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IMPLEMENTATION OF LEAN CONSTRUCTION IN FINLAND

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Abstract

Implementation of Lean Construction (LC) can result in profound operational transitions in companies.

The paper explores how different-sized companies in Finland, are approaching the Lean transition: which problems they have solved, and their current priorities.

The objective is to increase the level of understanding of the LC implementation in Finland, following the latest publications in the field. The gained results provide starting points for future studies on LC Implementation and can increase opportunities for Lean managers to be more involved in all levels of the construction process.

Data collection comes from Qualitative Analysis of semi-structured interviews with collaborative visualization.

Introduction

Following the lesson acquired in *The Foundation of Lean Construction* (Ballard et al., 2002), the generally adopted Lean principle amongst companies is to avoid *waste* of time and *money*. If asked, each construction company will answer they would implement new tools to improve productivity flow by increasing their outputs.

This is the case in the construction sector, where Construction Companies (CC) aim to continuously improve productivity in a complex and project-based environment, with scarce resources, little markup margins, and high uncertainty levels in all the project stages, especially in the execution one.

After the seminal work of Koskela (1992), which aimed to introduce Lean production philosophy in the construction sector, the academic debate about the Lean Construction (LC) implementation has been rich, but the actual implementation in many countries, especially for Small Medium Enterprises (SMEs) is behind expectations.

Therefore the transition of CC from a traditional process based to a Lean one, need to be deepened.

The topics covered by the research in this paper illustrate the experience gained by four companies through their evaluation of the different tools LC provides. It explains the difficulties they faced during their transition from a traditional, to a Lean mentality.

The investigation of how these companies applied their Lean transition becomes central: involving their employers, colleagues, and external actors through the implementation of LC tools, like Takt Time, Last Planner System®, Target Value Delivery, BIM 3D to 5D, Clouds platforms, and BIM 6D to 9D.

The identification of these elements, founding LC, comes from the experience acquired from "Lean Construction: Core Concept and New Frontiers" (Tzortzopoulos et al., 2020) and its suggestions for future studies.

This research aims to understand better the practical approach to Lean Production in the construction sector experienced by the four companies selected.

There are two main research questions to be explored. Theoretical Lean Production body-of-knowledge gives already the answers, but there is always a gap between theory and practice.

The two research questions are the following.

What is Lean Mentality? According to the Lean Enterprise Institute: "*Lean is a way of thinking about creating needed value with fewer resources and less waste. And lean is a practice consisting of continuous experimentation to achieve perfect value with zero waste. Lean thinking and practice occur together*."

Who is a Lean manager? A lean manager is a mid- or senior-level employee in a company implementing lean management tactics to produce significant and long-term company improvements.

The research for this paper was collected by the first author during an international exchange program between the University of Tampere and the University of Bologna, and in the following text, the findings from professional interviews with Lean Managers can be found.

At the end of this work, the reader will find a final discussion of the results gained, and some suggestions for further studies.

Methodology

Qualitative research methodology is suitable to ascertain and theorize prominent issues (Shazia, 2014). One-to-one interviews are a commonly used data collection method in qualitative research. The individual interview is a valuable method to understand people's experiences of a given situation or issue that can be used to gather information and data collection. Interviews can be

unstructured, structured, or semi-structured. Semi-structured interviews are in-depth interviews where the respondents have to answer a set of open-ended prepared questions. Anyway, the interview is more than a conversation between two people, and the role of the interviewer to create a good relationship with the interviewee is of capital importance (Frances et al., 2009).

Therefore, the data collection of this research work was done by applying the method of qualitative analysis of semi-structured interviews.

The collection of professional interviews was voluntary, through email or telephone conversation about the interview topics, followed by an hour interview, face to face whenever possible.

The respondents discussed their personal experiences including the difficulties they faced during the Lean implementation path for their companies.

The interviews were divided into four sets of questions and presented to the respondents as a fluent conversation. Finally, a table (Figure 2) was filled by the interviewees, to evaluate the presence of Lean Construction elements in their working environment.

About your experience as professional:

1) What do you think about Lean Construction?
2) When did you discover the importance of Lean Philosophy?
3) Which are, in your working experience, the similarities and the differences between Lean Construction and the traditional Project Management?

