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Insights from Finnish Experts on the Construction Practices and Future Prospects of Cross-Laminated Timber (CLT)

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Abstract: Given that CLT is a relatively recent innovation, there is a notable scarcity of market research in Finland. Presently, there is a limited body of literature that provides a thorough comprehension of the present state, varied applications, and anticipated future developments concerning the use of CLT within the Finnish construction sector. The limited availability of research data underscores the need for more extensive studies to fill this knowledge gap and provide a more nuanced insight into the evolving landscape of CLT adoption within the Finnish construction industry. This article aims to fill this gap through semi-structured, in-depth interviews with 15 Finnish experts. Key findings highlighted that (1) the hierarchical order of familiarity with CLT among construction professionals in Finland, ranging from highest to lowest, was identified as follows: architects, engineers, developers, builders, and contractors; (2) a pronounced necessity exists for heightened expertise and training within the realm of CLT; (3) CLT was considered a promising option in endeavors aimed at mitigating the impacts of climate crises; (4) CLT showcased adaptability to environments marked by highly fluctuating climatic conditions, emphasizing the importance of a comprehensive approach, including proactive maintenance strategies; (5) Finland adopted commendable and forward-looking sustainable practices in forest management; (6) the adaptability of CLT across a wide range of building categories; (7) the perceived vulnerabilities in CLT construction primarily included a lack of cost-competitiveness, insufficient sound insulation, and inadequate production volume; and (8) key future market prospects encompassed the versatility of CLT, increasing demand propelled by environmental considerations, and collaborative advancements in hybrid construction techniques. This article will contribute to the greater usage of CLT in the building industry in Finland by revealing the challenges, potential, and future outlook of CLT use.

Keywords: wood/timber; CLT; construction practice; future prospects; experts; Finland

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1. Introduction

The global construction market contributes substantially to greenhouse gas emissions and is among the biggest consumers of natural sources [1,2]. At present, approximately 40% of carbon dioxide (CO_2) emissions and 35% of overall energy consumption emanate from the construction industry [3,4]. In addition, according to the Paris Agreement, CO_2 emissions worldwide must be lowered by 50% by 2050 (compared to the 1990s) to maintain the average temperature increase below 2 degrees Celsius worldwide [5]. Considering the current annual carbon dioxide emissions worldwide [6,7], a critical step towards realizing such a vision is to reduce the climate impacts caused by the construction sector as much as possible.

Likewise, the significance of the Finnish construction sector extends to its crucial role in addressing climate goals, considering that approximately 30% of CO_2 emissions and around 40% of energy consumption in Finland are attributed to the construction industry [8]. Aligned with the ambitious 2050 targets set by the European Union, the Finnish government's policy aims to achieve carbon neutrality by the year 2035 [9,10]. To actively contribute to these environmental objectives, the contemporary construction sector employs two pivotal strategies: (a) the adoption of 'green' construction materials and (b) the optimization of energy consumption throughout the service life of structures [11,12]. These approaches underscore a proactive commitment within the Finnish construction industry to foster sustainable practices and minimize its environmental footprint in the pursuit of national and international climate targets.

Advances in building technologies are vital to achieving sustainability targets in this industry. At the level of construction materials, this objective can be achieved by adopting solutions that promote either reduced usage of the same material or the incorporation of alternative ecological materials [13–15]. Concrete and steel, which are the most employed building materials today, are carbon-intensive materials [16–18]. As per the International Energy Agency, the production of one ton of steel results in the direct release of approximately 1.4 tons of carbon dioxide into the atmosphere [19]. On a global scale, the annual production of cement surpasses the substantial quantity of 4 billion tons. Remarkably, the environmental impact of this production is significant, as each ton of cement contributes to carbon dioxide emissions. The emissions vary depending on the type of cement, with high-mix cement producing around 250 kg of carbon dioxide per ton, while regular Portland cement emits a notably higher amount, reaching up to 930 kg per ton [20]. On the other hand, it is known that bio-based building materials such as timber (engineered wood products (EWPs)) have many more advantages in terms of environmental benefits compared to their traditional non-renewable alternatives (for example, steel or concrete) [21–23].

EWPs are increasingly used as structural materials owing to their various mechanical advantages, e.g., uniform strength and rigidity, as well as their environmental properties [24]. Moreover, EWPs are becoming progressively more viable, specifically in tall building construction [25,26]. These products are frequently assembled by laminating smaller boards or lamella into larger structural elements, possessing exceptional structural characteristics that enable the construction of intricate timber frameworks [27]. During the fiscal year 2022, the EWP market exhibited robust performance, attaining a valuation in proximity to USD 18.5 million. This promising trajectory is underpinned by a projected compound annual growth rate (CAGR) of approximately 9.4%, which is anticipated to persist consistently over the entire forecast duration. As the market continues to evolve, this steady growth pattern is foreseen to lead to a substantial expansion, culminating in an estimated market size of around USD 32 million by the conclusion of the year 2028. [28].

Within the realm of EWPs, cross-laminated timber (CLT) occupies a pivotal position [29]. CLT stands out as a prefabricated and multilayered EWP, crafted by bonding the surfaces of at least three layers of panels together in a 90-degree configuration using adhesive under pressure [30]. Originating in the early 1990s, CLT has evolved into a globally recognized construction material, with its production footprint expanding significantly across the world, particularly within the European Union [31]. Notably, as of 2017, approximately 70% of the global CLT output was concentrated in Europe [32], underlining the region's prominence in this industry. This prevalence of CLT production in Europe has attracted attention from academics and experts in the construction field worldwide, highlighting its significance as a subject of interest and study in both research and practical applications.

Key contemporary trends in CLT technology include:

(i) Expanded acceptance and adoption [33]: CLT is progressively recognized and embraced globally as a feasible substitute for conventional construction materials, including concrete and steel. Architectural and structural designers and construction professionals are integrating CLT into their undertakings at an escalating pace.

(ii) Scientific inquiry and advancement in novelty [34]: continual research and development endeavors are focused on improving manufacturing processes [35], bolstering strength [36], augmenting fire resistance [37], and enhancing the sound insulation [38] capabilities of CLT. Innovations in adhesives [39], coatings, and manufacturing methodologies are being pursued with the objective of advancing the overall performance of CLT across a range of applications.

(iii) Tall timber buildings [40–42]: the application of CLT in the construction of tall timber buildings is experiencing a notable increase, posing a challenge to the conventional dominance of steel and concrete in high-rise construction. This tendency is anticipated to endure as innovative design concepts and construction methodologies continue to evolve.

(iv) Digital technologies [43]: the incorporation of digital technologies, exemplified by Building Information Modeling [44], is streamlining the design and construction of CLT structures. Digital tools play a pivotal role in optimizing material utilization and elevating the efficiency of the construction processes.

(v) Sustainability emphasis: CLT is actively advocated as an environmentally friendly construction material owing to its renewable origin (wood) and its ability to capture carbon. The implementation of sustainable forestry practices [45] and adherence to certifications [46] are pivotal in guaranteeing the ecological advantages of CLT.

(vi) Building regulations and standards [47–50]: the ongoing evolution and revision of building codes and standards pertaining to mass timber construction, including CLT, are in progress. With the increasing prevalence of CLT, regulatory frameworks are adjusting to ensure the security and dependability of structures.

Finland embraced the utilization of CLT in construction, a notable instance being the Haltia Nature Centre in Espoo, which was completed in 2013 [51]. Although Finland initially imported CLT from Austria, the country took significant strides by establishing its own CLT factories, including Crosslam Kuhmo (Kuhmo, Finland) [52] in 2014, Hoisko (Hoisko, Finland) [53] in 2016, and CLT Plant (Kauhajoki, Finland) [54] in 2018 (Figure 1) (detailed in the next section, 'History of CLT construction in Finland'). This strategic move toward domestic production marked a shift towards self-sufficiency and sustainability in the building sector. In a collaborative effort to promote and standardize CLT practices within the nation, these CLT factories came together to form a unified CLT association in 2023. This association is dedicated to advocating for the widespread adoption of CLT and ensuring standardized practices across the Finnish construction landscape.

As detailed below, a substantial amount of research has been conducted on the CLT industry in the world, but there are limited works on this subject in the Finnish context. Among the featured studies on the CLT sector, Ilgın et al.'s research [55] delved into the perspectives of international representatives within the CLT manufacturing sphere, including individuals from countries such as Austria, Italy, Czech Republic, Sweden, Japan, Canada, and Uruguay. Their research comprehensively covered their viewpoints on current practices related to CLT and their insights into the prospective trajectory of CLT within the industry. Key findings included (a) a predominant emphasis on insufficient knowledge and experience among construction professionals; (b) a clear recognition of the necessity for heightened expertise and training in the domain of CLT; and (c) the acknowledgment of CLT as a favorable choice in endeavors aimed at addressing climate change. De Araujo and Christoforo [56] executed a literature review and a sectoral inquiry of its main actors. They found that (1) there are a few CLT manufacturers limited to North America and Europe; (2) these producers do not adequately promote the ecological advantages of CLT and focus only on their local market. Hamalainen et al. [57] explored two contemporary transformation practices in the construction sector: the adoption of CLT and advancements in digital transformation. They found that actors must adopt an inter-organizational view in CLT construction. Liu et al. [58] examined the financial fluctuation effects of CLT in Japan. Their results suggested that activities falling under the category of 'not classified elsewhere', lumber, logs, road freight, and wholesale trade were the top five segments exerting the most significant financial impact on CLT manufacture. Benedetti et al. [59] explored the integration of a production template for the expansion of CLT production, incorporating a comprehensive financial analysis in cases where the product and its attributes are not thoroughly understood. Their results demonstrated the advantages of CLT manufacturing, emphasizing the need for a high degree of integration. Hassler et al. [60] scrutinized the problems confronting the enhancement and market establishment of CLT in the USA. They addressed two critical issues: (1) authorization of certification for hardwoods; (2) manufacturing structurally classified panels. Martinez Villanueva et al. [61] conducted a review of CLT and the effect of the fourth industrial revolution in the construction sector. They found that the Industry 4.0 application in CLT is still in its infancy. Larasatie et al. [62] made an international CLT industry survey with the 2020 updates. They recognized 66 producers of CLT, of which only 12 underwent a structured survey conducted via an interview method. Muszynski et al. [63,64] focused on the CLT industry and underlined the fact that the CLT industry is new in current markets, specifically when timber is used for buildings. Brandner et al. [65] presented a state-of-the-art report on particular subjects related to CLT, especially manufacturing and knowledge, material features, and connectivity. They recommended that a package of globally harmonized standards be established for wood engineering, as this will expand the application areas and reinforce CLT. Vatanen et al. [66] guided an interview-based study in Finland on the future of CLT use. Results showed that CLT has a positive image and has great potential to serve as an ecological alternative for future sustainable construction.

