Chapter 1
Sustainable Development of Recent High-Rise Timber Buildings

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1.1 Introduction

High-rise buildings may be designed and constructed with increasing complexity because of technological advancements. Buildings that are over 25 m can be categorized as “high-rise buildings” [1]. It can be assumed that taller buildings have bigger areas, more premises, higher energy consumptions, and more CO$_2$ emissions, thus, creating a bigger negative impact on the environment. High-rise building construction is often expensive, takes a long time, and requires a lot of labor. In contrast, high-rise buildings are distinctive because of the direct influence they have on the surrounding environment due to their height and architectural design.

Börjesson and Gustavsson [2] revealed that the primary energy input (mainly fossil fuels) in the production of building materials was about 60–80% lower for timber frames compared with concrete frames. According to Oliver et al. [3], using wood substitutes could save 14–31% of global CO$_2$ emissions and 12–19% of global fossil fuel consumption by utilizing 34–100% of the world’s sustainable wood growth.

Till now, reinforced concrete, steel, and glass have been the most popular materials utilized to build high-rise buildings for historical reasons. In the late nineteenth century, towns were frequently affected by fires, resulting in the adoption of fire safety measures in numerous countries throughout the world, including laws that restrict the use of timber structures in the construction of high-rise buildings. Recently, the fast development of construction technology, the introduction of...
modern engineered timber products (such as cross-laminated timber (CLT) and glued laminated timber (glulam)), and the modification of construction restrictions prompted a new era, which led to the growth of multi-story timber construction [4]. As previously mentioned, the construction of high-rise timber buildings directly contributes to the success of sustainable construction goals across the three aspects of sustainability.

The implementation of CLT in Australia has been gradual for a variety of factors, including cultural, structural, economic, and maintenance issues [5]. Perhaps the most important is the traditional cultural resistance to change in construction and a misconception by industry professionals and users that engineered timber possesses the same traditional weaknesses associated with timber, i.e., a susceptibility to fire and pest damage, poor acoustics, cost premiums, and issues of durability. The authors also stated that the “people” part of marketing is the reason for CLT’s poor adoption, highlighting that purchasers must be encouraged to realize the advantages of a product and want it. To that purpose, goods must be developed not just to please but also to motivate buyers.

Doubts regarding the quality and traits of timber constructions are produced by a variety of perspectives in different countries. It is a frequent misconception that timber structures change in size over time, they are not stable and durable, not pest and moisture-resistant, and very flammable. Poor building procedures have formed these public impressions, where materials made of timber lost their qualities and durability owing to incorrect preparation or use.

Despite the aforementioned challenges, there has been an acceleration of interest in a new type of multi-story timber building globally. Compared with materials like steel and concrete, building materials made of timber have shown to have a significantly lower influence on climate change [6].

Recent interest in high-rise timber buildings is thanks to timber’s sustainability and its other considerable advantages. Timber is the only building material that is sustainable and takes minimal energy to prepare. Timber is 500 times more thermally resistant than steel and 10 times more thermally resistant than concrete. In terms of energy efficiency, timber is a good heat insulator. By using it in construction, thermal bridges are decreased and walls’ ability to retain heat is increased. Additionally, wood goods acoustically perform exceptionally well. When it comes to the transmission of impact noise, the results are better than those for concrete [7]. As they are durable, lightweight, and simple to install at a building site, timber products are an excellent option from the financial perspective [7].

Carbon is stored in all wood products. Wood is naturally made up of carbon, which trees absorb from the atmosphere as they develop. Timber products have a positive carbon impact owing to substitution and sequestration [8].

According to the 2020 Global Status Report for Buildings and Construction, annual growth in building energy usage was seen; but in 2019, energy-related CO₂ emissions rose to 9.95 GtCO₂. When building construction emissions were added to operating emissions, the sector was responsible for 38% of all worldwide energy-related CO₂ emissions [9].
To fulfill the Paris Agreement commitment and the sustainable development goals, the building and construction sector must reduce carbon emissions [10]. The United Nations has established legally binding guidelines for lowering greenhouse gas (GHG) emissions and implementing sustainability measures as a result of the growing threat of climate change. In this context, the European Union (EU) aims to be climate-neutral by 2050. The European Green Deal effort is focused on achieving this goal, which is also consistent with the EU’s dedication to global climate action under the Paris Agreement [11].

