Chapter 1

From Cedar Longhouses to Mass Timber High Rises

Since the earliest civilizations, humans have been using wood to construct dwellings, places of worship, and many kinds of daily-use goods and tools. Wood is the only natural building material that can be harvested continuously as long as local conditions are supportive of forest growth and the resource is not being depleted by overuse.

Together with natural stone, wood has for many millennia been the material that facilitated daily life and helped build civilizations.

Mass Timber: Materials, Design, and Construction, First Edition.
Peggi L. Clouston and Alexander C. Schreyer.

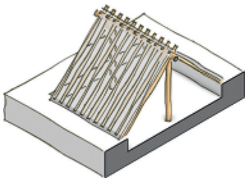
Published 2026 by John Wiley & Sons, Inc.
Companion website: www.wiley.com/go/masstimber

Unlike stone, however, wood is available in long shapes (i.e. logs) that allowed for the creation of spanning structures like floors or roofs without the need for arching. Wood is also comparatively lighter, which made it easier to harvest, transport, and erect. And while wood is not as durable as stone in adverse environments, building components made of wood have always been much easier to fix and replace, a common practice for many historic structures.

This chapter aims to provide a historic timeline of key moments in solid or massive wood construction, from the earliest buildings to recent wood structures (Figure 1.1).

Figure 1.1 Hundreds of years lie between these two wood surfaces. One (on the left) is a medieval solid wood door, and the other (on the right) is a contemporary glulam structure.

1.1 INDIGENOUS BUILDERS



The first timber builders came from the many indigenous tribes that – influenced by their local climate, culture, and wood availability – used this material in various ways to create dwellings and ceremonial buildings that commonly followed a regional vernacular.

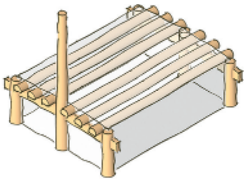
Nordic builders often created low-slung frame structures that internally featured post-and-beam systems and, on the exterior, were fully covered with soil and sod to provide comfort in harsh climates (Figure 1.2). In contrast, those in tropical regions often utilized small-diameter wood (or bamboo) in pole structures that raised the building off the ground to provide dryness and keep animals away from living or food storage areas.

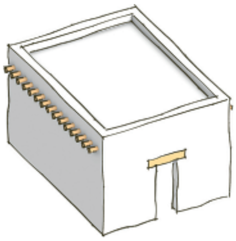
For nomadic tribes, portability of the dwelling was of prime concern and thus *tent structures* like the North American teepee or the Mongolian yurt were devised. They consisted of a simple frame structure that was either transportable or replaceable, onto which a covering made from hides was draped.

Arguably, the most massive of all indigenous wood construction methods was that of the North American Haida and Salish tribes, located in the Pacific Northwest. Their material of choice was a locally available tree species, Western Red Cedar (*Thuja plicata*). This tree

Figure 1.2 Reconstruction of a Viking village in L'Anse aux Meadows, Canada. *Source:* Wikimedia / Dylan Kereluk.

Figure 1.3 A Haida longhouse in Canada.



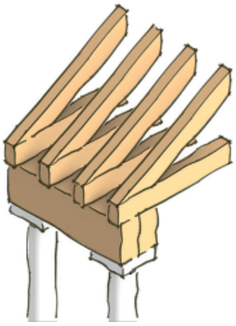


grows very tall and straight, has a comparably low density, splits easily along the grain, and is naturally durable – all desirable qualities in a building material. As can be seen in Figure 1.3, Haida *longhouses* often feature entire logs as columns, as well as purlins that rest on large rectangular rafters. Story-tall siding and roofing boards were split from a log in the same manner that we manufacture shakes today – albeit at a much larger scale (Stewart 1974).

In areas where trees were scarce and construction relied on stone or clay as the main building material (i.e. in regions closer to the equator), wood was still often the material of choice to frame roofs. Typically, several small-diameter tree trunks were used, installed horizontally in masonry walls and then covered with clay to form a solid roof. Without knowledge of vaulting, spanning stone structures were only feasible with closely spaced supports, so wood offered the most efficient material solution to span rooms and provide *lintels* over window and door openings.

1.2 GREEK AND ROMAN BUILDERS

Greek temples and palaces, like the Acropolis in Athens, are known today as massive stone structures with solid masonry blocks for walls, lintels, and shaped round stone drums to build up columns. Interestingly, their builders had no knowledge of vaulting either, which necessitated another solution when it came to covering these structures with a roof. As a result, large timbers were used as *beams* and *truss members* to form roofs (see Figure 1.4). While the roof structures of ancient Greek temples are long gone, some of their wooden structural elements (namely the repeating ends of roof beams and rafters) have survived as ornaments in classical stone architecture: the *triglyph* and the *dentil* (Figure 1.5).



This approach changed when Roman builders devised arches and vaults using stone (or even the newly discovered concrete), which could now span significant distances. Nevertheless, even a stone arch needs to be constructed with wood, albeit as a temporary support framework, known as *centering*.

Some of the more massive Roman wood structures were likewise temporary in nature and emerged out of Rome's desire to expand its empire: *Bridges* were needed to allow passage over rivers such as the Rhine in Germany. While its structure is lost to us now, archaeologists estimate that the bridge that is depicted in an illustration in Figure 1.6 and dates to 55 B.C. had a length of 1300 ft at a width of 13 ft. It consisted of rammed *piles* that were combined into a frame structure, which was then covered with longitudinally spanning beams to form the road surface.

Figure 1.4 Cutaway model of the temple of Zeus that shows some of the wooden rafter structure.

