Concrete cracks, wood burns: Competing narratives in the construction sector

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Abstract

Innate to the human condition are rules of thumb, or heuristics, important for our survival. It is widely understood that wood is combustible, and concrete is prone to cracking. These factors significantly drive our perceptions concerning the selection of materials used in construction. The present study aimed to better understand the competing narratives employed by supporters on both sides of this construction "material warfare" and specifically investigate their advantage and disadvantage arguments. To meet our research objective, we looked at news media articles through Google search tool using keywords "wood vs concrete building construction". The articles are published as early as 2006, and along the years, the competing conversations are more prominent with a "birth" of mass timber in North America. The topic is also becoming an interest for specific audiences such as architects, engineers, and insurance companies. Through inductive thematic analysis of 100 articles, we find that cost and sustainability are two dominant factors in the narratives. Each industry claims to be more cost effective and sustainable than the other, typically sniping at each other. This rhetoric, we argue, will not be beneficial for society and environmental justice. A sustainable built environment requires cross-sector collaboration between wood and concrete companies to handle difficulties that they cannot address successfully within their own sector.

Keywords: Construction material, wood advantage, concrete advantage, environmental justice, sustainable built environment, cross sector collaboration

I. Introduction

Facing global issues such as urbanization and climate change, people must use resources wisely to meet their basic needs. The built environment heavily influences quality of human life. As an illustration, the average American populace tends to allocate almost 90% of their time within enclosed spaces (Klepeis et al., 2001). This number increased during the pandemic with stay-at-home orders and remote working/learning (Nwanaji-Enwerem et al., 2020). As a result, buildings and their materials have a major impact on occupants' health and well-being. With the world's urban areas increasing by 200,000 people per day, access to affordable and healthy buildings is more critical than ever (World Economic Forum, 2016).

While the construction sector is beneficial for social development and economic growth, its impacts are undeniable. Buildings are responsible for 30-40% of the global total energy use, representing a major proportion of carbon dioxide emissions (World Green Building Council, 2019). As much as 39% of global greenhouse gas (GHG) emissions are attributable to buildings, with 28% from operational emissions, and the remaining 11% released during the process of their manufacturing, transportation, and construction.

Given the situation, the construction industry faces several challenges that are related with environmental justice (World Economic Forum, 2016). This type of justice encompasses a range of policy and advocacy efforts aimed at achieving fair and just protection from environmental hazards and equitable access to environmental benefits across diverse demographic groups. The multifaceted concept extends to various dimensions of daily life, such as education, housing quality, and healthcare (Walker, 2011). Modern conceptions of environmental justice emphasize three interrelated dimensions: distribution, procedure, and recognition. Distributive justice refers to the fair distribution of environmental benefits and the prevention of any disproportionate environmental burdens on any community (Schlosberg, 2007). Procedural justice is a mechanism that enables individuals who have been adversely affected by environmental injustices to participate in the formulation and implementation of public policies. Lastly, recognition refers to the idea that everyone should be treated with respect and that each person should be seen for who they are (Schlosberg, 2007).

The construction sector possesses significant potential to facilitate the advancement of environmental justice. There is a clear need for the sector to transform to provide equal access to healthy and livable environments for communities, regardless of race, economic status, or geographic location. The significance of enhancing the quality of materials employed, promoting a healthier indoor environment, and augmenting the sustainability of buildings while diminishing their expenses is noteworthy. Any effort directed towards achieving this objective will yield advantages in terms of environmental justice.

The utilization of wood construction and engineered wood products is gaining momentum as a potential solution to replace carbon-intensive construction materials, as it is believed to have a substantial impact in this regard (Heiskanen et al., 2022). The act of renewal is frequently denoted as a transition towards a bioeconomy that is centred on wood, commonly known as a wood-based bioeconomy. This transition has garnered significant political backing, particularly from the European Union and its constituent nations (D'Amato et al., 2017).

As key decision makers in construction material selection, architects have positive perceptions regarding the use of wood (Conroy et al., 2019, 2018). However, the new "threat" from wood/timber and competition among construction materials has resulted in accusatory advertising campaigns and other rhetoric about the "other" material. We argue that a sustainable built environment requires use of many different materials, in concert. For example, a wooden skyscraper likely requires a concrete foundation. So, although wood and concrete compete, they are often complementary. Here, the rhetoric between the two camps does not benefit society and environmental justice. This study, therefore, aims to capture the rhetoric by focusing on the competing narratives employed by supporters on both sides of this "material warfare". We specifically investigate advantage and disadvantage arguments made by the wood and concrete industries.