Figure 1. Location of CLT manufacturers in Finland (figure by authors).

Overall, as CLT is still a relatively new product, market research in Finland is scarce [66], and to date, there is no comprehensive understanding in the literature about the status, applications, and projections of Finnish CLT construction. This article aims to fill this gap via specialist interviews considering the following main themes: (1) comprehensive overview; (2) properties of the material; (3) environmental impact; and (4) current market conditions. Our objective is to offer valuable insights, data, and recommendations through our research, with the goal of advancing the comprehension, application, and endorsement of CLT as a leading construction material in Finland. By examining both the strengths and weaknesses of CLT, our aim is to promote its extensive incorporation into construction projects in Finland, fostering a more environmental and effective building sector in the long run.

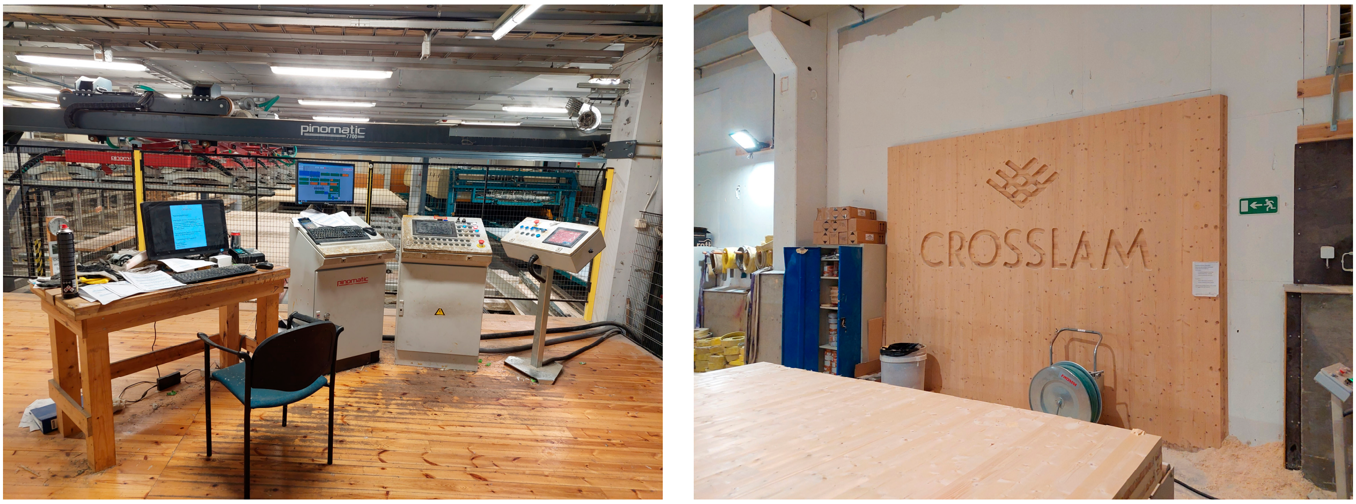
The formulation of our research questions was driven by the overarching goal of acquiring a thorough understanding of the pivotal aspects, potentialities, and impediments that shape the design and application of CLT structures in the Finnish construction landscape. The structured inquiry is designed to address three key dimensions: firstly, an assessment of the existing status of CLT construction in Finland is undertaken to establish a baseline understanding of the prevalence and application of CLT within the country. Secondly, an exploration of the primary driving factors and challenges regarding the adoption of CLT in Finnish timber construction is pursued, aiming to elucidate the catalysts propelling its use as well as the hurdles constraining its broader integration. Lastly, the research endeavors to project the foreseeable future of CLT utilization in the Finnish context, probing into the anticipated trajectory and potential evolution of CLT applications within the nation's construction sector. Through this methodology, our research aims to contribute nuanced comprehensions that inform the strategic development and sustainable advancement of CLT construction practices in Finland.

This study's principal novelty emerges from its precise and all-encompassing investigation into the adoption of CLT within the Finnish construction industry, a subject that has been notably underexplored in the existing academic literature. This research significantly contributes to the field by meticulously addressing a conspicuous knowledge gap, delving into multifaceted dimensions of CLT implementation in Finland. By examining the present state, diverse applications, and prospective developments of CLT, this research transcends surface-level analyses and offers a profound understanding derived from semi-structured, in-depth interviews conducted with 15 distinguished Finnish experts. Through these interviews, the study not only captures the current landscape of CLT usage but also provides a nuanced perspective on the intricate dynamics shaping its integration, thereby elevating the discourse surrounding CLT in the Finnish construction sector to a more sophisticated and informed level. This approach not only expands the academic foundation on CLT within the Finnish context but also lays the groundwork for informed decision-making and strategic planning in the realm of sustainable construction practices.

The subsequent segments of this manuscript are structured as follows: firstly, a historical retrospective of CLT construction in Finland is provided. Subsequently, the materials and methodologies employed in the study are explicated. This is followed by the presentation of outcomes obtained from interviews conducted with experts in the Finnish CLT industry. The subsequent section comprises a broad discussion, delving into the ramifications and subtleties of the findings, encompassing insights into future prospects, recommendations, and limitations inherent in the research. Following the discussion, the manuscript advances to the conclusions section.

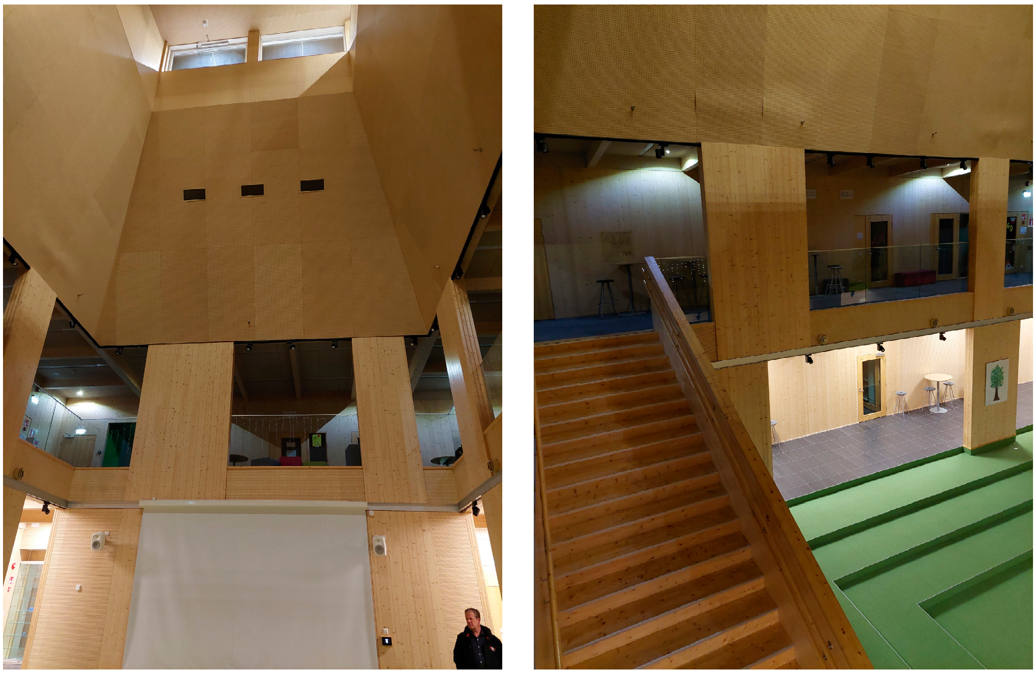
2. History of CLT Construction in Finland

Despite Finland's extensive history of large-scale wood construction, such as the traditional log technique, CLT represents a relatively recent but emerging construction method within the Finnish context. The inaugural Finnish CLT manufacturing facility commenced operations in Kuhmo in 2014, as illustrated in Figure 2. Since its inception, numerous small houses have been erected utilizing CLT. Noteworthy among these constructions is the Tuupala elementary school and daycare center, showcased in Figure 3, boasting a substantial total area of 6165 m^2. This establishment, completed in 2018, holds the distinction of being the first CLT school building in Finland. A distinctive feature of the project is its structural CLT crafted from spruce, a characteristic that extends to the external facade where the CLT panel structure corresponds with a solid spruce veneer [67]. Furthermore, CLT elements were employed in the lower ceiling panels of Helsinki-Vantaa Airport, serving as one of the pioneering and prominent instances of CLT application in Finland [68]. These early examples showcase the nascent yet promising trajectory of CLT as a noteworthy construction methodology in the Finnish architectural landscape.



(**a**) (**b**)

Figure 2. Crosslam Kuhmo: (**a**) production control area; (**b**) an interior view (photo by authors).



(**a**) (**b**)

Figure 3. Tuupala elementary school: (**a**) atrium view; (**b**) inner staircase view (photo by authors).

In contemporary construction practices within Finland, CLT has ascended to the status of the preferred material for multi-story and tall buildings. This trend mirrors the utilization of CLT observed in the 8-story high TOAS-Kauppi (Figure 4) and the 14-story high Lighthouse Joensuu (Figure 5), highlighting a broader shift in the construction industry towards embracing CLT as a key component in the construction of high-rise structures. The preference for CLT in these buildings can be attributed to its inherent qualities, including structural strength, environmental sustainability, and efficiency in construction processes. This signifies a noteworthy transformation in architectural and construction paradigms, underlining CLT's role as a leading material in the built environment, particularly evident in the architectural landscape of Finland.

(**a**) (**b**) (**c**)

Figure 4. TOAS—Kauppi: (**a**) exterior view (photo by authors); (**b**,**c**) interior views (Photos courtesy of Suomen metsäkeskus).

Figure 5. Lighthouse Joensuu (photo by authors).

Overall, in Finland, the integration of CLT into discussions within the construction industry gained considerable prominence with the decision to embark on the construction of the Haltia Nature Centre in Espoo. Notably, the facility was meticulously designed, with CLT serving as its primary structural material. The project, initiated in 2012, reached completion in May 2013, marking a significant milestone. However, a noteworthy development unfolded in the media and governmental sectors, revealing a somewhat incongruous situation. Despite Finland actively endorsing large-scale timber construction, CLT elements for a substantial public project were imported from Austria, raising sustainability concerns. This situation prompted a strategic response, leading to the establishment of Finland's inaugural CLT manufacturing facility in Kuhmo in December 2014 under the name CrossLam Kuhmo Oy (Kuhmo, Finland). Subsequent expansions included the establishment of additional facilities in Alajärvi (CLT Finland Oy, Hoisko, Finland) in 2016 and Kauhajoki (CLT Plant Oy, Kauhajoki, Finland) in 2018, as depicted in Figure 6 and Table 1. These facilities, equipped with advanced capabilities, currently have the capacity to meet the country's demand by producing CE-marked standardized CLT. The collaborative efforts of these competitive factories culminated in a significant development in 2023 with the formation of a unified CLT association in Finland. This association serves as a collective platform for advocating and standardizing CLT practices within the nation, aligning with the shared objective of advancing the sustainable and widespread use of CLT in Finnish construction projects.