Figure 1.5 Triglyphs (on the frieze) and dentils (above it) decorate this neoclassical façade in Edinburgh, Scotland.

Figure 1.6 Illustration of a Roman bridge over the river Rhine.
Source: Lo Scaligero / Wikimedia Commons / Public domain.

1.3 MEDIEVAL BUILDERS

Gothic and medieval builders in Europe and many other regions worldwide continued the tradition of building walls in stone and roofs in wood, especially for larger buildings like castles and churches. While gothic cathedral builders of the time refined the roman stone arch into a pointed shape (and thereby made it more structurally efficient), vaults built using this technique often provided just the internal space closure at the ceiling level and depended on a massive multi-story wood structure above those vaults to support the roof, resisting all its wind and snow loads (Figure 1.7).

Builders of civic houses developed a way to create efficient structures using a wood frame that featured regularly spaced posts of reasonably small diameter, together with a grid of beams and joists. With that, *half-timbered post and beam construction* was developed (Figure 1.8). This method of construction, which follows the same basic structural principles – with minor, regional differences – in Europe as well as in Asia and elsewhere, created a wood frame whose walls needed to be filled with material to make the buildings weathertight. This was often accomplished using a method called *wattle and daub*, where a lattice framework between the wood members supported a mud render that was commonly reinforced with straw or horsehair (Figure 1.9). Later, builders used brick to close those openings, and where further weathertightness was needed, a series of overlapping boards was added to the exterior (Figure 1.10).

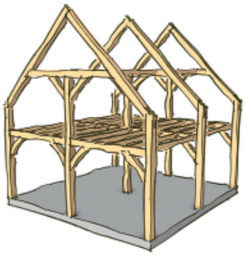


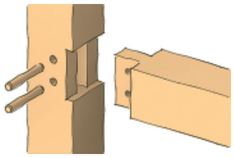
Figure 1.7 A roof structure detail from a 13th century German castle showing original and refurbished timbers and plank covering.

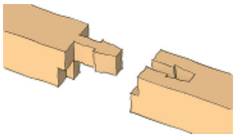
Figure 1.8 Half-timbered houses in Germany.

Figure 1.9 Wall section of a half-timbered house under renovation. Between the wood frame is a wattle and daub wall infill, and on top of it is a plaster render (visible at the top left).

Figure 1.10 An early version of clapboard siding is being demonstrated in this reconstructed house in Plymouth, Massachusetts.

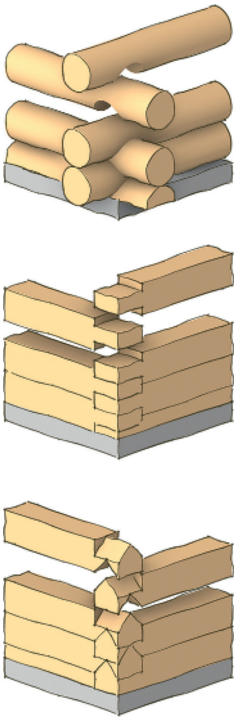
Connections in such timber buildings and houses utilized intersecting and overlapping wood cuts, where each connection type was intricately designed to transfer a specific kind of force. For example, where a beam connected to a column, a *mortise and tenon* connection transferred gravity floor or roof loads into the column through bearing. The connection also needed to secure the individual members against withdrawal, which was commonly accomplished with wooden dowels or pegs. Because lateral building forces were commonly resisted by the triangulation afforded by *knee braces* (short diagonals installed in the top corners of post-and-beam intersections), a mortise and tenon connection did not need to be designed for rotational forces or moments.





Other connections that were designed to hold two members linearly together (e.g. to splice a sole plate) commonly used various overlaps and keys. In some cases, more than

Figure 1.11 The Hyde log cabin from 1783 in Vermont.



two members needed to be connected in the same location in this manner (e.g. where a tie beam and a purlin sat on a corner column).

Japanese carpenters developed many intricate (and often extremely well-crafted) connections that used not just a simple tenon but rather many different kinds of keys, wedges, and other detailing. These connections had the benefit of being able to transmit forces often in more than one direction.

Where timber was abundantly available and where the climate was harsh (in mountainous regions, for example), a vernacular massive timber construction method was devised: the *log house*. In this construction type, entire debarked logs are stacked horizontally to build external and usually also internal walls (Figure 1.11). The structure is stiffened by the overlapping corner connections, and any gaps between logs are filled with mud, straw, or similar material.

Several (often regional) variations of this building technique exist, using either circular logs that are overlapped with one- or two-sided *saddle notches* or squared logs that use a *square notch*, a *V-notch*, or a *dovetail* notch (not shown here).

Because log construction uses entire, unseasoned logs, the drying of those over time and the resulting shrinkage and checking need to be considered, especially when it comes to window and door detailing (Figure 1.12).

Figure 1.12 A contemporary log home.

1.4 INDUSTRIAL REVOLUTION BUILDERS

The Industrial Revolution during the 18th and 19th centuries brought with it several crucial changes to wood construction. On the one hand, improved mechanization made better sawmilling possible, which led to standardized dimensions, more quality control, and higher output. This ultimately facilitated the development of *light-frame construction*, which is a more standardized version of the traditional post and beam timber frame but uses smaller cross-sectional members spaced closer together.

On the other hand, this period also led to significant improvements in steel production (especially with the Bessemer method, invented in 1855). It provided builders with a new, industrially made product of consistent quality that was able to compete with wood and replace previous wood uses, e.g. for bridges and roofs. Nevertheless, wood was still the material of choice for housing and cost-efficient industrial buildings since steel required masonry encapsulation to provide fire protection. Wood is also generally better able to deal with corrosive environments (as existed in factories and train yards) and is much lighter than steel – two aspects that continue to sustain its popularity today.