In the next sections of the article, we will first present a framework for the research, a description of the methodologies that were utilized in the study, the results, and a discussion. After that, we offer our perspectives on the various possible ways forward.

II. Research context

The selection of materials in construction is of paramount importance, given that these materials constitute a significant proportion of the environmental impact of built environments. (Horvath, 2004). In many places in the world, nature has been converted to a concrete dominated landscape as it is considered as structurally sound construction material. Concrete itself is claimed as the most consumed man-made material in the world and has contributed to millions of jobs (Naik, 2008). Nevertheless, the manufacturing process of concrete results in the emission of substantial quantities of CO_2 and other GHGs (World Green Building Council, 2019).

Aiming for a sustainable built environment, government, architects, and engineers are nowadays increasingly specifying/using mass timber, a highly suitable substitute for concrete-based building. Mass timber is a versatile substitution for concrete, regardless of whether it is wet-poured, steel-reinforced, or in the form of solid section 'tilt-slab'. The material also can be used for low- to high-rise buildings serving both residential (e.g., housing) and non-residential (e.g., offices) needs (Kremer and Symmons, 2015).

Buildings made from wood have a positive combination between health benefits, aesthetics pleasure, and eco-friendliness (Gold and Rubik, 2009; Lähtinen et al., 2019). In terms of environmental implications, a study employing a comparative, cradle-to-grave, life-cycle assessment demonstrates that wood is capable of efficiently sequestering and retaining carbon, and the overall fossil fuel impact of utilizing wood in construction may be lower than that of concrete and steel (Milaj et al. 2017). Another study utilizing environmental indicators such as GHG emissions, energy consumption, waste production, and water utilization shows that wood-based construction often has lower environmental impacts compared to concrete-based construction (Žemaitis et al., 2021). The analysis of the production value chain, encompassing the entire process from the extraction of raw materials to the manufacturing of wood-based construction materials, has further elucidated the favourable socio-economic effects of such materials. The socioeconomic benefits of wood could lead to an improvement in a region's competitiveness and contribute to sustainable development.

As an alternative, wood is often considered to be more sustainable, largely because it is a renewable material and can be regrown. However, wooden structures are commonly perceived to be less safe than concrete buildings, as the material is vulnerable to external threats such as fire, wind, insects, moisture, and mold (Gold and Rubik, 2009; Larasatie et al., 2018).

Increasing both industry and public knowledge about using wood in construction is mentioned crucial to positive market development (Larasatie et al., 2018). The knowledge plays a pivotal role in mitigating prejudice within the construction industry. As professionals gain deeper insights into diverse materials, techniques, and methodologies, they are better equipped to challenge biased assumptions and embrace innovation. Simultaneously, media representations greatly impact consumer perceptions, influencing their expectations and preferences. The ongoing debate within the industry is fueled by various factions striving to assert the dominance of traditional materials such as concrete, while simultaneously introducing environmentally sustainable alternatives. Gaining insight into the present condition of this discussion is essential for understanding its influence on the dynamics of the industry. Based on literature above, we focus on the advantages and disadvantages of wood and concrete to picture the rhetorical narratives in the construction industry.

III. Method

To respond to the research aim, we utilised rhetorical analysis by looking at news media articles as one of the best platforms to gain rhetoric insights (Mehta and Guzmán, 2018) into the arguments employed by both wood and concrete supporters. We focused on positive (translated to be “advantage of material”) and negative (translated to be “disadvantage of material”) narratives, commonly found in media articles. We created our article database through Google, currently the largest search engine. Since the results of a Google search are dynamic day by day, we did the search on a specific date (January 26, 2023).

The following are the steps we took in our search (Figure 1): Using keywords “wood vs concrete building construction”, we found 153,000,000 results (Appendix 1). We then sorted the results by relevance and implemented several filters. First, we selected the “News” tab, yielding about 299,000 articles (Appendix 2). Next, we further arranged the results interface by clicking the “Tools” tab and chose “Archives” and “Sorted by relevance” (Appendix 3). Unfortunately, there is no number of results totals shown at this level. Instead, 33 pages were indicated with approximately 10 articles in each page (or approximately 330 news articles).

