Aalto University
School of Science
Master's Programme in Information Networks

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Developing resource-efficient aggregate stone use with lean thinking: case study of an urban area development project

Master's Thesis

Espoo, May 24th, 2017

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School of Science

Aalto University School of Science Master's Programme in Information Networks	ABSTRACT OF THE MASTER'S THESIS

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Title: Developing resource-efficient aggregate stone use with lean thinking: case study of an urban area development project

Number of pages: 77 (+3)	Date: 24th of May 2017	Language: English
Major: Knowledge Intensive Business	Code: T3008	

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The Finnish aggregate stone industry is shifting towards resource-efficient use of stone aggregates. The process of aggregate stone use, however, has not been studied or modelled before. This thesis studies an urban area development project and its use of aggregate stone, and applies lean thinking to the development of resource-efficient aggregate stone use.

A literature review of lean thinking is first conducted which results in a theoretical synthesis of lean implementation to intra- and inter-organizational contexts. The literature review reveals that in inter-organizational contexts, a collaborative atmosphere and contextual understanding are prerequisites of lean implementation. Application of lean and continuous improvement in such settings occur through waste elimination, partnering, and structuring the context.

In the empirical study, a combined process model of the urban area development project and its use of aggregate stone is created based on the analysis of one case project. The findings reveal the challenges of the current aggregate stone use process, and important development ideas for improving the process. Applying the theoretical synthesis of lean to interpret the empirical findings, the key characteristics of a generic resource-efficient aggregate stone use process are derived.

The empirical case study shows that the urban area development project features an uncoordinated and invisible process of aggregate stone use. Aggregate stone issues are only occasionally discussed and other aspects of urban area development are prioritized. This results in increased costs for the municipal organization and higher taxes for the residents. A new process for aggregate stone use should be developed that coordinates the aggregate stone masses in and across municipal construction projects, streamlines the collaboration of administrative officials, and keeps all relevant stakeholders informed and involved.

The core activity in a resource-efficient aggregate stone use process is the coordination of the aggregate stone masses produced and used in different municipal projects. Value creation is optimized by planning and scheduling projects in a way that allows resource-efficient use of stone aggregates. Wastes are reduced by avoiding unnecessary transportations and temporary storing of stone aggregates. Partnering with nearby municipalities is required to achieve an optimal situation of resource-efficient aggregate stone use across municipal borders. Collaboration between administrative officials, elected officials, and local area users and residents is required to streamline the urban planning and permit processes, and to reduce the amount of appeals. The process of resource-efficient aggregate stone use should also be continuously improved.

Keywords: resource-efficiency, aggregate stone use, lean thinking, urban area development, process development, process modelling

Aalto-yliopisto
Perustieteiden korkeakoulu

Aalto-yliopisto Perustieteiden korkeakoulu Informaatioverkostojen maisteriohjelma		DIPLOMITYÖN TIIVISTELMÄ
Tekijä: Artti Kaipainen		
Työn nimi: Resurssitehokkaan kiviaineshuollon kehittäminen lean-ajattelua soveltaen: tapaustutkimus kaupunkialueen kehittämisprojektista		
Sivumäärä: 77 (+3)	Päiväys: 24.5.2017	Julkaisukieli: englanti
Pääaine: Tietointensiivinen liiketoiminta	Koodi: T3008	
Työn valvoja: Professori, TkT Riitta Smeds		
Työn ohjaaja: TkT Rita Lavikka		

Suomen kiviainesteollisuudessa tavoitellaan entistä tehokkaampaa kiviainesten käyttöä. Kiviaineshuollon prosessia ei kuitenkaan ole tutkittu tai mallinnettu aikaisemmin. Tässä diplomityössä tutkitaan aluekehitysprojektia ja sen kiviaineksen käyttöä sekä sovelletaan lean-ajattelua resurssitehokkaan kiviaineshuollon prosessin kehittämiseen. Työn kirjallisuusosa käy läpi lean-ajattelun teorioita ja luo synteesiä yritysten sisäisiä ja yritystenvälisiä prosesseja koskevasta lean-johtamisen tutkimuksesta. Kirjallisuuden mukaan yritystenvälisissä prosesseissa keskeisiä leanin edellytyksiä ovat hyvä yhteistyöilmapiiri ja yhteistyön kontekstin ymmärtäminen. Yritystenvälisissä yhteistyöprosesseissa leanin soveltaminen ja prosessien jatkuva kehittäminen tapahtuu poistamalla prosessista erilaiset hukat, luomalla sopimus- ja yhteistyömalleja, ja jäsentämällä yhteistoiminnan kontekstia.

Tutkimuksen empiirisessä osassa luodaan tapaustutkimuksen avulla yhden aluekehitysprojektin prosessimalli, joka yhdistää aluekehitysprojektin ja sen kiviaineksen käytön. Empiiriset löydökset kuvaavat kiviaineksen käytön haasteita, ja esittävät runsaasti prosessinkehitysideoita. Tutkitun aluekehitysprojektin kiviainesprosessi oli koordinoimaton ja näkymätön. Muut aluekehityksen osa-alueet ohittivat kiviainesasiat, joista kunnan eri yksiköiden virkamiehet keskustelivat keskenään vain satunnaisesti. Tämä lisää kuntaorganisaation kustannuksia, mikä voi johtaa veronkorotuksiin. Kiviaineshuollon prosessia voidaan kehittää koordinoimalla kunnan rakennusprojektien massojen tuotantoa ja käyttöä, sujuvoittamalla yhteistyötä lupaviranomaisten kanssa, lisäämällä viestintää sidosryhmille ja osallistamalla olennaiset sidosryhmät prosessiin. Koordinaation tulisi toimia myös läheisten kuntien rakennusprojektien välillä. Empiiriset kehitysideat tulkitaan työn lopussa lean-johtamisen teorian avulla. Tuloksena saadaan resurssitehokkaan kiviaineshuollon geneerisen prosessin tärkeimmät ominaisuudet.

Rakennusprojekteissa tuotettujen ja tarvittavien massojen koordinointi on resurssitehokkaan kiviaineshuollon prosessin ydintoiminto. Sen arvonluontia voidaan optimoida projektien ennakoivalla suunnittelulla ja aikatauluttamisella. Turhien kuljetusmatkojen ja välivarastointien välttämisellä vähennetään hukkia. Yhteistyö lähialueen muiden kuntien kanssa parantaa resurssitehokkuutta edelleen. Kiviaineshuollon prosessilla on oleellisia liityntöjä aluekehitysprojektin lupa- ja kaavaprosesseihin. Prosessien sujuvoittaminen vähentämällä kiviainesten käsittelyyn liittyvien valitusten määrää edellyttää kunnan virkamiesten, lupaviranomaisten, luottamushenkilöiden sekä alueen käyttäjien ja asukkaiden yhteistyötä. Resurssitehokkaan kiviaineshuollon prosessia tulisi kehittää jatkuvasti.

Asiasanat: resurssitehokkuus, kiviaineshuolto, lean-ajattelu, aluekehitys, prosessikehitys, prosessimallinnus

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I INTRODUCTION

1. INTRODUCTION

This master's thesis studies the development of resource-efficient aggregate stone use. The empirical part of this thesis examines a case study of an urban area development project and its potential to use local aggregate stone. From the empirical data, a combined process model of the urban area development project and its aggregate stone use process. The current aggregate stone use process and its challenges, as well as development ideas for improving the process are examined in the empirical study. These development ideas are then further refined with the theoretical lenses formed as a synthesis from a literature review of lean thinking. Thus, new understanding about the key characteristics of a generic resource-efficient aggregate stone use process is created.

This first chapter sheds light on the background and topic of the thesis. Chapter 1.1 introduces the Finnish aggregate stone industry, and the Finnish planning process is described in chapter 1.2. The shift towards resource-efficiency in the Finnish aggregate stone industry is discussed in chapter 1.3, and chapter 1.4 introduces the REKI-project and the motivation for the thesis. The research process and thesis objectives are presented in chapter 1.5, the research problem and questions are formed in chapter 1.6 and finally, the research approach and method are described in chapter 1.7.

1.1. THE FINNISH AGGREGATE STONE INDUSTRY

Finland has a cold and therefore challenging climate, which needs to be considered in construction. The foundations of buildings and infrastructure need to be constructed under the ground frost level. They also need to be built thicker than in other European countries because of the ground frost. The vast Finnish road network requires a tough foundation and thus a lot of stone aggregates, as well as frequent maintenance, due to the ground frost and the use of skidded tires during winter time. These factors combined increase the use of stone aggregate and thus, the use of stone aggregates per capita in Finland is one of highest in European countries. (Lonka & Loukola-Ruskeeniemi 2015, p. 11-12)

In Finland, the yearly usage of stone aggregates for the construction of new structures and for the maintenance of existing structures is approximately 100 million tons. Most

of the stone aggregates are used for the construction of roads, streets and railroads. The Finnish aggregate stone industry employs 3000 people and has an annual turnover of 550 million euros. The annual turnover includes the transports of the aggregates, which make up for approximately half of the price of the aggregates. (Lonka & Loukola-Ruskeeniemi 2015, p. 11-14) The public sector, consisting of the municipalities and the state, is a major buyer of stone aggregates used for infrastructure building. Together, the municipalities (34%) and the state (22%) account for 56% of stone aggregates bought for infrastructure building. (Lonka & Loukola-Ruskeeniemi 2015, p. 67)

1.2. THE FINNISH PLANNING PROCESS

The Land Use and Building Act (Available at: http://www.finlex.fi/fi/laki/kaannokset/1999/en19990132.pdf, Accessed 18 May 2017) defines the Finnish planning process, which is described in this chapter. A lot of responsibility is given to the municipalities, who produce and approve the plans used to guide local land use. The planning process on all its levels has a significant impact on the use of stone aggregates and is an important part of the context of this thesis.

The Finnish Land Use Planning System

The Finnish land use planning system is a hierarchical system with four stages, in which the higher level plans guide the lower level plans. The Finnish government issues **national land use guidelines**, which must be taken into account in regional planning, municipal land use planning and the activities of the state authorities. **Regional land use plans**, which are done by regional councils, take the national land use guidelines into account and provide a general framework for the local master plans, joint master plans or partial master plans. The **local master plans**, which give general land use directions, are drafted by municipalities and they are approved by city councils or municipal councils. If the plan is formed by groups of municipalities, it is called a joint master plan. If the plan only covers a part of the municipality, then it is called a partial master plan. The local master plans coordinate and direct the **local detailed plans**, which are also drafted by municipalities and approved by city councils or municipal councils. The local detailed plans have the highest impact on the design and construction of local neighborhoods, as they include regulations on the use of areas and on the types of allowed construction. They also include the volumes and

locations of buildings and specify the street and park areas. (www.ymparisto.fi/en-US, 8.9.2016)

Urban Planning as a Networked, Municipal Process

The preparation of local master plans and local detailed plans are done by the municipalities and are a part of urban planning processes. Väyrynen (2010) defined urban planning as follows:

Urban planning is a political, social, professional and architectural practice with related processes, aimed at influencing the future of the municipality and the living environment of its member citizens.

Therefore, it is a complex process which involves lots of different stakeholders with differentiating values, motives and possibly contradictory goals. Pursuing resource-efficiency, which is defined later, in the aggregate stone industry can be considered as one of them.

Impact Assessments, Participation and Appeals

Impact assessments are a core part of the planning process. The impact assessments, which must be backed up by sufficient studies and reports, are case-specific and based on the Land Use and Building Act. The reports and studies need to provide adequate information for the assessment of immediate and derived impacts on

1. the living conditions and living environment of people
2. ground and rock, water, air and climate,
3. animal and plant species, natural diversity and resources,
4. regional and community structure, community and energy economy and traffic,
5. urban setting, landscape, cultural heritage and built environment. (www.ymparisto.fi/en-US, 8.9.2016)

The processes of the Finnish land use planning system are **participatory** in their nature. Finland's Land Use and Building Act preserves the citizen's right to take part in the land use planning processes, which are specially designed to facilitate participation. The participation is open to both:

- landowners, local residents and people whose livelihoods or other interests are significantly affected by plans and
- private firms, public authorities and organizations, whose activities may be affected by plans.

As a part of the process, residents, organizations, and authorities have the right to make objections to the plans. The right of **appeals** applies to all concerned parties, whose livelihoods or interests are considerably affected by the plans. Appeals against regional land use plans and joint local master plans are handled by the Ministry of Environment, whereas the appeals against local master plans or detailed plans are handled by administrative courts. All further appeals are submitted to the Supreme Administrative Court. (www.ymparisto.fi/en-US, 8.9.2016)

1.3. SHIFTING TOWARDS RESOURCE-EFFICIENCY

Finland has good natural stone resources as well as a solid bedrock foundation, from which crushed aggregate stone can be excavated. These resources have served the needs of the scattered Finnish population in its large area for a long time. However, there is societal pressure to change towards using the stone resources more efficiently. In the past, the natural stone resources, such as gravel, were used a lot in construction because they require no crushing or further processing. Natural gravel occurrences, because of this, have diminished. This causes environmental damage since the natural gravel occurrences are very important for the protection of groundwater sources. There are nowadays stricter requirements for getting a permit for natural gravel excavation.

Instead of gravel, crushed aggregate stone from the solid bedrock foundation can be used in construction. In the last few decades, there has been a shift towards using more and more crushed aggregate stone instead of gravel, and the shift is expected to continue in the future. Also, mining and crushing technologies have developed, which has contributed to the shift alongside the desire to preserve the groundwater sources. This shift is more evident in the bigger cities of Finland, where there are not so many available natural gravel occurrences nearby to fulfill the needs of all construction projects. Using crushed bedrock aggregate instead of natural gravel is more demanding because it involves the extraction of the bedrock aggregate and in most cases the processing or crushing of the bedrock aggregate to the desired form.