Figure 1.13 Loggers felling a 12-ft diameter redwood tree in California in 1908. *Source:* Unknown author / Wikimedia Commons / Public domain.

Figure 1.14 Exterior walls of an industrial mill building in Easthampton, Massachusetts, showing the common brick exterior wall and its large window openings.

Furthermore, the expansion of railroads during this time led to further migration and exploration, which brought with it the need for new and cost-efficient construction and thus the need for more raw timber. In North America, the *old-growth forests* of the west coast provided a bounty of such material and thus logging of sometimes huge trees yielded the needed raw material for this time (Figure 1.13).

With an eye on mass timber uses, it is educational to look at the many industrial *mill buildings* that were built during this time throughout North America and elsewhere (Figure 1.14). While their architectural details and even materials varied from location to location, most of these buildings used large timber cross-sections for their post and beam systems, which were then covered with 3-in. *plank decking* and a wear surface (Figure 1.15). Exterior walls were always constructed of masonry to provide a durable and fireproof enclosure. Large windows then offered ample daylight for the various factory operations on the inside.

Commonly, the solid wooden beams in these mills were arranged on a structural grid of less than 20 ft, and the decking was laid across either horizontally (on flat) or vertically (on edge), depending on load and span requirements. Decking was usually laid over more than one bay to take advantage of structural continuity.

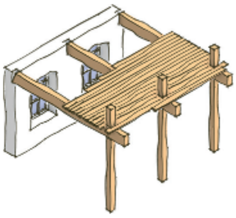
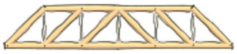


Figure 1.15 The interior space of an industrial mill building, now converted to a brewery.

The builders of these mills understood very well that wood shrinks and swells mostly across the grain (more on that in Chapter 3) and therefore devised a method so that columns would never rest on beams. A "*pintle and post cap*" system (Figures 1.16 and 1.17) used those two cast iron elements to securely seat one column above another and thereby allow vertical loads to bypass the crossing beams completely.

Some of the largest wooden structures of this time were the many bridges that supported the increasing road and train traffic. Of note are the various covered and open bridges, especially those that utilized truss designs by William Howe and Caleb Pratt, which were devised in 1840 and 1844, respectively. *Howe's design* combined a diagonal wooden lattice truss with vertical tension rods that provided a simple and cost-efficient solution for high-load requirements (Figure 1.18).



Pratt basically inverted Howe's truss by using wood for the verticals and steel for the diagonals. Due to the larger use of steel in this design, the cost of steel had a more pronounced impact on whether this design was utilized.

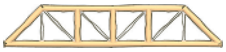


Figure 1.16 Wooden columns, beams, and decking in a typical mill building.

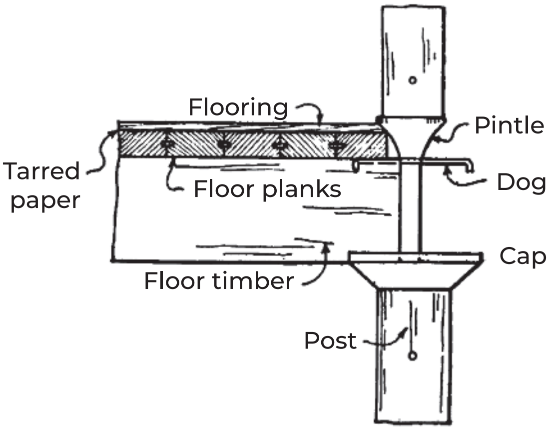


Figure 1.17 Typical pintle and post cap mill building construction.
Source: Paul, 1916 / Public Domain.

1.5 NEW WOOD MATERIALS

Given the major changes in construction technology during this time (and into the early 20th century), several timber builders decided to rethink traditional wood building methods for it to remain economically viable. This led to key novel technologies whose patents originated during this time.

One of those ideas came from Otto Hetzer, a German carpenter from Weimar, who in 1906 devised a novel way to create a roof structure. His concept – to glue smaller cross sections together under pressure, after which they created a larger cross-section and permanently remained in the pressed shape – was basically the first iteration of a curved *glue-laminated timber* (Figure 1.19). While he constructed several buildings using this method (e.g. a museum in Altenburg, Germany), the maturity of this technology was only reached in the 1930s when water-resistant synthetic adhesives became available (Figure 1.20).

Another invention of note was patented in 1923 by Frank J. Walsh and Robert L. Watts, both of Tacoma, WA. They devised a novel composite lumber product that used alternating layers of wood strips that were arranged at 90-degrees to each other (Figure 1.21). While

Figure 1.18 A Howe truss-type covered bridge in Quebec, Canada.

they also devised this product to be made under high pressure and therefore compress the fibers, the basic premise of this invention is what would later become *cross-laminated timber*.

The second half of the 19th century and the first half of the 20th saw several further key developments for timber design: research on fasteners (nail- and dowel-type) laid the groundwork for a design theory that is still in use for such connectors. Also, *plywood* and the underlying rotary-cutter technology were invented, which provided builders with a panel product that could be used for spanning and stiffening applications, e.g. for floors and walls, respectively.

1.6 A (MASS-)TIMBER RENAISSANCE: 20TH AND 21ST CENTURIES

Most of the 20th century saw building innovations mainly in reinforced concrete as well as steel building technology (e.g. using post-tensioned concrete). A house building boom after the Second World War, however, led to an increase in wood light-frame construction. Starting in the 1970s – and prompted by the energy crisis at the time – a new focus on energy-efficient buildings and the desire to use natural building materials was also rekindled. This brought along with it a renewed interest in the traditional craft of *timber framing*, which then led to the formation of community organizations such as the Timber Framers Guild (established in 1985).