The current chapter’s objective is to investigate sustainability of modern high-rise timber buildings using multiple-criteria evaluation techniques. Modern high-rise timber buildings need to have their design evaluated more closely in order to determine their sustainability. Using wood in construction has a positive environmental impact due to several factors: (1) The only sustainable building material that takes minimal energy to prepare is wood; (2) All wood products involve carbon; (3) Wood produces less GHGs during manufacturing and does not release any CO$_2$ when a building is in process; and (4) Timber products are reusable and recyclable. Environmental impact studies of buildings are a crucial component of modern construction and are included in sustainable design.

1.2 Recent High-Rise Timber Buildings

Mjøsa Tower, an eighteen-story multipurpose building in Brumunddal, Norway, is now the highest timber building in the world. It was completed in March 2019 and is 85.4 m in height (Fig. 1.1). The skyscraper has a hotel, offices, and apartment buildings. The load-bearing structure is constructed of Kerto laminated veneer lumber (LVL), with glulam columns and beams. The first 10 stories are made up of prefabricated timber components, while the top story decks are made of concrete to provide weight for the building. Compared with a reinforced concrete building having the same height, prefabricated parts made it possible to finish construction far more quickly. With the majority of the materials coming from within two miles of the site, Mjøsa Tower’s construction was planned to have as little impact on the environment as possible [12, 13].

At the University of British Columbia in Vancouver, Canada, Brock Commons (Fig. 1.2) is a 53 m-tall accommodation facility that can accommodate 404 students. The hybrid building of the 15,000 m$^2$ project consists of 17 stories of CLT floors supported by glulam columns on top of a concrete foundation and two 18-story concrete cores. The roof comprises steel beams and metal decking. The building envelope is a prefabricated panel system clad with wood-fiber high-pressure laminate. According to its designers, the building weighs 7500 tons less than a concrete counterpart [14]. Interior wood elements were coated with gypsum board to comply with fire regulations, which were tighter than those for conventional steel or reinforced concrete buildings [12, 13]. The building was constructed in 2017 using
Fig. 1.1  Mjøsa Tower, Brumunddal, Norway

Fig. 1.2  Brock Commons Tallwood House, Vancouver, Canada
prefabricated parts, and construction was finished 70 days after the parts were brought on-site.

In Bergen, Norway, Treet (Fig. 1.3), often known as The Tree, is a 14-story apartment block with a height of 49 m that was completed in 2015, 4 years after the design phase started in 2011. A glulam load-bearing structure, called Treet, supports 62 prefabricated modular apartments with CLT walls. The glulam structure is the only component that gives the building stiffness; however, the concrete slab floors on levels 6 and 11 add additional stability. To prevent wood on the building’s façade from deteriorating, portions of it are covered in glass and metal [12, 13].

In Melbourne, Australia, the construction of a 32.2-meter-tall, nine-story building, known as Forte Development, was finished in 2012 (Fig. 1.4). It became the country’s first high-rise timber building. Shear walls made of CLT panels were used to construct the building. The panels were piled at an angle, glued to the surface, and hydraulically pressed. There are four townhouses and 23 residential flats in Forte Development. The apartments are dual aspect to make the most of natural lighting, and were also designed with thermal efficiency in mind, requiring less energy to be heated [12, 13].

In Hackney, northeast London, Murray Grove Stadthaus, a nine-story residential building with a height of 26 m, completed construction in 2009. There are 29 apartments there (Fig. 1.5). Murray Grove was named the world’s first housing high-rise building constructed entirely from prefabricated CLT panels, with its core, load-bearing walls, floor slabs, stairs, and lift. CLT panels were used on the building’s structural core because of their noticeably higher density than timber frames. Then, independent layers were included to keep the acoustic performance good [12, 13].
Fig. 1.4 Forte Development, Melbourne, Australia

Fig. 1.5 Murray Grove Stadthaus, London, UK
Table 1.1 Trend of high-rise timber building in the world