About your Companies experience:

4) How does your Company deal with the changes towards a Lean Management perspective, step by step, changing its approach to the field of Constructions?
   - Which tools of Lean has been previously integrated? (For Example, Revit, BIM software with Clouds system, Transparency, work-together, Integrated Project Delivery/Alliance, reduction of Waste, etc…)
   - **How do you start your Last Planner Thinking in a project? Could you show me some examples?**
   - Which are the tools able to change the façade-image of your company, due to the *final costumer* opinion?
   - Problem faced from Manager level to medium and lower levels introducing new tools.
5) Which are, in your experience, the *"never do without it again"* tools of Lean Construction in your company?
   - Which particular tools is your company using during the project development, from the starting design phase to the final one of the Building Sites?
   - IPV (Integrated Project Delivery), TVD (Target Value Delivery), LPS&PPC (Last Planner System® and its Percent of Work Completed), Takt Time, BIM and planning 4D/5D, Coaching, Weekly/daily meeting, Sustainability, Reduction of CO_2, and so on.
6) Which benefits have you gained with the implementation of Lean?

About Building Sites Management & Contracts:

7) How did the management in your Building Site changed (if changed) with the introduction of Lean Thinking?
8) How is it possible, following your experience, the reducing of the arbitrariness on the building sites management **avoiding Waste of Time and Resources**?
9) How do you manage, as construction company, **the subcontracts** in order to keep a high level of Output and good relationship with Stakeholders?
   - Which kind of contract methodologies did you implement to reward the actors of the production process for the Goals reached instead of applying the Land Use and Building Act?
10) Talking about the **Respect for people**, central argument nowadays, how your company is taking care of its employers?

The final question:

12) What do you think about Lean Construction application in Finland and its future coming?

Figure 1: The questions and their structuring for the semi-structured interview process.

The first set of questions above was used to create an opening conversation and establish mutual knowledge between the interviewer and the respondents.

- First set of questions*: about the background of the Respondents*, understanding their previous experiences in the field of Lean Construction, and their reason for adopting it.

The second, third, and fourth sets of questions represented the core theme of this work. Here responders explained the different steps he/ she faced in the past, and the future goals he/she aimed to reach in terms of LC implementation, following the idea of *Continuous Improvement*, to reach a better step for their company in the view of Lean.

- Second set of questions: *About your Company's experiences in the Lean Transition* (transition path step by step; initial application of LPS®; Lean Tools Implemented or discharged; Sharing of Knowledge; Teaching-Coaching);
- Third set of questions: *About Building site Management and kind of Contracts applied*. (How they succeeded to reduce *Arbitrariness* and *Variability* on-site; how they are managing their relationship with sub-contractors; Supply Chain Management; Qualitative Analysis of Building Site; Sharing; Transparence);
- Fourth set of questions: inquiring the respondent about his opinion on LC's future in Finland (Why is a Lean mentality so important nowadays).

Camuffo and Gerli (2012) have identified a lack of skills a Lean manager needs for being effective, and for implementing successfully the lean transformation in his company.

During the interview process, it was necessary to understand the background of the respondents, both theoretical and practical (in LC studies and general Project Management), and their working background combined with their actual field of work.

The combination of these elements indicates the respondents' proficiency in the *"levels of Abstraction"* as from the *"Fruit level"* metaphor (Modig and Åhlström, 2012): training in Lean Principles, their previous working experience and their working position in the company, bring all combined the reaching of different results in term of complexity and fullness, due to the respondents' chance to be more or less incisive and effective about bringing substantial change in their company.

	TOOLS OF LEAN CONSTRUCTION													
YEARS		TVD	LPS	TAKT	BIM	Plann. 4D	Plann.5D	V.M.	Coaching	Qua.Check	IPD	R.for P.	Contr.Rw	Improve.	Transpar.	Sharing
	2009-2015															
	2015-2018															
	2018-2019															
	2019-2020															
	2020-2021															
	2021-2022															
	future															

	TOOLS OF LEAN CONTRUCTION															
Rating		TVD	LPS	TAKT	BIM	Plann. 4D	Plann.5D	V.M.	Coaching	Qua.Check	IPD	R.for P.	Contr.Rw	Improve.	Transpar.	Sharing
	N/D															
	1															
	2															
	3															
	4															
	5															

Figure 2: Style of tables presented to respondents.

Figure 2 shows the two tables presented during the interview phase, that needed to be filled out by respondents at the end of the interview. This process contributes to the gaining of data, about the company timeline implementation of the single Lean Tool, evaluating it in form of a rating on the Likert scale (1 to 5); In addition, the respondents got the chance to talk

about the future idea of implementation of the single tool, not yet implemented. The use of these tables was explained during the conversations and made the interviews more dynamic and involving. (Collin et al., 2014).