Resource-efficiency, in the context of this thesis, refers to using crushed bedrock aggregates instead of natural gravel in construction and maintenance of existing structures. Resource-efficiency also entails using aggregates in an optimal and environmentally friendly way. This means minimizing the transportation distances and temporary storing. Minimizing the transportation distances lowers the harmful emissions from trucks, reduces the wear of road networks, as well as the costs for

transportation. Avoiding temporary storing as much as possible is important since optimal locations for it are hard to find and the heavy, temporarily stored aggregates harm the ground beneath it.

1.4. THE REKI-PROJECT AND MOTIVATION FOR THE THESIS

This thesis is one outcome of the REKI-project, which is a joint project of the regional councils of Häme, Päijät-Häme, and Uusimaa. The full name of the project is '*Resurssitehokas Kiviaineshuolto'* and REKI is the abbreviation for it. In English, REKI stands for resource-efficient aggregate supply. One of the main motives behind the project was the desire to define the process of a resource-efficient aggregate supply, as the regional councils want to preserve their natural gravel occurrences and groundwater sources. Three objectives were set for the REKI-project:

- To define the process of resource-efficient aggregate supply and the magnitude of its economic and social effects
- To identify necessary actions to improve the industry and its innovative policies
- To come up with a financially eligible consortium project for 2016-2020, that creates a new set of industrial services based on sustainable use of natural resources.

Alongside the three regional councils, the steering group of the REKI-project featured representatives of the Ministry of Economic Affairs and Employment, the Ministry of Environment, TEKES, Aalto University, the Finnish Environment Institute, the Geological Survey of Finland, ELY Centers, Vahanen Oy, Outotec Oy, Morenia Oy and Infra ry. The REKI-project began in early 2015 and lasted until the end of February 2016. Four workshops and a seminar were organized during the project to gather and create knowledge about resource-efficiency in the Finnish aggregate and natural stone industries.

This thesis does not directly aim to pursue the objectives of the REKI-project. The objectives, though, had a clear impact on the motivation for this thesis. Also, my study background, especially in the SimLab's study track of knowledge and business networks in Aalto University, greatly affected the motivation behind this thesis. The focus of my studies has been in managing collaboration and innovation in networked

contexts and developing organizational processes in knowledge-intensive business networks.

During my studies, I have seen the potential of process understanding and modelling. Modelling processes and making them visible to the people that manage them and are affected by them, is something that can be highly valuable to people. By making the process visible to the people participating in it, they better understand the role of their work in the process and how it affects others. Thus, also the development of the process becomes more meaningful and effective. If people do not see the benefits of taking action to develop processes, they are hesitant to change their ways of working and implementing the change can be difficult.

I found it intriguing, that the process of resource-efficient aggregate stone use has not been defined or made visible before. In fact, no process of aggregate stone use has been researched before. This fact alongside my study background motivated me to focus my research on understanding this process better.

Another motivating factor for this thesis stems from the pursuit of resource-efficiency in the REKI-project. I wanted to add a theoretical point of view to this pursuit. Lean thinking was a theoretical concept that I had a basic understanding of: it is about removing all unnecessary activities from your organization's processes and optimizing the core, value-adding activities. It also has been applied to many different kinds of contexts, e.g. construction projects and software development, which demonstrates that there is potential in applying it to new contexts. It is also used nowadays by many companies as a process development approach or methodology. Therefore, I wanted to explore lean thinking more thoroughly in the theoretical part of this thesis. Thereafter, I wanted to apply lean thinking to find ways to increase the resource-efficiency in the aggregate stone use process and by testing the applicability of lean thinking in this context.

1.5. RESEARCH PROCESS AND THESIS OBJECTIVES

The research process of this thesis started in the Autumn of 2015, when the REKI-project was introduced to me. I was intrigued by the Finnish aggregate stone industry and its future development towards resource-efficiency, which seemed like an interesting topic to research in my master's thesis. However, I was not familiar with

the industry and I needed to first get a better understanding of the research context so that I could focus my research properly.

To do so, I interviewed six different people, whose work was related to the Finnish aggregate industry. Four of the six interviewees were involved in the REKI-project through the steering group and the two others were involved in projects that faced issues regarding crushed bedrock aggregates. Different themes related to aggregate and natural stone industries of Finland and the use of aggregates were discussed in the interviews. The thematic structure of the interviews and the fact that all the interviewees represented different organizations allowed me to gain a broad perspective of the research context.

This initial, knowledge gathering phase of the research process led me to develop two objectives of this thesis:

- To understand the process of resource-efficient aggregate stone use in a case study
- To develop a generic model of a resource-efficient aggregate stone use process by applying lean thinking

Based on the aforementioned interviews, a case study was chosen as a research method. Two projects that were facing issues regarding crushed bedrock aggregates were related to each other, as both projects were managed by the same municipal organization and concerned the same urban area. In the first project, there was a need to find use destinations for a huge amount of excavated crushed bedrock aggregate, since a large underground tunnel for a new metro line was under construction. The related second project was the Finnoo urban area development project, that provided an opportunity to use the crushed bedrock aggregate from the first project in a resource-efficient way. However, there were many challenges related to this opportunity. Therefore, the two related projects provided a prime opportunity to examine the process of aggregate stone use using a case study of the Finnoo urban area development project, that included opportunities and issues related to the use of stone aggregates.

1.6. RESEARCH PROBLEM AND QUESTIONS

To meet the objectives set for this master's thesis, a research problem and supporting research questions needed to be formed. I have defined the research problem of this master's thesis as such:

What is a resource-efficient aggregate stone use process like, in the Finnoo case study, and how can it be developed with lean thinking?

The first part of the research problem, referring to the process of resource-efficient aggregate stone use in the case study, is solved in the empirical part of this thesis. A process model of the Finnoo urban area development project with its potential to use stone aggregates resource-efficiently is made. From the empirical findings, the current combined process of the Finnoo project and its aggregate stone use is modelled. The empirical data is also used to analyze the challenges and find development ideas for the current combined process towards resource-efficiency.

Thus, based on the empirical part, an understanding about the resource-efficient aggregate use process and the challenges related to it is achieved. The theoretical part of the thesis, which is a literature review of lean thinking, is then used to analyze the empirical findings. The key characteristics of a generic process for resource-efficient aggregate stone use are then derived based on the application of lean thinking to the development ideas. All in all, four research questions were formed to address the research problem of this thesis:

RQ1: What is the current combined process of an urban area development project and its aggregate stone use?

- **RQ1.1: What are the challenges of the current combined process?**
- **RQ1.2: What are the development ideas for the current combined process?**

RQ2: What are the key characteristics of a generic resource-efficient aggregate stone use process?

The first research question (RQ1) and its sub-questions (RQ1.1 & RQ1.2) are addressed in the empirical study of this thesis. The second research question (RQ2) is answered by interpreting empirical findings with the theoretical synthesis of lean thinking.

This thesis provides both practical and theoretical contributions. The practical contributions stem from the empirical findings, as they are valuable for practitioners and experts working in the aggregate stone industry. The findings provide helpful insights for them to adjust their ways of working towards a more resource-efficient

way. In addition, this thesis analyzes the existing lean literature from a new point of view. Lean theories have been applied to many contexts, but there is no research focusing on the application of lean theories to a complex, project-based, municipal context. This thesis combines the relevant existing lean literature to create a synthesis, which helps to answer the fourth research question. The generated synthesis is tested, through interpreting the case study findings by applying the theoretical lenses. This thesis contributes to the identified research gap by creating a framework for implementing lean to a new, complex context and then evaluating it with a case study.

1.7. RESEARCH APPROACH AND METHOD

The research method used in this thesis is a single qualitative case study. According to Yin (2009), a case study is an empirical inquiry, which "investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident".

Moreover, Yin (2009) describes, that the case study inquiry

- copes with the technically distinctive situation in which there are many variables of interest,
- relies on multiple sources of evidence,
- benefits from the prior development of theoretical propositions to guide data collection and analysis. (Yin 2009, p. 18)

In this empirical study, the contemporary phenomenon is the development of the Finnish aggregate stone industry. The real-life context, which features possibilities and challenges related to the phenomenon in question, is the context of the empirical case study, the complex urban area development project that includes aggregate stone use.

As suggested by Yin (2009), this empirical study relies on multiple sources of evidence. The sources of evidence include interviews of 16 key people, whose work is related to the case study and the use of stone aggregates, an audio and video recorded workshop with 34 stakeholders, and feedback questionnaires from the workshop.

According to Hyde (2002), deductive and inductive reasoning are the two general approaches, which may result in the acquisition of new knowledge. Deductive reasoning refers to a process of theory testing that starts with an established theory or

a generalization. Then, the applicability of the chosen theory determined in a specific context. Inductive reasoning, on the other hand, refers to a theory building process that starts from observations made in a specific context. Then, the studied phenomenon is explained with generalizations made based on the observations. Balancing induction and deduction is of high importance in all research. Focusing too much on induction can lead to the lack of useful theoretical perspectives and concepts which could assist in analyzing the studied phenomenon. On the other hand, focusing too much on deduction can prevent the researcher from developing new theoretical insights. (Hyde 2002, p. 83 & 88)

In this thesis, inductive reasoning was first used when the development ideas for the current combined process of Finnoo urban area development project and its aggregate stone use were derived from the empirical findings. Then, deductive reasoning was applied when the theoretical framework of lean thinking was tested in the case study by interpreting the empirical findings with it. This resulted in the key characteristics of a generic process for resource-efficient aggregate stone use being created. Thus, both forms of theoretical reasoning were used in balance to avoid favoring one over the other, which could have led to the problems identified by Hyde (2002).

II THEORETICAL BACKGROUND

The second part of this thesis, the theoretical background, consists of a literature review of lean thinking. First, in chapter 2, the literature review focusses on the origins of lean thinking in the manufacturing context. Thus, the original context of lean thinking is explored and a definition of lean thinking is made. Then, the literature review moves to other contexts where lean has been successfully applied. In chapter 3, lean industrialized housing production, lean supply networks, and lean construction are examined. These applications of lean were included in this literature review because they resemble the context of the empirical study of this thesis better than the original manufacturing context of lean thinking. Then, in chapter 4, the implementation of lean thinking is discussed. Finally, chapter 5 provides a theoretical synthesis of the literature review. The theoretical synthesis summarizes the lean thinking principles and important factors for implementing lean thinking to a new context.

2. WHAT IS LEAN?

In this chapter, lean thinking and its emergence in the car manufacturing industry are explored. This is done by first examining the origins of lean in chapter 2.1. Then, the core principles of lean thinking are introduced in chapter 2.2 and finally, after analyzing the evolution of lean in chapter 2.3, the concept of lean is defined.

2.1. THE ORIGINS OF LEAN IN CAR PRODUCTION

Lean principles originate from the Japanese automotive industry. In their book “The Machine That Changed the World” Womack et al. (1990) introduce Toyota’s production system (TPS) and its lean ways of working. TPS is indeed the machine that changed the world and it allowed Toyota to produce a variety of different car models and at the same time maintain good production quality. ’Lean’ was chosen as a term by John Krafick, a researcher from MIT, because “the Japanese used less of everything – time, resources and money” (Ballard and Tommelein 2012, p. 85; Krafcik 1988; Womack et al. 1990). Krafcik (1988) described lean operations as high-risk, high-reward way of manufacturing and introduced these characteristics of lean operations in the car production context:

- Low inventory levels for cost saving and quick detection of quality problems
- Continuous-flow production with bufferless assembly lines
- Tiny repair areas, because quality lies within the process

This production management policy of lean presented high risks, as any disturbance will stop production completely, but they could be addressed by an experienced, well-trained workforce, responsive suppliers, and good product designs. Producers with such resources will find lean-system implementation comparatively painless. (Krafcik 1988)

Krafcik (1988) argues though that it was not only in Japan where lean production methods were used. There were lean production plants also among the automotive industry in North America and Europe, but the lean production methods were best exemplified by Toyota (Krafcik 1988, p. 45). The starting point for the development of Toyota's lean production goes all the way back to the year 1950. After the World War II, the American automotive industry was miles ahead of its Japanese counterpart in terms of efficiency and mass-production techniques. Toyota's President, Eiji Toyoda, traveled to the USA to visit a Ford production plant and to learn from their production methods. He spent three months at the plant and was amazed by its total output, but at the same time thought that it was wasteful in terms of effort, materials and time. Toyoda used his learning experience at the Ford production plant to start developing the production methods used back home in Japan. Through continuous improvement, Toyota's development efforts resulted in the lean production system, which used less of everything (e.g. labour, floorspace, investment in tools and engineering hours) compared with American mass-production. (Gann 1996)

Lean ways of working were, therefore, already used before the terminology was created around the 1990's. The original context of lean was the manufacturing context in the automotive industry, but the underlying principles of lean were quite universal and could be applied in other contexts as well. Green and May (2005), for example, argue that leaner ways of working were already used in the 1970's in the UK construction industry. Even though it was not labeled as anything lean-related at the time, it shows that there was a lack of research in the area and it took many years to finally come up with the terminology around lean and bring it to the attention of the scientific community.

