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# MASS TIMBER PROJECTS IN NORTH AMERICA: AN EXPLORATORY ANALYSIS

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**ABSTRACT:** Mass timber construction has gained significant traction in recent years, yet a comprehensive data-driven assessment of its design trends remains limited. This study analyzes 679 mass timber projects from the Woodworks Innovation Network (WIN) to examine the relationship between material selection, building use, and geospatial attributes. Through web scraping, key project characteristics—including location, building type, construction year, and material usage—were extracted, cleaned, and geocoded. Geographic data were integrated with FEMA's National Risk Index (NRI) to assess natural hazard exposure, though Canadian projects were excluded from risk analysis. Three analytical methods were employed: descriptive statistical analysis quantified material adoption trends, geospatial analysis mapped project distribution across hazard zones, and clustering analysis (using the K-modes algorithm) identified distinct material usage patterns. Results indicate that mass timber adoption has surged since 2010, with educational, office, and recreational buildings leading the trend. Type V and Type III construction dominated the permitting of the analyzed projects due to the ability to maximize the return and reduce the complexity of mass timber utilization. Geospatial analysis reveals regional variations in material preferences, influenced by hazard risks and policy factors. Clustering analysis identified four project groups with distinct material combinations and building characteristics, highlighting evolving design strategies. These findings provide a foundation for future research on mass timber's long-term performance, environmental impact, economic feasibility, and stakeholder networks. By leveraging this dataset, researchers can further investigate the role of policy, resilience, and innovation in advancing mass timber construction across North America.

## 1. INTRODUCTION

The building and construction industry is one of the largest contributors to global greenhouse gas (GHG) emissions, accounting for approximately 39% of energy-related carbon dioxide (CO2) emissions worldwide (D'Amico et al. 2021). Within this sector, the embodied carbon (EC) of buildings—the energy required to extract, manufacture, and transport building materials—plays a crucial role in shaping the overall environmental impact of the built environment. The urgency to mitigate climate change has driven increased interest in sustainable building materials that reduce embodied carbon and promote environmental responsibility.

Among these materials, mass timber has emerged as a viable alternative to conventional structural materials such as concrete and steel due to its potential to significantly lower emissions while offering structural and aesthetic advantages (Said et al. 2024). Mass timber encompasses a family of engineered wood products, including cross-laminated timber (CLT), glued-laminated timber (GLT), laminated veneer lumber (LVL), and dowel-laminated timber (DLT), among others. These products have demonstrated structural adequacy, fire performance, and durability, making them suitable for a wide range of building applications, including mid- to high-rise structures. Notably, mass timber has a much lower embodied carbon (EC) compared to traditional building materials (Gu et al. 2021). This considerable difference underscores the potential of mass timber in contributing to a low-carbon built environment.

The adoption of mass timber in North America has been facilitated by several factors, including advancements in engineered wood technology, increased automation in timber processing, and evolving prefabrication strategies. Additionally, regulatory changes, such as the 2021 International Building Code (IBC) revisions, have expanded opportunities for mass timber construction by allowing taller timber structures, further bolstering industry adoption. Despite these positive developments, mass timber still faces challenges related to fire safety perceptions, supply chain limitations, and entrenched reliance on traditional materials within the construction sector.

Despite growing interest in mass timber, research on its application in North America remains fragmented. While existing literature has explored market penetration, regulatory barriers, and sustainability benefits, there is limited empirical analysis of mass timber projects, particularly concerning design trends, material selections, and project attributes. This study aims to fill this gap by conducting an exploratory analysis of mass timber projects in North America using data from the Woodworks Innovation Network (WIN) online repository. By examining a diverse dataset of completed projects, this research seeks to provide insights into the evolving landscape of mass timber construction, identifying key trends and factors influencing material choices.

## 2. RELATED WORK

The use of mass timber products in construction has gained significant attention due to their sustainability, structural performance, and potential for market expansion. Several studies have explored different aspects of CLT, including its environmental benefits, material properties, economic viability, and adoption trends.