Four companies were selected, a solid SME (Small and Medium Enterprises) consultant company in Tampere founded in 2009, and three international construction companies with thousand of employers worldwide and historically settled in Finland at the beginning of the 2000s.

The choice to select an SME for this work comes from the desire to show how different-sized companies can reach a proper Lean transition in a less complex structure when compared to larger ones. In this small-sized company for example, *Continuous Improvement* comes mainly in the implementation of BIM (Building Information Modeling) in *different dimensions* (ref. Table 1, Sbiti et al., 2021), and the desire to reach a most transparent and interactive coordination between the different actors of the planning and design phases. It also incorporates improving quality control and synergy during the processes of using cloud platform systems.

Table 1: Role in the company and general Background of the different respondents

	SME Company	Construction Company	Construction Company	Construction Company
Named As	Company A	Company B	Company C	Company D
Respondents	R.A	R.B	R.C	R.D
Studies Background	Construction Technology	Construction Management and Economics	Construction Engineer	Construction Management and Economics
General Background	Researcher Junior Designer	Ph.D. in Lean Management, Responsible for Procurement and Supply Chain,	VDC-BIM responsible, Site Engineer, Design manager	Researcher/assistant, Production Coacher
Actual Level of Recruitment	Manager	Senior Manager Senior Vice President	Manager	Manager
Actual Field of Work	Virtual Design and Construction	Operation Efficiency and IT	Development, Transformation, and Business Model	Production Process Development, Training Coaching,
Year (Y) of Actual Employment	4 Y	5 Y	2 Y	3 Y

Table 1 shows the summary of the four companies and related respondents' fields of specialization and background in studies and previous working experiences.

The letters **A**, **B**, **C**, and **D** represent the anonymous respondents related to their company of origin: **R.A** (a national SME company); **R.B**; **R.C**; **R.D** (respondents of the three international construction companies).

During the interview process, the author was able to present the questions to two different senior managers, **R.B** and **SVP.C**, the Senior Vice President of Company **C**.

SVP.C was not involved from the start of the semi-structured interview process, being useful at a later time, to offer specific insight from the management point of view of the Lean implementation process in Company C, about the argument afforded with **R.C**.

The professionals that have been interviewed during this work remain anonymous, so as not to violate privacy standards. Anyway, this does not compromise the quality of the research concerning the discussed topics.

Discussion and result analysis

In coding the qualitative interviews, some common needs come out. They are all factors of interest from the point of view of both SME companies and big-sized construction ones. Where necessary, each theme is presented in form of problems-solutions:

- The need for more reliable ways of sharing information, especially through software to improve better coordination between all the actors involved in the building process.
- The need for a quality control platform, to share comments about the reliability of external suppliers and subcontractors to gain more reliability in the construction process.
- Accessibility to the Suomi Language.
- *Takt Time* and *Last Planner System* ® according to the companies involved;
- The importance of Lean Mentality in Today's world, after the pandemic and during a European War that increases the cost of materials due to the lack of their availability.
- The importance of skilled Lean managers in companies' top positions, to drive the company in the right direction.

The need for a new way of Sharing information.

Following the teaching of *Technology adoption in the BIM implementation for lean architectural practice* (Arayici et al., 2015), about the importance of convincing SME to complete adopting BIM for personal advantage, the **R.A**, is focusing on BIM implementation in the company business. Not only as a 3D-design tool enabling a company to provide all simulation processes necessary during the design process (like BIM 6D, 7D, 8D) but also in a Lean perspective: he desires to enter the new phase of BIM, the 9th (BIM 9D, the Lean dimension).

Following the idea of *Continuous Improvement*, in the past 3 years **R.A** worked on different kinds of platforms to create a continuous connection of BIM data between all actors in the construction process, applying BIM in a form of a shared information tool, where the complexity of the project could be managed simultaneously by all actors involved.

Nowadays these kinds of interactive sharing platforms are

generally accessible. The problem comes when a company would like to improve all aspects of the planning, design, and quality control processes with stakeholders and sub-contractors, on their platform, to avoid *Wasting Time* and lack of information in general.

