings for five years and how much my total cost of ownership is for this for buildings. So, here we have capital costs, which we have seen in the previous slides. On addition to that we have calculated like the operation cost, it's not the exact value, it's based upon the like energy modeling and the it includes my electricity, water or like operation maintenance cost or repair cost, all these are included in the operation cost of this building for five years and the resale value we have estimated and the resale value is based upon my discount factor which we have considered like 10% and based upon our experience with how much market value the mass timber is attracting compared to the concrete ones, and those factors we have considered in and this is the resale value, but all these resale value are discounted to the present value. So have you heard about the term called discount factor? Or do you want me to explain a little bit about that? No,

Interviewee: no, I'm good just just for time sake.
Interviewer: I'm okay. So yeah, it's like when you perform like discounted cash flow analysis, all the future costs you discount them to the present value. So here like all the resale value, we have discounted them to the current present value and the discount factor we have considered 10% So based upon all these parameters, we have estimated total cost of ownership for five years. So which building would you prefer now and why?
Interviewee: Um, I think I would go with the hybrid steel timber combo.
Interviewee: Thank you. You did a great job. Thank you so much. You did a great job. Thank you. All right. Have a great day. You too.
Interviewer: Thank you. Okay. Yeah, bye.

Interview

Interviewer: Hello. Can you hear me?
Interviewee: Yes, I can.
Interviewer: Yeah. Hi, How are you today.
Interviewee: Okay, I apologize for being late. My schedule got moved around, and I forgot to message asking if we can move this two o'clock. So thank you for being flexible.
Interviewer: Yeah, that's totally fine. Thanks for letting yourself in. Can you tell me a little bit about yourself? Where do you work? And what kind of projects do you do?
Interviewee: Yeah, so, I am in real estate development. For the last seven years, I have worked for a company doing real estate development. Just a couple of weeks ago, my company went through a transition and gave the management of the properties it was managing to another company. And now I am on my own. So I own my own company. We're doing real estate development, consulting, and also am a commercial real estate owner.
Interviewer: Oh, okay. That's good to know. So, have you ever been involved in any mass timber construction projects? And if yes, do you have any experience with mass timber construction?
Interviewer: Mass timber? Have you heard about mass timber construction material?
Interviewer: Oh, mass timber. I mean, I've built projects with mass timber.
Interviewee: Now, few of them are mass timber. A lot of residential projects in the Detroit market, five storeys or lower, are standard timber wood construction, some cold-formed metal steel, and then concrete podium.
Interviewer: Okay, I see. So currently, do you build the properties or do you deal in trading the properties? Mostly, I mean, buying and selling, or building the properties and then selling them.
Interviewee: Um, so I didn't work for a construction company. I worked with contractors, but I didn't work for a construction company specifically. I worked as a developer. So, we're hiring contractors. I just want to be clear, when I say I build properties, I'm not building them as a contractor, but I'm building or renovating them as an owner's rep or developer of the property. So, yeah, some are buying and selling, some we're holding.
Interviewer: Okay, I see. That's good to know. Okay, so like, when you buy a property, how many years do you plan to own them? And then sell them? Or is it like, Do you own the properties for five to ten years and then sell them? Or do you buy and sell for a very short term duration?
Interviewee: It depends. Properties come in various stages. You could be buying land, a building that's operating, or a vacant building. Those are the main conditions. I think three

main conditions that a property might be in is either... mostly concerned about the real estate properties and not the other ones like land or the other one you mentioned. So mostly, what factors do you consider?
Interviewer: Okay. Yeah. That's great to know. So, yeah, I remember you said about like, you are mostly looking towards energy efficient buildings, like you want to mostly try to, like invest in those properties, like those have less operating expenses. So if you would have like, heard about mass timber buildings. They are mostly energy efficient compared to the concrete ones. So, what is your perception? Like, why mostly the contractors or developers owners around in your community are not moving towards that kind of construction material, and rather use concrete or traditional wood for the construction?
Interviewee: Can you hold on one moment? I'm gonna, I seem to mute myself for a second and then I'll answer that question just as I can. Okay.
Unknown Speaker: No problem. Okay.
Interviewee: Thank you. So, yes, I mean, looking, loving to qualify what I said here because you said looking for energy efficient buildings? Yeah, of course you want an energy efficient building that doesn't have high operating costs. But I mean the truth, the truth is, is that you it when we're construction costs, and in this, is this going to be specific to Detroit again, because this is my experience, construction costs for new for new construction use important to differentiate between new construction and an already existing building, because when you're buying an already existing building, it is incredibly expensive to update the systems. And you have to work you have to work with what you've got, oftentimes, yes. And, and in new construction, but when you're picking in, and so the likelihood of choosing a sample construct a more sustainable construction material is really driven by by cost, because you're not going to, you're not going to get a bank loan, you're not going to get investors to invest, if the cost is high, so then you're you're looking at, Okay, is there a specific subsidy, that can artificially lower the cost to build something that's going to be more sustainable. And so, I mean, just time and time again, every time you look at doing something more sustainable, it just comes across costs cost as funds back to drive you material selection, you know, marmoleum, sort of locally on, you know, any any, like, using less plastic materials, like, it all drives the costs, and I hate that I hate plastic I use, I try to use as little plastic in my life as I can. But one of my conundrums being in this industry is how resource intensive it is. And, and at the same time, money wants to go where it's gonna get paid back. And it just doesn't go into places where it doesn't think it's gonna get paid, at least get paid back and get a return. And that's the way that banks and investors are looking at it. So you have to find ways to artificially bring down the costs of doing construction. And then you also have, you know, you also have affordable housing needs as well. And so, if you're looking in the market, and you're and you're looking at, okay, you know, there's, we need to provide more affordable housing or that there's just no, no, at least in Detroit, and I'm only speaking about Detroit, because this isn't the case in other markets, but you cannot build new construction, sustainable housing. at an affordable price. Without some sort of artificial subsidy to lower the costs and allow you to charge lower rates.
Interviewer: Okay. Yeah. That's a good answer. It will help us a lot for the study, I think. Okay. So why do you think like the cost with this new kind of material, where like, it's energy efficient, and operating costs are less? Why do you think like, Those are expensive compared to the traditional ones like concrete? And is there like a supply chain issue, or

there are not enough suppliers in the market for those? So why do you think like the cost is getting higher for those kinds of new materials?
Interviewee: I don't know. I genuinely don't know. Okay. I mean, some of it is probably some, I mean, economic principles of supply and demand. You have a lot more companies out there. I'm just speculating, I don't have not going off of any data. Okay, with what I'm saying. So I have zero data. My speculation is that with supply and demand, you have a fewer number of companies that are producing the sustainable materials so they can charge a higher premium because their stuffs in demand. Whereas you have a lot more companies producing the less sustainable material. So stay competitive. And the price is down. Okay.

Interviewer: "Great, let's delve deeper. I'll be sharing my screen shortly to explore some high-quality quantitative questions that will provide us with a deeper understanding of these mass timber projects. Now, the data we're examining pertains to a 14-story building located in Madison, Wisconsin. It encompasses four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Let me elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, in the full mass timber scheme, both beams and columns, as well as the framing, are exclusively composed of glulam, supplemented by braced steel framing."
Interviewee: "Got it, so we have a variety of options to consider."
Interviewer: "Exactly. Now, based on the initial capital cost, which building option would you prefer?"
Interviewee: "I would definitely choose the full mass timber option. Despite its potentially higher initial cost, I believe in the long-term benefits and sustainability it offers."
Interviewer: "Interesting choice. Now, let's explore the operating costs for these different building options over a five-year period. Any thoughts on why the operating costs for a mass timber building might be lower than for a concrete building?"
Interviewee: "I'm not entirely sure, but I'd be interested to learn more about the factors influencing these costs."
Interviewer: "Certainly. We've conducted energy modeling simulations and found that mass timber buildings tend to have lower energy consumption, particularly for heating and ventilation, due to the nature of wood as a building material."
Interviewee: "That's intriguing. I'd like to learn more about how that translates into cost savings."
Interviewer: "Absolutely. We'll explore that further in the next slides. Additionally, we've observed that mass timber buildings often command higher market value, particularly in markets like Madison. This has been factored into our analysis of total cost of ownership."
Interviewee: "That's good to know. I appreciate the thoroughness of your analysis."
Interviewer: "Thank you. Now, let's consider the impact of different discount factors on total cost of ownership. Based on this analysis, which building option would you prefer?"
Interviewee: "Given the factors we've discussed, I still believe that the full mass timber option offers the best value in terms of total cost of ownership."
Interviewer: "Understood. Thank you for your insights. It's been a pleasure discussing this with you."
Interviewee: "Likewise. Thank you for the opportunity. Goodbye."
Interview