<table>
<thead>
<tr>
<th>Name of building</th>
<th>Location</th>
<th>Height (m)</th>
<th>Story</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treet</td>
<td>Bergen/NO</td>
<td>52</td>
<td>14</td>
<td>2014</td>
</tr>
<tr>
<td>Mjøstårnet</td>
<td>Brumunddal/NO</td>
<td>85.4</td>
<td>18</td>
<td>2019</td>
</tr>
<tr>
<td>Hoho Vienna tower</td>
<td>Vienna/AT</td>
<td>84</td>
<td>24</td>
<td>2020</td>
</tr>
<tr>
<td>Haut</td>
<td>Amsterdam/NL</td>
<td>73</td>
<td>21</td>
<td>2021</td>
</tr>
<tr>
<td>Hypérion</td>
<td>Bordeaux/FRA</td>
<td>57</td>
<td>18</td>
<td>2021</td>
</tr>
<tr>
<td>Silva</td>
<td>Bordeaux/FRA</td>
<td>50</td>
<td>18</td>
<td>2022</td>
</tr>
<tr>
<td>Ascent MKE</td>
<td>USA</td>
<td>87</td>
<td>25</td>
<td>2022</td>
</tr>
</tbody>
</table>

Table 1.1 displays the global trend of high-rise timber buildings. Construction is underway on further high-rise timber buildings, such as Terrace House in Vancouver, Canada.

1.3 GHGs

Buildings involve a major amount of carbon dioxide emissions, which is notable given the tremendous environmental impact of buildings’ development [15]. Building materials are produced, built, used, and demolished on a large scale, which greatly adds to global resource utilization and waste. Construction and demolition activities require around 40% of all raw materials worldwide [16]. Additionally, 32% of all energy used globally and a third of all GHG emissions are related to construction activities. Buildings release 35% of GHGs, 10% of airborne particles, and 25% of landfill waste. Due to these adverse environmental impacts, sustainable alternatives such as less energy-intensive materials or recycled or biodegradable materials need to be introduced in the construction sector [17]. The circular economy of construction materials in this context also plays a noticeable role, helping maximize the efficient material use of construction and demolition waste, and minimize fossil fuel energy use and resource consumption [18]. Timber has recently been proposed by researchers as a structural material with fewer energy requirements and lower carbon emissions. Approximately 88% of all timber may be utilized to make lumber or other products with little to no waste being produced. A closed-loop circular economy is a term used to describe this kind of reuse mechanism. Construction and demolition wood or wood fiber waste is employed in engineering wood panel products, which is known as open-loop circular economy [18]. Various industrialized timber goods (such as particle board and laminated flooring) can be produced in addition to engineering wood products. Currently, 63% of waste wood is disposed of in landfills and burned without being converted into energy. Although landfilling and incinerating waste have a negative effect on environment and human health, they provide little or no energy. As waste-wood reuse, reduction, and recycling (bio-concrete, wood-plastic composite) are part of the circular economy, these activities will reduce environmental impacts [19]. For sustainable development, a systemic evaluation is thus needed to investigate the construction of wood-frame structures.
1.4 Assessment Criteria

Seven characteristics that represent the quantity of timber used in construction have been established to assess the various high-rise timber buildings. The assessment includes the achieved height in terms of meter and number of floors, duration of construction, and cost efficiency as well as environmental parameters such as reduction of CO$_2$ emission and energy use.

Based on the prior study and experience, the authors of the current chapter assessed the significance of the criteria in Table 1.2 [13].

<table>
<thead>
<tr>
<th>Table 1.2 Assessment criteria and their significance</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
</tr>
<tr>
<td>Use of wood</td>
</tr>
<tr>
<td>Height of building</td>
</tr>
<tr>
<td>Number of floors</td>
</tr>
<tr>
<td>Building cost</td>
</tr>
<tr>
<td>Length of implementation</td>
</tr>
<tr>
<td>Reduction of CO$_2$ emissions</td>
</tr>
<tr>
<td>Use of energy</td>
</tr>
</tbody>
</table>

Note: $^a$ Max – higher value of criterion is preferred; Min – lower value of criterion is preferred
The most sustainable building, according to the overall assessment of sustainability of buildings, is Brock Commons in Canada, while Mjøstårnet is in the second place with a slightly lower index.