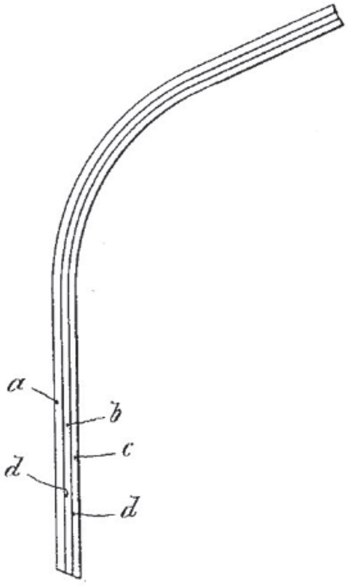


Figure 1.19 Patent diagram for glue-laminated wood. *Source:* Hetzer, 1906.

Figure 1.20 Various contemporary glulam beams in a shop.

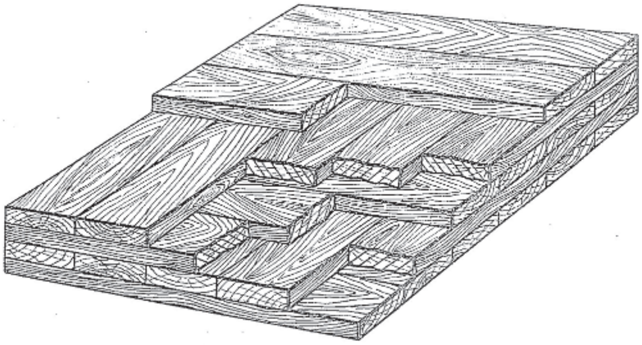


Figure 1.21 Patent diagram for crosswise laminated timber.
Source: Walsh/Watts, 1923.

A significant step forward for wood building technology occurred in the 1980s: Hans Hundegger, a mechanical engineer, started a company in Hawangen, Germany that produced what would become the standard for *fully automated wood machining tools*. His machines made it possible to cut, drill, and shape large wooden structural members at a precision much higher than is common for other materials (Figure 1.22). Combined with improvements in CAD design software and a more general availability of *parametric digital design tools*, architects now had a highly customizable, precise, and comparatively cost-efficient way to produce structures that had the added aesthetic benefit of the beauty of wood, together with the societal benefit of providing a sustainable solution for the built environment.

While glulam had been available and in use for almost 100 years, the 1990s saw the appearance of a new glued wooden building material: cross-laminated timber (CLT) (see

Figure 1.22 A Hundegger wood processing machine (control display, at left) and the resulting precision-cut beams (right).

Figure 1.23 Cross-laminated timber panels at a construction site.

Figure 1.23). Driven by the desire to use low-quality wood in a high-quality product and the European wood industry's interest in providing an alternative to the predominance of concrete and masonry construction, manufacturers set out to produce CLT, a solid timber plate made from alternating layers of lumber. Based on a French patent from 1985 and supported by Gerhard Schickhofer's Ph.D. research in 1994, CLT was henceforth being manufactured and used in buildings, first in Europe and later in North America.

Figure 1.24 A Sustainable Forest Initiative (SFI) sustainability rating stamp on lumber.

Recent years have seen other technological developments in this area: *Nail-laminated timber* (NLT, a panel product made from side-nailing 2× lumber) and *dowel-laminated timber* (DLT, a panel product made without any glue or metals) have seen renewed interest. Full-thread screw connections (of sometimes significant lengths) have become a highly viable and easy-to-install fastener for connecting or reinforcing wood structures. And various custom connecting elements are being researched that can improve the seismic behavior of wooden structures, especially where wood shear walls are used.

While it had long been understood that wood is a natural, renewable, and *sustainable building material*, recent efforts to quantify this using life-cycle assessment (LCA) tools have helped foster a science-based understanding of this topic (more on this in Chapter 2). Such data can then be fed into building sustainability rating systems, which commonly makes wood structures a highly desirable option where carbon-mitigation efforts need to be implemented (Figure 1.24).

As we will cover in more detail in Chapter 7, *building code* adoption of wood has traditionally had two goals: creation of opportunity and public protection. The historic existence of wood structures (with a particular consideration of their combustible nature) is the reason that regulations for wood buildings were included in building codes from their very beginning. Arguably, together with sanitation concerns, fire concerns were the reason building rules and regulations were written in the first place (Mathewson 2023). On the other hand, wood has always provided an accessible, cost-efficient means of construction that uses a structurally efficient, natural building material – a fact that served the needs of the public while providing economic incentives.

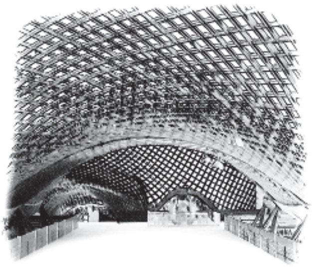
The extent to which wood has been included in codes has varied, however, and from a mass timber perspective, the most crucial building code changes only occurred in recent years. Traditionally, US building codes – exemplified most recently by the International Code series that was introduced in 2000 – had provided rules for solid sawn as well as glue-laminated construction as part of its construction Types III or IV (in addition to wood light-framing Type V). The 2015 IBC (International Building Code) revision then started to modify the Type-IV construction by allowing CLT in exterior walls. Most recently, however, the 2021 IBC code revision introduced three new sub-classes to Type IV construction (IV-A, IV-B, and IV-C) that now permit wood structures up to a height of

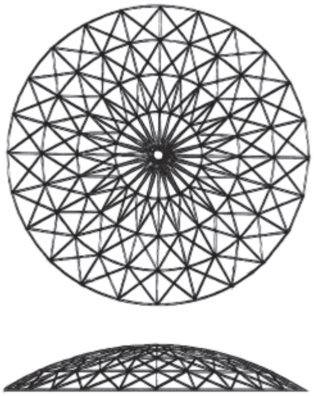
270 ft and 18 stories. At the time of writing, however, the 2021 IBC code rules had not yet been implemented by all states. As a result, building code support for mass timber structures varies.