(**a**) (**b**)

Figure 6. CLT plant: (**a**) view from the production line; (**b**) prefabricated building facade module produced (photo by authors).

Table 1. Finnish CLT manufacturers.

Producer	Factories and Operation Started	P = Production C = Capacity	Wood Species	Strength Class	Adhesive	Thickness Max. Width Max. Length	Application
CLT Plant	Kauhajoki 2018	C = 50,000 m^3	spruce pine	C24	Polyurethane Reactive (PUR)	60–360 mm 3.5 m 16 m	(non)load-bearing framework
Crosslam Kuhmo	Kuhmo 2014	P = 13,000 m^3	spruce pine	C24	PUR	60–300 mm 3.2 m 12 m	(non)load-bearing framework
Hoisko	Hoisko 2016	C = 12,000 m^3	spruce pine	C24	PUR	60–400 mm 3.2 m 12 m	wall floor bridges

3. Research Methods

In this research paper, a comprehensive approach was adopted, employing literature surveys and interviews with CLT industry professionals to bolster the study, as indicated in previous works (e.g., [69–71]) and detailed in Table 2. The research methodology involved engaging with Finnish specialists from diverse fields, including manufacturers and architectural companies. These professionals were selected for in-depth interviews with the objective of incorporating a wide array of perspectives. The intention was to cast a broad net, gathering insights from various stakeholders to illuminate the status and prospective trajectories of CLT utilization in Finland. By tapping into the expertise of professionals representing different facets of the industry, this research aimed to provide a comprehensive understanding of the multifaceted aspects of CLT implementation in the Finnish construction landscape.

Table 2. Interviewees by their position/title, organization type and characteristics.

	Interviewee 1	Interviewee 2	Interviewee 3	Interviewee 4	Interviewee 5
Position/title	Project manager	Planning manager	Senior executive	Managing director	Managing director
Organization type	Association providing assistance to the CLT sector	Construction company	Federation of the Finnish Woodworking Industries	Construction company	CLT manufacturer
Characteristics of interviewees	Long-term experience in CLT industry	Long-term experience in CLT design projects	Long-term experience in CLT production and construction	Long-term experience in mass timber projects	Long-term experience in CLT production
	Interviewee 6	**Interviewee 7**	**Interviewee 8**	**Interviewee 9**	**Interviewee 10**
Position/title	Sales director	Consultant	Project development manager	Managing director, Architect	Project manager
Organization type	CLT manufacturer	Timber construction consultancy firm	Construction company	Architectural company	Housing foundation
Characteristics of interviewees	Long-term experience in log house and CLT production	Long-term experience in mass timber construction	Long-term experience in CLT production and construction	Long-term experience in mass timber design and construction	Long-term experience in mass timber construction
	Interviewee 11	**Interviewee 12**	**Interviewee 13**	**Interviewee 14**	**Interviewee 15**
Position/title	Board member, architect	Inspection engineer	Managing director	Construction manager	Chief architect
Organization type	Architectural company	Building control authority	Construction company	Construction company	Housing Finance and Development Centre
Characteristics of interviewees	Long-term experience in mass timber design	Long-term experience in mass timber construction	Long-term experience in mass timber construction	Long-term experience in mass timber construction	Long-term experience in mass timber industry

In-depth interviews were conducted with numerous professionals to collect and consolidate qualitative data about CLT practices in Finland. The method used is a qualitative research approach that involves detailed individual interviews with a small group to discover their understanding of a particular idea, path, or situation [72]. The primary benefit of this method is that it gives much more comprehensive information than other data collection techniques [73]. In-depth interviews also create a relaxed setting for collecting information that is more stimulating to the conversation. Moreover, in this study, semi-structured interviews were administered as the appropriate method. In this way, the procedure allowed for more open interaction between the questioner and the contributor, and thematically set questions formed the core of dialogue [74]. In this method, different viewpoints encourage the growth of new themes beyond those originally studied [75–77]. The creation of the interview varies according to the formation of principal themes.

The formulation of interview questions involved a thorough and systematic approach, incorporating elements from various sources. This included integrating findings from analogous studies, e.g., [56], conducting a comprehensive investigation into the CLT industry, extracting insights from additional research efforts centered on wood construction, seeking valuable input from industry experts, and engaging in extensive discussions with authors who possess a deep understanding of both the present state of the wood construction market and the intricate details of wood-related research. This diverse methodology guaranteed that the interview queries were not solely based on pre-existing literature and empirical data but were also enhanced by the nuanced viewpoints and expertise of significant stakeholders in both the CLT industry and the broader domain of wood-related research. Moreover, the structure of the interview was crafted to foster candid conversations, allowing the gathering of data using predefined queries and corresponding answers. Simultaneously, it encouraged the exploration of novel questions, leveraging the considerable expertise of the participating professionals.

Goal-directed sampling methodology was employed to select specialists for inclusion in the study. The primary criteria guiding this selection process were the specialists' substantial knowledge of the CLT market, direct involvement in CLT-based projects, or close monitoring of the evolution of CLT construction. The experts were specifically chosen from among individuals who are recognized for their expertise and extensive experience in the Finnish CLT construction sector. This deliberate selection approach aimed to capture a comprehensive perspective on how professionals, with notable proficiency and hands-on involvement, perceive the present state of the CLT market.

Between August and November 2023, an extensive outreach initiative was undertaken to engage with over 23 Finnish experts in the field of CLT. The commencement of communication was facilitated via email exchanges or by employing the available contact forms on their individual websites. To guarantee proficient communication and sustained participation, a sequence of up to five reminder emails was sent to each stakeholder. In spite of concerted endeavors to establish communication channels with all manufacturers, it was noted that interactions with 15 specialists occurred. This result highlights the varied responsiveness within the industry, underscoring the importance of persistent communication strategies when pursuing collaboration or information from CLT experts in Finland.

In the qualitative investigation, the thematic evaluation technique was designated as the predominant mode of assessment, as observed in numerous instances [78–80]. This approach involves the systematic grouping, exploration, and systematic categorization of themes within the data. Themes represent discernible patterns inherent in datasets, essential for characterizing an event and intricately linked to specific study issues. These identified themes subsequently serve as categories for further analysis and the development of a comprehensive understanding. The assessment process encompasses the formulation of field interpretations, the scrutiny of transcripts, and the coding of interviews [81–83].

Every concept, theme, and grouping is thoroughly examined within a thematic structure. The identification and structuring of themes in literature surveys are guided by prevailing trends, facilitating seamless model fitting and comparisons among contributors. The identified themes, along with theme-related questions, are comprehensively outlined in Table 3 and the appendix. Additionally, the formulation of interview questions was carefully tailored to align with the expertise of the interviewed professionals, ensuring a focused exploration of matters pertinent to the CLT sector. This meticulous approach serves to enhance the coherence and relevance of the study's thematic analysis, integrating insights from both the literature and the perspectives of industry experts.

Table 3. Main themes, corresponding sections, addressee, and primary objective of the interview questions (Appendix A).

Main Themes		Corresponding Sections	Addressee	Primary Objective
Subjects	**Subcategories**			
Comprehensive overview	Acquaintance with CLT	Section 4.1 Section 4.2 Section 4.8	Finnish professionals with extensive expertise in CLT design/production/construction	Exploring the perspectives of Finnish experts on CLT
	Enhancing understanding of CLT			
	Suitable building types			
Properties of the material	Varying climatic conditions	Section 4.4 Section 4.9 Section 4.11		
	Vulnerabilities or limitations			
	Suitable wood species			
Environmental impact	Climate crisis	Section 4.3 Section 4.5		
	Sustainable forest practices			
Current market conditions	Impact of raw material prices	Section 4.6 Section 4.7 Section 4.10 Section 4.12		
	Impact of the Pandemic			
	Impact of standards			
	Prospects for the future			

As the participants were proficient in the Finnish language, the interviews were carried out in Finnish, recorded in audio, and later transcribed using software. The accuracy of the Finnish-to-English translation underwent scrupulous scrutiny. Comprehensive comparisons were conducted between the translated version and the original to ensure accuracy and consistency. The authors carefully listened to the interviewees' explanations and what they meant in order to avoid conducting a leading interview and any bias. The authors spoke for a much shorter period of time than they actually did when actively listening.

In this study, data analysis was undertaken with a deliberate commitment to maintaining methodological rigor. This research employed a controlled number of interviewers to ensure a standardized approach to data collection. The subsequent analysis of the collected data was conducted through a manual process involving a meticulous examination of interview responses. Notably, the absence of a predetermined numerical coding system emphasized a qualitative approach to data analysis, allowing for an in-depth exploration of the nuanced content present in the responses.

The identification and categorization of emergent themes and patterns within the dataset were integral components of the analytical process. The absence of a predefined coding structure underscored the interpretative nature of the analysis, wherein each response was considered individually and thematically classified based on content. This qualitative approach facilitated a nuanced understanding of the information obtained from the interviews.

The classification of acquired data served as a foundational aspect of the analytical framework, enabling the extraction of meaningful insights from the responses. The deliberate avoidance of a numerical coding system reinforced the commitment to a qualitative paradigm, recognizing the complexity inherent in the data and allowing for a more comprehensive exploration of the multifaceted perspectives provided by the interviewed professionals.

It is imperative to acknowledge that the reliability of the study's results hinges on the robustness of the qualitative analytical approach and the diverse perspectives presented by the professionals. The analysis aimed to present a comprehensive and scientifically informed depiction of future scenarios anchored in empirical information derived from the qualitative examination of professional insights. This methodology underscores the conscientious consideration of subjectivity and the pursuit of a holistic representation of the study's findings.

Upholding ethical standards and ensuring the privacy of interview participants constituted a paramount concern. To fulfill this imperative, rigorous measures were instituted to maintain the confidentiality of their identities. Every possible step was taken to withhold and safeguard any information garnered from the interviews that could potentially reveal the identities of the participants. Our steadfast commitment to strict confidentiality highlights our dedication to upholding moral codes and respecting the privacy rights of the people involved in this research.