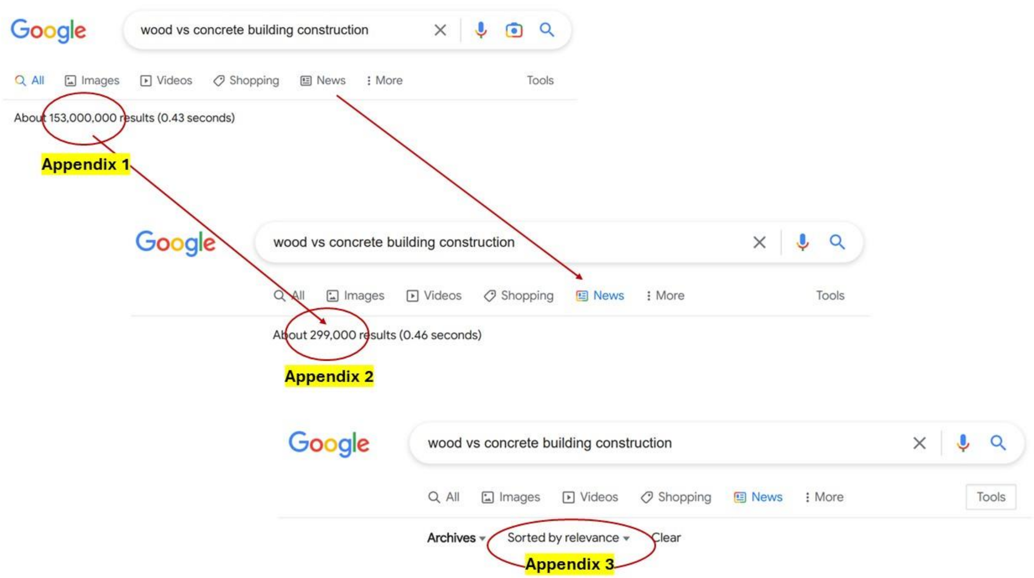

Figure 1. Google search flow.

We next selected the first, relevant 100 articles using two criteria: (1) the article addresses the advantages and/or disadvantages of wood and/or concrete and (2) the article is limited geographically to US and Canada. The limited geography is chosen due to the authors' language ability and familiarity with the two countries as well as the similar industry ecosystems. All the articles that were reviewed in the process of selecting the 100 were recorded in Microsoft Excel, along with its link, source, year, and the rationale for selection or rejection. In the selection process, the first and second author read the articles independently before comparing the results. When there was doubt regarding inclusion or exclusion, the third author gave his professional opinion. In the process of selecting 100 relevant articles, we reviewed a total of 185 articles. The final 100 articles are included in Appendix 4.

Our data was analysed through qualitative content analysis. We followed Braun and Clarke's (2006) inductive thematic analysis, conducted in four steps. During the initial phase, the primary and secondary authors engaged in a discussion to establish and validate the analytical methodology prior to proceeding with the subsequent phase independently. Subsequently, the authors engaged in a process of re-reading the articles and discerning themes and sub-themes (Figure 2) from salient phrases and sentences, which were then categorized as first-cycle codes. During further analysis, several first-cycle codes were consolidated, and newly emerged themes and sub-themes were identified, resulting in the second-cycle codes. Finally, considering the possibility of divergent interpretations by multiple coders, the authors proceeded to a fourth stage in which they engaged in a comparative and deliberative analysis of the emergent second-cycle codes. The codes were then compared between concrete advantages vs wood disadvantages and concrete disadvantages vs wood advantages (Appendix 5).