Mass timber is widely recognized as a sustainable alternative to traditional construction materials like concrete and steel. CLT has the potential to reduce carbon emissions and fossil fuel consumption throughout its lifecycle (Oliver et al. 2014; Scouse et al. 2020). Timber buildings function as carbon sinks, storing carbon during their service life and transforming the building sector from a major emitter to a potential mitigator of climate change. Research suggests that mass timber can contribute to substantial greenhouse gas (GHG) savings, with estimates ranging from 20–80 metric tons of $CO_2$ by 2050 if widely adopted (D’Amico et al. 2021). Furthermore, CLT buildings offer energy efficiency advantages, achieving up to 40% energy savings compared to traditional systems (Cabral and Blanchet 2021) and requiring up to 37% less energy for heating and cooling (Tettey et al. 2019). And beyond these carbon benefits, engineered materials like CLT and GLT are designed for disassembly, making them particularly useful for reuse in future construction or repurposing. This directly contrasts with materials like steel and concrete, which need energy-intensive recycling procedures. Thus, these characteristics make mass timber particularly fit for circular construction applications, reducing landfill waste and magnifying sustainability.

CLT’s structural resilience makes it suitable for diverse climatic conditions and high-performance applications (Ilgın et al. 2023). It offers a high strength-to-weight ratio and superior dimensional stability, making it an attractive choice for mid- and high-rise buildings (Abed et al. 2022). Mass timber structures can withstand seismic events and be designed to meet fire safety requirements. However, further research is needed to assess CLT’s resistance to windborne debris in hurricane-prone regions (Zelinka et al. 2019).

Mass timber has demonstrated cost competitiveness with steel and concrete, particularly in mid-rise and high-rise applications. Studies indicate that shell costs for CLT become competitive at five stories and more financially advantageous at eight stories (Brandt et al. 2021; Douglas 2013). Additionally, CLT construction results in cost savings related to reduced labor, shorter construction timelines, and lower foundation costs due to the material’s lightweight nature (Abed et al. 2022). However, while initial capital investment may be higher than reinforced concrete, rental premiums and long-term returns can offset the costs (Van der Westhuyzen and Wium 2021).

Despite CLT's success in Europe, Australia, and Canada, its adoption in the U.S. remains relatively low (Ahmed and Arocho 2020; Lehmann 2012). The lack of established information frameworks for industrial-scale production poses challenges for broader implementation (Bermek et al. 2019). However, regulatory progress has facilitated market growth; Oregon became the first state to approve mass timber buildings up to eighteen stories. The Pacific Northwest has been a key region for mass timber development due to its strong manufacturing base and evolving building codes (Brandt et al. 2021).

While CLT's environmental and economic benefits are well-documented, several barriers to adoption remain. The uncertainty surrounding long-term performance and durability discourages some potential adopters (Lindholm and Reiterer 2017). Additionally, concerns about supply chain limitations and regulatory constraints must be addressed to facilitate broader implementation. For example, the manufacturing capacity may not be sufficient for engineered wood products (mass timber) in unpopular regions, the lead times could increase because of decentralized production places, and high transportation costs because of the heavy timber materials. Thus, these bottlenecks in logistics will be particularly challenging for projects located far from the popular, central manufacturing hubs, notably in the Northwest region. Increasing awareness and knowledge dissemination among design professionals is critical to accelerating CLT adoption (Zhong and Gou 2023). Open-source design strategies have been proposed as a means to democratize architecture and expand mass timber's impact (Dangel 2019).

Overall, CLT and mass timber products represent a transformative opportunity for the construction industry, balancing sustainability, structural performance, and economic viability. Future research should focus on optimizing manufacturing processes, expanding regulatory support, and improving public perception to drive wider adoption. A fundamental step to enable these future studies is to analyze the previous industry design and construction practices of mass timber projects.

