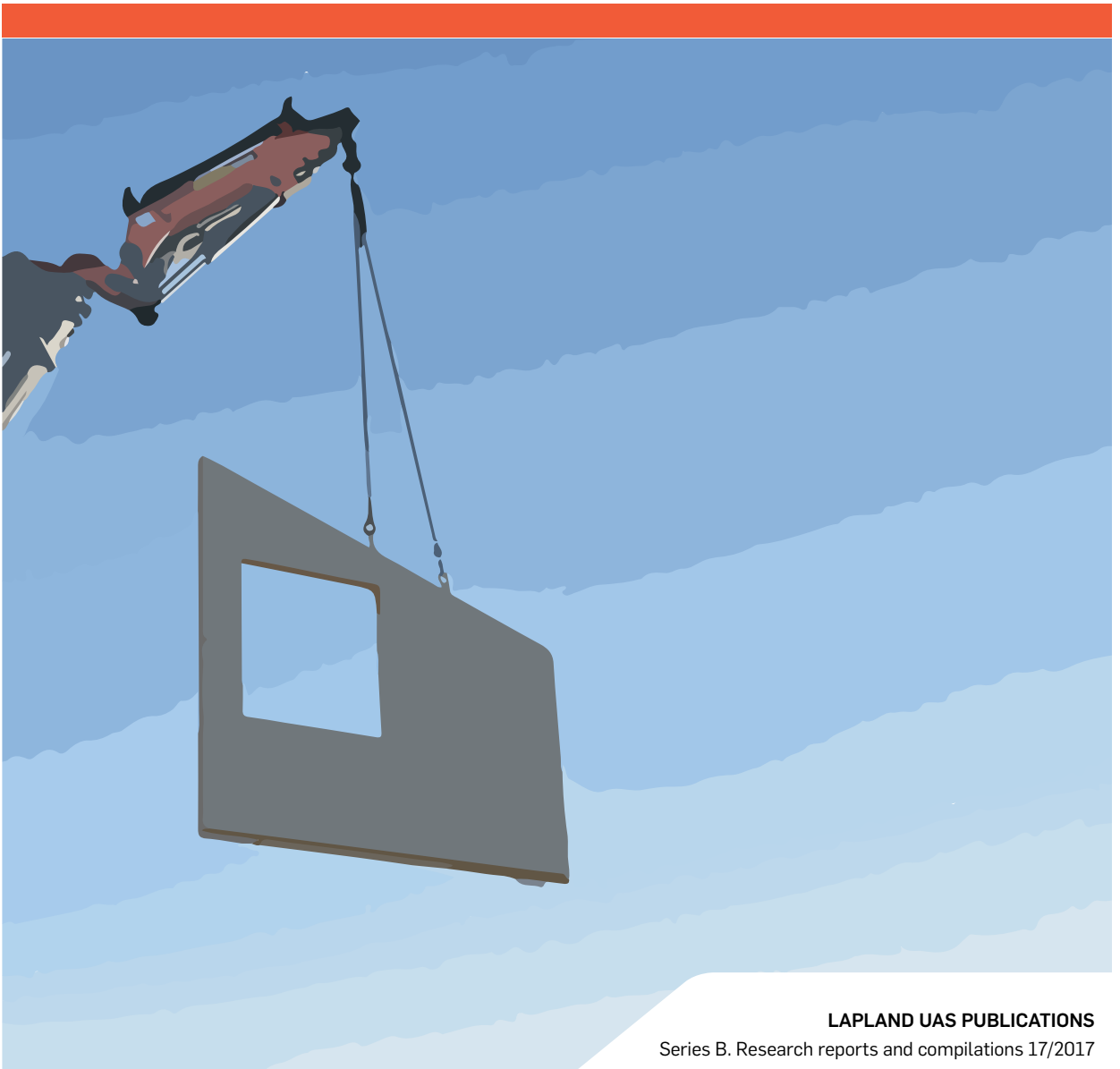


Current state and future of CLT construction in Finland

Interview study 2016



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Mikko Vatanen • Antti Sirkka • Valtteri Pirttinen • Tytti Ahoranta

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Abstract

This interview study was conducted within the Future possibilities for CLT (FCLT) Nya möjligheter för CLT project financed by ERDF Interreg Nord. FCLT is a research project implemented by Luleå Technical University, Technical Research Institute of Sweden (SP), Centria University of Applied Sciences, Digipolis and Lapland University of Applied Sciences. The project started in September 2015 and will continue until May 2018. The main goal of the project is to promote the use of CLT and to increase the knowledge about the possibilities of CLT as a building material within the Interreg Nord area.

The interview study was executed with a qualitative research approach and data was collected by means of a semi-structured interview. Case study was used as a research method and the experiences of using CLT in the Finnish construction industry were studied as cases. The study was planned to include wide variety of actors from different phases of construction projects. A total of 18 different professionals that have been involved with CLT building projects were interviewed.

The aim of the interview study was to find answers to the main research question: *What are the experiences of construction professionals on using CLT in building projects?* Answers to more defined subsections were also expected: *Differences when compared to other building systems, The effects of the material's characteristics, Knowledge and competitiveness, and Future expectations and needs for development.*

Based on the themes that were identified from the interview data, a strategic action plan called *Build using CLT* was created. The action plan has five different sections and the proposed actions were written as in the imperative mood so as to make the message clear and the use would be as simple as possible. The *Build using CLT* action plan consists of the following sections: *Use the value of the material, Work efficiently, Be active in communications, Develop operational models and Co-operate and evolve.* Based on the interview data, the most discussed topics were additionally highlighted using word clouds.

Based on the results of the interviews, we can conclude that CLT has a positive image and it is seen to have a great deal of potential to serve as an ecological alternative for future sustainable construction. Wooden surfaces are seen as valuable and aesthetically impressive enablers of high-quality indoor environments. As a

construction material, CLT is a relative newcomer, and the lack of references and experience are seen as its main challenges at the moment.

The expected effect of executing the case study was to widen the perspective of earlier work in FCLT project regarding the knowledge-base of building with CLT. During the next phase of the project the focus will be in helping the companies in the Interreg Nord area to find new possibilities for business in using CLT. The objectives in the next phase are to create interest towards CLT and sustainable building solutions and then to help companies create preliminary value chains for CLT construction. The work towards the objectives is carried out by mapping the interested pilot companies, working together in workshops and distributing information via seminars, informative sessions and publications.