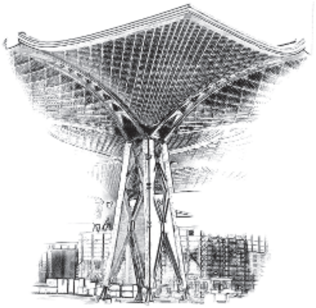
1.7 KEY BUILDINGS AND WOOD STRUCTURES

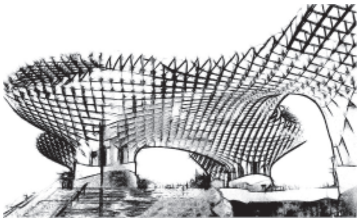
As part of the wood building renaissance (and mass timber *naissance*), many key structures and buildings have been realized. The following are of special note, due to either their size or to the implementation of a particular technological innovation.

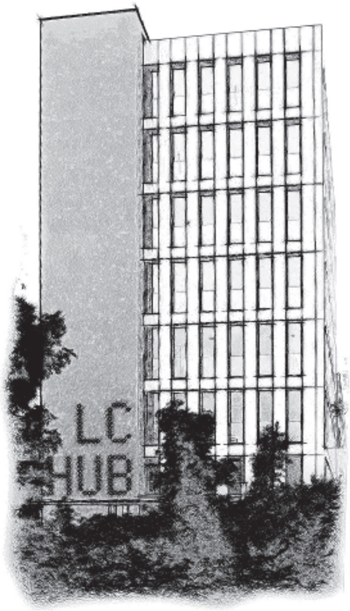
- **1975:** The **Multihalle Mannheim** in Germany is one of the several examples of wooden, free-form (grid-)shell structures. Other more recent examples of note are the **Downland Gridshell** in the United Kingdom or those by Shigeru Ban (e.g. the **Centre Pompidou** in Metz, France, or the **Swatch headquarters** in Biel, Switzerland). Designed by Frei Otto, the Multihalle was built for a national garden exhibition and still remains the world's largest self-supporting timber grid shell, with its longest span measuring 197 ft.
- **1983:** Long-spanning wood structures reached a new peak when the **Tacoma Dome** was constructed in Washington state. This building can seat 21,000 people during events under a tessellated roof structure that spans 530 ft and has a height of 152 ft. Its main structural system consists of 414 glulams with 1568 additional purlins as secondary members.
- **2000:** The 170,000 ft^2 **Expo 2000 Roof** structure above a plaza on the trade fairgrounds in Hanover, Germany, was intended as a showcase project for timber design and fabrication. This project was designed by Herzog + Partner, engineering was provided by Julius Natterer's office, and it was fabricated by Züblin and Holzbau Amann. All roof panels featured a gridded wood structure that was glued in its final shape on-site prior to erection. Expo 2000 also featured other notable wood structures like the **Swiss Pavilion**, which was a globe-shaped wood structure that utilized curved glulam beams with a round cross-section.
- **2008:** The **e3** residential building in Berlin, Germany, was a seven-story structure that utilized a glulam frame with intricate corner connections, together with a wood-concrete composite floor system. It was designed by Kaden Klingbeil Architects, with engineering by Julius Natterer. Wood construction was done by Holzbau Merkle.