4. Results: Interviews

As previously stated, the results derived from the interviews were systematically classified into specific themes with the objective of providing a comprehensive understanding of the status, advancements, and future outlook of the Finnish CLT industry. These recurring themes were identified consistently across diverse contexts within the interviews, irrespective of the specific questions posed or the individuals interviewed. The findings from the interviews were methodically arranged into distinct categories, delineated as (1) comprehensive overview; (2) properties of the material; (3) environmental impact; and (4) current market conditions, as outlined in Tables 2 and 3.

4.1. The Level of Acquaintance among Professionals in the Construction Industry with CLT

The collective viewpoint among experts within the architectural sphere emphasizes a prevailing consensus that, at a visual level, there is a commendable level of familiarity with CLT. Architects and designers, captivated by the distinctive layered appearance of CLT, frequently recognize it as a visually appealing choice for contemporary structures. However, this apparent familiarity belies a discernible gap in understanding when it comes to comprehending the complete benefits of CLT properties and its nuanced applications. While the visual allure of CLT is readily acknowledged, there exists a need for a deeper exploration and dissemination of knowledge regarding its structural attributes, environmental advantages, and versatile applications. This nuanced understanding is crucial to fully unlock the potential of CLT as a sustainable and innovative building material, urging architects to go beyond its aesthetic appeal and embrace its multifaceted benefits in the pursuit of creating resilient, eco-friendly, and structurally sound architectural designs.

It was also underlined by the experts that traditionally, construction practices within medium and large Finnish companies have steadfastly adhered to the prevalent use of concrete, relegating timber construction to the realm of experimentation. Even though various stakeholders within these companies possess a reasonable understanding within their respective niches, there persists a conspicuous dearth in comprehending the holistic advantages and optimal exploitation of CLT within the Finnish construction industry. The conventional reliance on concrete reflects a deeply ingrained approach that has, to a certain extent, hindered the widespread adoption of timber construction methods. This reluctance to fully embrace CLT, despite its well-established benefits such as sustainability, speed of construction, and design flexibility, highlights a need for a paradigm shift within the building sector. Bridging the gap in knowledge and dispelling misconceptions about CLT is essential to encourage its broader acceptance and integration into mainstream construction practices, paving the way for a more sustainable and innovative construction landscape in Finland.

Interviewed professionals stated that the landscape of construction oversight in various Finnish municipalities and cities is presently undergoing a transformative shift, characterized by a departure from conventional norms as building inspection authorities grapple with the novel concept of timber construction extending beyond its familiar terrain in row houses and single-family homes. Over the last three years, a notable upswing in awareness has been observed, with even prominent construction entities displaying a heightened interest in this versatile material. This shift in perspective reflects a growing recognition of the multifaceted benefits offered by timber construction, including its sustainability, environmental friendliness, and versatility in design. The evolving interest from building inspection authorities and prominent construction entities signifies a potential turning point in the wider acceptance and integration of timber construction practices within diverse urban contexts. As these entities explore and embrace the possibilities presented by timber construction, it heralds a promising era for innovative and sustainable building practices in Finland.

In a broader context, it was imperative to acknowledge that the prevalence of certain terms, such as CLT and timber itself, extends far beyond mere linguistic familiarity within professional spheres associated with construction and architecture. These terms represent not just the linguistic fabric of the industry but are integral components shaping the very framework of contemporary structural practices. However, amidst the apparent ubiquity and commonplace usage of these nomenclatures, a complex and intricate web of misunderstandings and misconceptions has insidiously taken root, subtly infiltrating the foundations of the industry's collective understanding. Beyond the superficial recognition of these terms lies a need for a deeper and more nuanced comprehension of their applications, benefits, and implications. This multifaceted lexicon forms the basis for communication and decision-making in the construction realm, and thus, addressing and dispelling misconceptions surrounding these terms is pivotal for fostering a more informed and progressive construction industry.

4.2. Enhancing Awareness and Understanding of CLT among Both Construction Professionals and the General Public

A consensus among Finnish experts underscored the critical imperative to heighten awareness within both the professional spheres of the construction industry and the discerning clientele or residents who avail themselves of these services. Recognizing the commendable qualities and advanced features of CLT as a building material, there is a collective recommendation to actively promote and advocate for its widespread adoption. The emphasis extends beyond merely acknowledging its inherent excellence; it pivots towards fostering a comprehensive understanding and appreciation for CLT among key stakeholders involved in the construction process, including architectural and structural designers and builders, as well as those investing in or inhabiting the constructed spaces. This proactive and educational approach towards promoting CLT not only serves to highlight its value as a superior and sophisticated building product but also aims to create a transformative shift in the construction paradigm, where sustainability, innovation, and environmental consciousness become integral considerations in decision-making processes across the construction ecosystem.

Moreover, it was highlighted that clients within the public sector necessitate more tangible support materials and comprehensive information to make informed decisions. Addressing the unique needs of public sector clients involves providing practical resources and detailed information that can aid in their decision-making processes and enhance their understanding of the benefits and applications of CLT. This targeted support aims to empower public sector customers with the knowledge and tools necessary to make judicious choices regarding the incorporation of CLT in construction projects.

Interviewed specialists also reported that noteworthy school projects and initiatives, such as those undertaken in Helsinki, emerge as effective channels for communicating this subject matter to consumers. These high-profile endeavors not only showcase the practical application of CLT but also serve as influential examples that effectively convey the advantages and merits of incorporating CLT in construction projects. By tailoring support materials to address the specific requirements of public sector clients and leveraging impactful projects as illustrative showcases, the industry can actively contribute to the broader dissemination and acceptance of CLT as a preferred and sustainable construction material in the public domain.

4.3. Utilizing CLT as a Construction Material in the Effort to Mitigate and Address the Challenges Posed by Climate Change

Throughout the course of interviews, experts from Finland emphasized CLT as an exemplary building material, particularly in the context of addressing the challenges posed by climate change. Their emphasis was keenly directed towards highlighting the inherent attributes of CLT that position it as a sustainable and environmentally responsible choice. These attributes encompass commendable sustainability features, reliance on renewable sourcing methods, and a unique capacity for efficient natural storage of CO_2. In essence, these experts passionately advocate for CLT as a pivotal player in the realm of sustainable construction practices. They accentuated its positive environmental impact, emphasizing how CLT's utilization aligns with broader initiatives aimed at mitigating the effects of climate change. By championing CLT as a key component of sustainable building solutions, these experts contribute to a paradigm shift in the construction industry, advocating for materials that not only meet structural demands but also align with the imperative of environmental stewardship in the face of a changing climate.

It has been duly observed that the optimization of material efficiency stands as a critical imperative, particularly in alignment with the prevailing production conditions, given that the construction mass in Finland is deemed inadequate for ensuring economically viable CLT production. A key facet of this optimization strategy involves the judicious utilization of waste CLT by-products, emphasizing the need for production facilities to pivot towards a low-carbon operational framework. This comprehensive strategy encompasses various considerations, ranging from the integration of sustainable energy sources such as solar power to evaluating the commuting distances of employees to reduce carbon footprints.

Moreover, the cleanliness of the energy source and structural optimization techniques, especially in the construction of CLT walls, assumed paramount importance within this strategic paradigm. By prioritizing material efficiency and embracing a low-carbon operational approach, the CLT production industry in Finland can not only overcome challenges associated with limited construction mass but also contribute significantly to environmentally responsible and sustainable manufacturing practices.

Several experts have highlighted that CLT significantly increases the proportion of wood material within a building when compared to structures based on traditional frameworks. This shift aligns with the commitment demonstrated by municipalities to enhance the use of timber in buildings, especially through the implementation of zoning regulations that align with their climate objectives. This strategic approach proves particularly effective in rapidly growing urban areas where municipalities can dictate conditions for land allocation, fostering sustainable and environmentally conscious urban development.

Furthermore, from the perspective of a circular economy, it was assessed that CLT emerges as a commendable solution. Its unique composition and construction allow for the efficient recycling of building elements, contingent upon the incorporation of circular economy principles during the initial planning stage of the construction project. This not only promotes resource efficiency but also aligns with broader sustainability goals, making CLT an attractive choice for environmentally conscious and forward-thinking urban planning.

4.4. Applicability of CLT in Settings Characterized by Highly Fluctuating Climatic Conditions

A consensus among Finnish experts underscored that CLT possesses outstanding suitability for environments marked by substantial temperature fluctuations, varying humidity levels, and irregular weather patterns. This adaptability has been identified as a pivotal attribute, positioning CLT as an exemplary choice for building structures that not only endure but also flourish in the face of diverse environmental conditions. The resilience of CLT to the challenges posed by fluctuating temperatures and humidity variations aligns seamlessly with the demands of dynamic climates, demonstrating its capability to provide structural stability and performance in regions characterized by a wide range of meteorological conditions. The acknowledgment of CLT's exceptional adaptability by experts affirms its standing as a reliable building material that caters to the intricate demands of varied environmental contexts, reflecting a robust solution for sustainable and climate-resilient building practices.

Moreover, it was stressed that a nuanced grasp of the intrinsic aging trajectory of wood is pivotal, given its propensity to undergo transformative changes and potentially deviate from its original visual qualities over time. Despite wood showcasing remarkable resilience in the face of severe weather conditions, a heightened focus on maintenance and strategic structural interventions becomes imperative under challenging circumstances. This involves the implementation of key measures such as incorporating eaves for added protection, opting for light colors to mitigate the impact of environmental factors, and optimizing ventilation systems to counteract potential issues.

Additionally, the observation that wood exhibits notable resistance to seismic loads reinforces its standing as a robust construction material, particularly in regions prone to seismic activity. This combination of factors underscores the adaptability and durability of wood, emphasizing the importance of a holistic approach that integrates a thorough understanding of its aging process, proactive maintenance strategies, and structural enhancements to ensure longevity in diverse environmental conditions.

Numerous experts placed significant emphasis on the crucial consideration of moisture control and weather exposure in the structural design phase. A fundamental element of this approach involves the incorporation of proper ventilation systems to effectively facilitate the efficient transfer of moisture away from various building components. This imperative, however, is not limited to the design stage alone but extends to the construction phase.

It was also emphasized that modules or structural elements fabricated in controlled, dry factory conditions should be meticulously shielded from any exposure to moisture during transportation and installation processes. The construction activities themselves necessitate a meticulous orchestration, taking place within conditions that provide protection against the unpredictable elements of weather. This comprehensive strategy, beginning from the design conceptualization through to the construction execution, underscores the importance of proactive measures in moisture management and highlights the significance of creating a controlled environment to ensure the structural integrity and longevity of the building.