Keywords: cross laminated timber (CLT), wooden buildings, sustainability

1 Forewords

1.1 ORIGINS

There's an interesting new wave of wooden constructions emerging in our built environment. Increasing know-how in the production technology and possible applications of Cross-Laminated Timber (CLT) sure looks very promising. There's a growing need in the construction industry to renew the range of products and operational models towards more industrial approach and advanced prefabrication. Sometimes a little help from research and development organizations is also needed to facilitate industry towards new direction. With this in mind five organizations from the northernmost parts of Finland and Sweden joined forces and started a research and development project called Future possibilities for CLT. The project consortium consists of following organizations:

- Luleå University of Technology
- Research Institutes of Sweden
- Centria University of Applied Sciences
- Digipolis
- Lapland University of Applied Sciences.

The project will be ongoing through September 2015 to June 2018. The project's main goal can be: an increased use of CLT by spreading information and increasing knowledge of how to efficiently produce and introduce new improved types of CLT into existing and new building processes. The project work has been broken down into five work packages:

- WP1 H2020 application: creation of H2020 application with increased number of partners for possible extension of project
- WP2 new designs of CLT: design of new taylormade CLT types. Design of efficient joints and coupling types for CLT.
- WP3 fast prototyping: compilation of existing CLT solutions and companies who use CLT. Activation for possibilities for fast prototyping.
- WP4 building quality and climate class 3: testing of quality and study of increased possibility for CLT use in humid climates (outdoors).

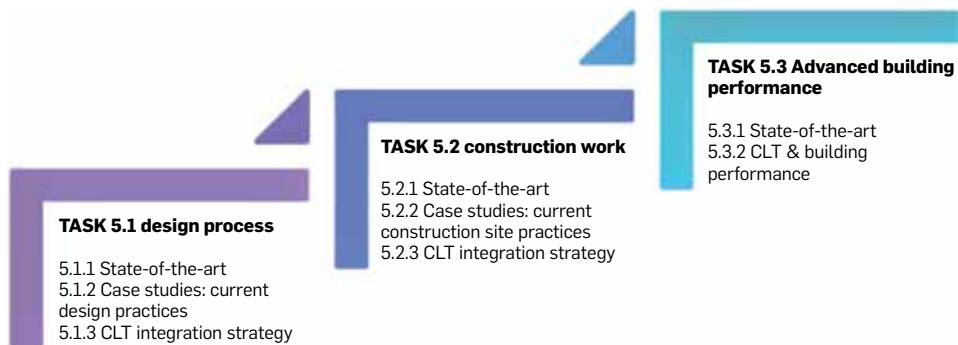
- WP5 building processes: study of how to introduce CLT in existing building processes.

Lapland University of Applied Sciences has the responsibility to lead the work in WP5.

1.2 WORK PACKAGE 5, CORE IDEA

The need to integrate CLT better into the current planning process and construction work has become well-known in the last few years. This is especially the case in the northernmost parts of Finland (also in Sweden & Norway), where the companies are probably more cautious towards making radical changes to their current policies and practices. At the same time the need to renew the industry has also become a very topical issue.

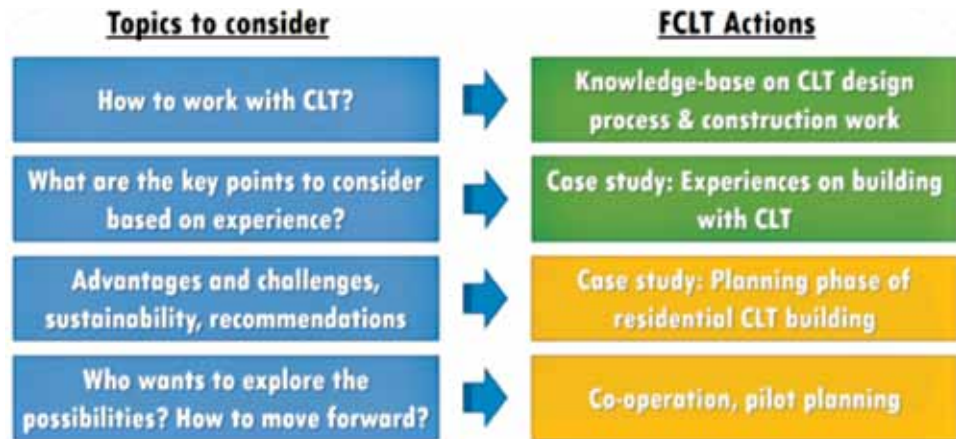
In this work package there will be made analysis on current practices of the planning process and also the work at the construction site. Then the methods of integrating CLT the best possible way into the current practice are examined. The way to manage the need for new knowledge or equipment and also examples for integration strategies are then proposed. Also the current trend towards advancing the building performance in many ways is being examined. Then the methods of using CLT to gain advantage in the building performance is being proposed. The task structure of WP5 is presented in the picture below.



Picture 1. WP5 research / tasks overview

INDUSTRY PARTICIPATION

To achieve results as planned in FCLT project, the local industry must clearly be in focus. The needs of the industry have to be heard and then addressed by distributing the needed information. The main topics to consider are presented in picture below.



Picture 1. WP5 research / tasks overview

The first contacts during FCLT project have been completed and overall about 70 contacts were made. About 45 discussions were documented. Several companies that were interested in CLT have been identified and preliminary value chains have been created for later co-operation in the project. As a summary most of the companies would need much more information about CLT going forward.

This need will be addressed by Lapland UAS by distributing general information about design process and construction work with CLT. Previous experiences and references about CLT building projects seem to be also in great demand. This report will be aiming at bringing forward that point of view. There are only a handful of completed CLT constructions in Finland at this time. Lapland UAS contacted several companies that have been working with CLT in those projects. The purpose of this action is to find some common opinions about building with CLT based on experience. Hopefully following report will shed some light on the experiences and interesting opinions of professionals who have already entered CLT business.

2 Introduction

2.1 CLT CONSTRUCTION NOW AND IN THE FUTURE

CLT is believed to be one of the most promising innovations of the century in the field of construction. Among the strongest arguments in its favour are its degree of prefabrication, ecological qualities and domestic origin. The high degree of prefabrication enables fast modular construction and is highly conducive to moisture-controlled implementations. The ecological qualities are due to lower the environmental effects and wood's capacity to serve as a carbon sink. Numerous studies have shown the positive effects of wood on the well-being and comfort of building occupants. The new CLT production and prefabrication factories bolster the confidence that the growth potential will be realised in the future.