Toyota's lean organizational culture

To understand the original context of lean production methods, it is beneficial to look at the organizational culture of Toyota. Liker (2004) presented Toyota's management philosophy and their 14 principles. These philosophical principles guided the actions of the whole Toyota organization including the top-level managers and the assembly line workers. Liker (2004) listed the principles as such:

1. Base your management decisions on a long-term philosophy, even at the expense of short-term financial goals.
2. Create a continuous process flow to bring problems to the surface.
3. Use "pull" systems to avoid overproduction.
4. Level out the workload (work like the tortoise, not the hare).
5. Build a culture of stopping to fix problems, to get quality right the first time.
6. Standardized tasks and processes are the foundation for continuous improvement and employee empowerment.
7. Use visual control so no problems are hidden.
8. Use only reliable, thoroughly tested technology that serves your people and process.
9. Grow leaders who thoroughly understand the work, live the philosophy, and teach it to others.
10. Develop exceptional people and teams who follow your company's philosophy.
11. Respect your extended network of partners and suppliers by challenging them and helping them improve.
12. Go and see for yourself to thoroughly understand the situation.
13. Make decisions slowly by consensus, thoroughly considering all options; implement decisions rapidly.
14. Become a learning organization through relentless reflection and continuous improvement.

A lot of focus is put on a well-trained workforce including both leaders and their subordinates. The leaders are expected to thoroughly understand the work, live the philosophy and teach it forward, as the aim is to develop exceptional people and teams who follow the company's philosophy. The focus in decision making is in the long run, and short-term losses are acceptable when it comes to following the company's long-term philosophies. Continuous improvement ('kaizen') is important and achieved through standardized work tasks. On top of that, through continuous improvement and relentless reflection ('hansei') the goal is to become a learning organization. (Liker 2004)

To conclude, there have been examples of 'lean-like' ways of working already before the term was introduced in the context of Japanese car production around the 1990's. The lean production methods were best exemplified by Toyota and their organizational culture: a well-trained and experienced workforce working according to a clear company philosophy of continuous improvement, learning and long-term profitability. Even though the management principles of Toyota were derived in the car manufacturing context, they do not appear very context-specific to car manufacturing, as you analyze them. This resulted in the scientific community to the generalization of Toyota's principles to a universal form applicable in other industries.

2.2. LEAN THINKING – VALUE CREATION AND WASTE REDUCTION

Womack and Jones (1996) used 'lean thinking' for the first time as a generic term to describe the application of lean beyond manufacturing (Green and May 2005, p. 499). They introduced the five key principles of lean as a concept:

1. Specify Value – Define value precisely from the perspective of the end customer in terms of the specific product with specific capabilities offered at a specific time.
2. Identify the Value Stream – Identify the entire value stream for each product or product family and eliminate waste.
3. Flow – Make the remaining value creating steps flow.
4. Pull - Design and provide what the customer wants only when the customer wants it.
5. Perfection – Strive for perfection by continually removing successive layers of waste as they are uncovered. (Hicks 2007, p. 236; Womack & Jones 1996)

The principles 1-4 are all somewhat related to the concept of value. The focus is on identifying all the value adding activities and removing everything else that does not contribute value into the process. The non-value adding activities can be therefore seen as waste and it is important to eliminate them. Besides focusing on value adding activities, also the end customer is of high importance. Finally, lean thinking is considered as an ongoing process in which improvements are constantly made when problems or layers of waste are uncovered.

In addition to offering additional features or services valued by the customer, value creation can also be seen as the reduction of internal waste. As the wasteful activities and the associated costs are reduced, the overall value proposition for the customer increases. (Hines et al. 2004, p. 997) Understanding which types of waste there can be and identifying them in an organization's value creation process is, therefore, essential for applying lean thinking.

Waste reduction as a part of lean thinking

Alongside creating value, another key aspect of lean thinking is the identification and reduction of waste. In the manufacturing context, several different types of waste can be identified. Womack and Jones (1996) reported the seven deadly wastes first identified by Ohno (1988):

1. Overproduction – Occurs when operations continue after they should have ceased. This results in an excess of products, products being made too early and increased inventory.
2. Waiting – Sometimes referred to as queuing – Occurs when there are periods of inactivity in a downstream process because an upstream activity has not delivered on time. Sometimes idle downstream processes are used for activities that either do not add value or result in overproduction.
3. Transport – Unnecessary motion or movement of materials, such as work in progress (WIP) being transported from one operation to another. In general, transport should be minimized as it adds time to the process during which no value is added and handling damage can occur.
4. Extra processing – Extra operations such as rework, reprocessing, handling or storage that occur because of defects, overproduction or excess inventory.
5. Inventory – All inventory that is not directly required to fulfil current customer orders. Inventory includes raw materials, work-in-progress and finished goods. Inventory requires additional handling and space. Its presence can also significantly increase extra processing.
6. Motion – Refers to the extra steps taken by employees and equipment to accommodate inefficient layout, defects, reprocessing, overproduction or excess inventory. Motion takes time and adds no value to the product or service.
7. Defects – Finished goods or services that do not conform to the specification or customer's expectation, thus causing customer dissatisfaction.

In addition to the seven types of waste, an eight type of waste was identified by Womack and Jones (1996). It is the underutilization of people and in particular their ideas and creative input for improving the processes and practices. (Hicks 2007, p. 236-237) Therefore, it is essential to understand the importance of people when moving towards lean thinking. They can provide input for the optimization of the value creation process, identify wastes in it and come up with potential improvement suggestions for the organization's ways of working.

In conclusion, value creation, and waste reduction are the two core elements of lean thinking. Both elements are connected to each other, as value creation can be seen as the reduction of internal waste, which manifests in many different forms in the context of manufacturing. Next, the evolution of lean is analyzed. Then, a definition of lean for this thesis is provided based on this chapter and the five core principles of lean introduced earlier.

2.3. THE EVOLUTION AND DEFINITION OF LEAN

In the two previous chapters, the origins and the core principles of lean were presented. At the same time, the initial path of lean from one industry to another was seen. First, Toyota, representing the Japanese automotive industry, learned about lean from their competitors in America. Then, Toyota optimized their ways of working through continuous improvement. This resulted in creating the terminology for lean production in the manufacturing context. Then, the lean production methods were generalized into the five key principles of lean thinking, which could be applied beyond the manufacturing context.

Hines et al. (2004) reviewed lean thinking and its evolution over time. They came to the conclusion that the fact that lean has actually evolved over time is not often acknowledged in the criticism about lean. It has evolved on the basis of its five principles and does not only apply to the original shop-floor level of a production plant but also to the management level. (Hines et al. 2004, p. 1006) Therefore, lean exists both on strategic and operational levels. The strategic level of lean is the customer-centered approach of the five principles of lean that apply everywhere. On the other hand, the operational level of lean only applies to the shop-floor level, where different tools can be applied for waste elimination purposes. To find the correct tools and strategies for providing value to the customer, it is important to understand lean from

both levels. (Hines et al. 2004, p. 1006) The two levels of lean are depicted in Figure 1.

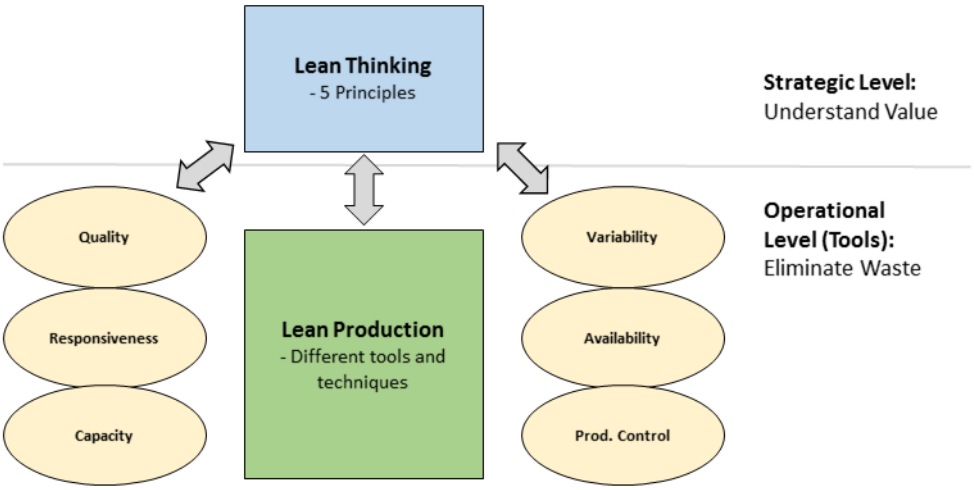

Figure 1: A lean framework adapted from Hines et al. 2004, p. 1007

Interestingly, the two core elements of lean are featured in the framework above. **Waste elimination** or waste reduction happens at the operational level and different tools or techniques, such as Kanban, can be applied for waste elimination purposes. Lean originates from this operational level, as lean production is included in it. **Understanding value and value creation**, on the other hand, happens at the strategic level. The five key principles of lean thinking, introduced in the previous chapter, form the strategic level of lean, and I will use them as a basis for the definition of lean. Based on the literature review, I answer to the theoretical research question by defining lean:

Lean is a customer-focused management philosophy which aims to identify and optimize all value adding activities and remove all redundant activities or waste from the value creation process while constantly improving it and developing further.

This definition takes both value creation and waste reduction into account and includes the customer focus and continuous improvement aspects as well. It is seen as a management philosophy and it needs to be spread to all the levels of an organization, from the assembly line workers to the managers. When the lean principles are spread throughout the organization, a truly lean organizational culture like Toyota's is achieved. Now, after a definition for lean has been provided, the literature review moves on to study the emergence of lean in contexts beyond manufacturing.

3. MOVING BEYOND MANUFACTURING – LEAN IN OTHER CONTEXTS

This chapter takes a deeper look at some applications of lean in other contexts than manufacturing. First, in chapter 3.1, lean is examined in the context of industrialized housing production. Then, the application of lean in supply networks is discussed in chapter 3.2 and lean in project-based construction is discussed in chapter 3.3. Lean has been applied to numerous other contexts as well, but these particular lean applications were chosen to be studied, because they are somewhat complex and feature inter-organizational processes like the aggregate stone industry. The aim of this part of the literature review is to learn from these previous applications of lean and the manifestations of lean in more complex contexts in order to help the formulation of the theoretical synthesis.

3.1. LEAN IN INDUSTRIALIZED HOUSING PRODUCTION

Gann (1996) studied the influence of successful lean production methods used in the car industry on the Japanese industrialized housing industry. A clear logic was present in the study. The story of Toyota's successful lean production system was that they first learned from their American competitor, and then through continuous improvement developed a more flexible and efficient production system than their competitors. Could this same story line be produced again in the context of Japanese industrialized housing industry by learning from Toyota's case in the automotive industry? (Gann 1996)

The results showed that the Japanese industrialized housing producers have learned from other manufacturing processes, but the different context of industrialized housing production means that the full benefits of lean production could not be achieved. Industrialized housing production generally involves distributed production activities, which makes it different from the typical lean production context, where all the activities from design to assembly occur inside the same plant in close proximity. (Gann 1996) Industrialized housing production can also involve subcontractors, making the context a bit more inter-organizational and project-based. "The contractual nature of project work, which must usually precede orders, means that firms are to an extent unable to gain some of the benefits of centralized and planned production enjoyed by many large firms in manufacturing" (Gann 1996, p. 450).

Höök and Stehn (2008) also studied the applicability of lean principles and practices in industrialized housing production, but in their case, it was the Swedish industry. Industrialized housing production is defined in the paper as such: "Production in a closed factory environment where only assembly is performed at the construction site, with one evident process owner and a clear product goal of repetition in housing design and production" (Höök and Stehn 2008, p. 1092). It was identified that the applicability of lean principles and practices in the context is affected by the traditional construction project culture which has three characteristics:

- Low worker motivation and awareness of built-in quality, continuous improvement, and flow
- Problems that appear are solved but are seldom thoroughly analyzed, and with restricted experience diffusion
- Ad hoc solutions and a low responsibility for maintenance of equipment, tools, work floor and work floor layout. (Höök and Stehn 2008, p. 1098)

Therefore, a cultural change in the industrialized housing production of Sweden is needed in order to benefit from the lean practices and principles. According to Höök and Stehn (2008), development and change towards a lean production culture in the Swedish industrialized housing require:

- Increased worker motivation and responsibility for flow, built-in quality and continuous improvement, through a leadership that guides and motivates workers
- Standardization of work, work floor layout and maintenance of equipment and work floor, to obtain flow in production, measurable quality and improvements, and increased worker motivation.

These requirements seem to be targeted mainly at the management level of organizations, but in the end, the key to change lies within the workers. The challenge for management is to make the workers see the benefits that are possible to achieve when implementing lean practices and principles.

Gann also (1996) argued that his study illustrated "the value in cross-industry learning, and just as construction has adopted from other manufacturing industries, so too can knowledge, particularly about project-based management and engineering, be of value in a wide range of manufacturing firms" (Gann 1996, p. 450). As stated by Gann, there definitely is value in cross-industry learning when it comes to the application of lean

principles, but as in the study of Höök and Stehn (2008), cultural changes might be needed to make lean practices and principles more applicable. Therefore, understanding the dynamics of the context where lean is applied, is important.

A further point was made by Gann (1996) that as the construction activities become larger, more complex and more bespoke, more coordination of inputs from a wide variety of sources to produce customized products is required. The sources of input can also originate from different companies, making the context more inter-organizational. Next, the literature review shifts its focus towards the inter-organizational contexts of supply networks and project-based construction.

3.2. LEAN SUPPLY NETWORKS

Lamming (1996) discusses the interaction of lean supply and supply chain management. The idea of lean supply is that the entire supply chain is considered as an integrated whole from raw materials to the end customer. According to Lamming (1996), there are three specific features of the theory of lean supply, which are: *cost transparency*, *relationship assessment* and *excuses and blame*. *Cost transparency* refers to the idea that all organizations in the supply chain must share their process data including cost data, so that improvements can be made based on it. *Relationship assessment* means that it is necessary to develop relationship assessment programs, so that the critical flow of value from one organization to another can be focused on. Normally, when something goes wrong in a process, excuses are given and someone responsible is found to take the blaming. In lean supply, *excuses and blame* are neglected, and problems are treated as targets for solutions. (Lamming 1996)

One of the main barriers when moving from traditional supply chain management to lean supply is the attitudinal change of managers (Lamming 1996). This is an interesting notion, as it correlates with the findings of Höök and Stehn (2008) about the need for cultural changes, when making lean principles more applicable in the context of Swedish industrialized housing production. It seems that in both sectors, the change is highly dependent on the management of organizations, since cultural changes need to be implemented throughout the whole organization. The upper management has a crucial role in the cultural change.