These results are consistent with those of prior research by Tupenaite et al. [13], which placed Mjøstårnet as the top system across seven categories. Moreover, it can be seen that the addition of other evidence benefited in the comprehensive evaluation of the buildings, changing the rankings. In addition, values of some sustainability indicators may change over time, e.g., a new supermarket or a new kindergarten could be built, thus, accessibility of a building may increase. Updated sustainability assessments are needed if the values of indicators change.

This study confirmed the findings of Leskovar and Premrov [4], which stated that the age of timber buildings is reflected in their architecture, and the height of the buildings increases with the year of construction. Furthermore, Brock Commons and Mjøstårnet, which are higher buildings, obtained higher sustainability ratings.

Based on determined efficiency indexes, the buildings were ranked—the higher the efficiency index, the higher the rank [20]. Based on calculations, Brock Commons is the most environmentally friendly building across all sustainability rating categories. In terms of environmental indicators, this building came in second, but it outperformed other buildings with respect to social indicators. The Mjøstårnet building is in the second place, and its overall rating is not much different from that of the Brock Commons building. Brock Commons has superior socio-economic performance, while this building has the highest environmental performance. A summary assessment of sustainability of the buildings is presented in Fig. 1.6.
1.5 Construction Cost

The bill of materials (BOMs) from the architectural designs and material pricing data from RSMeans are used to estimate the cost of building construction. RSMeans is a database of up-to-date building construction expense estimates. It includes localized industry average cost data for construction materials, labor, transportation, and storage. Plumbing design systems and energy simulation software are often able to estimate operational energy use, such as daily electricity, natural gas, and water usage.

A 12-story, 8360 m² mixed-use office and residential complex with CLT and glulam materials was intended as the first high-rise mass timber building in the United States. The design for the mass timber building was a detailed construction document with materials takeoff. Although the building was intended to be constructed in Portland, Oregon, the project was put on hold due to a lack of funding [21]. Then, for comparative purposes, a reinforced concrete building with the same functional fireproofing, insulation, and energy consumption results was also created. Both building designs were completed by LEVER Architecture (Portland, Oregon) with additional structural design and analysis from their partner, KPFF Engineering (Seattle). Because CLT weighs less than concrete, when utilized in buildings as structural elements, the mass timber building’s overall weight was around 33% lower than that of the reinforced concrete building.

The architects and building contractors did not submit detailed cost estimates for the two planned buildings. As a result, the RSMeans 2018 database, which shows cost information for the most popular building materials, was employed to quote the material unit, labor, and overhead prices for each material listed in BOMs. For CLT, the unit cost was estimated based on the glulam cost, including the labor and overhead cost data found in RSMeans, as a proxy. These construction costs are all based on the material’s regional industry average cost data in Portland, Oregon. The summarized construction costs for the two buildings, timber and reinforced concrete, grouped into building assemblies are presented in Table 1.3 and Fig. 1.7. With the data derived based on BOM supplied from the building designs and RSMeans database, the mass wood building is expected to have 88% higher total front-end costs than the reinforced concrete building in this example. This resulted from CLT and glulam’s higher pricing as non-commodity goods compared with commodity items like steel and concrete. Even though manufacturers of CLT are emerging because of the increasing demand in the building sector, the price is still high as a result of limited suppliers in North America. In mass timber buildings, CLT is mainly used in the floor and wall assemblies, and glulam is utilized in the post and beam assemblies, whereas less expensive concrete is mainly employed in these assemblies for reinforced concrete buildings. If full commercialization of mass timber products is achieved, the front-end cost of high-rise mass timber buildings can become more competitive, especially with the time and cost savings during the erection of high-rise mass timber buildings compared with traditional reinforced concrete buildings [22].
Table 1.3 Two different high-rise buildings’ construction costs by assembly types