The forest industry is extremely important to the Finnish national economy. Approximately 20% of export income and 5% of the gross national product are attributable to it, it employs about 200,000 Finns, and it produces roughly 70% of the renewable energy used in the country. Construction is the most prominent area where wood products are used, as some 70–80% of domestic wood products end up being used within the sector. Finland has the potential to increase felling volumes and the use of wood in a sustainable manner, as approx. 55% of the growth of Finnish forests is utilised each year, which constitutes to approx. 78% of the sustainable felling volume (54–59 million m³/year). Even at the current level of forest management and use, the amount of harvesting could be increased substantially (almost 20 million m³/year). (Haapio, 2016, Karjalainen 2016, MTK 2015)

Wood raw material is the only industrially significant renewable natural resource used in construction. The environmentally friendly qualities of wood construction come into sharp focus when we consider the carbon trapped by the wooden structures. Furthermore, the structural change of the forest industry favours the promotion of wood construction. In addition to other areas, the most significant growth potential for wood construction is considered to lie in wooden multi-storey buildings, and increasing the use of wood in the implementations of public buildings, repairs, additional floors and supplementary construction. Among the methods of wood construction, CLT is seen to provide the best potential for serving as a frame system in multi-storey construction. Thanks to the fast and simple worksite methods and technologies as well as other qualities, such as the airtight and rigid nature of the frame, CLT can be a highly competitive solution in the construction of multi-storey buildings. (Haapio 2016, Karjalainen 2016)



Figure 1. CLT panel (Stora Enso, 2016)

The term CLT (= Cross Laminated Timber) refers to a construction material in which cross-laminated solid wood panels, glued together in layers in a crosswise pattern, serve as vertical or horizontal elements (Figure 1.). The CLT method is one of the structural systems used in implementations of wooden multi-storey buildings. (Stora Enso, 2016)

2.2 AIM, PURPOSE AND FUNCTION OF THE STUDY

The Future possibilities for CLT (FCLT) project is implemented as an international research project involving the Luleå University of Technology, Technical Research Institute of Sweden (SP), Centria UAS, Digipolis Oy and Lapland UAS. The project was initiated in September 2015 and will continue until October 2018. The primary objective is to promote the diverse use of CLT and increase awareness of the possibilities provided by CLT construction. The first phase of the work package under the responsibility of the Lapland UAS involved the preparation of state-of-the-art reports.

The purpose of the reports was to put together an information basis on the design process, worksite process and efficient construction in the context of a CLT construction project. In the second phase, information on the current practices of CLT construction was collected. The aim was to expand the information basis assembled on the implementation of a CLT construction project. This was to be done by conducting an interview study to survey the experiences of CLT construction in Finland. The goal of the interview study was to answer the following main research question along with exploring the specifying subtopics:

What are the experiences of construction professionals on using CLT in building projects?

- *Differences when compared to other building systems*
- *The effects of the material's characteristics*
- *The know-how and competitiveness*
- *Future expectations and needs for development*

3 Implementation of the study

3.1 RESEARCH METHOD, APPROACH AND PHASES

The study was implemented in a qualitative format, and a semi-structure thematic interview was used as the method for material collection. The approach was that of a case study, which examined the experiences of Finnish construction professionals of CLT construction as a case.

Almost all qualitative studies are case studies, which are empirical by nature and aim at collecting information on the case being examined in a variety of ways. The objective of a case study is to reach a deeper understanding of the phenomenon in question. The results of a case study may not necessarily be generally applicable, as the more essential goal is to understand the specific case in question. Naturally, the results can serve as a small step towards generalisation. (Metsämuuronen, 2006).

The material for the case study was collected through a semi-structured thematic interview. The interview process forms a pool of discussion-oriented material in which the planned themes are explored. What is typical of this approach is that all interviews may not cover all themes to the same extent. It is also important to note that the preselected themes may not be the same that are found essential based on the material collected. (Saaranen-Kauppinen & Puusniekka, 2016).

To select the themes for the interview study, a workshop was held, which examined the phases of a construction process based on knowledge base accumulated. The workshop specified the needs for expanding the knowledge base and established the core themes for the interview study based on these needs. In addition to this, the themes were supplemented with key questions that served to guide the interview. A theme and question matrix, which is presented Appendix 1, was formed to assist the interview process. The main themes and subthemes of the interview are presented in Figure 2.