"A defining characteristic of lean supply chains and networks is that they are formed and maintained by proactive, system-wide collaborative relationships among all-tier

suppliers and customers" (Adamides et al. 2008, p. 35). However, forming and maintaining such networks can be difficult. When employing lean techniques throughout the supply network, the aim is to remove unnecessary material, processing and transportation activities, as well as unnecessary information and knowledge supply by providing them only when needed. Inter-organizational boundaries make it harder to achieve these goals, and the importance of collaboration is therefore highlighted. Adamides et al. (2008) consider that the collaborative strategic processes and the management of complex interactions and behaviors among the agents that hold it are crucial for the implementation of the lean supply network. These strategic processes, such as value specification, innovation, strategy, development, and improvement are "messy, involve social complexity, and require the development of shared understanding through capturing and communicating knowledge" (Adamides et al. 2008, p. 36).

Collaboration and process integration are two constituent parts of the development and management of lean supply networks. Adamides et al (2008) studied how they both can be supported with ICT technologies. The collaboration, especially in collaborative developing of strategic processes, "requires either face-to-face interaction or the employment of advanced information and communication technology to 'virtualise' social interaction and support rich knowledge exchanges" (Adamides et al. 2008, p. 36). To enable this type of collaboration and process integration, Adamides et al. (2008) developed the Co-LEAN software suite, which consists of five interconnected tools operating over the internet. Three issues of concern were identified in the phase of adopting the Co-LEAN software suite for lean supply network management:

(1) The need for technological integration and consistency with the rest of the ICT infrastructure of customers and suppliers.
(2) The necessity of a pre-existing positive approach looking towards a co-operative environment – technology itself cannot create this, it can just enhance it.
(3) The leading role of the focal company in making clear to its suppliers and customers that the software tool is just an instrument for facilitating the lean management process. It does not guarantee lean performance, and it is up to the organizations involved to devise the appropriate means and processes for achieving it. (Adamides et al. 2008, p. 48)

It is an important notion that technology itself cannot create a positive approach towards a co-operative environment. The focus should be first on creating a co-operative atmosphere in the network, and only when the network truly functions collaboratively together, importing ICT tools can be beneficial. The focal company plays a big role in this, too. The focal company could through effective communication, the use of facilitators, contractual agreements and incentives build a co-operative atmosphere in the network, which by itself would ease the implementation of lean into a supply network.

However, inter-organizational collaboration in supply networks features its own challenges. Boundaries between companies and different functions continue to exist, and they inhibit communication and prevent individuals from altering their knowledge in response to events and attitudes occurring in a network. As a solution to these problems, Adamides et al. (2008) discusses the theories of Carlile (2002), and more specifically the role of boundary spanners and boundary objects. "Boundary spanners (individuals assigned to the specific role of facilitating the meaningful communication between organizations and/or organizational entities) and boundary objects (artefacts like models used to create shared context among different organizations) can overcome the problem of knowledge boundaries and facilitate distributed co-ordination" (Adamides et al. 2008, p. 49; Carlile 2002). The key is to organize meetings, workshops, and other events, which bring people from different organizations and functions together. Boundary objects can be used by the boundary spanners to help facilitate the discussion and create a collaborative, and co-creative atmosphere.

Shamah (2013) studied the implementation of lean in the supply chain context for the purpose of value creation. As it was concluded earlier in this literature review, finding the value adding process and creating value are core strategic elements of lean thinking alongside waste reduction. Shamah (2013) defined leanness in supply chains as follows:

"*Leanness in supply chains is a process that helps organizations find, select, organize, disseminate and control their resources in order to gain a business advantage through controlling environmental phenomena. Consequently, managers need to perform suitable actions in order to improve or to maintain specific aspects of lean thinking.*" (Shamah 2013, p. 216)

Shamah's study took place in the Egyptian industrial sector and the main practical implication of the study was that internal resistance is more of a barrier than external (customer, supplier; or competitors) resistance to lean thinking. Therefore, organizations should first implement lean thinking into their own organizational processes before moving on to inter-organizational integration. (Shamah 2013, p. 216) There is a lot of emphasis again on the managers, who need to spread the lean thinking principles inside the organization and also find the suitable actions to improve and maintain them.

Shamah (2013) noted too that a trusted atmosphere between the business provider, the suppliers, and the consumer service receiver is important when striving for value creation by lean implementation. A trusted atmosphere somewhat differs from the co-operative environment mentioned by Adamides et al. (2008), but I think they are related in the sense that a trusted atmosphere is a good starting point for a co-operative environment.

To conclude the findings of this chapter, I have compiled a list of key aspects to take into account when implementing lean to the context of supply networks:

- Managers play an important role in lean implementation. Attitudinal change might be required from them, as they need to start spreading the lean culture throughout the organization and lead by example.
- Lean should be implemented first inside an organization before moving to inter-organizational implementation of lean to the whole supply network.
- A collaborative atmosphere is required for lean implementation in a networked context. The network needs a focal company to bring all the actors together into a collaborative environment.
- ICT technologies can enhance the collaboration, but first the collaborative atmosphere inside the network needs to be established.
- Boundary spanners or facilitators and boundary objects, such as process models, can be used to create the collaborative atmosphere, and thus ease the implementation of lean to a supply network.

3.3. LEAN IN PROJECT-BASED CONSTRUCTION

The next context of lean investigated in this literature review is traditional, on-site construction. The operating environment of the Finnish aggregate stone industry is closely tied to the construction industry, as most of the operations happen in the preconstruction and infrastructure construction phases, which support the actual construction phase.

Interestingly, it did not take a long time after the initial introduction of lean terminology for it to be brought into the construction industry. Koskela (1992) was the first person to make a linkage between lean and construction. It was sort of a wake-up call for the construction industry to start thinking about new ways of working. "Koskela challenged the construction industry to stop hiding behind the excuse that construction is not manufacturing and to learn from the revolution underway in manufacturing" (Ballard and Tommelein 2012, p. 87).

However, problems might emerge when applying principles developed in another context to a new field. This is especially relevant in the construction industry, as it differs a lot from other industries. Bresnen and Marshall (2001) discussed the problems and challenges related to applying management approaches from different contexts, such as lean principles from the manufacturing context, to the construction industry. The construction process, its particular nature, and its surrounding institutional-cultural environment need to be taken into account when trying to import management approaches developed in other contexts. The construction industry features two main sources of differences that stand out (Bresnen and Marshall 2001):

(1) the project-based nature of activity and
(2) the multiorganizational setting.

Due to the particular nature of the production process of construction, the industry can be seen as a complex systems industry. In complex systems industries, the organization of production is characterized by "its project orientation, the contribution of temporary coalitions of firms to production, the heavy involvement of the client in the process, and, most notably, the adamant refusal of the industry to move down the product life cycle". (Winch 2003, p. 652) Thus, the differences in the organization of production make the comparisons of complex industries with other industries, such as motor vehicle production, misplaced.

As a result, the five core principles of lean could not be brought as such to the construction industry. The characteristics and the complexity of the industry needed to be taken into account, so that the lean principles could be applied. Thus, the concept 'lean construction' was born. Eriksson (2010) did a literature review and proposed that the aspects of lean construction can be grouped into six core elements:

- Waste reduction
- Process focus in production planning and control
- End customer focus
- Continuous improvements
- Cooperative relationships
- Systems perspective

These core elements of lean construction are quite similar to the five key principles of lean thinking introduced earlier in chapter 3.2, but there are some differences. A systems perspective and cooperative relationships appear to be new aspects to be taken into account in the context of lean construction. The traditional, operational waste reduction, as well as continuous improvement and end customer focus, which all were a part of the original lean principles, are also of high importance in lean construction.

The systems perspective is an important part of lean construction. From a systems perspective, it is more important to see the process as a whole and to treat it as such. Instead of focusing so much on the value creation process, as in the manufacturing context, lean construction seems to be more about taking the bigger picture around the whole process into account. Sub-optimization is viewed as a bad thing and the systems perspective allows the increase of overall efficiency by simplifying the process. (Eriksson 2010, p. 396)

Cooperative relationships in the network or partnering refers to the facilitating of integration of different actors' competencies and efforts in joint problem solving (Eriksson 2010, p. 396). It is not necessary to build good partner relationships between all of the small subcontractors in a large construction project, but the crucial thing is to identify the key actors and establish cooperative relationships between them with good communication and coordination. The cooperative relationships, which were already discussed in the context of lean supply networks, seem to play a critical role in lean construction as well and this was emphasized a lot by Eriksson (2010). "Increased cooperation among supply chain actors is, however, a prerequisite and an

appropriate starting point for a further development of the lean concept" (Eriksson 2010, p. 401).

The lean construction aspects were further generalized by Ballard and Tommelein (2012) to fit project management. This was quite a natural proceeding, as construction is project-based. Ballard and Tommelein (2012) reviewed the history of lean construction and the adaptation of its principles and methods to the project environment. Four basic features of the lean approach to project management were introduced:

1. All life cycle phases are to be taken into account in designing and making.
2. Project phases are conceptualized as interlinked triads, and development within phases is understood to occur through a kind of 'conversation', consistent with the fundamental lean principle to do work only on request.
3. Decisions regarding product and process design are to be made together.
4. Work structuring (process design at every system level) and production control are the primary management methods for governing project delivery through all its phases. (Ballard and Tommelein 2012, p. 87-88)

These features were derived from a series of white papers published by the Lean Construction Institute in 1999 and 2000 (Ballard and Tommelein 2012, p. 87). To manage a project according to lean principles, Ballard and Tommelein (2012) introduced the Lean Project Delivery System, which is depicted below in Figure 2.

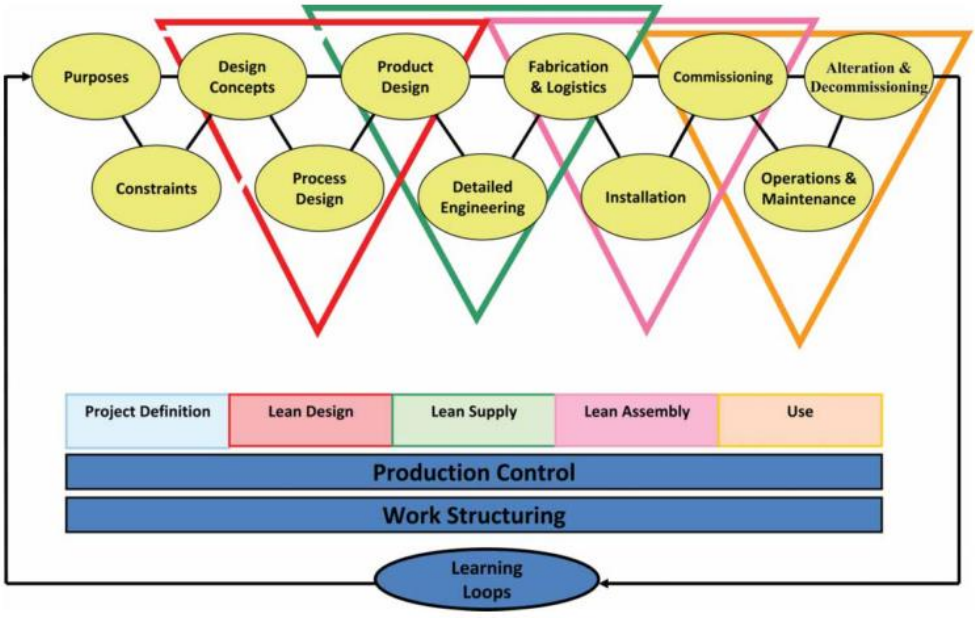

Figure 2: Lean Project Delivery System (Ballard and Tommelein 2012)

The four features of lean project management put a lot of emphasis in decision making on the whole project life cycle and all of its phases. Figure 2 shows the connections between different project phases, as the interlinked triads overlap each other. Learning loops go through all the phases, which makes the lean project delivery system improve continuously.

Ballard and Tommelein (2012) suggest that lean management methods suit the needs of more complex and uncertain projects better than those of simple and certain projects. In the case of simple and certain projects, traditional, non-lean management methods can be successful, but as the complexity and uncertainty of projects increases, more and more lean methods are needed. (Ballard and Tommelein 2012, p. 95) However, it can be more difficult in complex projects to perceive the whole process and the phases of a project. To apply the lean project management principles, you need to have a clear picture of the process of the project, its phases and the environment, where the project is delivered.

To conclude this chapter, the surrounding institutional-cultural environment and the complexity of production systems in construction make the straight-up implementation of the five lean principles challenging. Therefore, the principles need to be adjusted to fit the context better and thus, the core elements of lean construction can be established. The original emphasis on value creation in lean thinking is replaced by the process focus, cooperative relationships, and systems perspective aspects in lean construction. In the complex and project-based environment of construction, it is crucial to understand all the project phases, their linkages, and the environment, where the project is delivered.

4. IMPLEMENTATION OF LEAN

This chapter discusses the three models of lean implementation in construction and the management of lean implementation. The findings of this chapter will be included into the theoretical synthesis.

4.1. THREE MODELS OF LEAN IMPLEMENTATION IN CONSTRUCTION

Green and May (2005) interviewed twenty-five policy makers of construction industry about their interpretations of 'lean'. Based on the interview data, Green and May found three dominant models of lean construction: waste elimination, partnering, and structuring the context.