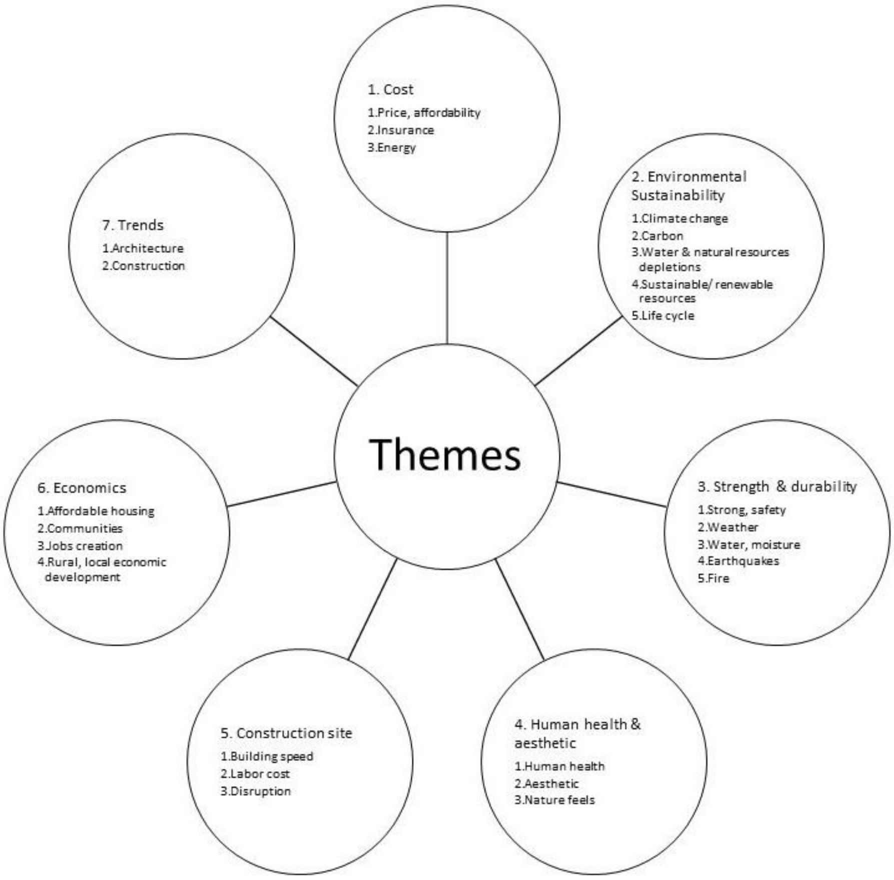

Figure 2. Themes map (primary and secondary themes) from data analysis.

IV. Results

Articles in our database (Appendix 4) are published as early as 2006 when *The New York Times* writes about *insulating concrete forms* as “an alternative to traditional wood-frame or stick construction that has become increasingly popular as a way to build a strong, energy-efficient house” with “security against hurricanes, termites, rot, aging” (Article #140, 2006). Reinforced concrete homes are predicted to attract more interest due to “growing concerns about hurricanes and other weather-related disasters” which make insurers more cautious (#140, 2006). The next item that was unearthed was written by CNN six years later. It presented a controversial concept of changing cities into "urban forests of wooden skyscrapers." (#134, 2012). Wood buildings are argued better because they “lock in carbon dioxide for the life cycle of a structure, while the manufacture of steel and concrete produces large amounts of CO2” (#134, 2012). The CNN article takes a huge step on not only discussing wood vs concrete as a low-rise construction material, but also introducing *mass timber,* modern wood materials, to build a skyscraper.

Along the years, the conversations are more prominent with comparisons between wood and concrete as a construction material, covered by different channels from international established news organizations such as *Reuters* and *BBC* to local university networks such as *Yale* and the *Massachusetts Institute of Technology*. The topic has also increasingly become of interest to specific audiences such as architects, engineers, and insurance companies.

4.1. Less grey, more green

In this section, we focus on how news narratives spotlight the trends of construction material shift from using less concrete to more wood. Despite advantages of concrete, concerns have been raised regarding its environmental impact. Efforts to balance the benefits and drawbacks of concrete have led to discussions around sustainability and alternative materials like wood.

Concrete, the world’s most used construction material, is praised due to its affordability as well as its resiliency over time against weather, earthquakes, and fire (#25, 2017). The provided material presented a cost-effective approach to reconstruct urban areas that were severely damaged by aerial bombardment in the aftermath of World War II (#90, 2019). Concrete quickly displaced load-bearing lumber as the construction material of choice (#149, 2022). An article, written after COVID-19, argues that concrete is a low-cost option with little price volatility compared to wood prices that tripled shortly after the pandemic (#85, 2022).

> “It’s an almost supernaturally cheap, easy way to quickly create sturdy housing for huge numbers of people. Concrete is strong, capable of holding thousands of tons worth of people, furniture, and water. It won’t burn or get infested with termites. And it’s incredibly easy to use. A single person can mix a batch of basic concrete and slap together a serviceable shelter.” (#151, 2019).