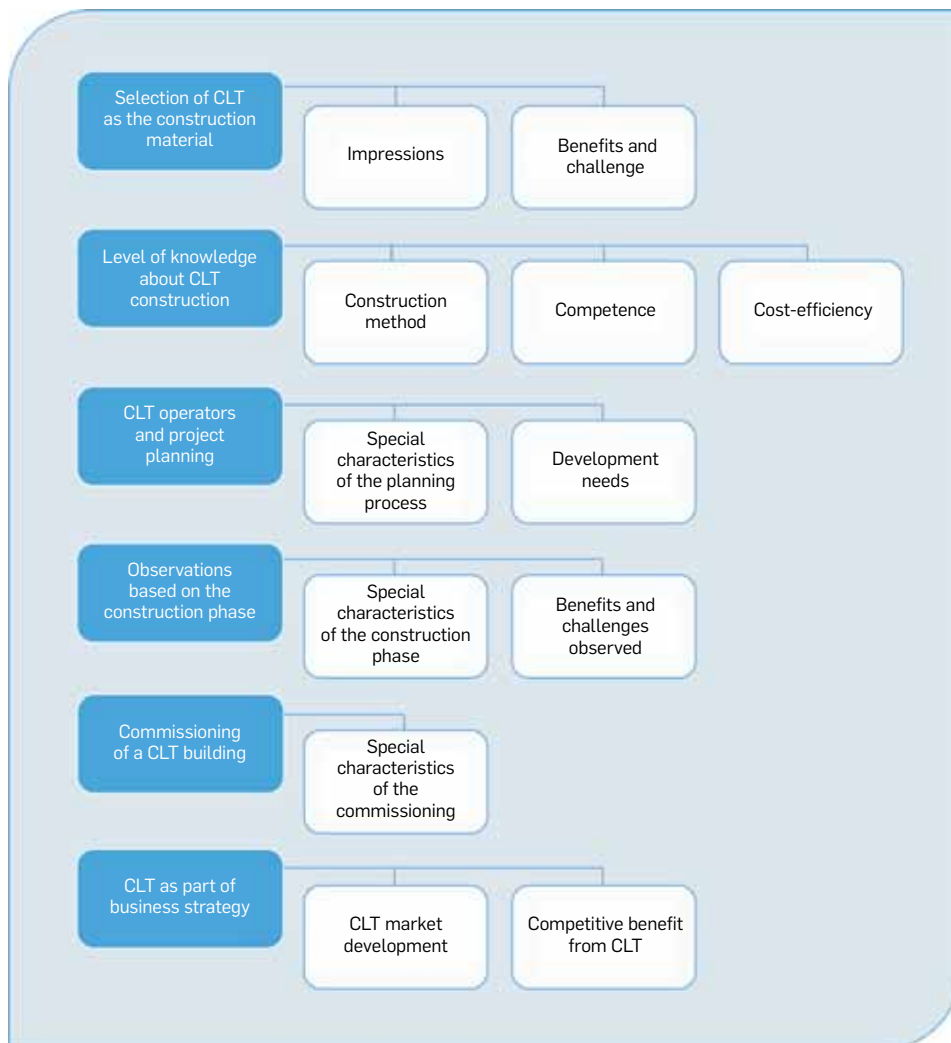


Figure 2. Main themes of the interviews

3.2 INTERVIEW STUDY AND TRANSCRIPTION PROCESS

A thematic interview matrix was prepared for the interviews with operators and companies that had constructed CLT buildings. In implementing the interviews, it was observed that the themes and specifying questions guided the interviews in the desired direction. The interviewees were selected among companies and operators that had been involved in the implementation of CLT construction projects. Some were already known but additional ones were sought by going through the background information of the most prominent CLT buildings. The operators selected for the interviews included developers, various planning parties, contractors and element

suppliers. A total of 18 CLT operators were interviewed in the study. The range of selected interviewees included three element suppliers, five developers, four planners and six contractors. The interviewees were initially contacted by e-mail. Then, they were called on the phone to set up a time for the interview. The interviews were primarily conducted over the phone, but a few people were met in person.

The interview study was conducted as a semi-structure thematic interview. As regards the reliability of the research material, the aim is to avoid errors and create a high-quality study. In order to confirm the above factors, two persons were involved in the interview process: the interviewer and a transcriber. Transcribing means writing up verbal material to a degree of accuracy dependent on the framework of the research in question. As a general rule, all spoken sentences are written down, but sometimes the things that are most essential to the research are picked out from the material. (Saaranen-Kauppinen & Puusniekka, 2016). In this study, the transcription took place simultaneously with the interviews, and only the aspects that were found to be most essential to the research were recorded. In order to ensure the accuracy and quality of the responses, each interview was reviewed with the interviewer after the actual interview. The material ultimately collected through the thematic interview process consisted of the interviews and the observations recoded in conjunction with them. After the interviews, the memoranda were consolidated under the preselected themes and specifying question to form the research material.

3.3 PROCESSING OF THE RESEARCH MATERIAL AND THE METHOD OF ANALYSIS

Material coding means adding various structuring markings to the research material to facilitate analysis. A variety of approaches can be employed for the coding (e.g. theory-based, theory-oriented or material-based). Typical coding methods include underlining and adding markings in different colours. The coding units can be words, sentences, paragraphs or even longer sections of text. (Saaranen-Kauppinen & Puusniekka, 2016). The coding for this interview study was done from the perspective of SWOT analysis. The strengths, weaknesses, threats and opportunities of CLT construction that were revealed in the interview study were highlighted in the material by colour coding individual words and full sentences (see Figure 3).

The qualitative nature of the material does not preclude the consideration of quantitative aspects. For example, it is sometimes easier to grasp the material's implied meanings by calculating incidence than by simply rereading the texts. However, the limited nature of the material often prevents statistical generalisations and the calculation of key figures. Tables and matrices, for instance, are still viable methods for presenting the results of quantification. (Saaranen-Kauppinen & Puusniekka, 2016). Within the scope of this study, the material was partially processed in a quantitative manner by forming "word clouds" based on the incidence of various

CODING WITH MARKINGS OR COLOURS

Coding with markings, e.g.

- Strengths (S)
- Opportunities (O)

S, O: "As a new type of solid wood structure, CLT drew interest; positive image. Stiff, robust and ecological alternative for steel structures. Opportunity to use CLT for the construction of fully complete, movable buildings."

Coding with colours, e.g.

- Strengths
- Opportunities

"As a new type of solid wood structure, CLT drew interest; positive image. Rigid, robust and ecological alternative for steel structures. Opportunity to use CLT for the construction of fully complete, movable buildings."

Figure 3. Coding of the material

keywords. The keyword cloud illustrates the content of the discussions in the interview study. Based on the interview responses, which were in sentence form, keywords were created to describe the theme of each answer. For example, the keywords "information modelling" and "prefabrication" were formed based on the response "The use of information models comes to the fore in wood construction; openings and lead-throughs are made at the factory." The incidence of each key word in the interview material affects the word's font size in the word cloud: larger words appear more frequently in the responses while smaller ones appear less often.

There are no clear formulas or technical tools for analysing qualitative material. A systematic review of the material is ensured by using applicable perspectives and methods of examination. Typically, the material is structured and condensed to form smaller parts of the whole. However, the work must not focus solely on material description. The researcher's interpretation is an essential part of formulating the actual research results, as it combines the observations made on the material, the theoretical framework and the researcher's own thinking. The aim must be to use this process of synthesis to form something more extensive and understandable from the disparate parts. (Saaranen-Kauppinen & Puusniekka, 2016). The material of the interview study was coded and simplified into two SWOT analysis tables from the perspectives of strategic positioning and operational efficiency. These two SWOT tables were consolidated to form a single SWOT analysis table on CLT construction. The SWOT analysis was used to define strategic operating alternatives and create a TOWS matrix, which describes alternative strategies (see Figure 4).