Interviewer: Good morning. Good morning. Can you hear me?
Interviewee: Yes. Like Yeah.
Interviewer: Hi. Thank you for joining. So can I know like a little bit about yourself and about your organization?
Interviewee: Sure, sure. So I'm the managing partner. We develop and build multifamily apartments, three and four storey garden style, as well as built for rent communities across the country, primarily concentrated on the east coast. From the mid Atlantic, down throughout Florida. Yeah, we're vertically integrated development, construction, investments and property management all in house. Okay,
Interviewer: that's great to know. So when you like invest in any properties, or any, take any projects, like what factors do you consider in like, from the investment perspective, to do you look like for long term ownership of the building? Or is it like a very short term? So again,
Interviewee: it's a little bit of both. I mean, over the last few years, we were merchant builders, because valuations have become so, so high and so frothy, but traditionally were medium to longer term holders. So anywhere from five to 10 years. Okay,
Interviewer: I see. Okay, so have you heard about mass timber buildings? Or have you ever been involved in mass timber projects?
Interviewee: Yes, yes. I've never been involved in a mass timber project. But I've seen a few projects that Skanska has developed and built and a few other groups. Interesting. Okay.
Interviewer: So currently, I can assume that you are mostly dealing with the concrete and steel construction or the traditional timber, right?
Interviewee: Yeah. Traditional timber. Yeah. wood frame construction. Oh, okay.
Interviewer : So can I know like a little bit about your current construction projects? And is there any reason like, why people are not shifting towards this new kind of mass timber materials where it is, like, more sustainable and, and it looks more aesthetic compared to the traditional ones? So do you have like, any perception from the community around you?
Interviewee: Yeah, yeah, I think like, mass timber is before that are beautiful projects. However, they're extremely costly to build, right? So regardless, yeah, I think, yeah, sustainability is nice. But at the end of the day, myself, as well as every other developer and builder, we all have partners, limited partners, investment partners, and we have to meet certain return thresholds. And in order to make sure our project is ultimately financeable and in this market where you've got so much pressure from a cost basis, you know, construction costs, higher interest costs, interest carries, you've got all these other factors that are increasing the cost of developing a project, adding one more item like mass timber, although it'd be nice, it's just not economically feasible at the moment.
Interviewer: Okay, I see. Okay, so. Okay. Let me ask another question. So, like, do you think like people in the community lacked experience in the mass timber construction compared to the other categories?
Interviewee: There's no doubt I think mass timber is a newer, although not newer, but relatively newer building material type, right. And the technology has evolved over the last few years that allow it to do more types of construction like multi storey office and getting larger spans and allowing for floor plans that are more appealing to the end user. However, a access to the product right and experience with erecting the product like for example here in Florida, it's probably going to be very difficult it unless they get a Florida building product approval and can secure or Miami Dade County Building approval because we have

the Florida Building Code, which is way more stringent than the International Building Code. And then you have the Miami Dade building code, obviously designed for strength to resist hurricane force winds and rain and everything else. So I think for us here in the southeast, it's a lot harder to find companies, subcontractors specifically that can supply the system, the total building system and erected like we could get with, you know, the steel subcontractor, or a tunnel form concrete subcontractor, or a traditional stick frame subcontractor. We even use panelization here on a lot of our projects, where they're all of our product is built in a factory, and it shipped and erected on site. So we're very open to new technologies, we just haven't found it to be feasible yet. And I don't think it's as readily available across the country outside of the Pacific Northwest, you know, DC and a few other you know, primary markets.
Interviewer : Okay, yeah, that's right. Okay. Yeah. Thanks for the great answer for that. So, okay. Let me see. What can be the next one. So, what do you think? Like, currently, what kind of projects you're involved involved in? Like, is it multifamily housing are mostly the commercial, kind of like office spaces? So what are the kinds of projects you deal in with?

Interviewee: Yeah, multifamily. Yeah. So we do horizontal apartments, which is like, I guess the new fancy way of saying, you know, build for rent housing, right cottages single storey, and we also do you know, low rise and mid rise apartments, so three and four storey garden, or, you know, five and six storey wraps.
Interviewer: Okay. And do they involve like any concrete constructions? Like the podium with the concrete and the top upper part with the traditional wood? Or is it like a concrete
Interviewee: podium? podium? Yeah, we're looking at for junuh. We're in pre K pre development right now and a podium in Tampa. Oh, that'd be a five. It'd be a five over three. Oh, okay.
Interviewer: So is it like a podium with the parking lot? And exactly,
Interviewee: yeah, so there's commercial on the ground floor. And then there's three levels of parking and then five storeys, so apartments above?
Interviewer: Okay. Okay. So do you think like, is there any supply chain issues?
Interviewer: With the concrete as well? And if you plan to switch from concrete to mass timber, do you think like, there is a huge supply chain issue in procuring the new kinds of materials as well as the current materials? Like? Yeah,
Interviewee : I think I think there is right like, just here in Florida, for example, I could go to no less than six or seven, you know, you know, traditional wood frame, subcontractors a little bit my work and get it done. I don't even know who in this market, I could even turn to, to supply to furnish and install a mass timber structure on top of that podium, I think it would be super cool. It'd be very interesting because I mean, we're always looking at you know, different construction methods and technologies like does it make sense to go to coal form steel? Because obviously taking into account fire ratings and everything else that comes into it, like if I build mass timber, you know, what do I have to do from a fireproofing and a fire stopping standpoint right? Does it need to be treated? How do you treat the structure? Those are questions that you typically have like in a wood frame building out wrapping everything and drywall we've got to our our separation walls those are complicated assembly so I guess it's one of those things that we would want to have a lot of discussions with our with our design team to understand like their it's great, it's a beautiful structure but what are all the other unintended consequences of going to that what do we

have to do to ensure the fire rating on the inside? Do you have to take that beautiful mass timber structure and then have it wrapped in yet to protect it ultimately, so but I don't even know who I would turn to here or take a little bit of digging before I can even find someone that could provide it and price it. I think that's part of the challenge. Yeah,
Interviewer: okay. Yeah, as far as I have read in the literature about this new like mass timber. It can sustain the fire like they have made like, made the material in such a way that it can sustain fire fire like they have a two hour or three hours fire eating something like that. Patricia Yeah. Okay, so, probably for the next part of the team, like, I will be sharing my screen and ask a couple of questions like continuity questions regarding the case study we did in Madison. So, let me share my screen and discuss about that. Okay, can you see my screen? Okay. So yeah these are quantitative type of questions so that we can go into more depth of this mass timber projects. Let me now explain this data is about 14-story building comprised of a 3-story concrete podium, we have assumed this building is in Madison Wisconsin. It consists of 4 different schemes. The schemes are hybrid steel/timber, full mass timber, concrete, steel. So let me just explain, for hybrid steel timber scheme the beams and column are made of glulam and framing is made up of steel. And for mass timber the beams and columns are made up of glulam and framing is made of glulam and braced steel framing. So, this is the initial investment cost for these buildings, like, which include all my labor material cost, which is which has been spent to construct these buildings. So, based upon this initial investment cost, like which building would you prefer among this? And in the later slides, I will let you know, like, what are the building schemes.
Interviewee: Yeah, if I'm assuming that all four buildings generate the same rent, I would choose Building C okay, because I have a fiduciary obligation to do so, to my investors.
Interviewer: Yeah, right. Okay. I see. And probably now, I show you like, what kind of materials we have used for these kinds of buildings. So, the first is like hybrid steel timber, where we use like a timber and steel, proportionately to for the construction. The second one was like a full mass timber scheme building, where mostly, all the construction material was like glulam or CLT, which are fully mass timber. Third one was concrete, and the fourth one was steel. So based upon this now, which category will you choose? Based upon? After revealing the material?
Interviewee: Or the cost? If so, choose concrete.
Interviewer : Okay, I see. Yeah, I think this goes in hand with your assumption as well, you, you think that this habit steel, timber or full mass timber are like costlier compared to the concrete, maybe that's why the market don't want to get switched towards this kind of materials. So, yeah, using like this case study, like, we have found as well, the initial investment cost might be was higher, because there was issue in supply chain, like, difficult to find materials. And maybe that's why the cost spiked up for this one little bit. But we realize from the, like, the contractors and the architects, that if everything gets resolved, and like if planned properly, the cost can be similar to the concrete ones. But yeah, this is just for the initial scenario. Now, probably, I will be discussing about how my cost looks like if if I own the building for five years, and what is my total cost of ownership for the buildings. Basically, it includes my capital cost, which is the cost which we have seen before. And it includes operation cost, which is my electricity, maintenance, repair, and everything, and, and the resale value. So basically, all these costs are discounted to the present value. So have you heard about discount factors? Or do you want me to explain a little bit about it?