## 3. RESEARCH METHOD

### 3.1 Data Collection

Data was collected from the Woodworks Innovation Network (WIN) online repository–a comprehensive but user-unfriendly database of construction projects. A tabular formatted dataset was extracted from the HTML using web scraping Linux commands while a Python script parsed the raw data into a tabular Excel file, ultimately resulting in 679 project entries. The web scraping process notably extracted the following attributes for each project: project name, description, location, year built, number of stories, square footage, construction type (per the International Building Code classification), building types (based on its use, e.g. commercial, residential, etc.), and material utilization. The database covers the use of 16 materials and products that are relevant to this study: glue-laminated timber (GLT), cross-laminated timber (CLT), dowel-laminated timber (DLT), nail-laminated timber (NLT), heavy timber decking (HTD), structural composite lumber (SCL), wood structural panels (WSP), lumber or heavy timber (LMB), I-joists (IJS), open-web trusses (OWT), light framing (LFR), hybrid timber system that includes the use of steel or concrete (HYB), post and beam framing (P&B), wood-concrete composite systems (WCC), coating (CRG), and fasteners and hardware (F&H),

### 3.2 Data Processing

The extracted data underwent cleaning, validation, and geolocation matching. Projects missing building type or height were removed, and material usage was binarized. Non-ASCII characters were stripped, and inconsistencies—such as unrealistic square footage or incorrect construction dates—were manually corrected using additional data sources.

For spatial analysis, project locations were geocoded to obtain latitude and longitude. Geographic data were parsed into broader regions and matched with FEMA's National Risk Index (NRI) to integrate county-level disaster risk scores for hazards like earthquakes and wildfires. Even though the NRI only covers U.S. locations, leaving 561 out of 679 projects with complete hazard data, Canadian projects were still used to support the broader statistical and clustering analysis. Thus, their exclusion from the geographical analysis was due to the limited data availability.

### 3.3 Data Analysis

Three types of analysis were conducted to examine mass timber projects from different perspectives: descriptive statistical analysis, geospatial analysis, and clustering analysis.

The descriptive statistical analysis summarized key project characteristics, including building type, construction type, number of stories, and square footage. To track material adoption over time, projects using hybrid and mass timber materials were aggregated into 3-year intervals. This approach helped smooth short-term fluctuations and highlight long-term trends in material usage.

The geospatial analysis mapped project locations and analyzed their distribution across natural hazard zones. FEMA's Hazard Type Risk Index Values (HTRIV) were used to classify risk levels, ensuring a consistent comparison of material use in high-risk areas. A cross-tabulated frequency table quantified how often each material was used in projects within specific hazard zones (e.g., earthquake, hurricane, wildfire). The results were converted into percentages to enhance interpretability and assess material preference under different environmental conditions.

The clustering analysis employed the K-modes algorithm to group projects based on material usage patterns. Since the dataset consisted of categorical variables, K-modes was selected over K-means, which relies on numerical data. The Elbow method determined the optimal number of clusters, and heatmaps were generated to explore material distribution across building types and story counts. Additionally, clustering results were integrated with geospatial analysis to assess material trends in hazard zones. This approach helped identify potential correlations while minimizing misinterpretations caused by overlapping geospatial trends.

## 4. RESULTS AND FINDINGS

### 4.1 Statistical Analysis

The use of mass timber materials in construction has grown exponentially since 2010, significantly outpacing hybrid materials, as shown in Figure 1. From 2022 to 2024, mass timber was used in 227 projects, a dramatic rise from just 3 projects in 2007–2009, whereas hybrid materials saw a more modest increase from 6 to 113 projects over the same period. Growth rate analysis further highlights mass timber's dominance, with its peak growth reaching 267% between 2013 and 2016, compared to hybrid materials' highest rate of 200%. Even in recent years, mass timber has maintained a higher growth rate (72% from 2019 to 2022) than hybrid materials (31%). Over the past three decades, mass timber has also steadily gained a larger share of material usage, surpassing hybrid materials in 2010 and reaching 66.76% by 2024. In contrast, hybrid materials, which accounted for 71.43% of projects in 1995–1997, have seen a gradual decline in proportional use, solidifying mass timber as the preferred choice in recent years.

The analysis also revealed the following observations regarding the use of mass timber over the code-driven construction types, building use type, number of floors and total area (see Figure 2):

- The sampled mass timber projects were permitted mostly under construction Types V (43%) and III (33%). Although Type V construction permitting has been dedicated for mass timber (after traditionally have been used for heavy timber), the analysis showed that it's not the favorite selection. Type V construction was the most observed in the projects because it allows for the most use of mass timber throughout the structure. Type IV construction is less favorable than Type III because of its stricter fire rating requirements for the use of mass timber and other wood systems.
- The number of stories were found to be related to the construction type. As most of the projects followed either Type V construction or Type III construction, they were limited by the height constraint or around 4 stories. 56% of the projects were either one- and two- story buildings, while 22.7% of them were 3 and 4 story-high. However, it is expected to see higher multi-story mass timber building as the industry impalements and trusts the recent 2021 IBC changes for Type IV

that pushes the limits for using mass timber products.