Figure 4. TOWS matrix (Meristö, Molarius, Leppimäki, Laitinen & Tuohimaa, 2007)

The TOWS matrix features four different operating strategies:

- *Maxi-Maxi (S/O)* This combination is the ideal situation where the aim is to utilise the opportunities and strengths.
- *Maxi-Mini (S/T)* This combination describes the strengths in relation to the threats.
- *Mini-Maxi (W/O)* This combination includes the weaknesses and opportunities. The weaknesses must be overcome to benefit from the opportunities.
- *Mini-Mini (W/T)* This combination describes the weaknesses in relation to the prevalent threats. (Meristö, Molarius, Leppimäki, Laitinen & Tuohimaa, 2007)

The TOWS matrix is formed as follows: In the SWOT analysis, the positive image of wood as a material emerged as one of the strengths (S) of CLT construction, whereas the high growth expectations were found to be the opportunity (O). These arguments form the Maxi-Maxi (S/O) strategy: Utilise the positive image of CLT and respond to the growing demand (see Figure 5).

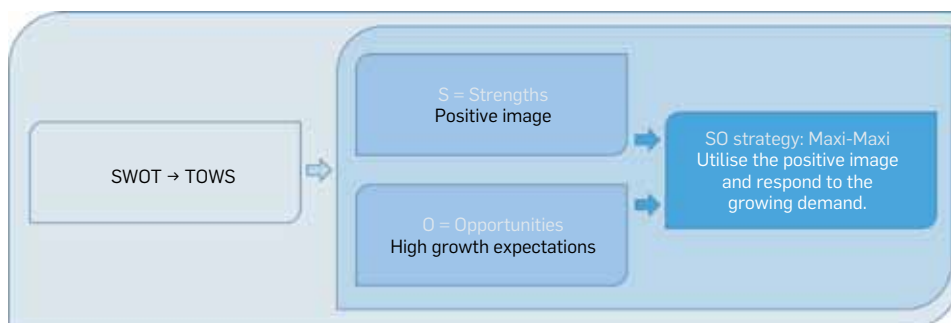


Figure 5. Example of using the TOWS matrix

After the preparation of the TOWS matrix, a material-based theme division was conducted, with the purpose of forming collections of operating strategies around the main themes that emerged from the interviews. The operating strategies were divided into five areas and phrased in the imperative mood in order to ensure that they would be as easy as possible to understand and implement. *Build using CLT* was chosen as the heading for the operating strategies, and the areas are material value, efficient operations, communications, development and co-operation.

4 Analysing the results of the thematic interview

4.1 KEYWORD CLOUD

Based on the responses under the various themes, separate keyword clouds were formed, which can be found in Appendices 3–8. The joint keyword cloud for the entire study is presented in Figure 6.



Figure 6. Keyword cloud for the interview study

All keywords collected from the responses under the six themes were consolidated into the keyword cloud presented above. The material indicated the term *prefabrication* as having the highest frequency of occurrence. Prefabrication and the opportunities it provides were seen as one of the most important characteristics of CLT and wood construction. Increasing the degree of prefabrication is seen to enable numerous benefits in construction: it significantly *accelerates* lead-times at the worksite, makes the implementation of *moisture control easier in factory conditions*, and the CNC machining conducted at the factory are always *dimensionally accurate* without the need for any machining in worksite conditions. The installation of *prefabricated wall units* and *modular units* made of CLT is *commonplace* and comparable with concrete element construction. The high degree of prefabrication also requires accurate planning based on *Building Information Models*.

CLT is a relatively new material in Finland, due to which there is little *experience* with regard to its use as a frame material, in contrast to *Central Europe*. The interviewed constructors of CLT buildings were unanimous in their view that knowledge will be accumulated quickly with experience, because wood is, after all, a very common and familiar building material. In addition to the lack of information related to solid wood innovations, the faster increase of CLT buildings is hampered by a deficiency in *planning expertise* and *competence* regarding wood buildings.

At the moment, the general opinion is that the *National Building Code of Finland* forces wood construction and *concrete construction* into positions of unequal footing. Especially the seemingly strict *fire regulations* affect the *cost efficiency* of wood construction. The *sprinkler obligation* affecting wood buildings with more than two storeys increases the costs of wood buildings compared to corresponding concrete buildings, which are not subject to the same requirement. Even so, the people who have implemented CLT buildings find that *sprinklers* make wooden buildings substantially *safer* from the resident's viewpoint, which is why this perspective should be used in the marketing of wood construction. There were also some comments about the *protective cladding* of wood buildings, which is seen as excessive. Due to the *protective cladding*, residents may not even know they are living in a wooden multi-storey building as the fire regulations necessitate cladding the solid wood frame with fireproof material, despite the sprinkler system. Plasterboard is often used as the cladding material. Relaxations of these requirements will be implemented in the updated fire regulations to be published in 2017. Currently, *functional fire design* has been utilised commonly to keep the wood surfaces of wooden multi-storey buildings visible.

Due to CLT *ecological qualities* and small *carbon footprint*, the positive *image* is seen as important for *future competitiveness*. CLT is seen as a structural *alternative* with *potential* due to its *ecological qualities* and *domestic* production increase.

4.2 OPERATING STRATEGIES: BUILD USING CLT

Based on the results of the “Current state and future of CLT construction in Finland” interview study, a compilation of results based operating strategies collected from the TOWS matrix was formed (Figures 7, 8, 9, 10, 11 and 12). The core is formed by *Build using CLT*, to which five operating strategies in imperative form are linked: Use the value of the material, Work efficiently, Communicate actively, Develop operational models and Co-operate and evolve. The study indicates that CLT’s positive image and ecological qualities, such as its domestic origin, renewability and recyclability, are factors that should be considered in utilising the value of the material. In addition to this, wood surfaces are seen as a valuable basis for high-quality interior environments.

One of the strengths of CLT is efficient construction, which gave rise to the operating strategy *Work efficiently*. This strategy leverages the rapid construction pace yielded by the high degree of factory prefabrication, along with the good and moisture-proof quality of the implementation. The information was obtained, in part, from the element suppliers’ documentation and the functional fire design documents prepared to implement the desired solutions. The third operating strategy “Communicate actively” is very important for a relatively new construction method. Good communications can highlight arguments for CLT construction, references (with due consideration to demanding and uncommon implementations) and the development of expertise in the field. The communications should also emphasise the fire safety of wooden multi-storey buildings with sprinkler system and the productivity benefits of fast CLT construction, as these aspects are often neglected in the initial phases of a project.

The two final operating strategies, *Develop operational models and Co-operate and evolve* are strongly linked to the most important theme, CLT as part of business strategy. CLT would appear to have excellent opportunities to emerge as a potential challenger for concrete multi-storey buildings, but the sector is also placing a great deal of confidence in hybrid construction, which involves selecting the best components and materials to achieve the principles of sustainable construction.