Lean Model 1 (Table 1) places a huge emphasis on the technical and operational level of activities. The main idea is to first remove all the inefficiencies from the technical and operational level of the process. Once a smooth, uninterrupted flow of activities has been achieved, one can start worrying about other aspects of the process. To achieve the optimal process and the desired, uninterrupted flow of activities, all waste must be eliminated. This includes eliminating needless movements, optimizing the workflow, cutting out unnecessary costs, obliterating non-value adding activities, and eliminating *muda* (waste). (Green and May 2005, p. 508)

Waste Elimination

Table 1: Lean Model 1 - Waste Elimination (Green and May 2005)

Lean Model 1: Waste Elimination
• waste elimination is paramount • technical/operational focus • espoused aim is to ensure a smooth, uninterrupted flow of activities • assumed that cost savings made at the operational level will aggregate to the corporate level • further assumed that all partiers will benefit equally from 'improved performance' • discourse dominated by a machine metaphor • underlying unitary perspective on organizations

Lean Model 2 (Table 2) shifts its focus from the technical and operational aspect to the inter-organizational relationships of collaborating firms. The aim is not to

eliminate waste from the inter-organizational processes, but instead, the aim is to change the culture in which the organizations collaborate. This means eliminating adversarial relationships, solving conflicts, creating trust, sharing knowledge, and learning. Thus, better relationships among the organizations are created which leads to improved collaboration and to leanness. Partnering workshops and effective facilitators, with the appropriate soft skills, were regarded very important by the advocates of this model. Through partnering workshops and effective facilitation, better relationships between organizations can be created. (Green and May 2005, p. 508)

Partnering

Table 2: Lean Model 2 – Partnering (Green and May 2005)

Lean Model 2: Partnering
• emphasis on relations between firms: partnering and supply chain management • project/corporate view • aim is to eliminate adversarial relationship/change culture • leanness is seen as the outcome of better relationships • less conflict, more trust equals improved collaboration • emphasis on knowledge sharing, learning

The third model of lean construction (Table 3) combines the first two models into a much bigger framework, and in addition takes the institutional context, within which the organizations operate, into account. The aims of the previous models, eliminating all waste and creating better inter-organizational relationships, are also of high importance in the Lean Model 3. In order to achieve them, the context of project delivery needs to be structured with appropriate long-term contracts and incentive systems. Integrated, inter-organizational processes and teams play an important role, as the collaborating organizations commit to 'continuous evolution'. System integration is also important, and different parts of the process (construction, design, and building operation) need to be considered as a whole. A greater emphasis on technology characterized the Lean Model 3 as well. (Green and May 2005, p. 508-509)

Structuring the Context

Table 3: Lean Model 3 – Structuring the Context (Green and May 2005)

Lean Model 3: Structuring the Context
• lean is about structural change in the way projects are delivered • long-term contractual relationships are an essential pre-requisite • implementation of lean requires a 'complete rethink of design and construction' • technology clusters, integrated teams, integrated processes • big emphasis on the simplification of design, standardization, pre-fabrication, application of information technology • dominant metaphors: psychic prison, organic, cybernetic • underlying pluralistic perspective on organizations

The three models of lean construction are characterizations of different levels or stages of lean implementation in the construction industry. However, they do not provide step-by-step means for achieving successful lean implementation. I argue, though, that they provide good guidelines for organizations seeking to implement lean construction.

Eriksson (2010) argues that only the third model of lean construction can be seen as full-fledged lean construction, whereas the first model is related to efficient project governance in general and the second model is similar to partnering. This seems like a quite natural conclusion by Eriksson, since the third model combines the first two. On their own, models 1 and 2 are not sufficient to be lean construction, but when combined in the third model, they are. This doesn't mean, though, that as an organization you cannot start your journey to lean implementation from the first two models or from just one of them. Starting with Waste elimination (Model 1) or Partnering (Model 2), an organization can already achieve some of the benefits of moving towards lean construction. In the following chapter, the actual change process towards lean is discussed.

4.2. MANAGING LEAN IMPLEMENTATION

Bhasin (2012) studied the implementations of lean among the British manufacturing organizations. In previous research publications, it had been determined, that organizational culture and change management have played a critical role in many

lean implementation failures. Therefore, the study aimed to explore an appropriate change strategy, which would increase the likelihood of a successful lean implementation. (Bhasin 2012)

The main findings of Bhasin (2012) about lean implementation were that every organization should find their own way to implement lean and treat it as a never-ending journey. There is no universal lean implementation method or a unique lean success recipe that can be used in every organization: all lean journeys happened under different conditions and it needs to be taken into account when changing towards lean. Therefore, it is nearly impossible to directly implement the results of Toyota's learning. Lean needs to be seen as a business philosophy and a journey that needs to start strong and that never ends. For many companies, the depth and magnitude of the required cultural transformation towards lean success turned out to be much bigger than anticipated. To put things into perspective, Toyota's ongoing lean journey has lasted over 50 years and some lessons of theirs were learnt over 100 years ago. (Bhasin 2012)

The case studies used in Bhasin's (2012) research revealed important factors of successful lean implementation. In the most effective lean implementations, there was a group of people inside the organizations who promoted lean and managed the lean initiative. This overarching group of personnel was referred to as the "Lean steering committee" in two of the case study companies. The importance of training and early commitment were both highlighted in the case studies as well. Over 30 per cent of managers and operators thought that there was not enough training for the lean implementation. Therefore, training should be seen as "an important preventive cost which aids the overall lean implementation and proceeds to reduce the time to implement lean" (Bhasin 2012, p. 455). An early commitment to lean is of high importance, since it was identified that lean requires significant effort and many organizations "overstrained their managers with the additional duties" related to lean implementation. (Bhasin 2012, p. 455)

But how does an organization find its own way to successful lean implementation?

Smeds (1994) developed a generic framework for the management of change towards a lean enterprise. The framework was developed based on the principles of innovation management in the context of manufacturing. The 'lean enterprise', with a new structure, strategy, and culture, can be seen as a radical techno-organizational

innovation, and the change towards it can be triggered by the reorganization of manufacturing according to lean principles. (Smeds 1994, p. 67 & 69) The framework created by Smeds (1994) features a process of six steps, which is depicted below in Figure 3.

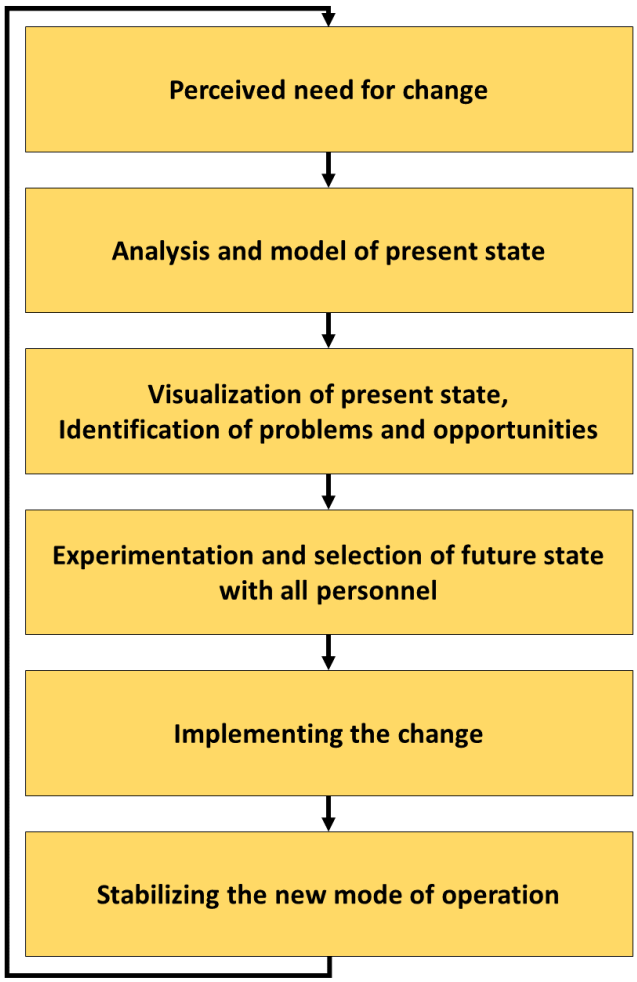

Figure 3: The Generic Framework for the Management of Change towards a Lean Enterprise, adapted from Smeds (1994, p. 74)

The process starts with the perception of a need for change. Then, the change agents and the managers of the organization analyze and model the present state of operations before visualizing it and identifying the related problems and opportunities. This is followed by the experimentation and selection of the future state together with all personnel in the process, and when the optimal new process design is found, it is time to implement the change. Finally, the organization begins its normal, day-to-day

operations according to the new lean process designs in the last step of the process, the stabilization phase. (Smeds 1994, p. 74-76)

The article by Smeds (1994) emphasizes the importance of social simulation games in the change towards lean enterprises. A social simulation game is a simulation of simplified business process model, and the human players of the simulation game generate the operations and decisions. The game is played according to some given rules and is guided by game designers and either internal or external facilitators, who can be change agents of the enterprise. The social simulation game allows the players to experience the relationships between business process activities and to see how process changes can improve the overall efficiency and quality of work. (Smeds 1994, p. 73)

Social simulation games can be used as a method in the six-step change process towards a lean enterprise. In the visualization of present state and the identification of problems and opportunities, simulation games can be used to build a shared understanding about the current business process. In the experimentation and selection of future state, simulation games engage all participants in the development and testing of alternative process designs and operation modes. In the final stabilization phase, simulation games can be used for on-the-job training of the new mode of operation. (Smeds 1994, p. 74-76)

Even though Bhasin (2012) argues that there is no universally applicable lean implementation method, I think the framework created by Smeds (1994) provides a solid step-by-step process for organizations to aid lean implementation and continuous learning inside their own organizational processes. The framework is general enough to leave room for improvisation, thus making it possible for organizations to find their own way to the never-ending lean journey by following the framework.

5. THEORETICAL SYNTHESIS

In this chapter, the literature review of lean thinking is compiled to a theoretical synthesis. This theoretical synthesis aims to provide an understanding of what is lean thinking and important factors for applying it to new intra-, or inter-organizational contexts. As a basis for the synthesis, I will use the definition of lean thinking that was derived earlier in the literature review:

Lean is a customer-focused management philosophy which aims to identify and optimize all value adding activities and remove all redundant activities or waste from the value creation process while constantly improving it and developing further.

Lean, being a management philosophy at its core, is a way of thinking about organizational processes. The focus is on identifying and optimizing all parts of the process, which bring value to the customer. Depending on the process, the customer can also be an internal receiver or another process of the organization. At the same time, all the other activities and parts of the process, which do not contribute value to the customer, are considered as waste and they need to be reduced or removed all together. This lean way of thinking about organizational processes should be spread to all parts of the organization, so that the organization can constantly improve and develop its processes further.

The theoretical synthesis is compiled together into Figure 4 which is divided into intra-organizational and inter-organizational levels, and the important aspects of lean and its implementation can be seen in the figure on both levels.

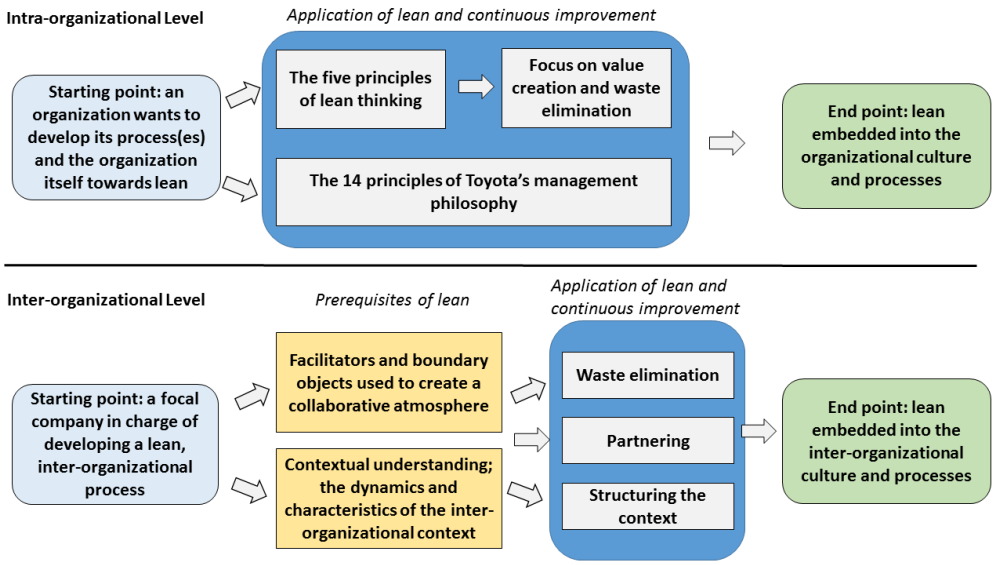

Figure 4: Theoretical synthesis: the implementation of lean in intra-, and inter-organizational processes

Intra-organizational lean implementation starts from the organization's need to develop its process or processes and the organization itself towards leaner ways of working. The implementation of lean requires adapting a continuous improvement mindset throughout the whole organization. The application of lean means working according to the five principles of lean thinking, adapting the 14 principles of Toyota's management philosophy to the organization's every day operations, and focusing on value creation and waste elimination in all organizational processes. Inter-organizational lean implementation, on the other hand, starts from a focal company that wants to develop a lean, inter-organizational process. Collaborative atmosphere and contextual understanding are needed as prerequisites for starting the lean implementation. Facilitators and boundary objects can help all the stakeholders come together with their different knowledge backgrounds, thus creating a collaborative atmosphere. From there on, the actual application of lean through waste elimination, partnering and structuring the context can start. Similar to intra-organizational lean implementation, the adaptation of a continuous improvement mindset throughout the whole inter-organizational network is crucial. Finally on both levels, the lean principles are embedded into the organizational culture and processes when the different aspects of lean application and the continuous improvement mindset are a part of the everyday operations. The aspects of the theoretical synthesis are next explained in a more detailed way.