Interviewee: Yeah, no, I'm very familiar with discounted cash flow analysis. Okay.
Interviewer: Okay. That's good. Great, actually. So it'd be more easier for me to explain this slide. So, yeah, all the future costs like our discounted to the present value, which be and we have considered discount factor of 10% for the short term and and see what is the total cost of ownership for the building and based upon this thing, which building would you prefer among this?
Interviewee: I think the question is interesting. Walk me through the methodology of getting to the resale value at fit at the end of the 50 Yeah,
Interviewer: yes. So let me so we have realized in like the market, we have studied this case study building. We have realized that mass timber building, get like more market share You compared to the concrete ones, like they sound based on based on what, based on rental prices and those things and their year on year, how many how much they are increasing compared to the traditional concrete buildings. So we realize, like, it's 7%, more seven to 8% more than the concrete buildings. And we have taken that one into the consideration into this study and realize this is the resale value, they will end this have basically discounted all the future costs or discounted to the present value. And based upon that, we got this price.
Interviewee: So I think that I think you're assuming that you're getting an increased value, because of the construction type, at the end of the day, it comes down to what rent you're gonna get. And you could dress up a concrete building just as much as you dress up. If it's a Class A building a great location, whether it's mass timber, or whether it's concrete, the user typically isn't going to care. I'll think that it's ultimately going to come down to the rent. So I appreciate what you're saying. But I think at the end of the day, it comes down to the value the cash flows, the vehicle doesn't is, frankly, most people are agnostic.
Interviewer: Okay, so. So your answer would be like building a in this assumption? No,
Interviewee: I just I would I don't I think the question is flawed, is what I'm saying. I think you're asking this question. Yeah, at the end of the day, all throughout all four of those buildings, you have to assume they're going to achieve the same amount of rent, especially in today's market. And if they achieve the same amount of rent building C would be the would still be the winner. Right? Because you have a lower basis. So it's, I think, the way the question has been, yeah,
Interviewer: the rental cost into it, it just how much cost? It is? Do you actually not? We haven't gone into, like, the profit side of it, or I mean, the revenue side of it, we are just looking, how much cost does it have to own the building for five years. So that's why it just have like capital cost operation cost, and what is the resale value and and based upon that, what is like my total cost of ownership. So we haven't included like rental cost in it. So we are assuming the rental would be similar for all the buildings, it just the resale value of the building is much higher compared to the building see. And we have seen the operating cost gets lower as well. Compared to like Building C and D for these two buildings. And based upon these assumptions, not assumptions, like based upon this market scenario. Which one would you prefer? Then?
Unknown Speaker: I would still build building C.
Interviewer: Okay, I see. Okay, yeah, probably in this question. We do the same kind of thing. Like, we just revealed the material. So the first two are like timber, this third and fourth, concrete and steel. And this is the total cost of ownership of like 10 years. Which building would you prefer them?

Interviewee: I think you'd take the lower cost of ownership, but it depends on how you're coming up with that number. Yeah, I mean, obviously, you'd want the lowest cost of ownership. Yes.
Interviewer: Okay. So I can assume that in this case, probably you will go with this building materials. Right. Okay. Ice I see. Yeah, probably I won't go into this slide. Huh? Yeah. Now probably like we changed the discount factors. We some our assumption on taking those discount factors were like couple of reasons. Like one was like how much one can on using like my stock market? Or how much my market fluctuates in Madison. So based upon that, we took like different discount factors and did the same kind of analysis. And based upon like 15% discount factors. Which building would you prefer? For the using, like the total cost of ownership?
Interviewee: And here's the question I have here, you're discounting that your initial cost of construction,
Interviewer : right? No initial cost of construction. We're not discounting it.
Interviewee: What are you using? So what are you discounting? What do you what
Interviewer: are the repair maintenance, energy costs associated with the buildings and all the Future resale value like you're going to learn. So, all the future costs are discounted like to the present value. And like the present initial like capital cost, we are not discounting it, we are assuming the person is paying, like this whole cost at the front end, like we are not taking in the future,
Interviewee: that if your list looking at it from that standpoint that you would choose the hybrid steel timber building.
Interviewer: Okay, I see. Okay. So yeah, probably, yeah, I did for 10 years as well, but I won't go into 10 years. So just one last question. But this is mostly for like, long term thing. So here, like we present the capital costs for the building for different buildings, and what is the lifespan of the building. So we realize that mass timber buildings have like, better lifespan, and they have like when you demolish the building, or construct a new building out of it, you can sell it at? Because you have like wood in it, right? So you can always resell the wood and get a better price from the market for that. So this is the lifespan for different buildings and the initial investment costs. Now based upon this, like which building would you prefer? I think you are a short term, probably owners. You want look for like how much lifespan of the building is right? No,
Interviewee: I mean, lifespan is important. Don't get me wrong, because I really consider what looking at Terminal valuation. But I mean, my question is, how do you know the lifespan of a mass timber building is 100 years, when it's a relatively new technology
Interviewer: like literature review, we realized that mass timber buildings have more lifespan compared to the concrete building. So based upon like,
Interviewee : based on no evidence, but only kind of, yeah, yes,
Interviewer: basically. Yes. Because mass timber like we can't know, like, how long will because it has been introduced, like just 510 years back. So we really don't know like, how long will it but based upon like certain stuff, like
Interviewee: you just answered the questionnaire, right from, from a developer's perspective, it's like, yeah, theory is great. But I know that concrete and steel are gonna last for a long time until it kind of gets proven. So this is a this is a tough one. But yeah, you would take the longer lifespan building obviously, right? You can, it's going to last longer.

Of course, based on this information on this slide, you would either choose option one or option two.
Interviewer: Okay. But the initial costs for Congress that
Interviewee: I disagree with, but I disagree with the the assumption that it's 100 year lifespan for those two, and then concrete steel are gonna far outlast the mass timber, or the hybrid sealer timber. And I understand what you're saying to you regarding like, with the buildings at the end of its useful life, if you tear it down, that's not going to happen, because at the end of the day, labor is the most expensive component in anything we do. And so it's going to cost you far more to kind of harvest that and recycle it than it would be just to tear it down and move on. And take it to a landfill or burn it or anything else a lot cheaper.
Unknown Speaker: Oh, yeah,
Interviewee: that's right. unfortunate, but yeah, that's okay.
Interviewer: Okay, that was great. Talk actually, with you just one last thing like, so currently, like, we are trying to do this study and get the opinion of different like developers owner or architects, or anyone from the construction industry and know their opinion, like, what are the issues they are facing? And like? Do they have any opinion towards moving towards like new construction materials? So we want to, like, reach out to more people about our study. So currently, we have very limited few people for our study, like among you. So do you have like any more context to whom which we can reach out and, and get their opinion about this? And grew our research mode and make it?
Interviewee: Yeah, I think I think I could refer you to a few more people. I'd be happy to send you some contacts that I had that could that could help you broaden your research. Okay.
Interviewer: Yeah, that will be really helpful.
Interviewee: Yeah, absolutely.
Interviewer: Okay. Yeah, it was really good talking to you and for your greater opinion regarding this study. Yeah. Thank you know, you're
Interviewee: very welcome. Have a good day. Good luck to you. Thank you

Interview

Interviewee: Hi, Good day.
Interviewer: Hello. Hi.
Interviewee: Howdy. How's it going?
Interviewer: I am good how about you.
Interviewee: yeah I am doing well.
Interviewer: Okay. So can you tell a little bit about yourself and your company?
Interviewee: I guess you want to provide me more context. And then I'd be happy to share but I need a little bit more context.
Unknown Speaker: Context regarding the question, you mean?
Interviewee: Yeah. Like what are you trying to accomplish? How is the information going?
Interviewer: Yeah. Okay. Yeah, let me try to give basically
Unknown Speaker: the objective and the outcome. Yes.
Interviewer: So the objective of this is to conduct like, master's thesis research, where we are trying to conduct a survey for developers owners and see what is their opinion in moving towards mass timber construction, and what are the difficulties they are facing currently in their construction projects? And like if there is any possibility for them to move towards mass timber? And if not, like, what are the difficulties they face in this