R.C discussed the need for tool sharing: "*Not for the logistics, we are looking into logistic partners but not for the management of materials and not for the timetable not for cost control. But for quality control that has changed a lot, the checks were made but not documented and this is something we are working on in the past years quite a bit of course like moisture management is something that we have changed the way of doing things"*. The respondent is referring to a specific platform that enables the actors to perform quality checks in BIM format, all the elements composing the building: if you are a contractor, a client, or a stakeholder, you can share your opinion over the work accomplished handy on-site, by the use of a mobile phone or a tablet connected with the software. Multiple articles have been published about it, especially in Finland. These kinds of tools are useful to connect the different actors, avoiding waste during the quality check process: daily on-site, employers and supervisors could verify the quality of the work accomplished by others, even critique it.

R.D is highly interested in a more modern way of looking at BIM, and in general, the process of sharing materials, blaming the loss of information that happened during the planning process and the technical design phase: *"We could lose time for an email not delivered, incomplete version of the files, a personal distraction, a file not saved, multiple files with the same names in different databases!"*.

A most complete platform of tools would facilitate synergy between all actors involved during the building processes, leveling up the quality of the entire design phase, through a considerable reduction in terms of timeline and economic waste. In general, it would be easier to identify the bottlenecks of the processes, instead of traditional passing by-hand information, avoiding lack of files, oversights, and loss of information in general.

Today's different software houses are involved in the creation of the most complete sharing platform, but there are two main problems needed to be afforded according to the Respondents. One problem is represented by the cost of this type of integration software. Usually, software companies sell a premade package of tools, that could not reach the exact interest in that form for designers and planners, and the integration of the requested tools into the package makes the license price rise, without giving the exact requested tools to the single company, increasing the waste of money). The second problem comes from the need for a general contractor company: spend an optimized amount of time to skill stakeholders and sub-contractors on the platform they used to work on.

To reach a better spread of their sharing tools, software houses are trying to make more accessible their products, with an original way of licensing. When a company holds the main license, all others involved in a particular project, receive access to the tools contained in the main license for free. This way of managing licenses represents a good starting point to make that software more accessible and widespread, increasing the chance of using the same-tools platform: fewer compatibility problems, less lack of files through other systems (like email, portable document, or general clouds system), less variability, and less time spent over external teaching.

[R.D]*: "Nowadays we lose a lot of time requesting the file, and documents, convincing subcontractors to start using our platform and not another (…) but is much easier to say. Every company designs in different ways, using BIM in its own form. The choice of a subcontractor consists of continuous work of increasing the quality of the mutual esteem and reliability"*

[R.A] *"One of the main problems I am facing is to keep the flow of the project while teaching an external company, our way of working on BIM, making them learn a sharing platform in a small amount of time; the main problems consist in keeping the investment of that time spent to reach a good point of synchro, for a sequent high-quality work in a second time."*

The problem faced by the previous professionals are common for others: **R.B**, declared to have started in the past years, mandatory courses for every external company who desires to work with them (subcontractors, suppliers, etc.), a necessary **prerequisite** that needs to be accomplished before any common initiative.

Company C acted differently. According to their **SVP**, they produced a new software, which become mandatory, to connect all the actors of the building process, which allow all to interact with each other, highly increasing the level of synergy.

For example, an elevator construction company provides 5 mandatory requisites to a Construction Company that called them to install different elevators, to avoid wasting time, and so money: space on-site for the elevator, space on-site for its employers, mandatory dimensions for the installation of its products, etc. The problem faced by this elevator company is quite simple: they blamed with **SVP** of Company **C** for the time spent in their car, by their employers, waiting for the accomplishment of the 5 requisites, despite that information being mandatory for the day programmed.

The problem was certainly due to a lack of communication between the construction company and its employers on one hand, on the other hand, the elevator company never thought to contact directly the site employers before reaching the location.

The software produced by company **C** allows for example to contact supervisors on-site, order materials, verify the availability of space on-site, and make checklists of building processes, in a stand-alone way, based on the needs of everyone. The *Waste of Time* spent and the lack of *Transparency* have been cut properly.

The need for an easy-access system of Quality feedback for external actors.

A common argument in the field of building processes is the need to find in the quickest way possible, external reliable partners to accomplish a construction project.

The selection of external partners in other countries, like in Italy, follows the rules of the "lowest bid" with some updates in the last two years. During the interview process, one of the main topics discovered, shared by all the respondents, has been the creation of an internal database where the companies declared to rate daily external collaborators who worked with, in terms of quality-output, reliability, capability, etc.