4.5. Implementing CLT Construction through Sustainable Forest Management Practices

During interviews, a prevailing sentiment among experts highlighted the conscientious management of wood resources within the Finnish sawmill industry, with an overwhelming majority asserting that nearly 100 percent of the wood is responsibly handled. A noteworthy practice contributing to environmental sustainability is observed among all CLT manufacturers in Finland, who exclusively source and utilize domestic wood. This distinctive approach positions these manufacturers as advocates for sustainable forestry practices. By prioritizing locally sourced wood, these CLT producers contribute not only to the resilience of domestic forests but also champion the principles of environmental stewardship, aligning their operations with the broader objectives of sustainable and responsible forestry management in the Finnish context. This concerted effort underscores a commitment to balancing economic interests with ecological responsibility within the realm of timber production and reinforces Finland's position as a leader in promoting sustainable practices in the forestry and construction sectors.

It was also conveyed that the primary impediment lies not within the forest or sawmill industry but rather in the manufacturing standards and their interpretation. Substantially augmenting the utilization of wood could be achieved if general or smaller dimensions from sawmills were permissible in manufacturing. The existing standard stipulates a thickness-to-width ratio of 1:4, wherein a lamella with a thickness of 30 mm must have a width of 120 mm, adhering to the most common and proven ratio for CLT subjected to initial testing. The adoption of alternative widths is restricted without undergoing testing procedures. However, the process of conducting new tests and modifying the standard poses a financial challenge for manufacturers, incurring costs that can amount to tens of thousands of euros.

A subset of experts underscored that, at present, the extent of CLT construction in Finland does not exert any discernible influence on the overarching forest stockpile. The oversight of suppliers' supply chains is notably commendable, and the management of forests in the Finnish context is exemplary when juxtaposed with practices observed in other nations. It is acknowledged that while it remains imperative to avert excessive harvesting of forests for sustainability reasons, the deployment of CLT in construction is not perceived to have a substantial impact on a broad scale. This observation underscores the efficiency and sustainability of current forest management practices in Finland, emphasizing the responsible utilization of timber resources in CLT construction without compromising the overall health and equilibrium of the country's forest ecosystems.

4.6. Impact of Fluctuations in Wood Raw Material Prices on CLT

Among Finnish experts specializing in CLT, it was highlighted that the pricing dynamics of CLT present a persistent challenge, manifesting both in the short and long term. Notably, the origins of this predicament trace back to the initial stages of the raw material supply chain, contributing to the elevated cost of the final CLT product. This pricing issue has cast, and continues to cast, a shadow over the prevalent acceptance and utilization of CLT within various building projects. In the present intricate market milieu, particularly within the residential construction sector, there exists a notable intensification of price competition. However, timber construction, more broadly, encounters a notable disadvantage as the competitive landscape does not exhibit the same propensity to drive down prices for wood, thereby exacerbating the economic challenges associated with CLT adoption in construction practices. Addressing these pricing dynamics in the context of CLT is crucial to fostering its broader integration and realizing its potential benefits within the construction industry.

Additionally, the Finnish experts emphasized that domestic CLT factories face a notable challenge in not possessing sufficient control over the entirety of the value chain. This lack of comprehensive ownership renders these factories exceedingly sensitive to fluctuations in both raw material costs and market conditions. The intricate nature of the CLT production process involves several stages, from raw material extraction to manufacturing, culminating in the delivery of the final product. The dependency on external factors, especially in terms of raw material costs, exposes these factories to vulnerabilities that can impact their economic viability. This heightened sensitivity underscores the importance of developing strategies to mitigate risks associated with fluctuations in both raw material pricing and broader market dynamics in order to enhance the resilience and sustainability of domestic CLT manufacturing enterprises.

Furthermore, the resonance of raw wood material costs was notably pronounced within the buyer community. In the context of construction projects, however, the share of CLT in the overarching construction costs typically ranges between 10 and 20%. Intriguingly, discussions surrounding CLT costs tend to take on a more emotive character, reflecting a nuanced interplay of perceptions and considerations. Simultaneously, it is imperative to recognize the broader context where prices of various other building materials have experienced an upward trajectory. The primary source of frustration within the construction sphere commonly arises from the comprehensive escalation in overall construction costs. This elevation is attributed not only to the surge in material prices, including that of CLT, but also to the increasingly stringent regulatory landscape, thereby amplifying the challenges faced by stakeholders in navigating the intricate economic dynamics of construction projects.

It was also brought to our attention that the inherent variability in prices constitutes a source of uncertainty for customers, thereby imparting a considerable challenge to decision-makers and manufacturers engaged in long-term planning. This fluctuation introduces a layer of complexity, particularly in anticipating and preparing for the future economic landscape. The ambiguity surrounding the costs of raw materials, a concern accentuated in the context of public construction projects, significantly impedes the decision-making process. This uncertainty not only hampers the strategic selection of materials but also poses obstacles to the meticulous planning required for successful project execution. The ripple effects of these challenges extend beyond immediate financial considerations, influencing the overall efficiency and adaptability of decision-making frameworks within the construction industry, emphasizing the need for comprehensive strategies to address and mitigate the impacts of price variability on long-term planning and material selection processes.

4.7. The Repercussions of the COVID-19 Pandemic on CLT Construction

In a detailed evaluation, experts offered a comprehensive analysis of the intricate ramifications of the COVID-19 pandemic on the building industry, yielding discernible implications for CLT construction. Notably, a positive consequence has emerged in the form of escalated utilization of timber resources, including CLT, which can be attributed to an augmented demand for year-round holiday homes fueled by the prevalent adoption of remote work arrangements. This shift in construction dynamics is particularly pronounced among single-family home customers who have undergone a noticeable shift in their preferences. They now accord significant importance to the antibacterial properties inherent in wood, particularly in the post-pandemic landscape. The increased emphasis on timber, driven by the desire for sustainable and health-conscious living spaces, underscores a noteworthy trend in material preferences within the building industry, especially in the context of residential housing responding to the evolving needs of the pandemic-influenced environment.

Nevertheless, this positive trend was juxtaposed by the adverse impact of escalated wood prices, encompassing the domain of CLT. The surge in prices poses a significant challenge, potentially impeding the widespread adoption of timber construction methods, including the utilization of CLT. Furthermore, an additional challenge has emerged with the occurrence of quarantine cases on CLT construction sites. This has led to intermittent halts in construction activities, driven by instances of illness and the inherent risk of infection, thereby disrupting the workflow and posing logistical challenges for project timelines. The pandemic, while exerting a positive influence on construction dynamics through the heightened preference for timber-based materials, has simultaneously introduced formidable challenges related to the economic aspect of pricing and the operational continuity of on-site activities. This multifaceted impact underscores the complexity of the challenges faced by CLT construction and the broader building industry as they navigate the evolving landscape shaped by the repercussions of the COVID-19 pandemic.

4.8. The Suitable Building Types for Construction Using CLT

Finnish experts widely affirmed the versatility of CLT for diverse building types, with its application in modular apartment construction showcasing particularly pronounced advantages. The crux of its efficacy lies in the strategic optimization of CLT's unique properties tailored specifically for these structures. In the realm of multi-story construction, CLT emerges as an outstanding choice, distinguished by its robustness and stiffness, culminating in a construction solution that is not only lightweight but also seamlessly implementable. Significantly, during the design phase, a heightened focus can be directed towards scrutinizing its stiffening characteristics, thereby simultaneously capitalizing on the opportunity to transform the building into a substantial carbon sink. This nuanced approach underscores the potential of CLT not just as a structural material but as an environmentally conscientious choice in contemporary construction practices.

While CLT may not consistently emerge as the most cost-effective choice in industrial construction, its value becomes apparent when crafting specific industrial spaces such as offices and social areas. The consideration arises that tall apartment buildings might not be the most fitting application for CLT due to a combination of factors, including a deficiency in design expertise and the substantial costs associated with intricate technical solutions.

It was crucial to emphasize that, in the broader context, construction projects have the flexibility to explore alternative materials and potentially adopt hybrid structures if the need arises. This nuanced perspective underscores the acknowledgment that while wood, particularly in the form of CLT, holds distinct advantages, it is not universally applicable in every construction scenario, necessitating a thoughtful and context-specific approach in material selection for optimal results.

4.9. Potential Vulnerabilities or Weaknesses in CLT Structures

The experts underscored a myriad of challenges within the realm of CLT construction. Notable among these issues are the scarcity of participants in the industry and concerns related to scalability. The inherent lightweight nature of wood introduced complexities in acoustics, necessitating intricate solutions for effective sound insulation in residential apartment buildings. Furthermore, challenges pertaining to the vibration design of the floor structure were duly acknowledged. The elevated cost of CLT construction was attributed to design solutions, compounded by the perception of CLT as a specialized material.

Moreover, CLT was recognized as resource-intensive, requiring a substantial volume of wood for production. Issues such as limited customer awareness, fluctuations in raw material prices, and restricted availability of raw materials, especially when compared to concrete, were identified as factors contributing to the current weak volume capacity of CLT construction. The industry's prevailing preference for concrete, coupled with inadequate advocacy and a shortage of design expertise, presented additional hurdles. The significance of meticulous planning and comprehensive understanding emerged as pivotal factors. Additionally, there was an acknowledgment that improvements are needed in the interpretation of standards and regulations. It was highlighted that the mechanical wear resistance of wood, in general, falls short of serving as the final flooring material in public buildings, indicating areas for potential refinement in CLT applications.

It was also observed that CLT material has been conspicuously absent from the purview of small-scale residential projects in Finland, which include single-family houses and semi-detached communities. This notable gap in accessibility is attributed to a reluctance among factories to participate in the consumer market. The primary focus of these manufacturing entities appears to be directed solely toward project deliveries, especially within the ambit of producer-driven construction initiatives. Despite this evident predilection, the discourse emphasized a promising prospect within the residential sector. It was highlighted that this domain could potentially serve as a source of sustained demand for CLT factories. This proposition raises the prospect of expanding CLT availability into smaller residential projects, shedding light on a potential avenue for bridging the existing gap in CLT utilization for smaller-scale construction endeavors.

4.10. The Influence of Standards within the Construction Industry on the Dynamics and Trends of the CLT Market

The discourse surrounding prevailing standards within the construction industry in relation to the CLT market was marked by divergent perspectives. While some experts expressed confidence in the limited impact of existing standards on the dynamics and trends observed in the CLT market, an alternative viewpoint underscored significant challenges stemming from non-enforcement and a lack of harmonization.

One notable assertion came from experts highlighting the apparent minimal influence of prevailing standards within the construction industry on the CLT market's dynamics. According to this perspective, the existing standards may not be robust or comprehensive enough to dictate the trajectory of the CLT market. This viewpoint could be grounded in the belief that other factors, such as technological advancements, market demands, or regional considerations, play more pivotal roles in shaping the trends within the CLT industry.