market? So basically, this is the overall idea of this survey. Sure. Okay. Yes. So, yeah, just to get into that part, we will get into that later on. But can I know, let it a little bit about yourself? And what does your company do so that I can direct my questions in that manner? For for the survey? Sure.
Interviewee: We're, we run a real estate investment company and we run a residential or not even just residential, construction business, we run an investment company. We do everything from purchasing existing buildings to ground up construction with new structures.
Interviewer: Oh, okay. Sounds great. So so if you like, own the building, or investing in property, how many years of ownership do you look for? Like, is it very short term five to 10 years? Or is it like a very long term ownership of the building?
Interviewee: Typically, I'm a little longer term. So minimum, I would say it's seven attend minimum, but our new thesis is to hold indefinitely.
Interviewer: Oh, okay. I see. So, so have you heard about mass timber buildings? And if yes, like, Do you have any experience in the mass timber construction?
Interviewee: I've heard about mass timber. I think that when you look at construction methods, yes. Permit ability and the understanding in the AEC what is it? architecture engineering construction? industry. We the methods we chose, we believe are innovative. But we have not worked on a project where we wanted to lead with mass timber No.
Interviewer: Okay, I see. So what are the difficulties? Like do you face? If you want to move towards mass timber construction? Do you feel like there is not much resources available in the market regarding it? Or is there is some other reason for that?
Interviewee: Well, for our company in particular, we look for well established building codes. So IBC, we don't want to get held up in the regulatory or the permitting process, we don't want to get held up in the inspection process. But for the most part, when you look at how buildings are designed, unless the owner themselves are specifying a specific construction method, typically, you're going to find that it's the architecture firm, or the engineers who are specifying the materials that's use. So once there for us, we just, we chose a selection that's more established and in established. Okay,
Interviewer: I see. So don't like, do you try to suggest them? Okay, if this design may be more profitable, or maybe more beneficial, compared to the, like concrete designs? Do you have those kinds of recommendations to your owners? Or is it just owners say, Okay, I want to have this kind of construction, and you do based upon just their opinion?
Interviewee: I guess now in our business, we educate the owner on the method that's going to be most cost effective and most efficient, we find that the owners typically aren't construction experts, they have no experience. So yes, you know, they typically want to deliver a certain product at a particular price point. And it's our job is to direct them into the best building method for the most efficient prep.
Interviewer: Okay, I see. So, what is your opinion regarding like the mass timber construction? Is it like the supply chain of mass timber is very difficult? Or is it very difficult to find contractors, designer architects who lacked experience in this mass timber construction? Yeah,
Interviewee: I think it's a little bit of all of that. I think that mass timber is not an established building method. Lumber construction is next. Once again, you go back to architecture, engineering and design. You need firms that are familiar and have either build projects or have the familiarity. And personally, I'm not sure the cost comparison of

whether it's more cost effective or at least cost effective. I think that when people are leading with the mass timber market, they're speaking more from a sustainability standpoint, rather than a cost standpoint. Yep,
Interviewer: that's right. Okay, thanks for the great answer, it will help us a lot. And so do you think like, people more like dive towards the environment factor or diet towards more like cost benefit factor when they invest in it?
Interviewee: For a typical developer, it's all about cost the developers working off of financial engineering, yes, rates and interest. So they're typically completely financially driven. Those who enter it from a sustainability standpoint, are typically trying to signal to the market, whether it's ESG, whether it's lead, but they're planting their flag and the sustainability and most likely they're going after an award or a design award, something like that. But most owners care about cost per square footage, and just the economics, the unit economics. Okay,
Interviewer: Okay. Sure, let's dive deeper. I'll share my screen shortly, and we'll explore some detailed quantitative inquiries to better understand these mass timber projects. Now, this dataset pertains to a 14-story building located in Madison, Wisconsin, featuring four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to provide some clarification: In the hybrid steel/timber scheme, glulam is used for beams and columns, while the framing incorporates steel. Conversely, in the full mass timber scheme, both beams and columns, along with the framing, consist entirely of glulam, supplemented by braced steel framing
Interviewee: Yes, please. Good.
Interviewee: you now just looking at it. There's not enough information for me to make a decision. Because although you're leading costs in the various costs, I can say that what about the cost to operate the building long term? It depends on what my what my KPIs are my key performance indicators, some people are just wanting the lowest cost for a construction. But one building B might be more efficient to operate than building C even though Building C is cheaper to build We're building a might get you know what I mean? So I think yeah,
Interviewer: yeah, and we'll discuss all those factors like in the upcoming slide it just like in this first slide, I just want to see, probably you will choose like one which is more cheaper, right? Based upon this information, not all the information, right?
Interviewee: If if it depends on the level of finish, I can't this was the tough because, yes, cost is not necessarily the factor in our business.
Interviewer: Okay, I see your opinion. Okay. So yeah, in the next slide, we just tried to reveal the building materials. And the first one, it's a hybrid steel timber kind of strategy. And the second one is full mass timber, third is concrete for the steel. Now, based upon like this materials, and this is the capital costs. So all these buildings have like similar features like same number of rooms and square footage and everything, it just a building material is different, I will
Interviewee: say steel, because steel is well established steel is very known steel is steel as a dominant market force. I think that from a timber standpoint, the only reason I would go with a hybrid is if the timber has certain levels of exposed newness, and it's adding to the aesthetic appeal, which can create more goodwill and value, but ultimately, otherwise, I would choose steel.

Interviewer: Okay, so is there any reason like to choose from concrete and steel? Like you chose steel?
Interviewee: Yeah, I mean, so concrete is a huge contributor to carbon emissions, it's massive, actually. Concrete has been getting more and more expensive. And I just believe that we use steel now. So I think steel is, you know, it's non combustible, it's sustainable. It can be reformed to size, I think steel offers a multiplicity of benefits, you know, that for us, then well established building code. Yeah,
Interviewer: that's right. Okay. Now, like, we will go more into depth of like how my cost looks like if I own this building for like, five years. So in this scenario, like, we give the same like building a to d, and capital cost, same as before, but we have estimated the operating costs and what would be my resale value at the end of like five years for these different buildings. So, this operation cost it includes all the operating costs, like my energy cost, which is electricity, gas and water, and operation maintenance, repair cost, all those costs are included in the operation cost. And we have estimated using like energy modeling software's of this cost, and this is the resale value, which we have estimated based upon the Madison market, and given what kind of materials we are using. So we have estimated like mass timber have generally gained like more, seven to 8% more market value compared to the concrete ones. So we have taken that factor into consideration, while estimating the like, approximately good resale value for these buildings. But all these future values are discounted to the present price, which basically means Have you heard about the term called discount factor? Yeah,
Interviewee: I mean, you're using a discounted rate on the PV. Yes,
Interviewer: yes. Right. So all these are like present value PV. And based upon this present value, we estimate what is the total cost of ownership for five years of this building? So now based upon this scenario, which building would you prefer? I mean,
Interviewee: initially, I chose D, which was all steel, but if you're telling me I can have steel and mass timber, and it's the move, no, it's not the lowest operating costs, B is the lowest which is full mass timber. However, I am unsure what the level of complexity to actually construct that building. Let me look at the cost initially, it's still cheaper for me to go all steel, but it's more for me to operate. If I go to the hybrid, it's a little bit more expensive, but it's the cheapest to operate and if I go straight mass timber, it's the most expensive, but it's the lower I go a hybrid, okay.
Interviewer: So, the reason I assume you chose this one, because it has a low operating cost compared to Building C and D and it have more resale value compared to the other buildings, right. Okay. Yeah. Now, the similar kind of fashion we did before like we just revealed the building materials we had the first one is hybrid steel, the second is full mass timber, this is concrete and steel. So based upon this, which one would you choose? The I will do a hybrid okay. So I have made steel timber right. Yes. Okay. So, this is based upon like 10% of discount factor on the market. But we have done analysis for different discount factor as well because we have seen like the discount factor, it's not fixed like it can vary based upon the market. risk. So, based on this short term like five years, we assume like if someone invest 15% of their money like sorry, if they invest money in stock, they will have 15% profit out of it. So, we have analyzed the scenario for like various discount factors, but here I will just show like 15% discount factor. So, based upon this we have estimated what is my total cost of ownership with this discount factor. So, which one would you choose based upon this?

Unknown Speaker: I mean, it still seems that the hybrid is the the lowest cost to operate.
Unknown Speaker: Okay. So,
Interviewee: total cost of ownership is, the lower the number, the better the higher the number, the more the
Interviewer: lower then it just like how much money you are putting out of your pocket. So,
Interviewee: the hybrid bias, the hybrid is in the best scenarios. Yes. So,
Interviewer: yeah, just want to mention here, like the concrete have the lower capital cost. But if you see the total cost of ownership, like probably hybrid steel or full mass timber, maybe have more profitability compared to the other two ones. And it's
Interviewee: just my belief that if people are unfamiliar with a technology, they'd rather with a hybrid and test it out before they go full. So if you're converting me from steel to mass timber, I do a hybrid first.
Interviewer: Okay, I see your opinion. Yeah. That's great to know. Okay. So just one last more question. Yeah, there was like 10 years analysis as well, like we have estimated. So here, like we estimated, like the total cost of owning the building for 10 years, and these are like my operating cost. And this is the resale value, and the discount factors. So it's same as before, but now in this scenario, which one would you consider? It's
Interviewee: still the same as before the lesson was a hybrid.
Interviewee: can get the metal but for $1 More basically. Or me, what is it a million more from steel? You're buying 25 years of usable life? Familiar? Yes.
Unknown Speaker: You Yeah, we'll have to circle back to email. No problem. Okay.
Interviewer: Thanks a lot. Thanks for all the great answers. Thank you.
Unknown Speaker: Okay, thank you. Nice to meet you. Have a good day. Nice to meet you. You too