Famous software houses are proposing their version of it, where you can rate, adding explanations, an exact company (stakeholder or subs) in a precise location: *"How do they work? Are they reliable? Can they respect the time schedules? What about the general relationship with other actors? Etc."* **R.D**

The use of this kind of software started in the past few years and could become news for both, SMEs and general construction companies: quoting the **R.B**: *"Finland is not a big Country (…) and we usually know each other but can happen you are working in a new geographical area and you cannot orientate yourself as usual (…) the creation of a platform where you can find reliable assessments of a new Subcontractor by someone you know, explaining the goals or the failures reached with them, is a need.".*

The Lean perspective coming out in the previous sub-chapters, following the experience acquired in "*Lean Construction Tools and Techniques*" (Ballard et al., 2007) is this one: we learned the importance of the "*use of technologies that facilitate lean design*" by "*Sharing Geometry and Web-based interface*", because the direct impact of better tools-sharing, will reduce the reaction time in the recognition of design failures or misunderstanding, increasing the quality of design phase thanks to the synergy between the parts, and a better starting point in the creation of reliable relationships, all fundamental factors in all the phases of the construction process.

In the work "*Rethinking Communication in Construction*" (Wikforss et al., 2007) the argument of communication in the Construction Process has been put in evidence as a focal point.

The arguments discussed with the multiple referents are in accord with the conclusion by UKEssays, 2018, about a deep connection between the organization of internal communication & Lean tools: the elimination of Waste occurred "*through the use of organizational communication in conjunction with the use of Lean Thinking tools*" in a continuous improvement mentality. (UKEssays, 2018).

In this modern era, where information (like BIM, spreadsheets, simulations, data collection, etc.) is a "good" shared digitally, it becomes a fundamental modern way of coordination, especially from the Lean Management point of view.

This way of being more synergistic will reduce, according to the respondents, 15-20% of time spent during the planning phase.

Company **C** brought this way of thinking to another level following the idea of the Toyota Way (Liker, Jeffrey K.,2004*)*: in the past, they used to work with tens of subcontractors, depending on the "lowest bid" offer. In the last 6 years, they drastically changed this way of thinking and they cut out the majority of those collaborators, creating lasting and exclusive long-term relations with just two of them. This accomplished more: both of these two sub-contractors used to work in different fields, from construction to installation plants. Now, one focuses its work on the construction process, and the other just on the plants. They have reached a high degree of optimization in quality and proficiency, which allows **C**ompany **C** to work with them on 90% of the work accomplished.

Finnish Language versions of software packages.

One of the main problems that come out during the interview phase is the lack of accessibility using the Finnish Language for the majority of the software previously discussed fundamental challenge for a complete mastery of it at the employers' level, especially on-site. This problem is present in nearly all software involving the multiple phases of the construction process (from the design and planning to the quality control). The social diversification in the world of construction and the accessibility of the prior language for a country is necessary to reach a hegemony from all levels consisting of a construction project, following in this way the suggestions of the EU laws in matter of accessibility and diffusion of BIM: *CEN/TC 442 (BIM), 2020.*

The extensive use of the Finnish language is necessary if we think to involve all the actors and the employers in the building process following the Lean principles. For example, during an IPD, where different-sized companies work together on a BIM cloud platform, the accessibility to the information flow and its management for local companies keeps the communication system standardized, improving the transparency of the entire building process, the synergy between the actors, and the production flow.

TAKT and Last Planner System® according to the companies involved.

TAKT: According to respondents **R.B**, **R.C,** and **R.D,** *Takt* is the most important Lean Tool implemented in their companies. It began to be applied firmly just after the previous pilots, on the one hand, due to the high level of standardization in the Finnish construction market, like residential buildings. On the other hand, it was introduced because of its capability to avoid arbitrariness, managing the three flows: Workflow, Trade flow & Logistical flow.

R.B*:* "*Especially in residential where we have a lot of repetition, Takt Time Planning is useful. In Commercial buildings, it is really hard to complexity use due to the lack of repetition. You need more reliability because you need to plan in more detail dedicating certain spaces to a certain crew. So it helps you, you early note if something goes or not.*"

R.C explained why considers Takt Time fundamental: *"It is fundamental for the improvement of the Flow (…) for not repetitive buildings you can organize the work looking for repetitive elements like windows, bathrooms, and others if you*

look deeper and you will find the key for the repetitiveness in all the project."