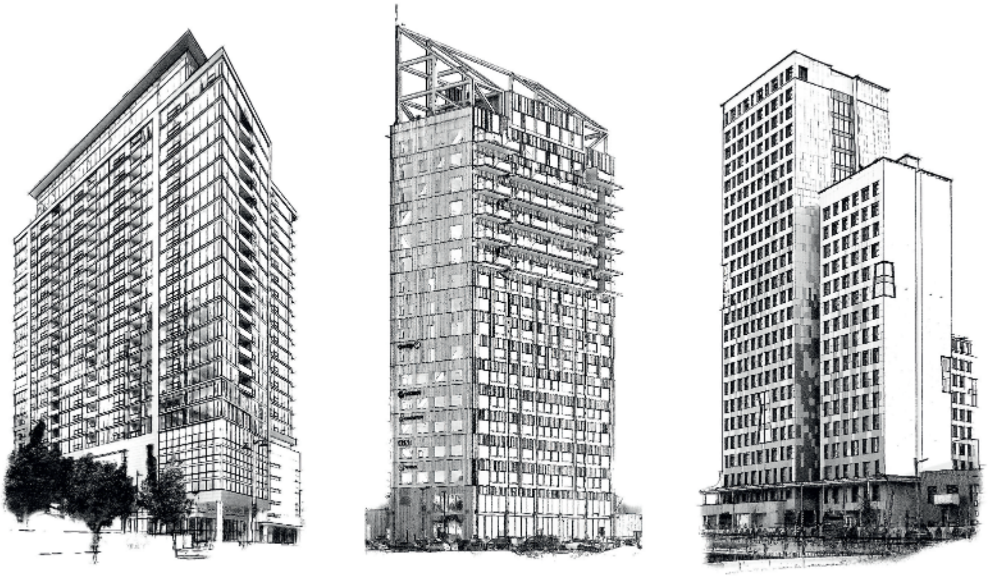




- **2009:** The **Stadthaus** in Hackney, London, UK, was the first residential nine-story CLT building that was made entirely out of CLT panels (including all floors, walls, stair shafts, etc.). This project was designed by Waugh Thistleton Architects. Engineers on this project were from Techniker, and the CLT was supplied by KLH in Austria.
- **2011:** As part of an urban renewal project, the Spanish city of Seville erected the **Metropol Parasol**, an 85-ft-tall wooden canopy structure that covers a plaza of approximately 490 by 230 ft. This project used a parametrically shaped grid of vertical Laminated Veneer Lumber (LVL) panels that were connected using force-couple fasteners to create a frame structure. Designed by Jürgen Mayer H. and engineered by Arup, this project was made mainly using Kerto, an LVL product by Finnforest.
- **2012:** The **LifeCycle Tower One** in Dornbirn, Austria, was an eight-story passive house-certified administrative building that introduced a fully prefabricated method of construction: 26.5 ft long wood-concrete floor panels were precast off-site and then assembled on a grid of double glulam columns. Fully finished external wall panels were likewise lifted into place, which allowed the builders to construct one floor in its entirety in a single day. This project was designed by Herman Kaufmann, with engineering by merz kley partner and construction/development by Cree GmbH.
- **2016:** The seven-story **T3** office building in Minneapolis became an example of a cost-efficient office building construction in timber. It is a 180,000-square-foot timber superstructure that utilized NLT plates instead of CLT and was installed in only 9.5 weeks. This project was designed by Michael Green Architecture in association with the DLR Group. Fabrication was provided by StructureCraft Builders. After this Minneapolis project, the developer (Hines) went on to construct further iterations based on the same design in Atlanta, GA; Toronto, ON; and Nashville, TN, with even more still in development.
- **2016:** The four-story, 87,500 ft^2 **John W. Olver Design Building** at the University of Massachusetts in Amherst, MA, became the largest academic mass timber building at its time and featured wood-concrete composite floors throughout to increase structural floor spans. It was designed by Leers Weinzapfel Architects with Equilibrium Consulting and Simpson, Gumpertz, and Heger (SGH) as engineers. Glulam and CLT were supplied by Nordic Structures (Figure 1.25).

Figure 1.25 The John W. Olver Design Building at the University of Massachusetts in Amherst, MA. This 87,500-ft^2 mass timber building features a glulam frame, CLT floors, roofs, and shear walls, as well as a wood-concrete composite flooring system. Interior views of this project will be visible in many locations in this book.

- **2017:** The 18-story-tall **Brock Commons Tallwood House** in Vancouver, Canada, which has since served as a residence for university students, became the tallest mass timber building at its time. It featured a beamless CLT floor and a glulam column grid that is laterally stiffened by two concrete cores. This project was designed by Hermann Kaufmann and Acton Ostry Architects. The engineers were Fast & Epp. CLT and glulam were supplied by Structurlam Products LP.
- **2025:** At the time of writing, the 25-story **Ascent** building in Milwaukee, which contains 493,000 ft^2 of usable space, was the tallest timber building in the world at 284 ft. It beat the previous record holder, the **Mjøstårnet** in Norway, by 4 ft. Third in line was the **HoHo** building in Vienna, Austria, which topped out at 276 ft. These buildings as well as others that are currently in the planning phases are part of an ongoing informal "race to the top" international competition for the tallest high-rise timber building. Ascent was designed by Korb + Associates Architects and engineered by Thornton Tomasetti. CLT and glulam were supplied by KLH and Wiehag (Figure 1.26).



Ascent
Milwaukee, USA
284 ft (86.6 m)

Mjøstårnet
Brumunddal, Norway
291 ft (88.8 m)

HoHo
Vienna, Austria
276 ft (84 m)

Figure 1.26 The current trifecta of tallest wood buildings.

This list is selective and not a full account of all the amazing wood buildings that had been constructed by the time this book was published (and afterward). While a historic overview of this topic is educative at the beginning of a book like this, it is likewise clear that we are very much in the middle of an ongoing history, with its various chapters being written daily by architects, engineers, builders, and researchers in this field. We encourage the reader therefore to keep an eye on relevant industry publications and wood promotion websites (see our web links at the end of the chapter), which feature a constantly updated list of project case studies together with their details and project images.

TIP We are covering three key buildings – that are each representative of a different mass timber building typology – in detail at the end of this book in extensive case studies: The John W. Olver Design Building, the Brock Commons Tallwood House, and the Origine building.

1.8 THE FUTURE OF MASS TIMBER

Given all of these recent developments, it is not surprising that the 21st century has often been called the century of wood structures. Many recent building projects – as discussed throughout the previous sections – attest to this. Still, there are barriers to overcome and more progress to be made. The construction industry is going through a transition with mass timber, and transitions, as we know, take time and effort.

For large-scale construction in particular, steel and concrete are still very much the status quo – and understandably so. Their extensive use is the result of centuries of dedicated research and development into their properties and design. They have been continually refined, as well as validated, through years and years of application giving rise to a societal culture that is deeply rooted in their use. Well-established supply chains keep costs low while supporting countless jobs. Education and training programs for construction professionals are also securely in place for these materials. Similar industry-wide support and infrastructure for mass timber began only a few years ago and is still quite regional in its levels of implementation. Figure 1.27 illustrates a side-by-side comparison of traditional, established construction methods and contemporary mass timber construction.