Interview

Interviewer: Hello. Hi thank you for joining.
Interviewee: Hello, yes.
Interviewer: Okay, yeah, thank you for joining. So basically, this survey is regarding thesis on mass timber construction. So I am trying to Identify like, why the people are not adopting the mass timber construction? And what are the difficulties they are facing? And what are the current techniques they are using, and if possible, like, through the case study, we can see how it can help her study. So that's the whole motive of this survey. So in order to go into this survey and the case study, which we are going to discuss, can I know a little bit about yourself, and what company do you work for?
Interviewee: Yes. Okay. You just want me to begin and then you can ask them anything on this?
Interviewer: Yes. Okay. I'm the President and Chief Executive Officer. And we are based in East Lansing. Our company, interestingly enough, is this year is 100 years old, a third-generation family business. And our specialty is in developing and investing in freestanding commercial properties, that is, properties for the most part, which are not multi-tenant. We have one tenant, so, you know, retail service, gasoline service stations, that's bank branches, a number of restaurants, and then some smaller office buildings.
Interviewer: Oh, okay. That's amazing. Like, throughout our like, whole this process, I haven't found anyone like doing in commercial properties, probably you are the one. So it will be really helpful to know your perspective. Thank you for the great introduction. So before, okay, now probably can I know like, when you construct any building or when you

own any property? How many years of ownership do you look for? Like, is it very short term? And afterwards?
Interviewee: It's the opposite, it's very, very long term. Properties, you know, some properties 50 or more years. So, what we do is to really invest in and make money off the income, the income, rather than trying to buy it and build it and sell it.
Interviewer: Okay, yes. So, I can assume that you, like, own these properties and give them on rent to the other like, commercial owners, as commercial user, so we use this somebody might buy, so we would lease them to a restaurant company or a bank or gasoline service station operator. properties and then we leased them to the operators.
Interviewer: Okay, that sounds interesting. Okay, so have you involved in any mass timber construction project? And if yes, like, is there any experience with mass timber? In your projects?
Interviewee: Sorry, I just might experiment. Can you repeat the question, please?
Interviewer: So have you been involved in any mass timber construction? And if yes, like,
Interviewee: I have that done? Oh, no. arity with it, you know, because I, I also taught at Michigan State number and no George and I took some some of my classes to some mass timber construction projects, in particular the STEM teaching building at Michigan State.
Interviewer: Oh, okay, I see. So that's that's kind of a limit of my familiarity.
Interviewer: Yes, I can assume like your family, you're not much familiar with the mass timber construction. And maybe I only am not so much in my day to day operations as I am. You're my work at Michigan State. And my connection with with Dr. Berg horn.
Interviewer: Okay, I see. Okay, the question, you know, one of the interesting things, if I may, is a question of scale. So, I wonder if Roger is looking into what scale mass timber can make sense. So, you know, candidly, our property, our buildings are pretty small, anywhere from 2500 to maybe 10,000 square feet. And my hunch, though I haven't really done the research is that they require some scale that I don't think is a technology currently exists sort of in its infant stages, it seems it seems unlikely that mass timber makes a lot of sense for smaller buildings at this time. I mean, maybe as it grows,
Interviewer: I haven't seen much like mass timber construction for the small scale, like most of the studies, like we have done, it's usually for the large scale maybe. Right? Exactly, it would be interesting to go in that direction, like how the mass timber is profitable, or like, beneficial for small scale.
Interviewee: Right? And I don't think it'll happen right away. My you know, I don't mean to, well, you know, you're interviewing me. So my observation would be that it's going to take some more adoption, and the adoption, the early users are going to have to be larger. Because that's really at this point in the, you know, if you will, in the lifecycle of the technology, you know, it's new, there's some costs associated with it that need to be spread over, you know, a larger building. And then, if that all works, and technology becomes adopted, is more of a standard in the industry, or at least, you know, a viable option in the industry, then, presumably, what will happen is that there'll be products that might be more readily available. That could be utilized by smaller developers such as me, but yeah, that's my quick take. You know, that's my quick tip.
Interviewer: Yeah, that's definitely I think, right? Yes. Yeah, yeah, it would have been interesting to go in that direction.
Interviewee: it started short term is an intermediate to long term. Yeah. It's interesting, because in other I think another products and technologies is the opposite, that you want to

try them out in smaller projects, right, where the cost of failing maybe isn't as great. Yeah. But this is, but in this particular case, for reasons I think you understand much better than I do. I do think they're most suited to larger projects.
Interviewer: Yeah, most of the studies like we have seen me and right. Most are basically, for the large scale, not the small scale ones. Yes. Okay. So yeah, I think you have already answered like, these things, using your opinion regarding it. So just few more questions like qualitative questions regarding this massive construction. So what difficulties like do you see like, any difficulty, adopting this technology, like any negative impact or any positive impact or any risks associated with adopting the massive construction?
Interviewee: Well, I think we've touched on them. You know, the main risk of difficulty, I think, is associated with, with the fact that it's new, and new technologies tend to have bugs. And so, if you're the first user, you're going to experience those bugs. And, you know, if you're a very large user, you have the resources, hopefully, to to mitigate those risks. But that would be that would be the the the principal difficulty, in my opinion. And I guess, related to that, you could say that there's, there's some risk associated with, with the life of the of the mass timber, because it is exposed to elements in a way that, you know, steel or concrete wouldn't be wouldn't be. So yeah, I think those would be the the main the main risks or difficulties.
Interviewer: Okay, I see. And any positive impact or any positive side of this massive construction, like, do you see any, like, in future, it might become really, like, helpful or profitable?
Interviewee: Absolutely. Absolutely. I mean, I don't think, I think that's, you know, sort of the the thesis of your, of your thesis, and the reason for for mass timber is that there's, there's a lot of benefits, you know, to to the environment to to the to the speed of construction to the to the aesthetics of the building, you know, there's, there's, there's a lot of there's a lot of pluses associated with it. I think, for us, though, you know, I think we, it's a little bit like, you know, like, self driving cars, like, we're just waiting for somebody else to figure it out. And then we'll, we'll, you know, we'll, we'll jump in. But but yeah, I think it's, it's a it's it's obviously, there's a reason why why there's so much interest and and you know, enthusiasm about the about the technology. It's it's very promising.
Interviewer: Yeah, that's really, that's really promising. I hope you're positive, like the side of it will like, somehow, over time, overcome the negative side of the mass timber construction. So yeah, okay, that's great. So I think that's all from my side. Do you have any questions or suggestions regarding the survey, or regarding like anything you want to suggest to us?
Interviewee: You know, I guess I'm curious as to whether you know, whether whether you think the, you know, the industry in general is, you know, sort of moving quickly enough to to address some of these these challenges and and, you know, sort of maximize the the potential of the of the of the of the mass timber construction technology, whether whether you think that, that there's, you know, that there's going to be a, sort of an adoption, you know, curve, or whether it's going to be slow. And then it's going to be a sort of like, kind of like a hockey stick. You know, that that's, that's what I'm, that's what I'm most curious about.
Interviewer: Oh, okay, I see. Um, yeah, like, it's really a, like, a very, like, you know, I'm just thinking about it. But like, most of the companies are like, adopting the slow pace of this technology. Because most of them are like, I don't know, most of the research, I have found like, most of them are in, like, laboratories, like doing some of the projects. And there are a

few of them who are like, doing the live projects. So I don't know, like, maybe the adoption will be really slow, and then it will take some time to, like, I don't know, for everyone to know about this technology, and then adopt it. But yeah, I'm not sure about the, like, the adoption curve, like, how the technology will adopt it, like, what the curve will be like. But yeah, I hope it will be adopted soon, because it's a really promising technology.
Interviewee: Right. Well, that's good to hear. And I guess, I mean, the other thing I would, you know, like, I'm curious about, and I guess it's related, is whether, whether you think there's, like, any public policy initiatives that that could accelerate the adoption of the technology. You know, I'm thinking in particular, I'm thinking, you know, about tax incentives, or, you know, building codes, or something like that, that that that might might might might speed the process along, you know, I'm sort of curious as to whether whether you've, you know, seen any evidence that that sort of thing is, is is is is happening, or, you know, might happen in the future?
Interviewer: Um, I haven't seen much of the public policy initiatives, like related to this, massive construction, or, or like tax incentives, or any other, like, you know, public policies. But I have read like, there are a few of the countries who are, like, introducing these public policy initiatives, like, I think Australia is one of them. And I think they are introducing some of the policies, like, to promote this mass timber construction. So I don't know, like, if in future, we might, like, adopt these policies, because it will be really helpful, because most of the research I have found is like, these technologies, like mass timber construction is really beneficial, and it's really, like, eco-friendly, so it will be really helpful if the government like, introduces any public policies like this. But yeah, I haven't seen much of them right now. But maybe in future, we will be seeing these policies, like, related to the massive construction.
Interviewer: I'll share my screen now, and we'll delve into some insightful quantitative questions to gain a comprehensive understanding of these mass timber projects. Now, this data focuses on a 14-story building located in Madison, Wisconsin. It encompasses four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Let me provide some additional context: In the hybrid steel/timber scheme, glulam is utilized for beams and columns, while the framing comprises steel. Conversely, the full mass timber scheme utilizes glulam for both beams and columns, as well as for framing, supplemented by braced steel framing. Considering this, let's talk about capital costs, which encompass the total cost of constructing the building, including labor and materials. So, based on these values, which building scheme would you lean towards? And I'll later explain our reasoning behind this approach.
Interviewee: "I'd likely opt for the most cost-effective option.
Interviewer: "I understand. Let me provide a breakdown of the different building materials. We have the hybrid steel timber, full mass timber, concrete, and steel options. Based on the initial investment costs for these buildings, which one would you prefer?"
Interviewee: "I'd go with the concrete option due to its lower cost.
Interviewer: "Interesting choice. It's worth noting that mass timber options are often considered more sustainable than concrete. However, cost-effectiveness is certainly a key factor."
Interviewee: "That's a valid point, but the cost difference is significant."