Respondent **R.D** declared *"They find Takt really useful, but they are proposing it as a volunteer tool, where all the actors involved asked for it because they know this way of managing the arbitrariness in the buildings process."* on the contrary they applied the traditional way of planning and building.

Following the *Continuous Improvement*, two of the companies involved in the Interview process are working today on a new platform that will bring Takt Time to the next level, using it in form of software: *"from schedule planning to production control and daily construction site management"*.

About ***Last Planner System*® (LPS)**. **R.A** explained they applied *LPS* as a tool, starting from the BIM, and increasing it on-site, in a standalone way with *Takt*, not already implemented in their company.

R.B and **R.C**, applied it strongly in their construction processes, finding it necessary nowadays, especially combined with *Takt Planning* due to its capability. Under the *Collaborative Planning* mentality, it increases the quality of relations between the actors of the processes and so, more reliable relations during the next works.

LPS is considered the tool able to cure the lack of involvement and transparency between the different actors in the building process. Daily and weekly meetings are fundamental to avoid communication gaps.

Following the *Continuous Improvement* mentality, *Table 2* showed a summary of the path for each company in their LC transition, showing the timeline of the improvement of the single LC tool combined with the rating the respondents gave according to their company experience.

Table 2. LC Tool, timeline-rating table.

Company	A		B		C		D	
Year of Foundation	2008		<2003		<2003		<2003	
Respondents	R.A		R.B		R.C		R.D	
BIM 3D	2018	5	2000-05	4	2010-15	3	2015-20	5
BIM 4D	2021-22	3	2005-10	3	2015-20	4	2020-22	4
BIM 5D	future	/	future	/	2015-20	4	future	/
TAKT	future	/	2015-20	5	2020-22	4	2020-22	5
LPS®	2020-21	3	2003	4	2015-20	4	future	/
TVDesign	2021-22	/	2010-15	/	future	/	N	/
Teaching	2019-20	4	2005-10	5	2010-15	4	2005-10	5
Sharing Tools	2019-20	5	2018	5	2015-20	5	future	/
Resp. f. People	2018-19	5	2010-15	5	2010-15	4	2020-22	4
Transparency	2019-20	5	<2003	5	<2003	5	<2003	5
IPD	Future	/	2015-20	5	future	/	future	/
Sustainability	Future	/	2010-15	4	2020-22	3	future	/

The Likert scale applied for the filling, (where "1" represented the minimum, "5" a maximum; "/" an impossibility in the rating due to its short-term status or for a "future" idea of implementation), gives the evaluation of the effectiveness of the LC tool implemented by the relative company, according with their direct experience: most important and effectiveness is considered the implementation of that tool, higher is the evaluation according to the respondent's opinions.

About the internal training and **Teaching** in the arguments of Lean Construction: during the interview with **R.B** comes out a singularity of his approach looking for a better way to implement Lean inside **C**ompany **B**, starting from the need to introduce changes in the daily routine of employers:

(**I**): *"Talking about **Teaching**, what are the reasons that bring you to decide to use other terms instead of LPS or similar, with employers? Did it work to help the new improvement mentality to them? How did you involve people without making them bored or having bad feelings about their working routines, acquired in years of studies and experiences?"*

R.B answered*: "This is actually a really good point because normally it is very difficult to implement anything just saying it is an advantage for the company; because people are still like resistant mentally, it seems they cannot gain anything by it so the interest is kept low. But basically when they discover a change in their work habits is making their work easier, with less hassle to do, ending their work at 4 pm, not at 6 or 7 pm, and having their working day done when it is supposed to be. So this is probably the biggest motivation that it takes interest out of people in this."*

This explanation is useful to understand the previous considerations about the importance of a Lean Specialist in a top position: this company started applying an LC mentality from its top management level to the downer.

During its LC implementation process, company **B** has been constantly monitored, data has been collected and evaluated, and in the end, redesigned, following an improvement path that requires time, and energy but ultimately enables it to reach big goals.

The Importance of Lean Mentality Today.

The importance of a Lean mindset today has been revealed by the interviews. The respondents pointed out the importance of LC mentality coming out from the 2008 crisis in Finland, and also currently because of the effects of the current crisis, that is affecting European construction. LC mentality was defined based on the five principles of the Lean foundation: 1) Identify Value, 2) Map the Value Stream; 3) Create a Flow; 4) Establish Pull; 5) Seek Perfection, (Womack & Jones, 1996).