Conversely, another school of thought emphasized the critical importance of adhering to the European harmonized product standard for CE marking in the context of CLT. Scholars and industry observers point out that the non-enforcement of this standard, coupled with a dearth of information regarding its completion, introduces a significant hurdle. The consequence is a lack of comparability among CLT products originating from Central Europe and the Nordic countries, creating a complex and fragmented market landscape.

This lack of harmonization poses multifaceted challenges. Firstly, it introduces intricacies into the planning and tendering stages of building projects that involve CLT. The absence of a standardized framework may lead to confusion, delays, and increased costs as stakeholders navigate varying product specifications and quality benchmarks. Secondly, the absence of a harmonized product standard creates a challenging environment for stakeholders seeking uniformity and coherence in the utilization of CLT across diverse geographical regions.

The incongruities inherent in the Eurocode system further compound these challenges, especially concerning its relationship with national guidelines. This misalignment not only hinders potential exports of CLT products but also discourages investments. The lack of a unified and universally accepted standard raises concerns about the structural integrity, safety, and performance of CLT structures, limiting their acceptance in global markets.

In conclusion, the discourse on prevailing guidelines in the building sector and their impact on the CLT market is complex and nuanced. While some experts downplayed the significance of existing standards, others emphasized the pivotal role of a harmonized product standard for the CE marking. The challenges arising from non-enforcement, coupled with incongruities in the Eurocode system, create a landscape that demands attention and concerted efforts from industry stakeholders, policymakers, and standardization bodies to foster coherence and facilitate the growth of the CLT market on a global scale.

4.11. Suitable Wood Species for the Production of CLT

Finnish experts systematically elucidated that, within the specialized domain of CLT production, certain wood species demonstrate optimal suitability. Their discerning evaluation establishes a hierarchical preference, with spruce and pine being accorded the foremost positions, succeeded by larch and beech. This expert perspective underscores the meticulous consideration afforded to the selection of wood species in the pursuit of manufacturing high-quality CLT. The prioritization of spruce and pine, followed by larch and beech, is indicative of a comprehensive analysis that takes into account critical factors such as structural integrity, mechanical properties, and overall suitability for the intended applications of CLT in the construction and allied industries.

The interviewed specialists' opinions emphasized a nuanced understanding of how different wood species contribute to the desirable attributes of CLT. This includes considerations for the structural robustness required for construction applications, the mechanical properties that influence performance, and the overall suitability to fulfill the intended functions within the diverse spectrum of applications in construction and related industries. The detailed assessment by Finnish experts highlights a commitment to ensuring that the selected wood species align not only with the technical requirements but also with the broader goals of creating high-quality CLT suitable for a variety of construction applications.

Furthermore, the discussion brought attention to the unique attributes of Nordic softwood, characterized by its dense grain and limited presence of knots. This particular wood type was emphasized for its notable strength properties, a quality that is further enhanced by its visually appealing aesthetics. The acknowledgment of these exceptional strength properties serves to underscore the material characteristics that significantly contribute to the structural robustness and overall performance of CLT.

The advantageous features of Nordic softwood, encompassing both its strength and visual appeal, position it as a favorable and strategic choice in the realm of CLT production. This recognition extended beyond mere structural considerations, as the material's aesthetic qualities align with the dual priorities of functionality and visual appeal in diverse construction applications. The emphasis on these material attributes reflects a holistic approach to CLT production, recognizing the interconnected nature of structural integrity and aesthetic considerations in the construction industry.

4.12. Prospects and Obstacles for the CLT Market in the Future

The expertise of professionals stressed the transformative potential of CLT, paving the way for the creation of structures that transcend conventional boundaries. The possibilities for constructing remarkable and imaginative buildings seem boundless, with the primary constraints being the limits of human creativity. The deployment of lightweight yet robust CLT building modules, manufactured in controlled factory conditions, and delivered in a fully finished state, heralds a paradigm shift in construction. This approach elevates the efficiency, precision, productivity, and safety of construction processes to unprecedented levels.

It was also stated that as the demand for CLT continues to surge, propelled by the prevailing wave of digitalization, its production undergoes a corresponding evolution. This evolution opens avenues for enhancing the productivity of industrial prefabrication, positioning the industry to bolster its competitiveness. Environmental considerations stand as a resolute advocate for the adoption of CLT, aligning with the global imperative to embrace sustainable construction practices. Moreover, the establishment of emission limit values for construction in various European countries lends support to the broader adoption of timber construction.

Additionally, some experts underlined that beyond the conventional realms, there exists a unique opportunity for CLT in regions grappling with the aftermath of conflict, exemplified by the massive reconstruction task in war-torn areas such as Ukraine. The sheer scale of reconstruction required in these contexts presents a complex challenge that few fully grasp, providing an avenue for CLT to contribute meaningfully to rebuilding efforts.

Looking forward, the trajectory of CLT appears poised for a substantial upswing in the coming years. This upswing is fueled not only by the inherent properties of CLT but also by an escalating awareness of environmental considerations within the construction industry. Delving deeper into future prospects, the versatility of CLT emerges as a key advantage, allowing for a myriad of applications and architectural innovations. Simultaneously, the market for CLT is anticipated to witness significant growth, further solidifying its position as a transformative force in the construction sector.

In a collaborative spirit, the future holds promise for the joint development of hybrid construction methods, where CLT can seamlessly integrate with other materials and technologies. This collaborative approach signifies a departure from traditional construction paradigms, fostering innovation and pushing the boundaries of what is achievable in the realm of sustainable and resilient structures.

When contemplating the forthcoming challenges within the market landscape, the constrained scale of CLT production in Finland emerged as a notable hurdle, particularly impeding its involvement in large-scale projects. The shortage of suppliers equipped to meet demanding project timelines and assume accountability remains a critical bottleneck. While the historic reluctance of clients and contractors to embrace wood projects has been a significant factor, the current predicament revolves around the incapacity of factory production to fulfill orders within the stipulated timeframes. This underscores a pressing challenge in meeting the demands of a burgeoning market.

Skepticism and unwarranted juxtaposition of materials add a layer of complexity to these challenges. The need for widespread understanding and acceptance of CLT as a viable and robust construction material becomes paramount in addressing these misconceptions. This challenge extends beyond the immediate logistical and operational concerns, encompassing a broader realm of perception and awareness.

Forest pest damage in Central Europe introduces an additional layer of complexity, creating a competitive environment for raw materials and driving up costs. The dynamic nature of these challenges necessitates a comprehensive approach that considers not only the economic ramifications but also the ecological implications. Managing this delicate balance requires innovative strategies and collaboration across the industry.

Pricing remains a focal point in the list of challenges, although it intertwines with the broader themes of economic viability, skill development, and ongoing product innovation.

The evolving nature of the CLT construction industry demands a proactive stance in addressing these concerns to foster sustained growth and market resilience.

The experts also stated that a unique challenge lies in bridging the gap in understanding outside of Finland regarding the sustainable forestry practices employed in Finnish forests. While these forests are meticulously managed with sustainable harvesting methods, the lack of awareness on an international scale poses a challenge in positioning Finnish timber as an environmentally conscious and responsible choice. This underscores the importance of communication and advocacy in global markets.

On a more introspective note, the need for a transformative shift in the construction culture within Finland becomes apparent, urging a move towards practices that are not only sustainable from an ecological standpoint but also align with evolving environmental criteria. The question of whether current construction practices involve the use of non-renewable materials that could impact future generations adds a dimension of ethical consideration to the challenges at hand.

Looking ahead, potential future challenges include navigating the increasing utilization of domestic raw materials versus imports, developing and promoting cost-effectiveness amidst economic uncertainties and rising interest rates, addressing unnecessary competition between different industries, such as concrete and wood, and streamlining regulations. Furthermore, a pronounced deficit in design expertise emerges as a challenge that necessitates strategic interventions for the industry's sustained growth and innovation. Addressing these challenges collectively will be pivotal in steering the CLT industry towards a resilient and sustainable future.

5. Discussion

Given the relatively recent introduction of CLT as a building material, there is a notable scarcity of market research in Finland, as documented in the literature. To date, a broad understanding of the status, applications, and future projections of CLT construction in Finland is absent from the scholarly discourse. This article aims to fill this gap by performing specialist interviews that focus on key themes, including (1) a comprehensive overview; (2) properties of the material; (3) environmental impact; and (4) current market conditions. Our objective is to fill this knowledge void and contribute to the widespread adoption of CLT in the Finnish construction industry.

Our research endeavors were directed toward offering constructive insights, data, and recommendations to improve the comprehension, application, and adoption of CLT as a principal construction material in Finland. Our goal was to advance the comprehension of CLT's strengths and weaknesses, ultimately promoting its widespread integration into construction projects in Finland. By doing so, we aspire to contribute to the advancement of a more environmentally friendly and efficient building industry in the long run.

The interviewed professionals' views were consistent, supportive, and complementary. Key points pertaining to the current status, implementations, and future projections of CLT usage in the Finnish construction market include:

(1) Finnish architects are quite familiar with CLT but often lack application knowledge. While a portion of engineers are acquainted with its use, only a limited number are familiar with the product. Developers, builders, and contractors require additional information regarding the potential and constraints of this material.
(2) The crucial requirement is to increase awareness among both professionals in the construction industry and the discerning clients or residents who utilize their services.
(3) Interviewed Finnish experts reached a consensus, establishing a mutual agreement that confirms CLT stands out as an optimal construction material in the collective endeavor to address and mitigate the impacts of climate change.
(4) It was reported that CLT demonstrates its ability to adjust to environments marked by substantial variability in climatic conditions, highlighting the significance of a comprehensive strategy that incorporates a thorough comprehension of its aging

process, proactive maintenance strategies, and structural enhancements to ensure longevity in diverse environmental conditions.

(5) Experts noted that Finland implemented laudable and forward-thinking sustainable practices in the management of forests, specifically adapted for CLT construction, underlying that the extent of CLT construction in Finland did not have a noticeable impact on the overall forest stock.
(6) It was emphasized that the pricing dynamics of CLT constitute an enduring challenge, manifesting both in the immediate and prolonged periods. Significantly, the roots of this challenge can be traced back to the initial phases of the raw material supply chain, thereby contributing to the heightened cost associated with the final CLT product.
(7) Professionals communicated that the repercussions of the COVID-19 pandemic on the building sector, including projects involving CLT, have manifested in a multifaceted manner. This includes both positive aspects, such as a rise in the utilization of CLT, and negative dimensions, exemplified by an increase in prices for mass timber products.
(8) The interviewed experts from Finland strongly asserted the adaptability of CLT across diverse building categories, highlighting its notable benefits when employed in residential construction.
(9) Perceived vulnerabilities in CLT construction were mainly identified as the absence of cost competitiveness, inadequate sound insulation capacity, deficiency in design expertise and awareness, and insufficient production volume.
(10) Concerning CLT standards within the market, reported problems include the lack of alignment between the Eurocode system and national guidelines, the absence of a consistent product standard, and the non-enforcement of the European harmonized product standard for CE marking.
(11) In accordance with the expertise of Finnish professionals, the preeminent wood species identified for the production of CLT are spruce and pine, with subsequent preference given to larch and beech.
(12) Primary future market prospects include the versatility of CLT, escalating demand driven by environmental considerations, and collaborative advancements in hybrid construction techniques. Conversely, critical future market challenges entail the limited scale of CLT production in Finland, necessitating a transformation in the construction culture towards greater sustainability and the necessity to improve cost efficiency.