<table>
<thead>
<tr>
<th>Assembly type</th>
<th>Material</th>
<th>Labor</th>
<th>Overhead</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ceiling and roof</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>164,819</td>
<td>240,260</td>
<td>149,794</td>
<td>554,873</td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td>98,592</td>
<td>126,928</td>
<td>80,347</td>
<td>305,867</td>
</tr>
<tr>
<td><strong>Floor</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>2,138,568</td>
<td>408,303</td>
<td>428,117</td>
<td>2,974,988</td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td>574,012</td>
<td>236,041</td>
<td>181,824</td>
<td>991,877</td>
</tr>
<tr>
<td><strong>Foundation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>60,701</td>
<td>50,489</td>
<td>37,115</td>
<td>148,306</td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td>84,444</td>
<td>71,526</td>
<td>53,035</td>
<td>209,005</td>
</tr>
<tr>
<td><strong>Post and beam</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>936,605</td>
<td>142,659</td>
<td>170,023</td>
<td>1,249,287</td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td>173,503</td>
<td>57,780</td>
<td>50,749</td>
<td>282,032</td>
</tr>
<tr>
<td><strong>Wall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>1,708,556</td>
<td>1,091,486</td>
<td>750,321</td>
<td>3,550,362</td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td>1,110,229</td>
<td>975,842</td>
<td>635,150</td>
<td>2,721,221</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mass timber building</td>
<td>8,477,816</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforced concrete building</td>
<td></td>
<td></td>
<td></td>
<td>4,510,002</td>
</tr>
</tbody>
</table>

![Building Construction Cost Chart](chart.png)

**Fig. 1.7** Front-end construction costs by assembly types for high-rise mass timber and reinforced concrete (concrete) buildings
1.6 Fire Safety

High-rise timber buildings may have serious problems from a fire safety perspective. The following are the primary extra challenges for high-rise timber buildings:

- Early fire risk. Large exposed interior wood surface areas are flammable.
- A fire spread outside. Vertical fire spreads through flammable facades or cavities.
- Fires that occur during construction. This is a particular issue for structures made of light timber.
- Burnout. After fire burns itself out, what happens?
- Fire resistance which helps with the structural performance and fire containment.

Excellent fire resistance in heavy timber has been thoroughly established in the literature [23]. This exceptional behavior is due to the intense flames’ gradual and predictable rate of surface charring, which makes it possible to calculate fire resistance by subtracting the charred area from the original cross-section together with a thin layer of heat-affected timber. Unprotected heavy timber structural components provide high fire resistance thanks to this charring characteristic, for example, much better than unprotected structural steel.

Encapsulation is the process of enclosing flammable materials with wood surfaces [23]. Although encapsulation can increase fire safety, not all fire issues in timber buildings are quickly resolved [24]. Full encapsulation requires that wood be encapsulated with enough layers of protective material to prevent any ignition or charring of wood in a complete burnout of the fire compartment, giving the same fire resistance as any non-combustible materials. Partial encapsulation slows down the development of fire on wood surfaces, but because there are fewer layers, they might fall off before fire burns out, leaving structural timber accessible to the advancing flames. In both cases, there is an aesthetic dilemma because building owners and users and their architects want to see wood, whereas fire engineers may need to cover it all from view.

Designing for burnout in a timber structure can only be done with absolute certainty by using full encapsulation, which prevents any structural timber from ever starting to char during the whole period of the fire growth, development, and decay. The necessary encapsulation relies on a number of variables:

- Intensity and length of the fire’s burning period.
- Speed at which temperatures fall as a result of ventilation during the fire’s decay phase.
- Ability of encapsulating materials.
- Intervention after fire has been put out.

An automated sprinkler system serves as the primary active fire defense strategy. The efficacy of the sprinkler system in high-rise timber buildings is the main concern for designers and code writers. The additional requirements for fire safety and fire resistance are low if sprinklers can be assured to function, but if for some reason they cannot, timber buildings fall into a distinct category and require extra care.
High-rise timber buildings must be designed with passive fire safety in mind on all levels, including egress, fire resistance, hidden cavities, etc. In order to protect the wood surfaces from fire, the focus is now on using encapsulation. Several choices include:

1. All exposed wood on walls and ceilings.
2. All walls are visible, but ceilings are covered.
3. All columns and beams are visible, and walls and ceilings are secure.
4. One layer of plasterboard covered in gypsum protects all wood (partial encapsulation).
5. Complete plaster board encapsulation, covering every piece of wood.

Designers of steel and reinforced concrete buildings work on the basis that if the compartmentation works and the structure is designed for adequate fire resistance, fire will eventually go out after the fuel is completely consumed, and the structure will cool to ambient temperatures after any heat remaining in the building has dissipated. This scenario is less certain for timber buildings because there will always be some fuel present in the wood components of the timber structure, leading to the possibility of slow charring which might continue long after the main fire has gone out. In this case, it is only possible to design a high-rise timber building with the same level of fire safety as a steel or reinforced concrete building if design for burn-out can be accomplished.