All of the respondents agree that a Lean approach in the evolution of their companies is the key to the reduction of general *Waste,* and reliably receiving a high return on Equity. For example, **C**ompany **C** declared to have reached a 25-30% of increase in value, after its LC implementation process.

The transition processes undertaken by the different respondents and companies increased drastically the quality of their relationships with the third actors involved in the construction processes, like sub-contractors, due to a mentality of *Transparent Collaboration*.

During another interview with Professor **Lauri Koskela**, it came out that the main aspects of the LC are strongly connected to Lean Manufacturing, and its pillars build on the desire to avoid any kind of Waste.

Under Koskela's view of Lean Construction, the most important part of a good Lean transition should be the current improvement of *Collaborative Planning* through *Last Planner System®*, the improvement of *BIM* in its all dimensions, and the *Continuous Improvement* of the output quality of the prefabrication building system.

The importance of skilled Lean managers in companies' top positions.

In comparison with the implementations in Companies **B** and **C**, in a Continuous Improvement mentality, the situations of **R.A** and **R.D** is quite different and more complicated: while applying their Lean competencies in their fields of work, they are trying to increase the level of the Lean implementation in their companies pushing their founding values and making them more suitable for the companies they work for, spending a lot of time and energy in this process. **R.B** and **R.C** on the other hand, work in companies where Lean is strongly applied and appreciated at all levels, and after years of structural change, they are able now to look into new goals, increasing their presence on the market with a new set of collaborative tools that should make possible an increase in the level of quality, and implementation of Collaborative Production on-site. Companies like **B** and **C**, are nowadays involved in the creation of a common project: a "Takt Time real-time schedule tool" quoting **R.B**.

In the work, *Project Managers' Competencies in Collaborative Construction Projects (*Moradi et al., 2020) the need of having a skilled professional in a top-level position in a company during an implementations phase, is fully explained and this mentality should be used also for Lean managers.

Conclusions

This paper has reviewed the situation of LC tools implementation, according to the companies. Tools like *BIM*, *Cloud platforms*, *Last Planner System®*, and *Takt*, can certainly be used without a Lean approach, but the theory of Lean Construction (Tzortzopoulos et al., 2020) furbished such well-structured companies a new set of reasons to put on trial and then start a new version of themselves.

It is easy to understand that Large-size construction companies have certainly an advantage, compared to SMEs, in the number of LC tools they can handle, but the level of gained benefits depends strongly on the level of involvement covered by Lean managers in the different sectors of the company. It is essential that LC top managers continuously monitor and direct the path for a Lean transition, keeping up the economical stability of the company during the multiple steps of development.

Deep internal dialogues within large-sized companies are necessary to understand the actual goals of the LC implementation. Compliance with the clients and market requirements should not be ignored.

Another result of the research work on which this paper is based is the proof of the importance of Transparency in LC. During the interview process, as shown in Table 2, it is the only LC tool that scored 5/5 on the Likert scale according to all the respondents, more than TAKT and LPS®.

As shown in the Discussion and Data Analysis chapter, Transparency is strictly interconnected with the Continuous Improvement approach, and it becomes central in all the sub-arguments afforded in this work. Its presence is constant and undertrack in:

- the improvement of the internal communication system for each company, to avoid bottlenecks during the multiple phases of the construction process;
- the improvement of quality relations between the different actors of the construction process through BIM-based Cloud platform software, to avoid loss of information and general misunderstanding;
- the need for a quality-based database platform to select reliable subcontractors;
- the implementation of tools like TAKT and Last Planner System®, to obtain higher levels of optimization of each elementary production process, and to allow real-time operations;

About the importance of Transparency in the construction sector, it is worth mentioning that Finland was ranked first in the list of "Most Transparent Countries" by USNEWS in 2022: LC principles seem to perfectly match in this society, despite the complexity of the construction world, due not only to the reliability and equity reached by the companies interviewed. It is a cultural argumentation.

The limitation of this work resides in the limited number of companies involved during the interview process. Involving more construction companies could produce a better understanding of today's practice of Lean Construction Implementation, and its actual priorities.

Thus, it would be interesting to apply the adopted research approach in larger numbers also outside Finland, to gain a better understanding of the L.C. implementation in the European industrial sector.

Possible future studies could address the mindset adopted by Lean managers during the transition processes of the companies they are working for, combined with a better knowledge of their internal organization, and the level of commitment of the entire company.

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