- The top observed building uses were educational (20.6%), office, (19.7%), assembly (11.5%), and recreational (11%). These building uses of mass timber are supported by their high sustainability goals that is supported by an institutional entity, preference for aesthetic appeal and biophilic design, and the need for design flexibility for large spaces.
- While most projects are under 50,000 square feet, there is a growing number of projects that exceed 200,000 square feet. This denotes the progress in mass timber for expansive projects.

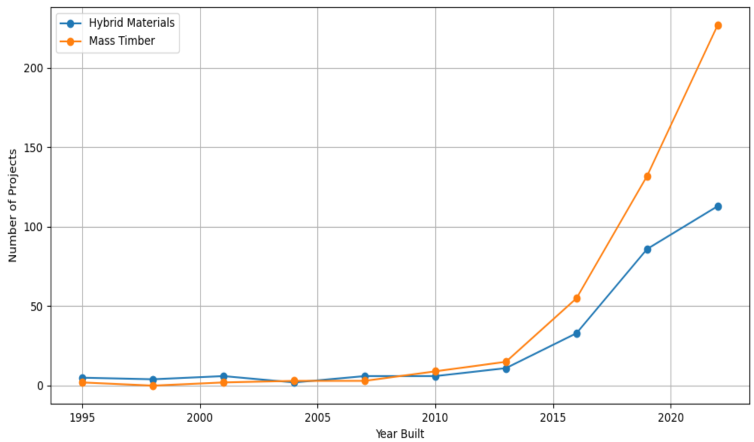


Figure 1: Number of US and Candaian projects using hybrid and mass timber materials, 1995- 2024