According to Hines et al. (2004), lean emerges on two levels: the strategic level and the operational level. The operational level of lean focuses on eliminating waste from the production processes, and different tools and techniques can be used for it. This operational level of lean was also the original context of lean in car manufacturing. To achieve the full benefits of lean, the lean production principles should, however, be spread throughout the entire organization and not just applied to manufacturing processes. Toyota was a prime example in this regard, and Liker (2004) listed the 14 principles of Toyota's lean management philosophy, which shed light on the organizational culture of a lean organization. The strategic level of lean focuses on understanding value creation through the five principles of lean (Hines et al. 2004) The five principles are value specification, value stream identification, flow of value creation steps, pull and strive for perfection through continuous waste reduction (Hicks 2007, p. 236; Womack & Jones 1996).

Smeds (1994) created a generic framework for managing change towards a lean enterprise like Toyota. The framework features a six-step process (Figure 3, p. 32), in which the relevant stakeholders of the enterprise including the personnel are brought together in social simulation games to understand the current situation of processes in the organization and to develop new processes together. In this way, the different stakeholders of all levels of the organization are creating the new, lean processes together and the lean ways of thinking are spreading throughout the organization. This also helps in the implementation of change towards the lean enterprise, as the employees are a part of creating the desired, new way of working in the organization. The employees are more likely to adapt to the change, as they feel they have contributed to it.

Lean has evolved over time from manufacturing to other contexts. The operational waste elimination tools of lean production cannot easily be applied as such to other contexts. However, the five strategic principles of lean thinking have been transferred to other contexts. In industrialized housing production, the application of lean thinking has been affected by the traditional construction project culture (Höök and Stehn, 2008). The managers that guide and motivate the workers play a critical role in changing towards lean in the context of industrialized housing production.

In lean supply networks, the role of the managers is to spread the lean culture throughout the organization and lead by example. The networked context of supply networks means that lean should be first implemented inside an organization before

moving to inter-organizational implementation. A collaborative atmosphere and environment is crucial for applying lean to the inter-organizational context of supply networks. This atmosphere and environment can be achieved with the help of facilitators and boundary objects, and then further enhanced by appropriate ICT tools.

Understanding the context, where lean is applied, is very important. The five principles of lean cannot be applied as such into all contexts. In the context of construction projects, Eriksson (2010) grouped the characteristics of lean construction into six core elements: waste reduction, process focus in production planning and control, end customer focus, continuous improvements, cooperative relationships, and systems perspective. The original focus on value creation in the five core principles of lean has shifted more towards a systems perspective in lean construction. Cooperative relationships and systems perspective highlight the importance of building a suitable context for lean to be applied. The value in lean construction, therefore, comes from understanding and building a structure for the inter-organizational collaboration in construction projects.

Green and May (2005) define three different stages of lean implementation in lean construction. The stages are waste elimination, partnering and structuring the context. To achieve full-fledged lean construction, Eriksson (2010) argues that both waste elimination and partnering must be combined in the third stage of lean construction, structuring the context. All the three stages of lean construction provide good guidelines for shifting towards leaner ways of working in inter-organizational contexts. The starting point and the level of implementation can be determined in the context in question, depending on its characteristics. As Bhasin (2012) stated, every journey to lean implementation is unique and there is no universal method for achieving successful lean implementation. In inter-organizational contexts, the partnering between organizations, understanding and structuring the context as well as the traditional waste elimination are all important aspects to consider when starting the change towards lean.

In all lean implementations, managers play a critical role. They need to lead by example and spread the lean principles into the whole organization with appropriate leadership. However, the managers should not be overstrained with the additional lean duties alongside their day-to-day work activities. Assigning a group of people for the sole purpose of lean implementation, a “lean steering committee”, can be beneficial in shifting towards a lean organization. (Bhasin 2012)

III EMPIRICAL STUDY

In this part of the thesis, the empirical study is presented. First, the context of the case is described in chapter 6. The data collection and analysis processes are described in chapter 7. Finally, chapter 8 concludes this part of the thesis by describing the empirical findings.

6. CONTEXT DESCRIPTION – FINNOO URBAN AREA DEVELOPMENT PROJECT

The empirical study of this master's thesis features a highly complex context. The Finnish aggregate stone industry, the Finnish planning process, the REKI-project and resource-efficiency in stone aggregate use are all related to the context of the empirical study and were described in the introduction part of this thesis (Chapter 1). This chapter describes the Finnoo urban area development project in more detail.

The case study examined in this master's thesis is the development project of a new housing area in Finnoo, Espoo. The new housing area will be in the nearby area of a new metro station and the new metro line. The digging operations for the new metro tunnel have been going on during the writing of this thesis and therefore a lot of stone has been needed to be blasted and transported away from the tunnels. The blasted stone material is a sort of a problem for the tunnel digging company, since from their point of view the focus is on building the tunnel as fast as possible and the blasted stone material needs to be removed quickly from the tunnels. However, the blasted stone material is good and valuable material for housing and infrastructure construction, if it is crushed and sorted properly. Even without crushing and sorting, the blasted stone can be used in some situations. The tunnels are located close to the coastal area of Finnoo, where a lot of infrastructure and housing construction is to be done in the future. Also, there have been plans to build an artificial island in front of Finnoo and the aggregate stone material from the tunnels could be used for that. These factors together form a complex context in which resource-efficient use of aggregate stones could be pursued. The Finnoo urban area development project and the related tunnel digging projects are closely connected to the themes of the REKI-project, and therefore the Finnoo project was chosen to be studied as a case.

7. DATA COLLECTION AND ANALYSIS

This chapter consists of two sub chapters that describe the empirical data of this study. In the first one, the data used in this empirical study and the way it was collected are introduced. In the second one, the analysis of the data is described.

7.1. DATA COLLECTION

One of the main methods for generating data in qualitative research is interviewing. According to Mason (2002), qualitative interviewing has four basic characteristics. First of all, the interactional exchange of dialogue is always there in qualitative interviewing, whether you are doing either one-on-one interviews or group interviews in a face-to-face setting or over the phone or even over the internet. Secondly, qualitative interviews feature a relatively informal style, which allows a purposeful discussion or a conversation rather than a formal question and answer format. Thirdly, qualitative interviews have a thematic, topic-centered, biographical, or narrative approach, which means that the researcher has some topics or themes wished to be discussed with the interviewee(s). The researcher usually has a very flexible interview structure with no specific question patterns, which allows a freer discussion around the themes and topics. Finally, in qualitative interviewing there is the underlying assumption that knowledge is situated and context-specific. Therefore, it is the purpose of the interviews to bring the relevant context into the discussion in order to produce situated knowledge. (Mason 2002)

The data used in this empirical study consists of ten interviews of 16 people in total and a process modelling session with 34 participants which was held during a workshop. The interviews and the process modelling session are related to each other, since the interviews were used to design the process modelling session. The interviews were qualitative in nature. Qualitative interviewing was chosen as a data collection method, since this master's thesis applies a qualitative research approach and it is one of the main methods for generating data in qualitative research. Also, qualitative interviewing seemed like the most appropriate data collection method in this empirical study based on its four basic characteristics or core features (Mason 2002) introduced earlier.

The interviews

The ten interviews were conducted in January 2016. I was involved in all the interviews and Professor Riitta Smeds joined me in four of the interviews. In the interviews with Professor Smeds, I was in more of a support role asking some questions in between and taking notes, while she was the main interviewer. In the other interviews, I was both interviewing and taking notes at the same time. The average length of an interview was 65 minutes and all the interviews were audio-recorded with permission given by the interviewees. Notes were taken during the interviews to help the analysis process later.

The main theme of the interviews was the Finnoo urban area development project and the resource-efficient aggregate stone use related to it. The interviews consisted of two parts. In the first part, a scenario was discussed, in which the blasted stone from the metro tunnels would be used resource-efficiently in the local area. The scenario involved an artificial island, which could be built with the blasted stone material, and the establishment of a crushing plant, where the blasted stone material could be crushed and processed, so that it could be used in the local area. Additionally, the possibilities for storing the blasted stone material in the nearby area for future use were discussed. The second part of the interviews brought lean thinking into the discussion. The interviewees were asked to think of the wastes they see in the case study project related to resource-efficient aggregate stone use and the importance of reducing them. To conclude the interviews, the interviewees were asked about their expectations of the upcoming workshop, in which the process of the Finnoo project based on the scenario would be discussed in a process simulation session. The whole interview template can be found in Appendix 1.

The selection of the interviewees required thorough preparation. Professor Riitta Smeds and the manager of the REKI-project played a crucial role in this. Together, we mapped out all stakeholders in the case study project and identified the most relevant ones to be interviewed. The most relevant stakeholder was obviously the city of Espoo. It is a big and complex municipal organization with over 14,000 employees. We interviewed representatives of different departments inside the organization. These departments were the urban planning department, the public works department, the environment center, the technical and environmental services, and the sports and youth services. Also, one interview was conducted with a member of the city board and the city council of Espoo to get understanding from the political decision-making

viewpoint. Other relevant stakeholders whose representatives we interviewed were the Helsinki-Uusimaa Regional Council, Regional State Administrative Agencies, Ministry of the Environment and the Uusimaa ELY Centre.

The interviews were done as one-on-one, pair, or group interviews depending on the stakeholder. I reached out to all the identified, relevant stakeholders, contacted them and informed them of the purpose of the interview. They pointed then the relevant individuals to be interviewed, and the interviews were arranged. Consequently, sixteen people were interviewed in ten interviews. With this group of interviewees, it was ensured that a broad and diverse set of qualitative data was collected. The descriptions of interviews are compiled into Table 4.

Table 4: Decriptions of the interviewees

Date	Working title of the interviewee(s)	Organization and unit	Length
18.1.2016	1) Construction Manager, 2) Outdoor and Recreation Manager	The City of Espoo – Sports and Youth Services	87 minutes
18.1.2016	3) Environmental Specialist	The City of Espoo – The Environment Centre	78 minutes
20.1.2016	4) Head of Geotechnical Engineering	The City of Espoo – Public Works Department	43 minutes
20.1.2016	5) Planning Manager of Regional Land Use Planning	Helsinki-Uusimaa Regional Council	55 minutes
21.1.2016	6) Member of the City Board and the City Council	The City of Espoo	58 minutes
21.1.2016	7) Environment Counsellor, 8) Environment Counsellor	Regional State Administrative Agencies	65 minutes
22.1.2016	9) Director of Urban Planning, 10) Project Architect, 11) Planning Architect	The City of Espoo – The Urban Planning Department	73 minutes
26.1.2016	12) Environment Counsellor	Ministry of the Environment	50 minutes
27.1.2016	13) Project Director of Finnoo-Espoonlahti Project	The City of Espoo – Technical and Environment Services	88 minutes
28.1.2016	14) Head of Environment Unit, 15) Water Act Supervisor, 16) Head of Area Use	Uusimaa ELY Centre	57 minutes

Process modelling session

The process modelling session was a part of the REKI-project workshop called "Local aggregate stone in urban planning". The workshop was held on February the 2nd 2016 in Otaniemi, Espoo. The session was a group discussion facilitated by the author of this thesis in front of a visual process model of the combined Finnoo urban area development project and its aggregate stone use. The visual process model had been developed by the author, based on the interviews. It included the past, present, and the future phases of the Finnoo development project. The model was drawn with Microsoft Visio, and projected on a large whiteboard on the wall.

In total, 34 people took part in the facilitated discussion that lasted approximately 90 minutes. The participants consisted of public servants of different units in the city of Espoo, elected officials of Espoo, board members of the REKI-project, representatives of Regional State Administrative Agencies, Uusimaa ELY Centre, Helsinki-Uusimaa Regional Council, Aalto University, and the users of the local area. The group discussion was video-recorded for research purposes.

The group discussion about the process model was facilitated in a chronological order. First, the past was discussed: what had happened in the process so far. Then, the current situation was discussed: what is happening now in the process and what is expected to happen in the near future. Finally, the discussion was steered towards the future of the process, which was modelled based on the scenario of using local aggregate stone resource-efficiently in the process. It could be seen in the visual model that the time windows for the supply and demand of local aggregate stone do not meet in the future. Therefore, the topics that came into discussion were: what has led into this situation, what should have been done differently in the process to avoid this situation, and what can be learned from this for future projects. Right after the group discussion, the participants filled out a questionnaire. In the questionnaire, the participants were asked what types of waste there are in the process regarding the use of local aggregate stone and how the waste types could be reduced. The questionnaire template can be found in Appendix 2.

7.2. DATA ANALYSIS

To summarize, the data analyzed for this empirical study includes:

- Ten audio recorded interviews of 16 key people (Table 4, p. ??)
- Audio and video recordings from the process modelling session with 34 stakeholders
- Questionnaires that were filled out by the process modelling session participants

The interview data was qualitatively content analyzed. The data analysis process started with listening through the interviews and reading through the notes made during the interviews. The notes were improved and relevant parts of the interviews were transcribed. At this point, I used the interview with the project director of the Finnoo urban area development project as a basis to create a first draft of the process model of the development project and its aggregate stone use. Next, I used relevant data from other interviews to improve the draft. This process model draft was analyzed and developed further together with the project director of the Finnoo urban area development project, the project manager of the REKI-project, and Professor Riitta Smeds. With the input of all the actors, the process model was finalized. The process model is already a result of this study in itself. It was also used as a boundary object in the process modelling session of the workshop.