In terms of insurance, concrete buildings are found to cost less to insure than wood-frame buildings (#17, 2017). A study about mid-rise wood and concrete residential buildings identified four main reasons for this insurance rate gap: (1) greater fire peril due to wood’s combustibility, (2) significant high moisture risk in wood frame structures, (3) climate change, and (4) difficulty in obtaining insurance for wood frame structures (#48 & #71, 2016). Concrete is beloved for its perceived strength and durability. There is even a suburb in Atlanta, USA, that banned wood construction and promotes concrete construction “because of its purported increased building quality, sustainability, durability, and longevity" (#175, 2018). Sustainability, however, is a complicated puzzle.

Despite its popularity, there is an increasing number of articles covering the risks of building with concrete. The risk most commonly identified is environmental related costs such as GHG emissions as well as water and natural resource depletion. Cement manufacturing is placed as the third largest emitter of GHG emissions worldwide (#43, 2016).

In 2019, *The Guardian* dedicated a "Guardian concrete week" in which they write its definition as "Guardian Cities celebrates the aesthetic and social achievements of concrete, while investigating its innumerable harms, to learn what we can all do today to bring about a less grey world" (The Guardian, 2019). One of the articles in the series is included in our database, #90 (2019).

> "Taking in all stages of production, concrete is said to be responsible for 4-8% of the world's CO2 ... Half of concrete's CO2 emissions are created during the manufacture of clinker, the most energy intensive part of the cement-making process. But other environmental impacts are far less well understood. Concrete is a thirsty behemoth, sucking up almost a 10th of the world's industrial water use. This often strains supplies for drinking and irrigation, because 75% of this consumption is in drought and water-stressed regions. In cities, concrete also adds to the heat-island effect by absorbing the warmth of the sun and trapping gases from car exhausts and air conditioner units – though it is, at least, better than darker asphalt. It also worsens the problem of silicosis and other respiratory diseases." (#90, 2019).

Thus, wood is often portrayed as a better construction material than concrete. As a renewable resource, harvesting timber "has a lower environmental cost than mining the materials to make concrete. Also, wood is 15 times more thermally efficient as concrete, reducing heating and air-conditioning demands." (#43, 2016). Wood can store carbon, making wooden buildings a carbon sink (#7, 2020)

Wood is also perceived to be calming (#145, 2021), warmer, and far more aesthetically pleasing (#24, 2019). The material is found to have "stress-reducing properties similar to being in nature" (#145, 2021). For some architects, timber is even considered as "the new concrete" (#145, 2021) and wooden buildings are believed as "the future of architecture" (#1, 2019). An architect describes CLT, a mass timber product, to be the "holy grail" (#31, 2016). Compared to concrete, the product is lighter, stronger, and more environmentally friendly (#31, 2016).

4.2. Concrete cracks, wood burns

As the conversation has shifted towards more attention on wood, there are increasing comparisons between wood and concrete. Each supporter comes with arguments which material is better. With a modern technology of mass timber products including Cross Laminated Timber (CLT), pro wood advocates address the weakness of using traditional lumber in construction. Mass timber is strong and performs well in fires (#7, 2020). The last-mentioned statement, however, becomes a vocal critique point from the concrete industry. *Build with Strength*, a US coalition formed by the National Ready Mixed Concrete Association, states that CLT is "an unproven material that poses major fire risks, especially in high-rise construction" and "exposed CLT panels can lead to the re-flare and re-growth of fires" (#185, 2020). The statement is, for sure, contradicted by mass timber supporters saying that "it's not only safe - it's actually preferable, as wood burns in a more predictable way" (#185, 2020).

Cost wise, although it is more expensive to produce (#185, 2020), using mass timber can be cheaper as mass timber buildings "tend to be quicker and easier to build, therefore reducing labour costs, transport fuel and on-site energy use" (#1, 2019). The innovative wood products are more easily customized (#64, 2020) and fabricated off-site with precise specifications (#24, 2019).

> "… the cost per square foot for the timber used for (the name of the building) was $42, versus a likely cost of $37 per square foot for concrete. Some of those costs were offset, he says, by money saved by having a lighter foundation, a smaller labor force, and using less drywall." (#23, 2022).

The construction site is said to be significantly quieter and cleaner (#25, 2017) as well as it smells good (#1, 2019). Since building designers can send their plan directly to the manufacturer, mass timber is considered to cause less disruption for existing cities (#64, 2020) as less heavy machinery is required both in transportation as well as on-site (#145, 2021).