Interviewer: "Indeed. Now, let's delve into the cost associated with owning the building for a period of 60 years, including resale value. We've used a discount factor of 3% to calculate the total cost of ownership. Are you familiar with discount factors?"
Interviewee: "Yes, I understand. So, based on these calculations, which building scheme would you prefer now?"
Interviewer: "Excellent choice. Now, let's explore the impact of different discount factors on the total cost of ownership. We've adjusted the discount factor to 7% and recalculated the total cost of ownership. Based on these updated figures, which building scheme would you prefer?"
Interviewee: "Given the new calculations, I'd lean towards the hybrid steel option."
Interviewer: "Interesting perspective. Thank you for your insights. It's been a pleasure discussing this with you."
Interviewee: "Likewise. Thank you for the informative discussion."
Interviewer: Okay. Thank you so much for, like, giving your precious time and sharing your opinion regarding the mass timber construction. So we'll be sharing this study with you once we are done with it. And if you have any further questions, or if you want to give any suggestions, you can like, feel free to reach out to me, anytime. And, yeah, thank you so much.
Interviewee: Sure, absolutely. Well, good luck with your with your work.
Interviewer: Thank you so much.
Interviewee: Okay, take care.
Interviewer: Bye.

Interview

Interviewer: Hello. Hi. Hi, Thank you for joining. So can you tell a little bit about yourself and what do you do and, and little bit about your organization?
Interviewee: Sure. I'm Director Are of planning design and construction. Okay. Have a have a group of 35 architects, engineers and project managers that oversee and drive all the new construction and major maintenance projects for the campus. Okay. I'm civil engineer by background, structural engineer and have been director of University.
Interviewer: Oh, okay. That's good to know. Okay so could you please tell me about your experience in mass timber projects? And like how many years of experience?
Interviewee: Well, just one we had, we've we very much involved with the STEM building here on campus, and developing that, that design. So that has been in place now for for three years. It was the first mass timber large structure, an academic building in the state of Michigan. At the time we built it. I don't think there's been another one since. Yeah, we were very instrumental in making that all happen. I would call it a very collaborative effort between our Department of Forestry here on campus. And, you know, their knowledge and promotion of it, along with our former president Satya shoot was was very instrumental in helping us call it have have the foresight to try something new like that, because, you know, there's not a template, if you will, certainly here in the state of Michigan for a similar structure. So it was very leading edge. But I think the results of have spoken for itself, we've won several awards. The the popularity and the use of the building is incredibly high. And, you know, it's its function and use as a teaching laboratory has been been very, very good. So, okay,

Interviewer: that's amazing. I never heard about like, so much expansion in the mastering but that's good to know. Okay, so. So like, in the university mass timber projects, like, who is the basic investors like for the project? Like, is it MSU? Or is it some private entity?
Interviewee : The STEM building was a mixture of funding between MSU and the state of Michigan, the state of Michigan Department of Management and Budget. funded a portion of the building total project costs was, excuse me, 110 million. Oh, okay. I don't remember, I don't know, off the top of my head, what the state's contribution is. I could I could find that and send that to you. It was significant, though. So but but no private funds. It was all Michigan State and state of Michigan. Okay,
Interviewer: I see. So probably, I think the ownership will be with MSU. And it will be like very long term ownership. That's nice. Okay. Okay. So, yeah, I just wanted to ask about, so when, like, you choose the project in for constructing at MSU or the department choose. So what factors do they consider like whether to choose mass timber or whether to choose concrete? So what influence this decision for choosing mass timber versus concrete?
Interviewee : Well, at the time, the project went to market which was about I call it five years ago, roughly, when we're in the design phase. Yes, it was being considered as a material and comparable to have concrete or steel options. And the construction manager did a very thorough analysis. And it was it was determined that it would be cost effective to pursue it. And I guess Furthermore, the encouragement of having the expertise of Department of Forestry on campus, and the desire to do sustainable demonstration project, it was it was decided to, to go that route. Okay, I think it's really important to acknowledge that the analysis of the alternatives is very complicated. It's just not a matter of okay, a steel frame building is going to cost x and a concrete building is going to cause why. And mass timber is going to cause the the analysis of how the building is built, the sequencing, the scheduling, and how tray other trades are effective after the structure is in all factor into that cost. Yeah, so the cost model becomes quite complex when you're looking at the alternatives. And in you need to consider all of those. When when looking at the at the alternatives.
Interviewer : Okay, yeah, that's right. So, like, did you see any, like, cost saving in the mass timber project you had? Compared to like concrete or steel? Like, is there any estimate for that?
Interviewee: We didn't see on on our particular case, necessarily a cost savings. Yeah, in that, like I said, when you consider all the other factors of schedule, erection, and how quick other trades can get on the project quicker than a steel or concrete option. Say though, those things start to equate or neutralize each other. What we saw was, if you can look at comparable alternative, and they're close to the same and cost, the intrinsic advantages of mass timber between the aesthetics, the sustainability of the embodied carbon, and call it the acoustics of a mass timber building. You're not looking at equals to equals.
Interviewer: Yeah, so you're probably looking for long term advantage of the mass timber building rather than, like, just short term, or is it cost effective compared to concrete or steel?
Interviewee: Yeah, so so it's not a simple A, B, and C comparison because that aesthetics and sustainability value, and, you know, as a demonstration project, being an educational institution, having a strong forestry department on campus, et cetera, et it all helped to resonate towards towards that selection. But it's not a simple thing to say, oh, yeah, we

save 10% By going going mass timber, it's we justified its its cost as compared to other alternatives, considering the value of all those things mentioned. Okay,
Interviewer: I see. Thank you. Thanks for that good answer. Okay, so doing this project, like did you experience or the project experience any supply chain issue related to mass timber or were there any like zoning regulations or some building codes, which prevented mass timber or hinder mass timber construction like supply chain or something?
Interviewee: No, the company ultimately that was awarded the project was from Canada. They're a very call it active mass timber manufacturer. And once we got into the you know, the flow of the project, delivery of materials on time and in meeting the production of the erection schedule, all went fairly seamlessly. But there is a ton of work upfront that has to be done to get in you know, the manufacturing schedule, etc. So, all that takes proper planning and design coordination But once all of that was orchestrated with the design professionals and the construction manager, we had a very efficient erection of the, of the structure as as a result, okay,
Interviewer : so did like any contractor designer or architects lacked experience in doing this project because I think the candidate team was probably the material supplier, right. But that's where, like the local Michigan supplier, or like contractors are, where they from candidates of
Interviewee : No, no, the the it was a local contractor that did the did the erection on site. And they did not have a strong mass timber background. They were call it excellent contractors and carpenters that that did the work. But they did not have a strong experience with putting the structure in place. So that speaks to the quality of the design and the workmanship of the manufactured product, that when it had arrived on site, it fit. And it went together, you know, in a very regimented sequential fashion. So I'm sure they learned some things along the way. Protection of the mass timber was an important aspect of you know, once you get the columns in place, we still have to pour the concrete floors and so forth. And last thing you want is concrete splatter on a brand new beautiful laminated column. So protection of of that in the field and orchestrating that they came up with some real clever ideas on how to do that. And that that was very effective. So certainly, there was a learning curve, but I would say because of the quality of the product, it was, it was pretty workable.
Interviewer : Okay, that's okay. So okay, so what is your, like, overall perception why this whole construction community like, still, like is using concrete or steel for the construction and not like, moving at that pace towards the mass timber construction? So what do you think like, according to your experience, why is that,
Interviewee: um, it's, it's still a cost issue. The comparison of conventional methods of concrete and steel versus mass timber, all three are dynamic markets, you know, steel prices fluctuate up and down. Mass timber is is, you know, subject to market fluctuations, and the labor market comparison to do reinforced concrete, all of those things have to be factored in, at the exact location and time that you're building. And it, it hasn't come out. So that mass timber is call it dramatically less costly than the other alternatives. And because of that, of having to pay some component of premium, if if the owner, the stakeholder, the primary person financing the project, if they don't have the sustainability goals or the appreciation for the aesthetics of the mass timber, they'll they'll choose a lower cost option. So it's it's all about cost competitiveness and what what the owner values were. Yes, you will continue to see more of it. But it's still going to be on a selective basis. It's not. I don't