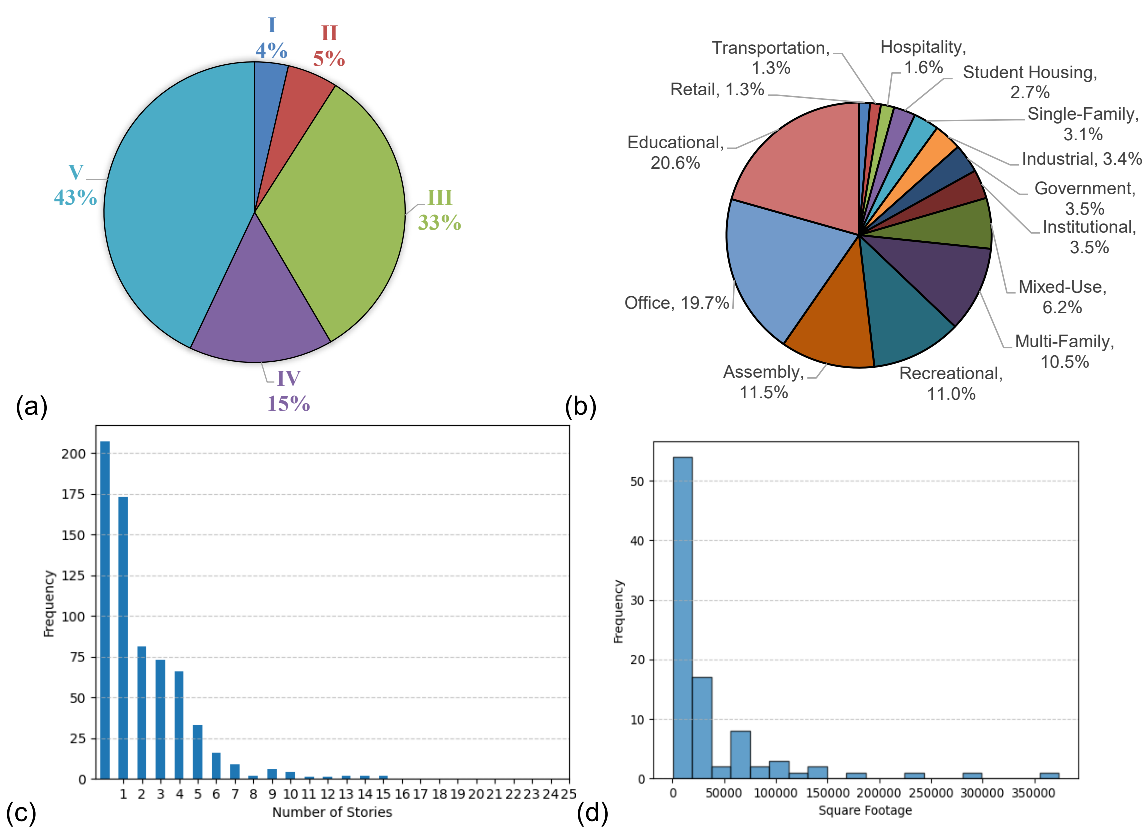

Figure 2 *Descriptive statistics: a)* distribution of construction types; b) distribution of building uses; c) distribution of the number of stories; d) distribution of the building total area

### 4.2 Geospatial Analysis

A simple mapping of projects across North America revealed clear trends. As Figure 3 demonstrates, mass timber and hybrid timber projects are widespread across North America, revealing their implementation in diverse environmental settings. However, it is important to note that these projects are concentrated in specific regions, with the highest density observed along the West Coast, particularly in Vancouver, British Columbia, Seattle, Washington, Portland, Oregon, and the California Bay Area. This is likely due to the region's liberal sustainability agendas, as well as the availability of timber resources. Additionally, notable clusters appear in the Northeast, attributable to the presence of urban development hubs and advocacy for mass timber because of support for sustainable construction.

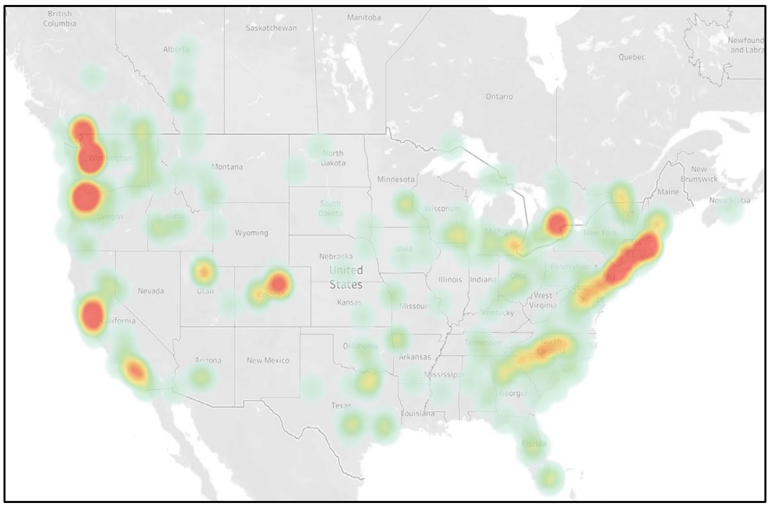


Figure 3: Geographical Density Heat Map of Total Projects by Location (Coordinates)

The frequency analysis of material usage in natural hazard zones shows that certain materials are more commonly used in high-risk areas. Table 1 presents the distribution of mass timber material uses over the geographic territories NRI natural hazard risk categories. Most notably, mass timber materials like CLT and GLT were the most frequently used materials in all natural hazard zones with 817 and 682 occurrences, respectively, or 23.9% and 19.5% of the entire material collage. Closer analysis resulted in these notable observations:

- There were significantly fewer projects constructed in areas that have higher risks for avalanches (200) and hurricanes (268), likely because these areas are typically not as densely populated and the lack of high-risk zones for such hazards in the United States. In contrast, there are many projects constructed in earthquake, tornado, and strong wind-prone areas. This is likely due to the geographical distribution of these hazards: earthquake-prone areas like the California Bay Area are densely populated, while avalanche-prone regions, like higher elevating mountains, and hurricane-prone regions, like coastal islands, have more open land and stricter building codes.
- WCC systems appear in very few projects across all hazard zones, with no hazard exceeding 8 projects using this material. This could suggest that hybrid systems like that of wood and concrete composite systems are not popular in buildings that need disaster-resistant materials.
- 48.4% of projects built in these areas were dominated by CLT (28.9%) and GLT (19.5%) materials. Furthermore, 8.8% of the projects used heavy timber decking, 13.8% more than its proportion in other natural hazard zones.
- 28.9% of all projects used in avalanche zones and 26.6% in earthquake zones have CLT in them, while 19.5% and 21% use GLT, respectively. This further strengthens our prediction that mass timber materials are the preferred choice in environments that require flexibility and strength as earthquakes and avalanches expel strong lateral forces on buildings.

- 45.1% of all CLT projects and 38.9% of all GLT projects are built in earthquake-prone areas. Furthermore, 39% of all CLT projects and 37% of all GLT projects are built in areas subject to ice storms. These findings reveal the trust in CLT and GLT in seismic and cold regions, likely due to their high strength-to-weight ratio and durability in cold climates.
- Unlike other hazards, wildfire-prone areas distribute material usage more evenly, with the highest usage for LFR (44.9%), SCL (42.9%), and LMB (42.4%). However, HYB materials systems are used less than normal (25.8%), potentially because these materials retain heat and weaken under prolonged fire exposure.
- Areas that are more susceptible to tornados show 50% of HYB projects, much higher than their presence in other hazard zones. It is also notable to mention that 43.8% of HYB projects appear in earthquake and ice-storm-prone areas.
- 57.1% of SCL projects are in either strong wind or tornado-prone regions, higher than in any other hazard. This indicates that engineered wood products like LVL and LSL offer more degrees against strong lateral forces like those found in these types of zones.
- NLT has the lowest proportional use in all natural hazard zones by a large margin at 20.23% and no category exceeding 33.3%. This is especially rare in wildfire-prone regions (4.2%), with the average (30.95%) being significantly higher, indicating that it is not preferred or may not have the durability, fire resistance, or structural stability needed for high-risk zones.
- 55.9% of all DLT projects are in ice storms and 70.5% are in tornado regions. This suggests that DLT was mainly used in regions with cold weather conditions and can withstand high winds, reinforcing our belief that mass timber is a great choice for natural hazard zones.

Table 1: Use of mass timber in natural hazard risk categories

| Natural Hazard | CLT | GLT | HYB | P&B | LFR | LMB | SCL | HTD | WSP | F/H | DLT | OWT | IJS | CTG | NLT | WCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Avalanche** | 46 | 31 | 19 | 14 | 8 | 10 | 7 | 2 | 3 | 3 | 5 | 1 | 4 | 1 | 2 | 3 |
| **Earthquake** | 179 | 141 | 78 | 53 | 43 | 36 | 25 | 21 | 13 | 15 | 17 | 9 | 16 | 10 | 8 | 8 |
| **Hurricane** | 47 | 42 | 25 | 15 | 15 | 10 | 10 | 15 | 7 | 5 | 5 | 5 | 2 | 5 | 2 | 0 |
| **Ice Storm** | 155 | 134 | 78 | 55 | 36 | 36 | 28 | 34 | 17 | 19 | 19 | 11 | 10 | 7 | 8 | 7 |
| **Strong Wind** | 135 | 120 | 70 | 46 | 43 | 40 | 32 | 27 | 26 | 20 | 18 | 14 | 10 | 7 | 5 | 4 |
| **Tornado** | 163 | 143 | 89 | 59 | 44 | 41 | 32 | 34 | 27 | 24 | 24 | 13 | 8 | 9 | 8 | 7 |
| **Wildfire** | 92 | 71 | 46 | 27 | 40 | 36 | 24 | 17 | 19 | 14 | 6 | 10 | 11 | 10 | 1 | 4 |

### 4.3 Cluster Analysis

The clustering analysis identified the distinct design practices in terms of the selection of mass timber material and system. It was determined, using the Elbow method, that four clusters of the projects result in the least overall fitting error. The projects were distributed almost evenly between the clusters, where 20%, 26.3%, 31.7%, and 22.1% of the projects were assigned to clusters 1, 2, 3, and 4, respectively. Table 2 lists the user of the mass timber material systems over these clusters. In addition, the building height use contexts of these clusters were analyzed by displaying their material use over the number of stories and the building types, as shown in Figure 4. These clusters can be described as follows:

- Cluster 1 represents the most diverse use of material out of the identified clusters. The most commonly used mass timber material and systems are (in descending order): post and beam system, light framing, structural composite lumber, hybrid wood systems (with steel or concrete), and dowel laminated timber (see Table 2). This cluster is the most restricted in terms of building uses, as it covers 11 out of the 14 building uses (no instances of hospitality, retail, or transportation buildings) (see Figure 4). Also, its average height (number of stories) is the shortest out of the identified cluster.

- Cluster 2 represents a focused use of CLT, with some level of hybrid use of other conventional materials (steel and concrete) and light framing. All building types were represented in this cluster, the mostly constructed buildings in this cluster were office, multi-family apartments, and educational. The average height is more than Cluster 1 (between 3 to 4 stories), but some instances of tall structures were achieved that go up to 17 stories.
- Cluster 3 represents a more integrative and hybrid design approach that enabled reaching to higher average building heights. In this cluster, an interesting coupled use of CLT and GLT was observed, which was supported by hybrid use of conventional materials. Although the use of wood concrete composite (WCC) was generally limited in the analyzed projects, it was used the most in this cluster. The most commonly building types in this cluster were: educational, office, multi-family, and recreational. This cluster showed the greatest potential of achieving taller buildings, as shown by the observed number of stories and the ability to construct 25-story buildings.
- Cluster 4 involves a focused use of GLT that is integrated with heavy timber decking, post and beam systems, wood structural panels, dowel laminated timber, and hybrid use of conventional materials. The most commonly building types in this cluster were: educational, recreational, office, and assembly. The building heights (number of stories) observed were similar those in the second cluster.

Table 2: Project clusters and their use of mass timber material and systems

| Cluster | CTG | CLT | DLT | F/H | GLT | HTD | HYB | IJS | LFR | NLT | OWT | SCL | P&B | WSP | WCC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | 1 | 0 | 13 | 4 | 0 | 15 | 24 | 6 | 25 | 7 | 8 | 17 | 28 | 11 | 2 |
| **2** | 5 | 181 | 1 | 11 | 0 | 4 | 51 | 3 | 30 | 3 | 3 | 7 | 21 | 4 | 2 |
| **3** | 9 | 215 | 6 | 14 | 215 | 8 | 57 | 4 | 16 | 2 | 4 | 14 | 33 | 15 | 8 |
| **4** | 10 | 0 | 14 | 17 | 147 | 39 | 48 | 11 | 19 | 12 | 8 | 18 | 31 | 16 | 4 |