While nearly 100% of architecture and engineering schools in the United States offer introductory courses in steel and concrete design, only 52% offer timber design, and many of those courses are only offered bi- or triennially (Lawson 2020). This translates to far fewer professionals with timber expertise. Without adequate training during their education, many designers enter the workforce ill-equipped to incorporate mass timber

Figure 1.27 A 190,000 ft^2 mass timber building is announced for construction on a billboard right next to a concrete frame that rises in the adjacent lot in Vancouver, BC.

Figure 1.28 Hands-on projects that allow students to design, fabricate, and test wooden structural components are helpful to reinforce understanding of the material.

effectively. As a result, they may either specify mass timber improperly or avoid using it altogether. In addition to having fewer experts, it also means that there are fewer faculty teaching timber design and, consequently, fewer graduate students (i.e. future faculty and researchers) specializing in timber. Even when institutions prioritize creating new positions in timber design, the pool of qualified candidates is often limited. It is the authors' hope that this book and the educational programs that may use it will help remediate this shortcoming. Figure 1.28 presents a wood truss competition – one of the many possible university activities designed to enhance understanding of wood structures.

Even though mass timber has been in existence since the early 1900s (in the form of glulam) and has been used in many buildings worldwide, there is still plenty of room for new ideas. The development of CLT as a new product over the past decades is an excellent example. And while many creative research teams, practitioners, and manufacturers propose new ideas in the form of novel materials, connectors, and other technologies, widespread adoption remains slow. This is in part a result of a naturally risk-averse construction industry, particularly when multimillion dollar budgets are involved. Fortunately, demonstration projects like the Olver Design Building, along with the many excellent advocacy groups and organizations, are helping to shift perceptions. As more stakeholders recognize the benefits of mass timber, its presence is steadily growing. According to WoodWorks.org, as of March 2025, there are 2427 mass timber projects in the United States that are either completed or in progress. That is a substantial increase from the handful of buildings that existed in 2014 during the planning phase of the J.W. Olver Design Building.

1.8.1 New Technologies

Every two years, the World Conference on Timber Engineering (WCTE) serves as a global forum where practitioners, industry leaders, and academics converge to exchange pioneering advancements in timber engineering. Originating in Montreux, Switzerland, in 1984, the gathering has grown from a niche group of a few hundred people to a few thousand people now. This conference is just one among many held globally – others are the annual International Mass Timber Conference in Portland, OR, and the *Internationales Holzbau-Forum* (*IHF*) in Innsbruck, Austria, plus various other smaller research- or construction-focused events. This is complemented by thousands of research publications dedicated to advancing timber technologies. These gatherings consistently showcase groundbreaking developments across a wide range of fields, pushing the boundaries of innovation and application. What follows is an overview of anticipated breakthroughs poised to shape the future of the mass timber industry.

Figure 1.29 A project in Somerville, MA, is using CLT made from a non-traditional species: Eastern Hemlock.

New products and configurations of laminated wood, together with material modeling, are a major focus of ongoing research. As demand grows, CLT production is expected to diversify, using a broader variety of wood species with more customization for specific applications (Figure 1.29). For instance, CLT panels that include more low-value and underutilized wood species could be used in less structurally demanding applications like multi-family housing (short spans and light loads), while higher-quality wood and more advanced layups and/or hybrid panels could be reserved for large-scale structures. Many recent research and development efforts have been devoted to hardwood and low-grade softwood resources.

The commodification of CLT is also a topic of growing interest in the industry. CLT is increasingly being viewed as a material that could be standardized for mass production, to make it more accessible and cost-effective like other wood-based panel products (i.e. sheathing). One CLT manufacturer, Sterling Structural, for instance, has a unique approach to their product line: panel lengths are limited to roughly 18 ft. While this has to do with plant constraints, it undoubtedly keeps costs lower than making panels of up to 60-ft length, as other manufacturers do. With proper design intent, 18-ft spans can be adequate for a large percentage of applications. More of this type of thinking could revolutionize how CLT is currently sold – from a custom-engineered, manufacturer-centric approach to a pre-engineered distributor-centric approach with inherent cost efficiencies from less engineering and material processing.

In addition to innovations that spawn new products, there are many studies focused on innovations to improve existing products in the areas of quality control, fire engineering, moisture protection (e.g. thermally modified or acetylated wood), acoustics, adhesives, and earthquake-resistant designs. New architectural approaches to parametric design with CNC (Computer Numerical Control) manufacturing and robotics are other notable areas of advancement.

A critically important aspect of mass timber is its prominent position in sustainable design. As buildings move closer to achieving net-zero carbon emissions, there is no doubt that greater research focus will be placed on zero-emission building technologies, life cycle assessments, circular economy principles, creating climate-smart societies, promoting human health, and generally reducing embodied carbon in construction. For instance, CLT is an ideal material for creating modular floor and wall elements, so studies exploring prefabrication techniques and streamlined processes are emerging. It is likely that with their precision fit and quick installation, mass timber will be a major component of lean construction. Moreover, all mass timber uses sustainably harvested wood and consequently, sustainable forestry management is also undergoing technological advancements, such as improved forest modeling techniques to produce high-quality forest data (discussed in Chapter 2).

As implied in the last few paragraphs, the future of timber construction will undeniably draw on expertise from a wide range of disciplines – forestry, engineering, architecture, construction, and beyond. To propel the mass timber industry forward, education must not only cultivate technical skills and advanced knowledge in these fields but also ignite curiosity, encourage creativity, and foster a willingness to take risks. This combination of innovation and interdisciplinary collaboration will be key to shaping a new age of timber construction.