### 1.7 Building Height

Table 1.4 lists various building heights, ranging from low to high rise, along with recommendations for passive fire prevention based on sprinkler protection and building height. The definitions of the rows labeled “no sprinklers” and “normal sprinklers” in Table 1.4 are as normal [24]. The additional row for “special sprinklers” has been added to allow designers to take special precautions, such as a dedicated water tank in the building to ensure that the sprinklers have water, even if the

<table>
<thead>
<tr>
<th>Height</th>
<th>Low-rise</th>
<th>Mid-rise</th>
<th>Tall</th>
<th>Very tall</th>
<th>High-rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stories</td>
<td>1–2</td>
<td>3–5</td>
<td>6–8</td>
<td>9–15</td>
<td>&gt;15</td>
</tr>
<tr>
<td>Likely escape</td>
<td>Quick escape</td>
<td>Slow escape</td>
<td>Assisted escape</td>
<td>Assisted escape</td>
<td>Difficult escape</td>
</tr>
<tr>
<td>No sprinklers</td>
<td>Local areas exposed</td>
<td>No exposed wood</td>
<td>Not allowed</td>
<td>Not allowed</td>
<td>Not allowed</td>
</tr>
<tr>
<td>Normal sprinklers</td>
<td>Large areas exposed</td>
<td>Local areas exposed</td>
<td>No exposed wood</td>
<td>Full encapsulation</td>
<td>Full encapsulation</td>
</tr>
<tr>
<td>Special sprinklers</td>
<td>Large areas exposed</td>
<td>Large areas exposed</td>
<td>Local areas exposed</td>
<td>No exposed wood</td>
<td>Full encapsulation</td>
</tr>
</tbody>
</table>
street mains are destroyed by an earthquake or landslide, in which case a greater area of visible wood could be provided in high-rise timber buildings.

The options provided in Table 1.4 are only examples to illustrate the variety of alternatives. It will be vital for code writers in many nations to create standards that rationally represent these concepts as high-rise timber buildings gain in popularity. More investigations of the possibilities, including quantitative risk assessment, could aid in their further definition.

The efficacy of automated sprinkler systems in high-rise buildings is the main concern for designers and engineers. The additional fire safety standards are low if sprinklers are guaranteed to function, but if they are not, timber constructions fall into a unique category and require greater care than non-combustible building materials.

1.8 Conclusions

This chapter dealt with the theory and practice of sustainability assessment and the knowledge about high-rise timber buildings. A summary and the key findings of the chapter are presented in the following:

• Modern technology and engineered timber materials like glulam, CLT, and LVL enable the construction of high-rise timber buildings. Comparing modern timber constructions with steel and concrete ones reveals advantages. The only renewable building material that is now accessible is timber, which is also ecologically favorable.

• Timber is an excellent heat insulator, and its manufacture requires less basic energy (mostly from fossil fuels) than concrete and other construction materials. Because of the prefabrication of components, cheaper transport of goods, and shorter project length, building with timber is more economical.

• Multiple criteria assessment allowed coming to the conclusion that taller timber buildings are efficient from both economic and environmental perspectives as the highest buildings received higher ranking positions.

• Building designers who prioritize sustainability objectives have long recognized the value in timber’s renewability and light carbon footprint. There has been discussion on environmental advantages or carbon savings from the new developing mass timber items utilized in buildings. The cost of investing in such low-to-zero carbon emission buildings is increasing.

• Based on commercial construction cost data from the RSMeans database, a mass timber building design is estimated to have 26% higher front-end costs than its concrete alternative. For mass timber buildings, there is not much historical construction cost data and little operational cost data; further research and data are thus required to generalize these findings.

Most of the researchers assessed the environmental impacts of the low-rise residential building. Very few researchers focused on high-rise commercial buildings.
Significant amounts of materials and energy are required for high-rise commercial buildings. Therefore, further research is needed in this field to achieve sustainable building construction.

This chapter has made a number of recommendations to address the present issues with fire resistance design for high-rise timber buildings. Depending on the height of the building and the dependability of the water supply for the required sprinkler system, different levels of protection or encapsulation of the wood structure should be offered.

References


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