The video recordings of the process modelling session and the ensued discussion were analyzed by taking detailed notes of how the discussion went and what was discussed, and transcribing the most relevant parts. The answers to the questionnaires were compiled into a document. At this point, all collected data from the interviews, the group discussion, and the questionnaires were combined into a single document. In an iterative fashion, I started going through the whole data document, removing the irrelevant notes and citations, and analyzing the remaining data to look for arising themes. Based on this iterative process, I grouped the data under the three following headings:

- Challenges of the current process
- External processes and factors
- From current problems to future improvements

The language used in the interviews, in the group discussion and in the questionnaires was Finnish, and up until this point the data analysis was also done in Finnish. This was done so that the original language and the authentic expressions would be a part of the analysis as long as possible. At the end of the analysis, I translated the citations from Finnish to English and started writing out the findings in English.

8. EMPIRICAL FINDINGS

The analysis showed that there currently is no clear process of aggregate stone use, but there is an implicit, yet un-modelled process of the Finnoo urban area development project which involves the use of aggregate stone. One of the main findings of the empirical study is the process model of the Finnoo urban area development project that includes the use of aggregate stone. The Finnoo project and its aggregate stone use were combined in this thesis into a process model, which is described in chapter 8.1. The combined process model answers the first research question (RQ1) of this master's thesis: what is the current combined process of an urban area development project and its aggregate stone use?

The further empirical findings were grouped under three different headings in the data analysis process. In chapter 8.2, the challenges of the current process are presented. In chapter 8.3, the external processes and factors that also have an impact on the situation are introduced. In chapter 8.4, understanding of current problems and future improvements to the process are presented. Finally, chapter 8.5 summarizes the empirical findings and answers the two sub-questions of the first research question (RQ1.1 & RQ1.2).

8.1. THE COMBINED PROCESS MODEL: THE FINNOO URBAN AREA DEVELOPMENT PROJECT AND ITS USE OF AGGREGATE STONE

The actors of the process and their tasks are summarized in Table 5, and described in the text that follows the combined process model, which is depicted in Figure 5.

Table 5: Descriptions of the actors and their tasks in the combined process

	Tasks in the urban area development project	**Tasks in the aggregate stone use process**
Elected officials of Espoo	• Give guidelines to public servants • Make decisions based on the proposals made by public servants	• Give guidelines to public servants • Make decisions based on the proposals made by public servants
Public servants of Espoo	• Preparation of necessary documents for the realization of the project • Local master plans, detailed plans, assessments, etc.	• Make sure the project gets the needed stone aggregates economically and on schedule • Find use destinations for excess stone aggregates
Administrative officials (ELY Centre, AVI, The Ministry of Environment)	• Handling of all permits and plan documents • Informing the applicants of all necessary assessments • Guiding local master and detailed planning	• Handling of all permits and plan documents • Informing the applicants of all necessary assessments • Streamlining collaboration in aggregate stone use issues
Aggregate stone supply and demand are depicted as two "actors" in the bottom two lanes of the model (Figure 5).		

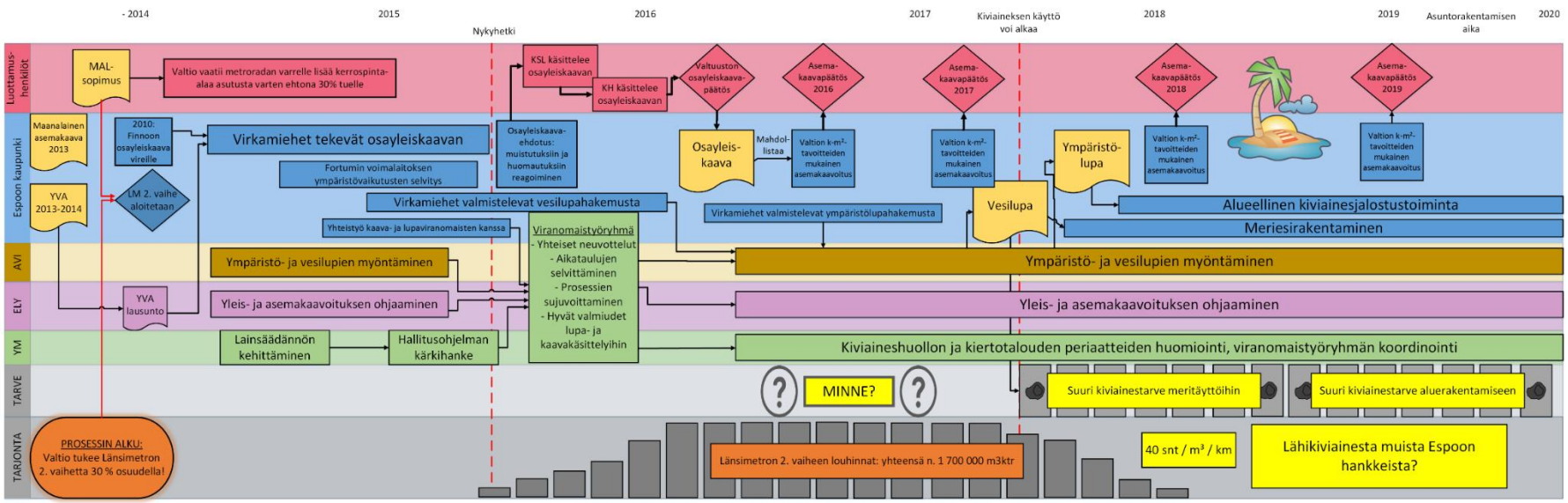

Figure 5: Combined process model of the Finnoo urban area development project and its use of aggregate stone (in Finnish)

Elected officials of Espoo

The elected officials of Espoo give guidelines to the public servants of Espoo, and decide upon the proposals prepared by the public servants. These proposals include the local master plans and local detailed plans. The planning documents and their approval have great impact on the use of stone aggregates. When a local detailed plan is approved and legal, it requires the construction of infrastructure for the area in question. This means building streets, draining, water supply, and other infrastructure which also requires the use of stone aggregates. Additionally, permanent or temporary storing areas for the stone aggregates can be assigned in the local detailed plans. Various political opinions and desires affect the decision making of the elected officials. In the Finnoo project for example, the MAL contract, which is an agreement between Finnish government and the metropolitan area municipalities about increased housing production, affects the decision making.

Public servants of Espoo

In the municipal organization of Espoo, different departments are involved in urban area development. The Environment Centre, Public Works Department, Technical and Environment Services and Urban Planning all have tasks related to an urban area development project. They prepare all the necessary documents and plans that are needed for the realization of the project. These documents and plans include local master plans, local detailed plans, environmental impact assessments, water permits, and environmental permits. It is important to anticipate that the approval processes for the local master and detailed plans as well as for the water and environmental permits can take a long time due to the appeals made by stakeholders such as local area residents and users. The public servants need to make sure that the project gets the needed stone aggregates economically and that the construction starts on schedule. Therefore, it is important that all the required permits are acquired on time. In the municipal organization of Espoo with its different departments, there are many different on-going construction projects and in many of them stone aggregates are either needed or produced. However, the supplies and demands of stone aggregates are not well coordinated within the organization. In the Finnoo development project, the schedules for the metro project and the urban area development project do not meet and it is challenging to find ways to utilize the stone aggregates in a resource-efficient manner.

The administrative officials

The administrative officials represent three different organizations: The Regional State Administrative Agencies (AVI), the Uusimaa ELY Centre and Ministry of the Environment (YM). In the Finnoo development project, representatives of the three organizations together with public servants of Espoo formed a working group. The tasks of the working group include joint negotiations about schedules, needed permits, documents, and streamlining the joint processes for permit applications. The actions of the working group have made the processes of permit and plan applications more swift and flexible. The Regional State Administrative Agencies oversee environmental and water permits. The ELY Centre guides the local master and detailed planning. The Ministry of Environment is responsible for the development of legislation and acts as a link in between the project and the government. The REKI-project is one of the top projects of the government, and the Ministry of Environment takes into consideration the principles of resource-efficiency in aggregate stone use in its future legislative work.

8.2. CHALLENGES OF THE CURRENT PROCESS

The current process of resource-efficient aggregate use in the city of Espoo can be characterized by the lack of planning and perception. In the Finnoo development project, this manifests itself in the timing mismatch for the supply and demand of aggregate stone. The supply comes from the vast amount of blasted stone from the metro tunnel. The demand consists of the needs around the local area to build infrastructure and eventually housing as well, but the required plans and permits are not ready yet to start the construction activities. There would be enough demand for the aggregate stone supply in this case, if the time windows were to match each other. The problem is that also the timing perspectives are different. The construction of the Finnoo area will last tens of years, whereas the supply of the blasted stone aggregates starts and ends in just a couple of years.

Status of aggregate stone use in municipal projects

Urban area development projects, such as the Finnoo project, are limited to their own scope and goals. Within those projects, the bigger picture of using stone aggregates resource-efficiently has not been thought upon. In the Finnoo project, the possibilities were investigated but only in the local area and not in whole Espoo. However, the

officials working in area development projects and other municipal projects do discuss questions regarding aggregate stone use: where it is needed and where it is produced now. It is not a clear process, however, since individuals discuss the aggregate stone issues occasionally, and there are no systematic procedures to handle it. During the process simulation session, it was mentioned that it has been a normal practice, in earthwork projects of the municipality, that the blasted or excavated stone aggregates are acquired by the contractor as a part of the contract. The municipality itself does not acknowledge use for it, since the needs for aggregate stone stem from the individual projects in the municipality.

The prioritization of the metro project

The metro project is a project of the city of Espoo, with its own goals and schedules. After the first phase of the metro project, it was deemed practical and cost-efficient to continue immediately with the second phase, since there was so much equipment and machinery already in place. The second phase is planned to reach the new Finnoo area. This boosts the development of Finnoo. Another accelerating factor was the decision of the Finnish government to support the second phase with a 30% investment. In return, the city of Espoo must substantially increase their housing production in the surrounding areas of the new metro line, including Finnoo, between the 2016 and 2019. The increase for housing production is documented in the agreement on land use, housing and transport, closed between the municipalities of the metropolitan area and the Finnish government. For the city of Espoo, this agreement means that they need to prepare new local detailed plans in the areas surrounding the new metro line. One of these areas is the Finnoo area.

The interviewees felt that in this case, the metro project has been prioritized over other projects in Espoo. The decision about continuing to the second phase of the new metro line came as a bit of a surprise. It is challenging to fit the increased housing production requirements stemming from the metro project to the slow processes of making new local master plans and local detailed plans. At the same time, the question about the use of the blasted stone material from the metro tunnels was left in the shadow. For the metro project, there are financial and temporal goals, which means that the tunnels need to be mined efficiently. In an optimal situation, there would be an available destination as close as possible to the tunnels, where the blasted stone material could be transported all night and all day. This would allow efficient tunnel mining to be done.

"The construction of the metro line cannot be slowed down by finding destinations for the blasted stone."

The above quote referred to the blasted stone being a marginal problem in comparison with other cost aspects of the metro project. The potential cost savings from finding use destinations inside Espoo for the blasted stone material are secondary if it slows down the construction of the metro line.

For the last three to four years, the representatives of the metro project have asked the officials of the city of Espoo about possible transport destinations for the blasted stone, but to no avail. Since there are not enough available destinations pointed out by the city of Espoo, the metro project needs to sign such contracts, that the mining contractor transports the blasted stone away. The contractor thus gets the ownership of the blasted stone material and can make business out of it by crushing it and selling it further.

Abnormal market situation

"In a normal situation, there is a shortage of aggregate stone materials."

According to the interviews, this situation in the stone aggregate market in Finnoo area is quite unique in its nature. In a normal situation, the supply and demand for stone aggregates in Espoo are close to each other. Now, the supply exceeds the demand, since the metro project produces so much blasted stone material.

"At the moment, the blasted stone material is kind of a waste product in Espoo, since there are not enough projects where it could be used."

The city of Espoo does not have enough own projects where the blasted stone could be used, as the quote above states. If the blasted stone from the metro project cannot be used in the construction of the artificial island, the vast amount of blasted stone will be a disturbance in the market for the next three years. It will cause delays for other mining projects in Espoo, since it makes no sense to start the mining due to the exceptionally large supply situation in the market for stone aggregates.

However, the interviewees also stated that there are destinations where the blasted stone could be used. The problem, though, is the lack of planning.

"In principle, we have areas, where we could use the blasted stone material as such from the [metro] tunnel, but we do not have complete plans. That is the problem."

There are even more possibilities to use the blasted stone material, if it is crushed first to a desired form. Construction goes on in Espoo all the time and stone aggregates are needed. If the blasted stone material were to be crushed first, it could be used in the different construction projects. Examples of use destinations mentioned in the interviews included the construction of streets, housing, noise barriers, and a breakwater.

There is a clear contradiction here. On one hand, the interviewees tell that there are not enough possibilities to use the blasted stone material from the metro project in Espoo. On the other hand, there are possible use destinations, but the plans are missing or the blasted stone material needs to be crushed first.

Difficulties in finding areas for temporary storing or crushing

It is hard to find suitable areas for temporary storing of rock aggregates. In the Finnoo area, there is a lot of clay in the ground. There is the risk that the heavy masses of stone aggregates would sink into the ground with the softer sediments like clay gushing out from the sides. Also, finding suitable areas near settlements has proven to be difficult. It is even harder to find suitable areas for crushing plants since they require an environmental permit. Certain restrictions also apply to crushing plants. For example, they need to be located at a certain distance away from the nearest settlements.

Finding suitable areas for temporary storing of stone aggregates and for crushing plants is difficult in the whole Helsinki metropolitan area. There are not many supportive grounds left that could be used for such purposes, since most of them have already been constructed on. As more and more people move from other parts of country to the metropolitan area, the situation will only become more difficult in the future.