The outcomes of this study aligned closely with and substantiated various findings documented in other research works, as exemplified by (e.g., [66]). This alignment with existing research underscores the consistency and reliability of the identified patterns or phenomena across multiple studies in the academic domain.

The results of our interviews brought to light a noteworthy trend among Finnish architects, revealing a nuanced relationship between their awareness of CLT and their practical application knowledge. While there is a discernible level of consciousness regarding CLT, our findings indicated a significant shortfall in practical application expertise. This parallel observation aligned with the conclusions drawn by Ilgın et al. [84]. Their study illuminated a prevailing theme of architects feeling familiar with concrete construction but demonstrated a notable deficit in proficiency when it comes to wood construction. This deficiency, as highlighted by [84], poses substantial challenges to the seamless integration of timber in residential building specifications.

Interestingly, our research echoed similar sentiments expressed in other studies, such as the work of Viluma and Bratuskins [85], thereby underscoring a broader industry-wide trend. The recurrent theme of perceived familiarity with one construction material, in this case, concrete, versus a marked lack of expertise in another, namely wood, emphasizes a systemic issue within the architectural community.

Furthermore, our study strengthened and corroborated these insights by emphasizing the persistence of knowledge gaps and insufficient expertise, specifically in wood construction. This observation closely aligned with the findings of Roos et al. [86], further underlining the existence of a consistent and widespread challenge within the architectural profession.

Our research also brought to light a clear and pressing need among developers, builders, and contractors for augmented information pertaining to the potential advantages and constraints associated with the material under consideration. This observed inclination aligned with the insights presented by [84], which emphasized that a significant hurdle to the widespread adoption of wood lies in the lack of demand from both clients and building contractors. This sentiment was further supported by Xia et al. [87], who underscored the dearth of interest from developers, highlighting a crucial gap in knowledge dissemination and awareness within the construction industry.

It is noteworthy to draw parallels with the findings of Xia et al., who suggested that architects participating in their survey may not perceive their influence on frame material selection as decisively impactful compared to the pivotal roles played by building contractors or clients. This perception mirrored findings from the realm of Swedish architecture, as evidenced by studies involving Swedish architects [88]. The implication here was that architects may not wield as much influence in material selection decisions, with other stakeholders, such as building contractors and clients, playing more decisive roles.

However, it is crucial to recognize regional variations in this dynamic. Contrasting with the Swedish context, North American research posited a different scenario, indicating that the process of material selection is a collaborative endeavor involving multiple disciplines. In this context, architects were depicted as predominantly steering the decision-making process [89]. This regional disparity underscored the importance of considering diverse perspectives and industry dynamics when addressing challenges related to material adoption and decision-making processes.

The current imperative demands a comprehensive elevation of awareness that transcends the boundaries of professional circles within the construction industry, extending its reach to encompass discerning clients and residents engaging in the services of these professionals. In response to the critical challenges faced by Finnish architects, the study conducted by [84] advocates a nuanced and multifaceted approach aimed at overcoming the barriers hindering the widespread adoption of wood in construction projects.

Firstly, the study recommends a strategic intervention targeting architects, who play a pivotal role in shaping the built environment. This involves providing architects with substantial support and industry-centric training. Workshops and seminars specifically tailored to address the nuances of the evolving technological landscape related to wood structures within the building sector are proposed. The primary objective is to augment architects' awareness and understanding, empowering them to navigate the complexities of incorporating wood into their designs. This approach is designed not only to enhance technical knowledge but also to mitigate perceived difficulties in meeting legislative code requirements. By doing so, the strategy aims to foster a more informed and adept architectural community that is proficient in leveraging the benefits of wood construction in their projects.

Secondly, the study emphasizes the need for a concerted effort to shift the perspectives of clients and contractors, identified as the ultimate decision-makers in construction projects. This transformative change can be facilitated through initiatives led by professional bodies. By intensifying awareness campaigns, these initiatives aim to elucidate the myriad advantages associated with timber construction. Educating clients and contractors about the environmental, economic, and aesthetic benefits of wood as a structural material can influence decision-making processes, making them more receptive to incorporating wood into their projects.

Lastly, the study advocates for governmental intervention as a crucial pillar of the multifaceted strategy. This involves the issuance of more supportive legislation and regulations, creating an environment conducive to the increased utilization of wood as a structural material, especially in the domain of multi-story construction. Governmental support in the form of regulatory frameworks that incentivize sustainable practices and streamline approval processes can act as a catalyst for change. By providing a conducive regulatory environment, this facet of the strategy aims to eliminate bureaucratic hurdles and encourage architects, clients, and contractors to embrace wood-based construction methodologies more readily.

The unanimous consensus among Finnish experts underscored the pivotal role played by CLT in tackling the urgent challenge of climate change. This collective agreement transcends local considerations and finds resonance in more expansive discussions, as evidenced by the study conducted by Vatanen et al. [66]. In their analysis of a cohort of 18 specialists in Finnish CLT, the study accentuated the environmentally conscious characteristics of CLT, positioning it as a preferred and sustainable option within contemporary construction methodologies. The positive perception of CLT as an eco-friendly substitute, as emphasized by Finnish experts, aligned with a broader trend indicating the growing recognition of CLT as a material inherently possessing sustainable attributes.

Furthermore, the work of Duan [90] reinforced this perspective by highlighting the practicality of utilizing CLT buildings as an effective strategy to address the climate crisis in China. This assertion suggests that the integration of CLT constructions holds tangible value and represents a concrete pathway to positively influence ecological sustainability within the Chinese building sector. These findings not only substantiated but also extended the conclusions documented in comparable inquiries specifically addressing the ecological attributes of wood construction, as exemplified by the research conducted by [91,92].

The interconnectedness of these studies formed a robust body of evidence supporting the contention that CLT, as a construction material, is not only environmentally conscious but also practical in mitigating the impact of climate change. This consensus among Finnish and Chinese experts reflected a global recognition of the intrinsic sustainability of CLT, positioning it as a key player in the pursuit of eco-friendly and climate-resilient construction practices. As the discourse surrounding CLT continues to gain momentum, these scientific insights contribute to a growing understanding of how innovative materials can drive positive change in the face of the complex challenges posed by climate change.

The results derived from our interviews stressed the remarkable adaptability of CLT in environments characterized by highly variable climatic conditions. This underscores the necessity for a comprehensive strategy that encompasses a nuanced understanding of the material's aging processes, proactive maintenance measures, and structural enhancements. The overarching goal of such a strategy was to ensure the prolonged durability of CLT structures in diverse environmental contexts. The intricate interplay between CLT and varying climatic conditions necessitates a proactive and informed approach to address potential challenges and optimize the material's performance over time.

Our findings aligned with those of Liu et al. [93], whose study focused on assessing CLT as a viable material for mid-rise apartments in cold areas of China. Their research not only corroborates but also extends our observations, emphasizing the potential of CLT even in cold climates. The key caveat highlighted by [93] was the importance of meticulous detailing to minimize environmental impact. This underscores the critical role of design and construction practices in maximizing the benefits of CLT in challenging climatic conditions. The collaborative insights from both studies highlight the versatility and applicability of CLT, showcasing its viability as a sustainable construction material across different climatic settings when coupled with thoughtful design and implementation strategies.

To fully harness the potential of CLT in variable climatic conditions, it is imperative to delve into the intricacies of its aging processes. This involves a thorough understanding of how CLT responds to environmental factors over time and how proactive maintenance measures can be implemented to counteract potential challenges. Structural enhancements, guided by this understanding, can further optimize CLT's performance and contribute to its sustained durability. By adopting a holistic approach that integrates knowledge of material science, climatology, and architectural engineering, practitioners can unlock the full potential of CLT in diverse environmental contexts.

The dynamics of urbanization and population concentration underwent discernible changes, marked by a notable shift in focus towards residential properties and living conditions. This trend was accentuated by the COVID-19 pandemic, a global phenomenon that has left a lasting impact on various aspects of societal behavior [94]. The pandemic, characterized by the closure and regulation of national borders, has prompted a significant pivot towards domestic travel and tourism. Particularly noteworthy is the increased prominence of second homes in various countries, including Scandinavia, Southern Europe, Australia, and New Zealand. A substantial portion of the population in these regions has sought refuge in second homes, often situated in rural areas [95].

These shifts in lifestyle and evolving demands notably fueled a rise in the construction of wooden cottages in Finland, a trend that reflects a broader global reconsideration of living spaces in the wake of the pandemic. This surge in the construction of wooden cottages was further substantiated by the findings of Häkkänen et al. [96], which resonate with our own observations. The study indicated a positive repercussion of the COVID-19 pandemic on construction practices, particularly a notable upswing in the utilization of CLT. This increased reliance on CLT aligned with the material's versatility, sustainability, and other favorable attributes, making it an appealing choice for constructing residential properties in response to the changing demands brought about by the pandemic.

The pandemic evidently influenced housing preferences and construction methodologies, instigating a heightened recognition of the advantages associated with wooden structures. The inherent qualities of wood, including its aesthetic appeal, sustainability, and rapid construction capabilities, have positioned it as a preferred material in the context of changing residential needs. Wooden cottages, often associated with rural retreats, have become a symbol of the desire for more spacious and nature-oriented living environments.

The challenges associated with CLT standards in the market manifested in a multifaceted manner, encompassing various issues that contribute to the complexity of establishing uniform criteria for the application and assessment of CLT within the construction industry. A notable challenge is the lack of alignment between the Eurocode system and national guidelines, leading to discrepancies in how CLT is evaluated and utilized across different regions. Additionally, the absence of a standardized product standard further compounds these challenges, creating uncertainties in the specifications and quality assurance of CLT products.

A parallel exploration by Hassegawa et al. [97] delved into key determinants that influence the widespread acceptance of CLT, shedding light on critical factors that can shape the trajectory of CLT adoption within the construction industry. Regulatory frameworks emerge as pivotal components, serving as catalysts for the adoption and seamless integration of CLT into conventional building procedures. The study underscored the significance of well-defined regulations that provide clarity on the permissible use of CLT in construction projects, thereby instilling confidence among stakeholders.