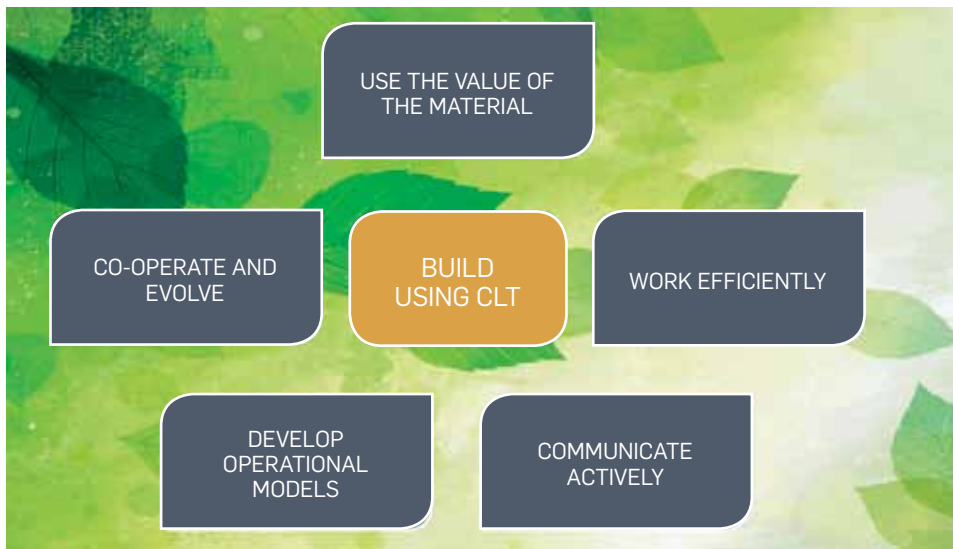


Figure 7. Build using CLT

USE THE VALUE OF THE MATERIAL

- Utilise the **positive image** of CLT and respond to the growing demand.
- Offer the **alternative of ecological construction** in the context of cities and regions are committing to sustainable goals.
- Highlight the material's benefits, such as **domestic origin**, **renewability** and high level of **recyclability** in the context of preparing strategies to increase the degree of refining domestic timber.
- Ensure maximum value creation by using plenty of visible wooden surfaces to create a **high-value visual appearance** and **high-quality interior environment**.

Figure 8. Use the value of the material

WORK EFFICIENTLY

- Utilise **ready-made documentation** of CLT element manufacturers in the design of simple structures that are easy to implement.
- Take advantage of the opportunities provided by the **high degree of prefabrication** to achieve faster construction times.
- Maximise **construction speed** by making good use of the possibilities of CLT modular units in the construction of multi-storey buildings and in the growing field of supplementary building, for example.
- Utilise **functional fire design** so that portions of the wooden frame can be left visible; this solution also lowers the overall costs.
- Implement planning based on Building Information Models to ensure that the machining work is conducted as far as possible in **factory conditions**.
- Utilise **weatherproofing** efficiently – the solutions and competence are developing rapidly, increasing the quality of the end result, along with safety and efficiency at the worksite.

Figure 9. Work efficiently

COMMUNICATE ACTIVELY

- Ensure the development of demand through active marketing that emphasises prior **references** (CLT projects).
- Improve the visibility of CLT construction by communicating about **experiences** regarding CLT construction through your own communication channels.
- Ensure that the developing parties have access to up-to-date information on **expertise** in CLT construction.
- Ensure that your communications emphasise the fact that, thanks to fire technical design and the sprinkler system, a wooden multi-storey building's **fire safety is first-rate from the perspective of the user**.
- Emphasise the **productivity benefits** yielded by the fast construction time in your communications – this benefits all parties involved.

Figure 10. Communicate actively

DEVELOP OPERATIONAL MODELS

- Seize the emerging opportunities – experiences have shown that CLT construction is **simple** and can be **easily adopted**.
- Prepare a progress plan from simpler CLT projects to more demanding ones, **develop the organisation's competence** with regard to CLT construction one step at a time.
- Combat the **competence deficit in design** by specialising in the design of wooden structures and providing related training – the procedures of CLT design can be adopted quickly.
- Offer **CLT prefabrication services** to the market – especially in the use of modular units, logistical solutions increase the value of local availability.
- Develop **competence related to ordering** in such a way that enables the added benefit of fast construction time.
- Define the projects **environmental goals** in such a way that the environmental impacts can be assessed when comparing the tenders.
- Create **competition in the CLT market** and ensure the availability of domestic material as the demand increases.

Figure 11. Develop operational models

CO-OPERATE AND EVOLVE

- Co-operate with various operators and areas to compile a **joint CLT reference bank** – this can increase the effect of communications.
- Participate in the development of sustainable construction so that the bases for **ecological value creation** can be defined better than at present.
- Engage in the development of **sound technical design** and **vibration management** – note the opportunities provided by **hybrid structures**.
- Utilise the **element supplier's design expertise** in order to manage the competence deficit.
- Engage in development work with designers and product manufacturers to **integrate building services** into CLT structures more efficiently than before.
- Take part in the development efforts to define reliable **labour consumption** and **cost levels** – the markets' prevalent uncertainties with regard to pricing must be dispelled.
- Manage **cracking of visible CLT surfaces** by using boards with bevelled edges, for example.

Figure 12. Co-operate and evolve

5 Summary

The interview study conducted under the “Future possibilities for CLT” project collected information from professionals who had worked in CLT construction. Among other things, the interviewed persons have experience about CLT production, planning the machining of CLT structures and panels, prefabrication and the implementation of buildings at the worksite. The goal of the study was to expand the information basis collected previously within the scope of the project. The study was implemented in a qualitative format, and a semi-structure thematic interview was used as the method for material collection. The approach was that of a case study, which examined the experiences of Finnish construction professionals of CLT construction as a case. The study sought to interview the selected operators as extensively as possible with regard to the various phases of the construction project. A total of 18 operators that had been involved in CLT projects took part in the interview study. The sample of the interview study was found to be sufficient.