Despite all its advantages, its green credentials with "prodigious climate benefits" (#24, 2019) is perhaps the major reason why mass timber popularity is rocketing. CLT is portrayed as "an important weapon in the fight against climate change" (#1, 2019). The argument is while concrete emits vast quantities of carbon, trees absorb carbon over their lifetime. If these trees are turned into mass timber and used as construction materials, the carbon is "sequestered, rather than returned to the atmosphere when the trees die" (#185, 2020). One cubic meter of CLT sequesters approximately one ton of CO_2, and a CLT building "uses 26.5 % less energy than its concrete equivalent" (#145, 2021).

> "Arguably, the best form of carbon sequestration is to chop down trees: to restore our sustainable, managed forests, and use the resulting wood as a building material. Managed forests certified by the Forest Stewardship Council (FSC) typically plant two to three trees for every tree felled – meaning the more demand there is for wood, the greater the growth in both forest cover and CO_2-hungry young trees." (#1, 2019)

As a preferred construction material, CLT is increasingly discussed as a potential solution in providing affordable housing. In Boston, for example, two firms have designed an affordable housing project prototype by utilizing CLT with a hope that it will serve as a model for sustainable architecture that can be reproduced by other housing developers in the city (#139, 2020). In Iowa, a government grant has been allocated to finance a project that aims to offer affordable housing to communities that have been historically marginalized and underserved (#4, 2022). By more projects using CLT, it is expected to create jobs in rural forest communities (#12, 2015), and thus, stimulate and support rural economic development (#1, 2019).

> "When I have heard people talk about mass timber in the past, it can sometimes sound like a magic cure-all, sort of like the way people talk about hemp or in the last couple of years maybe they did that, this will sequester carbon, bring back timber jobs and manufacturing jobs, solve homelessness because this is, this will be the cure for affordable housing or at least a component of it." (#39, 2021).

Mass timber, however, is not without critics. The President of the Center for Sustainable Economy even states that he has a mission "to debunk the myth that mass timber is in any way, shape, or form related to some kind of environmental benefit" (#24, 2019). There is a high concern that extensive use of mass timber will translate to a risk of a large increase in clear-cutting forests. The industrial, monocultural type of forest plantations – fast-growing trees are planted on a large scale – is labelled as a "biological desert … and it's driving the extinction of thousands of species. Mass timber is mass extinction." (#24, 2019).

There is also a building's life cycle question. As long as the wooden structure stands or the wood material is reused, the carbon remains sequestered; but if the wood rots or is burned, the carbon is released (#1, 2019).

V. Discussions and conclusions

Responding to the research aim, we discuss the competing narratives employed by supporters on both sides of this "material warfare" and specifically investigate their positive (advantage) and negative (disadvantage) narrative arguments. Knowledge is crucial in reducing biases in the construction sector. As construction professionals acquire more profound understanding of various materials, procedures, and methodologies, they become more capable of questioning prejudiced preconceptions and embracing innovation. Media portrayals have a significant and simultaneous effect on these views, shaping their expectations and inclinations. The sector is currently engaged in arguments trying to establish the superiority of traditional materials like concrete, while also promoting the use of environmentally sustainable alternatives. It is crucial to gain a grasp of the current state of this conversation in order to comprehend its impact on the industry's dynamics.

As some of the quotes in the results section above illustrate, the two sectors focus on the most favourable attributes of their material and can, at times, stretch the truth or muddy the waters. Environmental justice and sustainable built environment require consistency in sustainability metrics. As all buildings use myriad materials, comparisons must be made more holistic based on cradle-to-cradle systems (i.e., life cycle analysis/LCA) rather than focusing on a limited area of the value chain.

5.1. Environmental justice

In the construction sector, many problems can be associated with distributive justice such as a challenge to provide fair distribution of healthy and liveable environments for communities across demographics (World Economic Forum, 2016). This can be achieved by, for example, increasing the use of sustainable, renewable, environmentally friendly, and healthier materials; reducing construction costs; and making buildings more eco-efficient over time with a goal to reduce lifetime costs.