see it taking over where it becomes the predominant choice. Because of those other factors. It could over time but it's all about cost competitiveness.
Interviewer : Yeah, that's right. Okay. Yeah. Thanks for the details. Okay, so now probably I will be doing some quantitative type of questions. So I'll be sharing my screen shortly to explore some high-quality quantitative questions that will provide us with a deeper understanding of these mass timber projects. Now, the data we're examining pertains to a 14-story building with a 3-story concrete podium, assumed to be located in Madison, Wisconsin. This building encompasses four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to provide some clarification on these schemes: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, in the full mass timber scheme, both beams and columns, as well as the framing, are exclusively composed of glulam, supplemented by braced steel framing So this was the initial investment cost for those different building materials. So based upon this cost, which building would you choose? So this is just a construction cost for building ABCD.
Interviewee : It really have to evaluate what you're getting with between A, B, C, and D to make that decision, and I look at these numbers. And there's not a large disparity. I don't know if this is millions or 1000s. Millions. I would go with C as it is cheapest.
Unknown Speaker: Yeah.
Interviewee: Yeah. Oh, sorry. So yeah, from building see to building a five, roughly 5 million differential. Before I would consider a I got to know more as as to what I'm getting for that and what the function of the building is going to be. Yeah,
Interviewer: yeah. Building those in the next coming upcoming slides. So here is the next one, like where we try to reveal the material like, so the first one was hybrid steel, or timber. And the see option which you chose in the last previous slide, was concrete one. So now like once we revealed the materials, which one would you prefer among this?
Interviewee: Well, this is a tough one to answer. And I'm not trying to be difficult it becomes what is the goal of the project and the stakeholder? Is if it's purely aesthetics and feel, you know, I have I look at this alternative and it's like, okay, am I going to pay $5 million more for hybrid steel, timber? Or even more for mass timber? Versus concrete? I can't make that decision, unless I'm the actual owner of the building and know what the, what the alternatives are? I mean, I suppose you could put these numbers in a in a percentage, where what is it mass timber is 6% more than concrete or 7% more? It becomes a full judgment call as to what the goals of the owner is hear. Me personally, I love maths.
Unknown Speaker: What would you prefer? In this case,
Interviewee: I would try like heck to to justify the mass timber. But you have to recognize that that's a significant multimillion dollar decision and have to be able to sell it that way. That would absolutely be my choice. Okay,
Interviewer: I see. Thank you. So now probably, I think university is probably a long term owner. So I'll be like asking little bit more questions about what the overall cost looks like in owning the building for long term ownership. So here, like we estimate total cost of ownership, like of owning this four buildings over the life of like over 60 years, and we choose a discount factor of 3%. So are you like a little bit aware of a discount factor or do you want me to go a little bit in detail about discount factor?
Interviewee: No, I understand that. Okay. So for this study,

Interviewer : We estimated what is my total cost of owning this building for like 60 years. And here we have the capital cost, which is the initial construction cost and the operation cost includes all the energy cost as well as repair, maintenance and extra cost in this operating costs and this is the residual value, which is at 60 a year. So, basically this is estimated by using a linear because till till like 60 years, the life of the building won't be the building wouldn't be that sustainable. So, we estimated like what is my resale value or residual value at 60 years and if we like do the sum of all this thing, we get total cost of ownership for all this building. Now, based upon this, which building would you choose?
Unknown Speaker: I would go with a
Interviewer: okay. So, yeah, probably like we now the same kind of thing we reveal the material and I hope you will have the same option like building a you know, okay. So, is there any like reason for choosing this compared to other ones
Interviewee: Total Cost of Ownership is a is a strong criteria, whether it be called lifecycle cost, present worth analysis, total cost of ownership, yes. That's an important factor.
Interviewer: Yeah. So, in our like, analysis, we found that mass timber or hybrid steamed timber, they have more life compared to the concrete building. So like till 60 years, the the concrete resale value will be much less compared to the steel timber or mass timber. So, because of this, we see the total cost of ownership for hybrid steel timber or full mass timber is less compared to concrete and steel. Okay, so, and all these costs are like discounted to the present value, all the future costs are discounted to the present value. So okay, I see your point, like where you're trying to go with this. Now, probably, like we changed to play with the market rates a little bit like we changed the discount factor to 5% Or maybe I let me go to 7% directly, rather than discussing about 5%. So if the discount factors is 7%, which means basically my inflation rate or the market fluctuation rate is basically like 7% each year. So these are the total cost of ownership for this building. So which building will you choose? Based upon this discount factor?
Unknown Speaker: Same, the same if we're calling that a yes.
Interviewer: Yeah. And yeah, I just wanted to explain a little bit. So if we compare like my discount factor, for 3% and 7%, we can see like the cost difference between my steel timber or full mass timber to concrete steel. With 3% It's a little bit less but if we go to 7% this difference become more and more and more drastic, yes. So which basically means that if there is more uncertainty in the future, like the steel timber or full mass timbers are more cost effective compared to concrete. And yeah, just one last question. So here we give the lifespan of all the buildings like we consider it's just a guess based upon the studies like lifespan for timber is 100 years for concrete and steel, we guess around like 75 years and this is the capital cost. Now based upon this, like which building would you prefer? Just based upon capital cost and the lifespan
Interviewee: it's gonna go back to that call it primary goals and criteria of the stakeholder personally I you know, I don't know where the assumptions come from. Lifespan mean we've got a lot of concrete and steel buildings around this campus that exceed 75 years. Yeah, probably probably be in this case, because those numbers I, you know, at that point are close in value, and aesthetically and sustainability wise would prefer the full mass timber option. Yeah, right. Yeah.
Interviewer: Yeah. Thanks for all the great answers. Yeah, just one last thing. So do you know like, Do you have any contacts with the mass timber construction owners or developers, because we are trying to do this survey and like, do a research study on this

thing. So if we can get more people for the survey, that will be more helpful for our study. But currently, we have very limited like around five to six. So we have got, so if we can get more survey and analyze the study in a proper way, it will be really helpful for us. So do you have like any more contacts with the master number? Or if it is a concrete developer as well, we are fine with that. Because we can know what are the difficulties they face?
Interviewee: Yeah, well, I could get you in touch with probably two other people that were involved with our project that would be willing to participate in the survey. I can send you their email addresses. Yep,
Interviewer: you can if you can send their email address that will be really amazing. Yes. Okay. Yeah. Thank you. Thanks a lot for your great answers. And it was nice talking to you.
Unknown Speaker: Hope that helps. All right. Thanks for your thanks for reaching out.
Unknown Speaker: Yeah, thank you. All right. See ya. Bye.

Interview

Interviewer: Well, hello. Hello. Hi, can you hear me?
Interviewee: Yeah, I can hear you. How you doing?
Interviewer: Yeah, I'm doing good. How about you?
Interviewee: Good. I have to run a little bit short today because I got slammed with a bunch of stuff. So why don't we just jump right to it? What questions can I answer?.
Interviewee: Yeah, that's fine. Okay. What can I do for you? Yes. So
Interviewer: Yeah, this survey is basically regarding master's thesis research. And we are trying to look like what are the difficulties which developers owners face for mass timber construction, and like, and if there is anything like we can help them out. And apart from that, like we did a case study, and we want to share the case study with you and ask some questions regarding that case study. So this is the overall like, theme of this survey. So can I
Unknown Speaker: start? Yeah, go for? Okay,
Interviewer: So can you before we get into all these things? Can I know a little bit about yourself and about your organization? And? Yeah, probably about those.
Interviewee: So we're real estate developers in Baltimore city, built about something like two and a half million square feet in the city. I've been here for about 12-13 years, have been part of about a million and a half of that. As far as I could probably just cut to the chase as to like decisions as to why or why we don't use mass timber or that kind of what you're what you're looking for here. Yeah,
Interviewer: we just wanted to know, like, what are the difficulties which developers owners face? Like, while moving towards mass timber construction? Or, like why they are you like still using a concrete construction? Okay, is there any reason for that? Yeah, we just wanted to understand those kinds of things from you. But we can discuss about those in the later part of this survey, but now probably at least mentioned about your institution and what kind of projects you handle.
Interviewee: We're mixed-use development. If you take a look at our website, that's probably the best way to just understand our organization. Okay, Matt has a portfolio of everything that we have on it. Okay, I
Interviewer: see. Thank you. So yeah, next question would be like, have you heard like, I think you must have heard about mass timber buildings. So have you dealt with any mass timber construction project in the past? And if here's like, how many years of experience
Interviewee: um, we had just built the mass timber building.
Interviewee: So do you just want to talk about that? Oh, yeah,