Based on the results of the interviews, we can conclude that CLT has a positive image and it is seen to have a great deal of potential to serve as an ecological alternative for future sustainable construction. Wooden surfaces are regarded as valuable and aesthetically impressive enablers of high-quality indoor environment. The amount of visible CLT surfaces can be increased in buildings through functional fire design. Multi-storey buildings with wooden frames are found to provide better fire safety than corresponding concrete buildings due to the obligation to include a sprinkler system. Rigidity, lightness and the capability to serve as a natural vapour barrier are seen as CLT’s good qualities. Due to the lightness of wood as a material, CLT is considered to have significant potential for modular construction (prefabricated wall units and modular units). In the implementation of CLT buildings, it is important to ensure moisture control and weather protection during construction, as is the case with all construction activities.

CLT is still relative new as a construction material, which is why there are currently relatively few reference projects to be found in Finland. Due to the lack of experience, CLT is seen as a moderately challenging material. However, CLT element suppliers and expert organisations can assist with the competence deficit. This is why those interested in CLT construction should contact CLT element suppliers early on in the project. Active communications regarding successful projects and new applications

open up new avenues for CLT to gain popularity in the multi-storey buildings market. However, success requires wide-ranging co-operation and the desire to evolve and develop one's operations.

In her interview study *Puurakentamisen tulevaisuuden näkymät* (Future trends of wood construction) completed in 2013, Appu Haapio of VTT Technical Research Centre of Finland stated: "Increasing the use of wood will require unbiased argumentation and research, along with producing information for both professionals and consumers. Successful reference projects increase interest in wood construction." On the basis of the quotation above and the results of our own interview study, the natural step in the next phase of the FCLT project is to contact construction companies and operators in the Interreg Nord region in order to determine the possibilities for furthering the increased use of CLT. The aim is to find companies and operators that are interested in CLT construction and that we can collaborate with to plan the integration of CLT into their operating strategy. It is important to find operators in all sectors of the construction sector in order to generate local co-operation and complete operational chains for the construction of CLT buildings, thereby complementing the construction cluster in Northern Finland. The results of the interview study and the information basis collected previously over the course of the project will guide communications toward companies and operators in future project activities.

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Appendices

Appendix 1. Question matrix

Appendix 2. Keyword cloud theme 1: Selection of CLT as the construction material

Appendix 3. Keyword cloud theme 2: Level of knowledge about CLT construction

Appendix 4. Keyword cloud theme 3: CLT – operators and project planning

Appendix 5. Keyword cloud theme 4: Observations based on the construction phase

Appendix 6. Keyword cloud theme 5: Commissioning of a CLT building

Appendix 7. Keyword cloud theme 6: CLT as part of business strategy

Appendix 8. SWOT analysis and TOWS matrix on CLT construction

Appendix 1. Question matrix

Selection of CLT as the construction material

- Why did you decide to build using CLT?
- What kinds of impressions did the various parties involved have about CLT construction, and how was the presentation received?
- What benefits or challenges were CLT estimated to have?
- What other alternatives were considered for the project?
- What uncertainty factors were related to the selection of CLT?
- Availability, delivery times?

Level of knowledge about CLT construction

- Is there enough information available on the costs of CLT construction?
- What CLT implementation alternative did you decide to use and why?
 - Structural solutions
 - Construction method (on-site/prefabricated wall unit/modular unit)
- How did the selection of CLT affect the permit process?
 - Regulations
 - Fire safety and fire regulations
- What kind of know-how was CLT construction estimated to require, and was there deemed to be enough know-how available.

CLT operators and project planning

- How many potential tenderers were available for the various work phases?
- How did the selection of CLT affect the implementation of the planning process?
 - Selection of the structural system, CLT's role
 - Building services engineering
 - Choice of the structural types
 - Joint solutions and sealing
 - What opportunities do CLT structures offer the designer?
 - What limitations do CLT structures impose on the designer?
 - How does CLT design differ from other design?
 - What requirements does it involve with regard to competence, knowledge and qualifications?
- How should the design and planning of CLT construction be developed?

Observations based on the construction phase

- What unexpected things have you faced in CLT construction?
- How did CLT construction affect the logistics and scheduling at the worksite?
- What different aspects were related to CLT element work compared to other construction methods?
- Moisture control
- Occupational Health and Safety

Use of a CLT building

Have you noticed any special characteristics in the commissioning of CLT buildings?
How should the users of CLT buildings be instructed in relation to their use?

CLT as part of business strategy

How can new operators in the field of CLT construction get started – where can you find information and what is required?

What are the most significant pitfalls?

Ecological qualities, small carbon footprint – are there discernible competitive advantages?

How will the CLT construction markets develop in the future?

Is it prudent for a company to specialise as an expert in CLT construction?

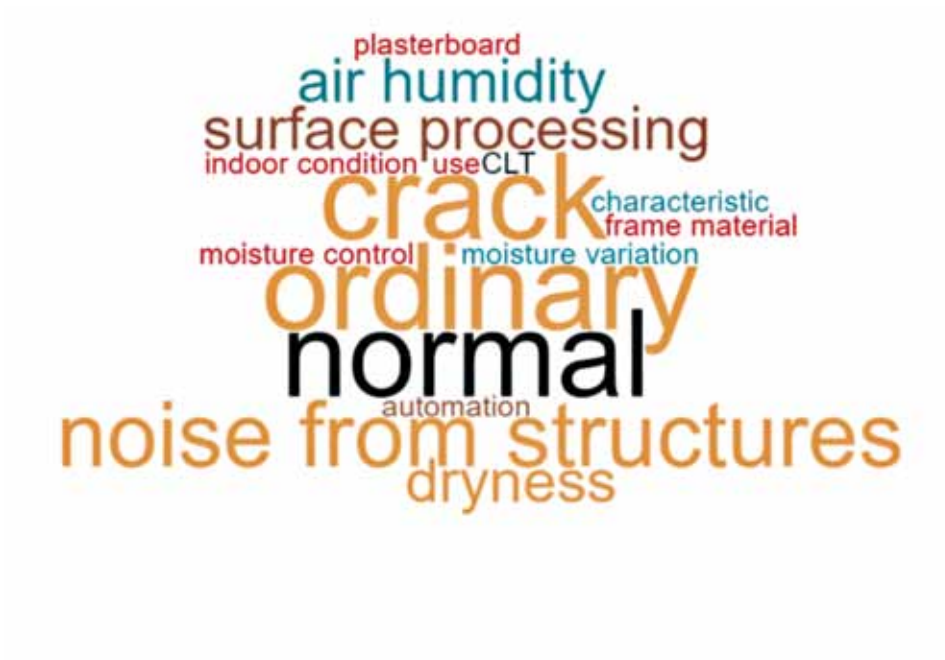
Appendix 2. Keyword cloud theme 1: Selection of CLT as the construction material