Identifying more sustainable materials for buildings has been investigated as the use of common construction materials has also posed health risks such as respiratory disease, allergies, and asthma (Horvath, 2004). Here, wooden structures have the potential to contribute to the sustainability of the built environment by offering a viable option to conventional steel and concrete construction methods. In addition to being renewable, wood is considered to be a healthier construction material. Because of chemical composition and molecular structure, many types of wood are naturally antimicrobial, and have even been suggested as a better material for healthcare facilities (Munir et al., 2021).

In his TED Talk, the Canadian architect Michael Green – a long standing advocate and designer of multi storey wooden buildings – predicted cost as the significant shift in timber construction (*Michael Green: Why we should build wooden skyscrapers | TED Talk*, 2013). With lower cost, residential buildings and others such as housing, schools, health care facilities can be affordable while still be functional and beautiful.

In the United States, housing, particularly affordable housing, is receiving considerable attention. To be considered affordable, no more than 30% of household income should be allocated for housing use (Diller and Sullivan, 2018). Unfortunately, many American households spend more for their housing. A study in Oregon, for example, shows that to be able to afford a one-bedroom apartment at the state wide fair market rent, two minimum wage-earning household members would need to work a combined 63 hours each week (Diller and Sullivan, 2018). Because of their comparatively lower incomes, many people of colour in Oregon are more affected by the lack of affordable housing. These minority communities often spend an excessive percentage of their income on housing expenses, endure living in subpar circumstances, or go without any form of housing. The prevailing circumstances has been exacerbated by the COVID-19 pandemic (Rodriguez et al., 2022).

The built environment should address housing affordability as a critical societal and economic issue. Providing affordable housing is also argued as a solution for homelessness. With this strategy, Atlanta and Houston have successfully decreased the proportion of their residents who are unhoused (Hobson, 2019; Kimmelman et al., 2022). Here, mass timber may play a role as an answer to provide affordable housing but with more environmental sustainability style. In fact, the carbon advantages associated with mass timber construction have the potential to be appraised as a carbon offset (Taylor et al., 2023). On average, the total carbon benefit derived from mass timber construction projects, which includes avoided emissions and carbon storage in wood materials, can be translated to be valued in the millions of dollars.

However, it is not a silver bullet. Mass timber is a specialty product, in which all panels are custom produced and fabricated for specific construction projects (Muszynski et al., 2022). The supply chain of mass timber is a multifaceted process that encompasses numerous stakeholders, including tree farmers, loggers, mill owners, architectures, engineers, project management, manufacturers (e.g., connectors, insulation, siding), and construction workers (Muszynski et al., 2021).

5.2. Sustainable built environment

5.2.1. Cross-sector collaboration

The construction sector is commonly recognized for adhering to conventional practices and upholding conservative organizational values, which may result in conflicts when engaging with a more progressive group of specifiers (Fernando et al., 2018). To be beneficial for society and environmentally sustainable, the built environment must be created from variety of construction materials in concert. In other words, although wood and concrete compete, they are often complementary. For example, together with architectural firms, wood and concrete companies should collaborate to build wood–concrete hybrid constructions (Guerrero and Hansen, 2018; Toppinen et al., 2019).

Cross sector collaboration is promoted as a management technique aimed at addressing challenges that cannot be effectively resolved by a single sector alone (Bryson et al., 2015). This type of collaboration is initially developed in the public administration literature, believing that governments should be partnered with organizations across sectors to tackle public issues that are beyond their own capacity to resolve (Kettl, 2015). Nevertheless, the ongoing competing narrative of wood vs concrete antagonism will definitely challenge collaboration efforts.

The intense rivalry between wood and concrete construction materials has significant implications for the future growth prospects of the construction industry. The supply chains within the industry are typified by traditional hierarchical power dynamics and informal, transitory, precarious, low-confidence, voluntary, and low-obligation associations that involve minimal resource, risk, and reward sharing (Barraket and Loosemore, 2018). Strong path dependencies in concrete are a barrier to increasing the share of wood (Hemström et al., 2017). The practice of utilizing concrete as a primary material in building construction is distinguished by well-defined cognitive principles that prioritize cost-efficiency and perceived effectiveness, while placing relatively less emphasis on customer preferences (Toppinen et al., 2019). Therefore, successful cross-sector collaboration implementation in the wood-concrete hybrid construction necessitates significant alterations in business processes and the exchange of vital resources such as information, knowledge, and leadership. The modifications may entail a reorientation in organizational priorities and managerial responsibilities, or the dissemination of confidential data such as technical specifications and expertise (Zander et al., 2016).