Moreover, [97] highlighted that an elevated level of customer consciousness plays a significant role in fostering the broad adoption of CLT. This emphasizes the importance of consumer awareness and preference in driving the demand for CLT-based construction solutions. In this context, producers of CLT products face the dual imperative of not only improving their understanding of CLT but also dynamically engaging in advocating its global ecological benefits to enhance consumer awareness.

These insights aligned with broader studies [98–100] that emphasized the interconnected roles of standards, regulations, and consumer awareness in shaping the trajectory of CLT adoption within the construction landscape. Standardization and regulatory clarity provide a foundation for the consistent and safe use of CLT, while consumer awareness creates a demand pull, influencing construction practices and material choices. The dynamic interplay of these factors underscores the need for a comprehensive and collaborative approach involving industry stakeholders, regulatory bodies, and consumers to overcome the challenges associated with CLT adoption and establish it as a mainstream and widely accepted construction material.

The identified lack of cost-effectiveness in the context of CLT stood out as a notable challenge anticipated in future markets, aligning with similar observations documented in the research conducted by Mallo and Espinoza [101]. These findings converged on the notion that the economic viability of CLT poses a significant concern, signaling potential hurdles in its broader adoption within the construction industry.

However, it is intriguing to note that earlier investigations by Roos et al. [86] presented a more nuanced landscape regarding the economic considerations of wood construction, specifically CLT. In their study, divergent viewpoints emerged among respondent architects, adding complexity to the understanding of the cost dynamics associated with CLT. Some architects asserted that wood, when correctly applied, can indeed be a cost-effective choice, emphasizing the importance of proper design and implementation. On the contrary, another subset of respondents expressed reservations about potential high costs associated with wood construction, citing perceived risk factors as a primary driver of their apprehension.

This discrepancy highlighted the multifaceted nature of the cost dynamics of wood construction, particularly with regard to CLT. It underscores the need for a nuanced understanding of the economic feasibility of CLT under varied circumstances within the architectural and construction industry. The variation in perspectives suggests that factors such as design optimization, construction techniques, and risk mitigation strategies play a crucial role in determining the cost-effectiveness of CLT. It is not merely a matter of inherent costs but involves considerations related to implementation practices, skill sets, and perceptions within the industry.

Incorporating the results of a global study investigating the viewpoints of CLT manufacturers on current practices and future trends would be highly advantageous within the scientific literature [55]. Our study's findings closely aligned with numerous outcomes observed in the investigation by [55]. Echoing our research outcomes, a consensus among global CLT manufacturers underscored a widespread acknowledgment of the knowledge and experience gap concerning CLT among construction industry professionals at large. These manufacturers emphasized a clear demand for improved CLT expertise and training, highlighting the prevalent familiarity with traditional construction materials. Our findings similarly support this observed trend, emphasizing the importance of addressing knowledge gaps and promoting specialized training to bridge existing disparities in understanding and utilization of CLT within the construction industry. In line with our research findings, there was a consensus among CLT manufacturers affirming that CLT is recognized as an optimal building material in the collaborative effort to mitigate the impact of climate change and adapt to environments characterized by significant climatic variability. Moreover, our study aligned with the observation that many countries involved in CLT manufacturing have implemented sustainable forest management practices tailored specifically for CLT construction. Consistent with the perspectives of CLT manufacturers, our study also indicated that the COVID-19 pandemic has contributed to a notable increase in the use of wood. Parallel to our study, international CLT manufacturers highlighted the lack of cost competitiveness as a significant drawback associated with CLT construction.

Our study exhibits scientific and technical rigor by systematically addressing a conspicuous lacuna in extant literature pertaining to the adoption of CLT within the Finnish construction milieu. Employing a methodologically robust approach through semi-structured in-depth interviews with a cohort of 15 esteemed Finnish experts, the research elucidates intricate nuances in the hierarchical familiarity with CLT across diverse echelons of construction professionals. Notably, the findings not only unravel pragmatic imperatives for professional development—underscored by the discernible exigency for heightened expertise and training—but also contribute substantively to the discourse on sustainable construction materials, characterizing CLT as a sanguine recourse for ameliorating the deleterious impacts of climate exigencies. Our study's discerning identification of vulnerabilities in CLT construction, encompassing cost-competitiveness and sound insulation, coupled with prognostications concerning future market dynamics, epitomizes a thorough and discerning analytical endeavor. The strategic articulation of our study's potential impact on augmenting the prevalence of CLT in the Finnish construction domain further accentuates its scientific and pragmatic import for industry stakeholders and policy formulation.

Exploring the realm of CLT construction opens up a wide array of potential research subjects. Delving into this field requires a multifaceted approach, encompassing various aspects related to user experience, regional comparisons, policy frameworks, and project analyses. Here is an expanded discussion on the suggested subjects:

1. User-oriented perceptual studies of CLT use: (a) investigate how end-users perceive and experience structures built with CLT, (b) assess the comfort, aesthetics, and overall satisfaction of individuals living or working in CLT buildings, (c) explore the psychological impact of CLT structures on occupants and how it influences their well-being.
2. Comparative studies in other Scandinavian geographies: (a) examine CLT construction practices in different Scandinavian regions to identify regional variations and best practices, (b) analyze the environmental, economic, and social impacts of CLT use in diverse geographical contexts, (c) compare the regulatory frameworks and standards governing CLT construction in different Scandinavian countries.
3. New sectoral research on local policies: (a) investigate local policies that promote the use of CLT in construction, (b) examine the role of government incentives, subsidies, and regulations in stimulating the CLT market, (c) assess the effectiveness of policies aimed at encouraging the adoption of CLT in various sectors, such as residential, commercial, and institutional.
4. Stimulating markets through consumption of more CLT: (a) explore strategies to boost market demand for CLT in construction projects, (b) investigate the potential for integrating CLT into different architectural styles and building types, (c) assess the economic implications of increased CLT consumption and its ripple effects on related industries.
5. Analysis of completed and ongoing CLT-based projects: (a) conduct a comprehensive analysis of successfully completed CLT projects, highlighting design innovations, challenges faced, and lessons learned, (b) monitor ongoing CLT projects to understand evolving construction trends and emerging technologies, (c) evaluate the long-term performance of CLT structures, considering factors such as durability, maintenance, and adaptability.

By addressing these diverse research subjects, one can contribute valuable insights to the growing field of CLT construction. This holistic approach encompasses the perspectives of end-users, regional variations, policy implications, market dynamics, and the practicalities of implementing CLT in construction projects.

While this study has provided valuable insights, it is imperative to recognize and confront specific limitations that could augment the depth and generalizability of the findings. One significant limitation pertains to the interview population, which, for a more comprehensive understanding, could have been expanded. A broader and more diverse range of participants would have added depth to the study, allowing for a richer exploration of perspectives and experiences related to CLT usage. The inclusion of a more extensive interview pool would not only bolster the study's internal validity but also contribute to the external validity by facilitating the generalization of results beyond the immediate context. Specifically, the results that are highlighted as beneficial to stakeholders in the Finnish CLT industry should be considered preliminary insights warranting further investigation. It is essential to validate and corroborate these findings across a larger and more diverse population scale to ensure their applicability and relevance on a broader scale. This could involve extending the study to encompass participants from other Scandinavian countries or even beyond, taking into account varying regional contexts, construction practices, and cultural influences. Furthermore, while the focus of this work was confined to the Finnish construction sector, recognizing the potential for enriching the research through comparative analyses with other countries is imperative. Comparative studies with nations where CLT is extensively utilized offer an opportunity to glean diverse perspectives, practices, and challenges. Such analyses can offer a more nuanced perception of the considerations shaping CLT adoption, shedding light on the contextual variations that may exist between different global construction environments. This cross-country comparison could uncover valuable lessons, best practices, and innovative approaches that might be applicable or adaptable to the Finnish context.

6. Conclusions

Our findings may have detailed policy or governing practices for the market dynamics of CLT in the Finnish construction industry. It will provide understanding, especially for key experts, e.g., engineers, manufacturers, and other shareholders in the wood construction sector, considering contemporary market demands and the statutory and legal requirements of related decision-makers.

Although CLT construction, driven by only a few domestic manufacturers, is relatively new in Finland, sustainability concerns may increase interest in renewable materials, and therefore, CLT may be more accepted in the Finnish construction market. Additionally, active communication about successful projects and new applications can open new avenues for CLT to gain popularity in the Finnish construction market. However, success requires wide-ranging collaboration and a desire to develop and improve one's operations. Because CLT, like other wood-based products, has a substantial ecological effect on the Finnish building sector, it can contribute to Finland's aim of becoming carbon neutral by 2035. In addition to its ongoing status as environmentally friendly, its usage in influential projects and the growth in exemplary applications will increase its positive perception.

Increased public initiatives for CLT should involve the development of sustainable business models. These models should receive legal and financial support from government authorities. In this regard, robust collaboration among essential stakeholders such as local authorities, builders, material providers, and design offices is imperative. Moreover, inter-organizational collaboration (such as closer collaboration with design teams, and CLT companies) will improve expertise and adoption of CLT usage in Finland. It is a critical topic to offer the required academic and practical instructions in the field of CLT use, both in the university and in the building sector. Moreover, legislators have crucial responsibilities in the regulatory procedures of subjects that will shape the outlook of the CLT market in Finland.

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Appendix A. Interview Questions

1. How acquainted are you with the processes involved in the production and construction of CLT?
2. In your opinion, how well-informed do you believe professionals in related fields (e.g., architects, civil engineers, clients, builders) within the construction industry are about CLT?
3. Do you think there is a need to enhance awareness and understanding of CLT among professionals in the construction industry or among the general public and residents?
4. In the context of combating climate change, do you anticipate an increased utilization of CLT as a building material in future construction projects?
5. Is CLT considered suitable for application in environments characterized by fluctuating temperature, humidity, and varying weather conditions?

6. From a sustainable forestry standpoint, is CLT manufactured specifically for the Finnish wood construction sector?
7. How have fluctuations in raw material prices for wood impacted the field of CLT construction?
8. What effects, if any, has the COVID-19 pandemic had on the landscape of CLT construction?
9. What kind of buildings (e.g., leisure, public, residential, office, apartment buildings) do you think CLT is best suited for?
10. What vulnerabilities or weaknesses do you perceive in the structural integrity of CLT?
11. How do prevailing construction industry standards in your country, such as the CE marking system, influence the dynamics of the CLT market?
12. In your view, which wood species are most suitable for the production of CLT?
13. From your perspective, what opportunities and challenges do you foresee for the CLT market in the future?
14. Are there any additional perspectives or comments you would like to share on the subject?

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