REVIEW QUESTIONS

1. Which of these structures was typically covered with sod?
    a. North American teepee
    b. Viking longhouse
    c. Haida longhouse
    d. Adobe houses
2. Which of these describes a traditional technique to create wall infill in houses?
    a. mortise and tenon
    b. triglyph and dentil
    c. wattle and daub
    d. pintle and decking

3. Glulam was initially invented to create…
    a. a new way to construct roofs
    b. a new bridge truss type
    c. a wall covering
    d. floor decking
4. Which of these buildings uses CLT in its walls *and* floors?
    a. Multihalle Mannheim, Germany
    b. T3 in Minneapolis, MN
    c. Brock Commons in Vancouver, BC
    d. Stadthaus in London, UK

EXERCISES

1. **Create a case study on the wood structure of one of the buildings mentioned in this chapter.** Find as much information about the structure on the web as you can. What are the sizes of the various structural members? What is the size of the structural grid? How was the structure put together? Once you have all this information, try to draw a cutaway structural model of a representative bay using the 3D modeling software of your choice.
2. **Find a historic or vernacular wood-wood connection** in a book like *The Complete Japanese Joinery*. If you enjoy woodworking, recreate it at full scale and document any fabrication challenges and show how well the parts fit together. Alternatively, use the 3D modeling software of your choice to create a fully detailed and accurately sized 3D model of that connection.
3. **Look for a mass timber building in your area that is either under construction or has been completed.** Reach out to the architecture firm and arrange for a site tour. If the building is still under construction, visit it every few days, especially during the structural erection, and document that process.

KEY TERMS AND CONCEPTS

sod-covered structures
tent structures
longhouses
lintels
beams and trusses
triglyph and dentil
centering
bridges
half-timbered post and beam construction
wattle and daub
mortise and tenon
knee braces
log house
saddle-, square-, v-, dovetail-notches
light-frame construction
old-growth forests
mill buildings
plank decking
pintle and post cap
Howe and Pratt trusses
glue-laminated timber
cross-laminated timber
plywood
timber framing
fully automated wood machining tools
parametric digital design tools
nail- and dowel-laminated timber
sustainability
building codes
key buildings
education and training programs
conferences
material innovations

WEB LINKS

- Gallery of award-winning projects from WoodWorks' annual awards – https://www.woodworks.org/award-gallery/
- Interactive Mass Timber Map for Canada – https://www.naturallywood.com/resources/interactive-mass-timber-map-canada/
- International Log Builders Association – https://logassociation.org/
- John W. Olver Design Building at UMass Amherst – https://www.umass.edu/bct/about-us/the-design-building-at-umass-amherst/
- Mapping Mass Timber – https://www.woodworks.org/resources/mapping-mass-timber/
- Multihalle Mannheim – https://mannheim-multihalle.de/
- The State of Tall Timber: A Global Audit – https://www.ctbuh.org/mass-timber-data
- Think Wood – https://www.thinkwood.com/
- Timber Framers Guild – https://www.tfguild.org/
- WoodWorks – https://www.woodworks.org/

SELECTED REFERENCES

Allen, E., Schreyer, A., and Thallon, R. (2022). *Fundamentals of Residential Construction*, 5the. Hoboken, NJ: John Wiley & Sons.

Carley, R. (1994). *The Visual Dictionary of American Domestic Architecture*. New York, NY: Henry Holt.

Forest Products Laboratory (2021). Wood Handbook—Wood as an Engineering Material. *General Technical Report FPL-GTR-282*. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory.

Halász, R. and Winter, S. (2021). *Zur Geschichte des Holzbaus*. In: *Holzbau–Taschenbuch, Grundlagen*. 10. Auflage. Berlin, Germany: Ernst & Sohn (John Wiley & Sons).

Herzog, T., Natterer, J., Schweitzer, R. et al. (2004). Timber Construction Manual. Birkhäuser, Edition DETAIL, Munich, Germany.

Hetzer, O. (1906). German Patent 197773: *Gebogener Holz-Bauteil für vereinigte Dach-Pfosten und -Sparren*. German Patent and Trade Mark Office.

Hofmeister, S. (Ed.) (2022). Holzbauten – Timber *Buildings*. Edition DETAIL, Munich, Germany.

Hofmeister, S. (Ed.) (2023). Herman Kaufmann *Architekten*. Edition DETAIL, Munich, Germany

Lawson, J. W. (2020). Used the most, taught the least. Structure Magazine. https://www.structuremag.org/article/used-the-most-taught-the-least/ (accessed 17 April 2025).

Mathewson, G. (2023). *A History of U.S. Building Codes*. Journal of Fine Homebuilding, Issue 317.

Paul, C.E. (1916). *Heavy Timber Mill Construction Buildings*, 2nde. Chicago, IL: National Lumber Manufacturers Association.

Sato, H. (1995). *The Complete Japanese Joinery*. Vancouver, Canada and Seattle, WA: Hartley & Marks.

Savage McAlester, V. (2013). *A Field Guide to American Houses*, 2nde. Borzoi Books.

Stewart, H. (1974). *Cedar: Tree of Life to the Northwest Coast Indians*. Vancouver/Toronto, Canada: Douglas & McIntyre.

Walsh, F.J. and Watts, R.L. (1923). U.S. Patent 1,465,383: Composite Lumber. USPTO.

Waugh, A., Weiss, K.H., and Wells, M. (ed.) (2009). *A Process Revealed – Auf dem Holzweg*. London, UK: Thames & Hudson.