Appendix 3. Keyword cloud theme 2: Level of knowledge about CLT construction



Appendix 6. Keyword cloud theme 5: Commissioning of a CLT building



Appendix 8. SWOT analysis and TOWS matrix on CLT construction

CLT CONSTRUCTION SWOT	
<p>STRENGTHS</p> <ul style="list-style-type: none"> → The extremely fast construction process enables competitive operations → CLT enables a high degree of prefabrication and structures that are easy to implement → Reliable, rigid and stable material → Interesting as a new solid wood structure, positive image → Ecological domestic raw material, high recyclability of the material → Visible wooden surfaces create a high-value visual appearance → The inclusion of a sprinkler system ensures excellent fire safety 	<p>WEAKNESSES</p> <ul style="list-style-type: none"> → Too few references at this point → Expertise in design and planning is currently relatively scarce → Strict fire regulations require competent fire technical design → The requirements for worksite moisture control are high → Sound technical design and vibration dimensioning require competent designers and planners → The price of ecological solutions is not easy to define
<p>OPPORTUNITIES</p> <ul style="list-style-type: none"> → The current demand is strong – high growth expectations for the future → Society's commitment to the goals of sustainable development, especially with regard to curbing CO2 emissions → The wood construction strategies of cities and regions are developing → CLT design and production methods can be adopted quickly → Complete solutions are available through CLT manufacturers, for example → Developments in the use of hybrid structures opens up new opportunities → Certain customer segments have the capacity to invest more into the added value sought through wood structures 	<p>THREATS</p> <ul style="list-style-type: none"> → Lack of knowledge gives rise to uncertainty among operators → Clients/developers do not know to consider CLT as an alternative → The benefits of faster construction time are neglected when comparing tenders → The construction phase price is decisive to this day, but will the situation change towards considering the life cycle impacts? → Excessive fire protection covers up visible surfaces – users may not realise being in a building with a wooden frame

MAXI-MAXI STRATEGY (S/O)

- Utilise the positive image of CLT and respond to the growing demand.
- Offer the alternative of ecological construction when cities and regions are committing to sustainable goals.
- Highlight the material's benefits, such as domestic origin, renewability and high level of recyclability in the context of preparing strategies to increase the degree of refining domestic timber.
- Ensure maximal value creation by implementing plenty of visible wooden surfaces to create a high-value visual appearance and a high-quality interior environment.
- Maximise construction speed by making good use of the possibilities of CLT modular units in the construction of multi-storey buildings and in the growing field of supplementary building, for example.
- Utilise ready-made materials of CLT element manufacturers in the design of simple structures that are easy to implement.
- Implement planning based on building information models to ensure that the machining work is conducted as far as possible in factory conditions.
- Prepare a progress plan from simpler CLT projects to more demanding ones, develop the organisation's competence with regard to CLT construction one step at a time.
- Seize the emerging opportunities – experiences have shown that CLT construction is simple and can be easily adopted.

MAXI-MINI STRATEGY (S/T)

- Ensure the development of demand through active marketing that emphasises prior references (CLT projects).
- Improve the visibility of CLT construction by communicating about experiences regarding CLT construction through your own communication channels.
- Make sure that the developing parties have access to up-to-date information on expertise in CLT construction.
- Always utilise functional fire design so that portions of the wooden frame can be left visible; this solution also lowers the overall costs.
- Ensure that your communications emphasise the fact that, thanks to fire technical design and the sprinkler system, a wooden multi-storey building's fire safety is first-rate from the perspective of the user.
- Take advantage of the opportunities provided by the high level of prefabrication to achieve faster construction times.
- Offer CLT prefabrication services to the market – especially in the use of modular units, logistical solutions increase the value of local availability.
- Emphasise the productivity benefits yielded by the fast construction time in your communications – this benefits all parties involved.

MINI-MAXI STRATEGY (W/O)

- Co-operate with various operators and areas to compile a joint CLT reference bank – this can increase the effect of communications.
- Participate in the development of sustainable construction so that the bases for ecological value creation can be defined better than at present.
- Manage cracking of visible CLT surfaces by using boards with bevelled edges or a similar solution.
- Combat the competence deficit in design by specialising in the design of wooden structure and providing related training – the procedures of CLT design can be adopted quickly.
- Engage in the development of sound technical design and vibration management – note the opportunities provided by hybrid structures .
- Utilise the element supplier's design expertise in order to manage the competence deficit.
- Engage in development work with designers and product manufacturers to integrate building services into CLT structures more efficiently than before.
- Utilise weatherproofing efficiently – the solutions and competence are developing rapidly, increasing the quality of the end result, along with safety and efficiency at the worksite.

MINI-MINI STRATEGY (W/T)

- Take part in the development efforts to define reliable labour consumption and cost levels in order to dissolve the markets' uncertainties with regard to pricing.
- Develop competence related to ordering in such a way that enables the added benefit of fast construction time.
- Define the projects environmental goals in such a way that the environmental impacts can be assessed when comparing the tenders.
- Create competition in the CLT market and ensure the availability of domestic material as the demand increases.

The interview study aimed to determine the experiences that operators involved in various phases of construction have had with regard to CLT construction. The study sought to interview the selected operators as extensively as possible with regard to the various phases of the construction project.

Based on the study, we can conclude that CLT has a positive image and it is seen to have a great deal of potential to serve as an ecological alternative for future sustainable construction. Wooden surfaces are regarded as valuable and aesthetically impressive enablers of high-quality indoor environments. CLT is still relative new as a construction material, and the lack of references and experience are seen as the main challenges at the moment. The “Build using CLT” collection of operating strategies was prepared based on the themes that emerged over the course of the interview study.

The interview study report was prepared under the Future possibilities for CLT (FCLT) project, which is implemented as an Interreg Nord research project funded by the ERDF. The project involves the Luleå University of Technology, SP Technical Research Institute of Sweden, Centria UAS, Digipolis Oy and Lapland UAS. The primary objective is to promote the diverse use of CLT and increase awareness of the possibilities provided by CLT construction in the Interreg region. The project was initiated in September 2015 and will continue until October 2018.



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