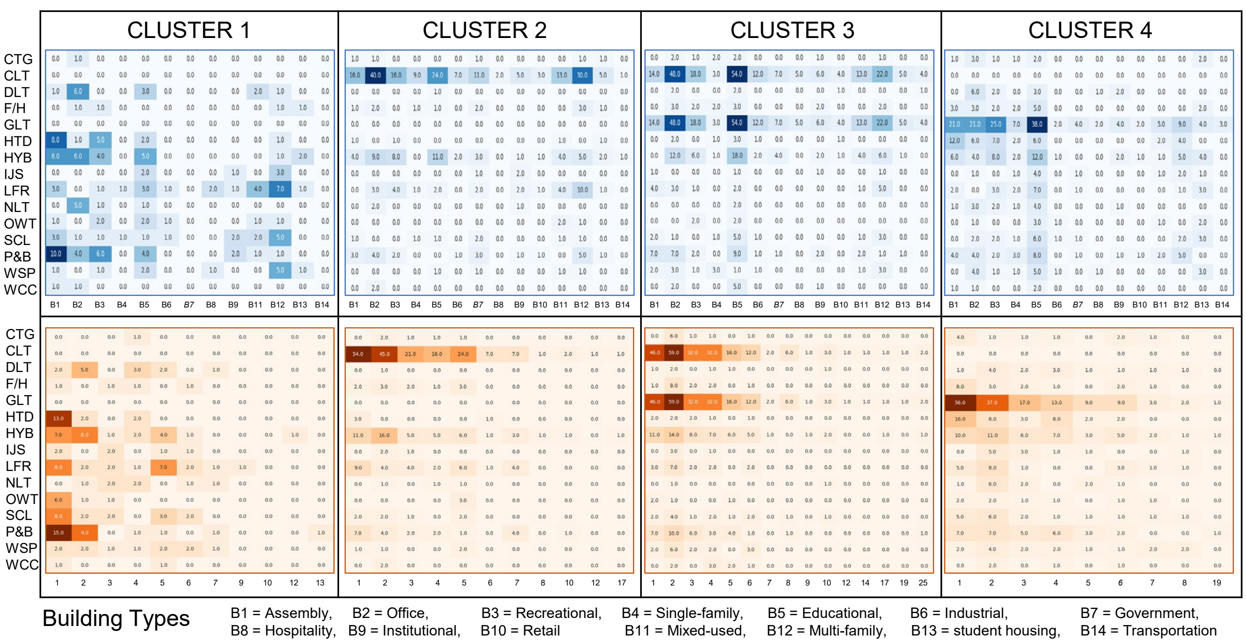


Figure 4: Mass timber project clusters based on material uses, organized by the building types (top row) and number of stories (bottom row)

## 5. CONCLUSIONS

This paper represents the first effort to conduct a data-driven assessment of the design trends of mass timber projects and their relation to the building use requirements and geospatial attributes. The study utilized data from the Woodworks Innovation Network (WIN) to analyze 679 mass timber projects, extracting key attributes such as location, building type, construction year, and material usage through web scraping. The dataset was cleaned, validated, and geocoded, with incomplete entries removed and geographic data matched to FEMA's National Risk Index (NRI) to assess disaster risk, though Canadian projects were excluded from risk analysis. Thus, the hazard analysis can be improved in future studies using Canadian risk indices for the hazard analysis. However, the novel integration of natural hazard data provides new insights on material performance under different climates. Three analytical methods were applied: descriptive statistical analysis summarized project characteristics and material adoption trends over time; geospatial analysis mapped project distribution and material usage across hazard zones; and clustering analysis used the K-modes algorithm to group projects by material patterns.

The statistical analysis revealed that mass timber usage has grown exponentially since 2010, surpassing hybrid materials in both adoption rate and total projects. By 2024, mass timber accounted for 66.76% of projects, with educational, office, and recreational buildings being the most common applications. The majority of projects were built under Type V (43%) and Type III (33%) construction, typically reaching up to four stories due to height restrictions. However, larger projects exceeding 200,000 square feet are becoming more frequent, indicating increasing confidence in mass timber for large-scale construction.

The geospatial analysis highlighted that mass timber projects are concentrated along the West Coast and in the Northeast, driven by sustainability policies and timber resource availability. Material usage varies by natural hazard zone, with CLT and GLT being the most prevalent materials in earthquake and avalanche-prone areas due to their flexibility and strength. Ice storm and tornado-prone regions showed a higher prevalence of DLT and SCL, suggesting their resilience against high winds and cold climates. In wildfire-prone areas, hybrid materials were used less frequently, possibly due to fire resistance concerns.

The clustering analysis identified four distinct project groups based on material selection and building characteristics. Cluster 1 featured the most diverse material usage but had the shortest buildings and limited building types. Cluster 2 was dominated by CLT and hybrid systems, with office and multi-family buildings reaching up to 17 stories. Cluster 3 demonstrated the highest potential for tall buildings (up to 25 stories) with an integrated CLT-GLT hybrid approach and increased WCC usage. Cluster 4 focused on GLT, heavy timber decking, and post-and-beam systems, with mid-rise buildings commonly used for educational and recreational purposes.

Additional research is needed to utilize this rich dataset to investigate other aspects of the mass timber construction projects in North America. Future studies can explore the longitudinal performance of mass timber design trends, the lifecycle and carbon footprint of these projects, the collaborative network of mass timber project stakeholders, and the socioeconomic drivers of mass timber project development. Furthermore, future research could expand on our findings by modeling mass timber adoption scenarios under different policy, economic, or climate risk trajectories, potentially even forecasting material demand and carbon reduction potential.

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