Interviewer: definitely. Like if you have been matched in the building, we can talk about that. Yes.
Interviewee: I wanna, I just share my screen. So I just just, you know, keep in mind I don't have too much time today because I got hit with some stuff but if you if you let me share the screen. What time like will you be like It's wild? 15 I gotta be out of here. So if you want to share that let me share the screen real quick and I can show you the building. Okay. I think you have disabled the participant's screenshare Oh,
Interviewer: yeah. So can you see my screen now?
Interviewee: Yeah, all right. If you just want to go to google development Baltimore.
Unknown Speaker: Just a second. Gone okay. What is can you see it again?
Interviewee: Walker. Yeah, there you go.
Unknown Speaker: Yep. And go our go to portfolio and if you scroll down, keep going. 4010 office building
Interviewee: I could probably like get to the root of your questions like why did we decide to use mass timber there and not other things? Yeah, that would be alright. So yeah, okay. So the when we price this out Um, the mass timber was a premium, the structure was a premium to concrete, and, well, concrete and steel. So we did it for the aesthetic reasons, because we thought it would be more attractive to tenants. But the baseline is, you can't spend more money on a structure. Unless you believe your tenants are willing to pay more or see their value, I certainly believe that we're able to get higher rents with the structure. And that's how it all worked. We stuck with concrete, we did a concrete podium with three levels of mass timber above, because the first floor is just retail tenants. And we didn't believe that they would value having exposed mass timber enough to pay more in rent. Or as the office tenants, especially like in a class a building, are looking at their office, not just the way retailers look at real estate is how much money can I generate at this location, right. But office tenants gonna have slightly different economics as to why they choose to put an office somewhere in the white building. And a lot of times that has to do with recruitment and corporate image, what they're trying to say. And we believe that in a class a building, we will be able to attract tenants who are willing to pay a little bit more to have these kind of nicer offices and who valued it. And that's generally what we've seen in the marketplace. In general, construction products development projects, I mean, I don't know how they're awesome other parts of the country, but they're very tight, they run on thin margins, and it kind of works because you have big scale. And the issue with using a more expensive structural system, because at the time, I want to say it was almost double, or maybe an extra $10 a square foot over the other options.
Interviewer: Oh, it was almost double of like concrete and steel structure.
Interviewee: Yeah, I think so. It's been, you know, this was in 2019, or 18, and got this price. So I don't know where things stand now. Okay. But the essential issue is that the buildings won't be worth enough to justify their cost. If you spend a premium on a portion of it like on the structure without being able to collect more in rent, or somehow your tenant valuating, or your customer valuing that choice more, right? You're competing with other buildings, you haven't used this premium structure.
Interviewer: But can I know, like, what was the reason it got higher, just because like the mass timber material itself is the cost is high, or because of the contractors or, like supply chain?

Interviewee: I couldn't really tell you on that, because what we would do is we just go to the structure crafted this. I'm sure you guys have heard of them if you're working in the mass timber industry. So basically, we you know, before we started the design of the building, actually, if you Google structure crafts, they got a great picture. They got great pictures on their website. So at the time, before we started the design process, we engaged with a general contractor to give us some preliminary Yeah, that one right there. And 4010 to the right. Yeah, yeah, click on that, that actually has real pictures. So we engaged with the general contractor, and they went out and then talked with a couple different mass timber suppliers to get, you know, general pricing per square foot. And then they compare that with historical pricing or pricing in the marketplace for other structures. And that's where we made the decision. So why the mass timber was more expensive. That's honestly a better question for like a structure craft who provides it? Because they really know what goes into it.
Interviewer: Okay, so I can understand like, even though the cost was higher, but you were thinking, like, it is more aesthetic, and it can have more like rental value or, like more office value. So that was the reason you went for the mass timber construction in this project, right?
Interviewee: Correct. Yep.
Interviewee: Like I would, I would note that it's, it's not always like a up to the developer, to just say, All right, let's go ahead and overspend for lack of better words on this portion of the building. Because if you do that, it will be hard to make the project even financially happen.
Interviewer: Yeah, right. Yeah. It seems like it's a lot more costlier than the routine structures like concrete or steel.
Interviewee: Yeah. And maybe that comes down as it becomes more widely adopted. Yes, yeah.
Interviewer: Okay, I see. And like, while this construction, was there any like building codes or zoning regulations, which was, like halting this project, or was it creating any difficulties? Actually
Interviewee: no, believe it or not, we have pretty good relationships with the city. But that aside the fact that it was like a podium with three stories of what above it, it made it digestible for the fire department, because it's the fire marshal, that's generally going to be the first, you know, guy who's going to have something to say about this. It's it's so for this particular building, to me, it just felt like it was almost like a three over one apartment building or four over one. And those have just been so common throughout, I'm sure throughout the country, that it, I think they felt better the fact that we have this three-hour fire rated podium between the first floor and the levels above, I think I made a lot easier. Yeah, right. Okay.
Interviewer: And also, based upon your experience, like, do you think like mass timber, get higher value compared to the other like materials in the market? Like, let's suppose if someone wants to rent or like build office space, does it have more market value compared to the other structures?
Interviewee: For office? We do think it it does. But I don't think you would see that. Like, again, obviously, we didn't build it on the first floor, which is all retail, right? Yeah, we did, because the podium was cheaper at the time. I think that's the challenge. It's like, if you were going to do this, let's just say in housing, with, you know, what people are already

paying and housing costs. Are you going to be able to find enough people who can even afford to pay more are willing to do it? And that's, that's been the general challenge.
Interviewer: Yeah, that's right. Okay. Yeah, probably, I think you have to leave soon today, because I had a case study to share. So, are you available? Like for next five minutes more? Or do you want, if we can do a really quick? Yeah, yeah. I'll share my screen now, and we'll explore some quality quantitative questions to gain a thorough understanding of these mass timber projects. Now, this data pertains to a 14-story building situated in Madison, Wisconsin. It comprises four distinct schemes: hybrid steel/timber, full mass timber, concrete, and steel. Allow me to elaborate further: In the hybrid steel/timber scheme, the beams and columns are constructed from glulam, while the framing consists of steel. Conversely, for the full mass timber scheme, both beams and columns, along with the framing, are exclusively composed of glulam, supplemented by braced steel framing."
Interviewee: okay, so I would either go full mass timber or concrete, and the rationale behind that is the concrete is obviously the cheapest option. For the full mass timber, what you're really doing is you're making a bet that I know I'm spending more on this structure, but I believe that the market is going to compensate the extra value. The steel makes no sense because it's the I don't see the customer finding value in steel over concrete, and the hybrid is okay, but I, for an extra dollar or so a square foot, it probably makes sense to get full mass timber.
Interviewer: Okay, I see your point. Now, like we have analyzed the cost, like if you own the building for five years, and then probably try to resell it in the market. And we have analyzed total cost of ownership for the buildings where we include like capital cost, which we have seen before. It may be next slide. Yeah. Which we have seen before. And we have included operation cost, which includes my electricity, energy, and all like operation maintenance, repair cost, and the resale value. And since resale, like it's not the cost, we it's a negative. So, and based upon this, we have estimated total cost of ownership. So we have used a discount factor like two of 10% to estimate the present value of all the future costs. So have you heard about the term called like, discount factor? Do you want me to? Yeah, no, I understand all that. Okay. So all the future costs, like, discounted to the present value. So based upon this total cost of ownership, which building would you prefer now?
Interviewee: Yeah, so So looking at building, see, because I know, you're saying that the total cost of ownership is higher, but what really matters is, or at least for us, is like that initial cost, because that's how do you fund that initial costs? Right? Right. And at a certain threshold, there there becomes different implications on do you get an investor? Do you have to get multiple investors like how do you make all these deals work? So what I see in the concrete is that if I'm getting the same rents, that's a much more attractive building because hopefully, maybe Don't need to take on partners. Versus if I have to take like building B, for example, and I'm still getting the same rents up front, I'm going to have to somehow bring an investor in to offset the extra costs, and then I got to pay that investor and it becomes more complicated. So even though the total cost of ownership, I understand that theory that might be more suited for owner operators, like institutions, rather than strictly developers. Yeah.
Interviewer: So yeah, this case to the building is in Madison, and we have realized that probably in that market likes, based upon like, going through the literature studies, we have realized, like it have more like market value, like seven to 8%, more market value compared to the concrete ones. So we have taken that into consideration. It's not a hard

fact, it just assumption based upon, like, some literature studies. So that's why if you can see the resale value is higher for like mass timber, but less for the other buildings.
Interviewee: So I get that, but whatever reason,
Interviewer: like you chose concrete in this strategy, and you saw that you chose hybrid steel team, full mass timber in this one, and you went to concrete in this one.
Interviewee: So no, I was saying that number five, I would choose concrete if I didn't think I could get a premium on the rent for the mass timber. I'm saying for this one, if we're saying we're gonna get a premium on the round and the mass timber, then yeah, I could see going with that.
Interviewer: Yeah, yeah. In this analysis, like we haven't taken the rental value into consideration, it just the market value of the building, like how much more resale value it have compared to the concrete ones.
Interviewee: Okay, so that's typically tied to what the building can rent for. Yeah, it's typically you're saying, yes, there's a premium because you've spent more on the structure. There's, there's a bigger risk in that, right. Because you're betting on that thing's gonna hold its value. And it's not like you can tie it to a financial return.
Interviewer: Yeah, that's right. Okay. Yeah, probably. That's it, I think for this interview. Yeah. It more read off the time. Yeah.
Unknown Speaker: Good timing. All right.