5.2.2. Low carbon construction policy

The utilization of wood in construction is subject to significant reliance on the regulatory framework (Hurmekoski et al., 2015). Until the late 1980s, the majority of European countries enforced building codes that prohibited the erection of wooden-framed edifices exceeding two stories in height. The underlying cause of this phenomenon can be attributed to unfavourable perceptions that have arisen as a consequence of past urban conflagrations. The implementation of the Construction Products Directive within the European Union during 1988 has resulted in the modification of domestic construction regulations (Hurmekoski et al., 2015). The modifications, which were intended to meet functional standards, have led to an increase in allowances for wooden frame construction across Europe.

The increasing inclination towards wood-based construction nowadays is predominantly propelled by environmental regulations, primarily associated with the issue of climate change. The National Energy and Climate Strategy for 2030 of Finland outlines its plan to enhance carbon storage by endorsing the utilization of timber in construction (Vihemäki et al., 2019). The Finnish government's bioeconomy and clean solutions initiative has prioritized the formation of the National Wood Building Program (NWBP) since 2016.

The NWBP objective is to promote the utilization of wood in urban development, including the public domain and infrastructure. In the intersection of climate and construction policies, the Finnish Ministry of Environment has developed a plan to decrease GHG emissions that stem from the construction industry, which encompasses the manufacturing of construction materials (Vihemäki et al., 2019). The aim of the current policy process related to low carbon construction is to comprehensively integrate the carbon footprint into building regulations by 2025.

Nevertheless, there are other detractors from wood such as concern over deforestation and illegal logging. This is aligned with perception studies of wood construction barriers (Larasatie et al., 2018). The signal confusion about the terminology of deforestation and illegal logging may need an education about sustainable forest management and clarification of forest harvest practices. It is claimed that when executed using suitable practices, the act of cutting trees results in a forest that is more robust, as it enhances the habitat, diminishes the likelihood of fire, and/or augments the variety of tree species through regeneration (Brang et al., 2014).

In the context of wood as a preferred material for construction, the management of its supply chain is geared towards promoting sustainability by regulating the material's initial stages of the life cycle, which include sourcing, extraction, processing, and transportation (Krueger et al., 2019). For ensuring wood is sourced from sustainably managed forests, many certification bodies have been established. Forest Stewardship Council (FSC), for example, is established with the objective of advancing the ecologically sound, socially advantageous, and economically feasible management of the global forest resources (FSC, 2023). Certified wood has been increasingly preferred by end-user consumers, who are even willing to pay a premium price (Larasatie 2018a; 2023). In addition, wood as construction materials can be made using waste and/or low-grade lumber (e.g., Jahedi et al., 2022).

VI. Future pathways

To successfully implement sustainability efforts, the construction sector must make learning a top priority (Silvestre et al., 2020). Learning about the supply chain demands its participants make a conscious effort to study and implement knowledge about sustainability into their day-to-day company operations. Nevertheless, as path dependence (i.e., resistance and tensions) is found to play a particular role in the results of sustainability initiatives within the supply chain (Silvestre et al., 2020), learning efforts in the wood and concrete sectors can be further investigated.

There is also a big question of the real sustainability value of wood in buildings. The pre-eminent tool for estimating its environmental effects, life cycle analysis, is criticized as a subject to assumptions and, at times, researcher bias (Reap et al., 2008). The variability of findings is exemplified by the impact of wood substitution, which has been observed to decrease overall emissions in the forest sector. However, it has also been determined that this practice cannot fully compensate for the negative effects of frequent tree harvesting (Law et al., 2018). Those narratives, both in the construction industry competition (e.g., wood and concrete) and within forest sector itself (e.g., climate change and logging) deserve deep investigation.

Regarding our recommendation of pursuing cross-sector collaboration, potential avenues for future research may involve exploring methods for knowledge sharing and collaborative innovation within the realm of construction. The study may involve the identification and description of case examples pertaining to cross-sector collaboration between wood and concrete companies. This can include but not limited to water control and moisture performance of mass timber construction. These challenges have been perceived as one of its biggest adoption barriers (Conroy et al., 2018; Schwarzmann et al., 2018) and, therefore, one of its highest research priorities (Espinoza et al., 2016). Additionally, such endeavours may delve into initiatives aimed at creating and developing wood-concrete hybrid systems for utilization in addressing social needs such as housing projects.

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