8.3. EXTERNAL PROCESSES AND FACTORS

From the empirical data, it became apparent that not only internal processes and factors of the municipal organization affect the resource-efficient use of stone aggregates, but also external processes and factors affect it.

Plans and environmental impact assessments

The municipalities have a lot responsibility in the Finnish planning process. The local master plans and local detailed plans are drafted by the municipalities and then approved by city or municipal councils. However, the ELY Centers direct the municipal planning processes by giving statements about the plans. In the Finnoo area development project, a new partial master plan is currently being made. The preparation of the plan was already started in 2010. Its draft was shown publicly in 2011, but at that time there was no certainty about the continuation of the metro project. A starting point for the making of the component master plan was that if there will be blasted stone from the metro tunnels, it will be used in the local area. However, this does not show in the master plan in any way. There are no locations pointed out that could be used for storage of the blasted stone. Negotiations about the contents of the new partial master plan have constantly been held between the city of Espoo and the Uusimaa ELY Center. The plan has been shown to the public, and the officials of the city of Espoo are taking into account the remarks made by the Uusimaa ELY Center and the public. The new partial master plan still needs to be approved by the city council of Espoo and if there are appeals about it, they need to be resolved in the court. Only after the new partial master plan has gone through the political bodies of the city of Espoo and the possible appeals have been processed, the new plan can be deemed lawful. The processes for approving new local detailed plans, which are needed for the required increase in housing production set by the Finnish government, cannot start until the partial master plan is deemed lawful. Preparations for the local detailed plans have already been made proactively.

Two environmental impact assessments have been made in the Finnoo development project, because the assessments need to be done for the approval of the new partial master plan. One is for the Finnoo harbor area and the other is for the power plant that is located near the Finnoo shore. The Finnoo harbor environmental impact assessment deals with the impacts of the dredging and fillings that would be done in the sea. The document does not note what kind of stone aggregate would be used in the fillings or where the stone aggregate comes from. Instead, it focuses on the amount of mass needed for the fillings and what kind of dredging needs to be done. The outcome of this environmental impact assessment process was that the Uusimaa ELY Centre accepted the document, but made some remarks about problems and deficiencies that need to be addressed in further planning. This means that the officials of the city of

Espoo need to make some additional investigations regarding the environmental impacts.

The other environmental impact assessment was made regarding the power plant that is located near the sea shore of Finnoo. In the eyes of the officials of the city of Espoo, this was huge waste of time. It took almost a year to finish the investigations about what the power plant means to the area. The result was that the impacts of the power plant mainly reach the power plant area itself and not the further surroundings. It was a bit unclear to the officials of the city of Espoo why they needed to do the environmental impact assessment of the power plant, instead of the company that owns the power plant. Even though the officials of the city of Espoo feel that the environmental impact assessments require unnecessary work and hinder other important processes, they are still an integral part of land usage planning and they need to be done. They cannot be avoided, if you wish to get the new partial master plan approved.

The construction of the metro line requires a lawful underground detailed plan, which was made in 2013. No appeals regarding it were submitted. The plan enables the construction of the underground metro tunnels and the related aboveground structures such as the metro stations. The underground local detailed plan does not take into account the blasted stone material from the tunnels. A question arose during the process simulation discussion about the underground local detailed plan:

"Could this underground local detailed plan be a good means of taking the blasted stone material into account?"

It was also said during the discussion, that aggregate stone was thought upon while the underground local detailed plan was prepared, but the question regarding the blasted stone material was not solved. There is no requirement for the underground local detailed plan to take the to-be-mined blasted stone into account.

Permits

In the discussed scenario for the future development of Finnoo area, two permits are needed. A water permit is needed for the construction of the artificial island. The environmental impacts of the construction of the island need to be investigated. These include, for example, the changes to the sea currents and the effects on the opacity of the sea water. In addition, an environmental permit is needed for the crushing plant. A

crushing plant causes dust and noise problems to the nearby area, and therefore those effects need to be taken into account. There are certain requirements for the establishment of a crushing plant and its distance to the nearest settlements.

The technical sector of the municipality is in charge of acquiring the needed permits. Unlike the partial master plan and the local detailed plans, the permits need not to be approved by the city council of Espoo. Instead, the Regional State Administrative Agencies are in charge of handling both water and environmental permit applications and their approval. Similar to the planning process, citizens and legal organizations can make appeals about water and environmental permits.

Local area users

The users of the local area are affected by the planned future scenario of Finnoo area. The plans to build an artificial island and to move the shoreline with fillings affect the harbor operations in the area. The users of the harbor currently have a ten-hectare area for storing their boats during winter time. The new size of the area will be half of the current size or even smaller in the future if the plans come true. This means that a lot of the boat owners would have to move their boats elsewhere for the winter time. The boatmen are used to storing their boats in the harbor area, and this change would mean that they would have to transport their boats twice a year between the harbor and the new winter storage area. Transportation of the boats and the new storage area inflict both costs as well as inconveniences for the boatmen. The city of Espoo has surveyed different winter storage alternatives for the boats that would need to be moved away.

Local residents

According to an interviewee, the case study area features a vigilant group of residents. The number of people living in the area is relatively small, but they are highly alert to environmental effects. There has been a power plant in the area for a long time, and the residents feel like it pollutes the air even though only water vapor comes out of the power plant's chimneys. The local residents have a really low tolerance towards environmental effects such as noise and dust problems. They feel like bad things are constantly happening in the area and if, for example, construction begins, it would only increase environmental problems in the area.

One interviewee expressed that because of the alertness of the local residents, it is important to clarify their worries and concerns and engage them in the planning. In

the planning phase of a project, attention should be paid to addressing these worries and concerns and solving them should be made visible to the residents.

Environmental and natural factors

The environment center of the city of Espoo makes sure that environmental and natural factors are considered in all urban development projects of the city. The decisions about what is to be built and where come from other departments of the city and the environment center makes sure that the environmental and natural values are preserved when those projects are carried out. There are a lot of different things to consider when assessing environmental and natural effects. The prioritization of environmental and natural values is not only for the environment center to decide, but political decisions play a big role. The environment center however expresses its views about conflicts regarding environmental and natural values.

In the interviews, it came clear that there are many environmental and natural factors that need to be considered in the development of the Finnoo area. In the middle of the Finnoo area, there is a protected wetland for birds. Protection of flying squirrels is of high importance in the area too. In the shore waters, there lives a certain protected species of leaf beetle, *macroplea pubipennis*. In the Finnoo project, the most important factors have been the preservation of flying squirrels and the shore waters. This means, for example, that the preservation of flying squirrels is more important than reducing the transportation distances of aggregate stone and thus the emissions from trucks.

Appeals

Appeals prolong both the planning and permit processes. It was strongly emphasized in the interviews, that appeals break the schedules of projects. One single appeal slows down the handling of a plan or a permit application. In the Finnoo development project, there are many different interests that can cause people to make appeals about the plans or permits.

The local area users, the boatmen, are likely to make an appeal since the winter storage area for their boats is planned to be moved. The local residents can make an appeal, because they are concerned about their living environment and its safety. People or organizations concerned about natural and environmental values are likely to make an appeal too, since there are a lot of natural values to be preserved in the area.

In a case like this, it is nearly impossible to avoid appeals. Due to the strong interests of different stakeholders, it is hard to negotiate with them. It is worthwhile to try to achieve a dialogue, but it is hard to influence the stakeholders in a way that they would drop the appeals. Thus, the municipal organization should prepare the plan and permit applications and the needed investigations so thoroughly and properly that they will hold up in court.

"The most unfortunate thing is if it [plan or permit] does not hold up in court, the situation goes back to the starting point."

The plan and permit processes can always be slowed down with appeals from stakeholders. It is important to prepare for that by finding out all the different things that need to be investigated and making the investigations properly. If it is decided in the court that further investigations need to be made based on an appeal, it will slow down the process even more.

8.4. FROM CURRENT PROBLEMS TO FUTURE IMPROVEMENTS

It was evident from the empirical data, that the current problems were widely known among the interviewees and the process simulation participants. In addition, they saw possibilities for future improvements in dealing with the problems and moving towards resource-efficient aggregate stone use.

The cost of transporting the blasted stone

One thing that opened the eyes of many process simulation participants was the monetary value assigned to the transportation of the blasted stone material. The supply of the blasted stone material from the metro project was depicted at the bottom of the process model. The total amount of blasted stone is about 3,4 million cubic meters. The whole amount of stone is going to be blasted in the next couple of years. It costs 40 cents per kilometer to transport a cubic meter of the blasted stone with a truck. Therefore, the assigned cost for transporting the 3,4 million cubic meters of blasted stone material is 1,36 million euros per kilometer.

These numbers were introduced to the process simulation participants by a representative of the metro project. Every extra kilometer that the blasted stone material is transported costs around 1,4 million euros. Also, the fact that the Finnoo

area will be constructed in the future means, that eventually some sort of aggregate stone material is needed there. This means back and forth transportations which double the costs and harm the environment.

"This is a really big economic question and also an environmental one, because if the blasted stone is transported back and forth, it affects the environment." (Member of the city council during the process simulation)

The members of the city council who attended the process simulation were not interviewed. Their understanding about the current problems, though, increased because of the process simulation as demonstrated by the citation above. They got valuable information out of the process simulation discussion, which they can use in the future to help with political decision making. The political decisions of a municipality, especially the ones about master plans and local detailed plans, have a big impact on the use of rock aggregates and their storage. Political decisions play a big role in the prioritization of environmental and natural values, as mentioned earlier.

Directing the possible cost savings

In the interviews, the targeting of the potential cost savings from resource-efficient aggregate use was discussed. The potential cost savings are project-specific and even though the metro project is a project of the city of Espoo, the savings cannot be directed towards another project. If the mentioned transportation costs are avoided, the savings go to the metro project. If the blasted stone material can be used in the nearby area, the savings will be directed towards the Finnoo area development project, since the stone aggregates need not to be bought from somewhere else. The local area residents and users however can be affected by disturbances caused by transportation. If the savings could be somehow targeted towards them, maybe they would be more toleration towards the disturbances. If the area could somehow benefit from the cost savings, the likelihood of appeals concerning possible permits or plans would probably be decreased.

Streamlining the collaboration with administrative officials

The collaboration with administrative officials in projects involving plans and permits has been viewed as quite a hindrance. The approach of administrative officials is viewed as controlling rather than orientated towards problem-solving. The current legislation encourages this type of an approach, where the focus is on listing the

shortages of investigations rather than finding solutions. The perception of the bigger picture is missing from the administrative officials.

As a part of the procees of the Finnoo development project, a work group of officials was formed in late 2015 to investigate the administrative challenges of aggregate stone use in urban development, and to come up with ideas to improve the legislation. The work group consists of the representatives of the city of Espoo, the Finnish Ministry of Environment, the Regional State Administrative Agencies of Southern Finland and the Uusimaa ELY Centre. The work group gathered together a couple of times to discuss and exchange knowledge about the Finnoo urban area development project. During the process simulation, a representative of the Regional State Administrative Agencies of Southern Finland commented that this kind of a work group of officials is important so that early on all the officials of different organizations know what is going to happen in the project. Then, they can be well-prepared for the incoming applications and also inform the project members, which in this case are the Espoo city officials, of all the needed investigations. The actions of the work group have been seen as a positive thing, even though the case of the Finnoo area development project is complicated by a very tight schedule. It was noted by the representative of the Finnish Ministry of Environment that these discussions and planning of procedures in the work group would have been needed a lot earlier in the process.

Mass coordination

Both in the interviews and in the process simulation discussion, mass coordination activities were mentioned as a way to avoid situations similar to the Finnoo case example. The city of Helsinki currently employs a mass coordinator, whose job is to coordinate the sources of masses, such as stone aggregates, and the projects, where masses are needed. This was seen as a good example and as something that the city of Espoo could learn from.

"The municipality itself is the biggest user and producer [of stone aggregates]. *And therefore the responsibility is on the municipality."*

The citation above highlights the role of the municipality in mass coordination activities, and that the municipality should take the responsibility for organizing it. It is known, that the municipality has a lot of projects where stone aggregates are either needed or produced. However, the stone aggregates are not coordinated at the moment.

The optimal solution, though, would not be mass coordination inside the municipality. The geographical area should involve all the nearby municipalities.

"The best solution would be that this coordination was done collaboratively between the big cities in the Helsinki metropolitan area."

Concerning the Finnoo area, the optimal situation would be reached if the big cities of the Helsinki metropolitan area were to collaborate in mass coordination. This already happened in the first phase of the metro project, when a lot of the blasted stone material was transported from Espoo to Helsinki.

"Systematics is always the first thing that needs to be achieved."

According to the data, a system for mass coordination is the first thing needed. Then, you could assess individual municipal projects within the system. There should be an inventory, that records the places where stone aggregates are stored or can be stored, as well as the places where stone aggregates are needed. Different types of stone aggregates, their amounts and the permits would be handled with the mass coordination system.

8.5. SUMMARY OF THE FINDINGS

In this chapter, the findings from the empirical data are summarized to characterize the current process of the resource-efficient aggregate use in the Finnoo urban area development project as well as the development ideas for the future process. There are different challenges and factors that have had an impact leading up to the current situation, which involves lack of planning and perception of the overall picture regarding the use of stone aggregates in municipal projects. External factors and processes also play a big role in the resource-efficient stone aggregate use process. Many stakeholders understand the problems in the current situation but also see ideas for improving the process in the future. I have compiled the empirical findings into two figures. Figure 6 depicts the current process and the factors affecting it and thus, answers the research question 1.1: what are the challenges of the current combined process?

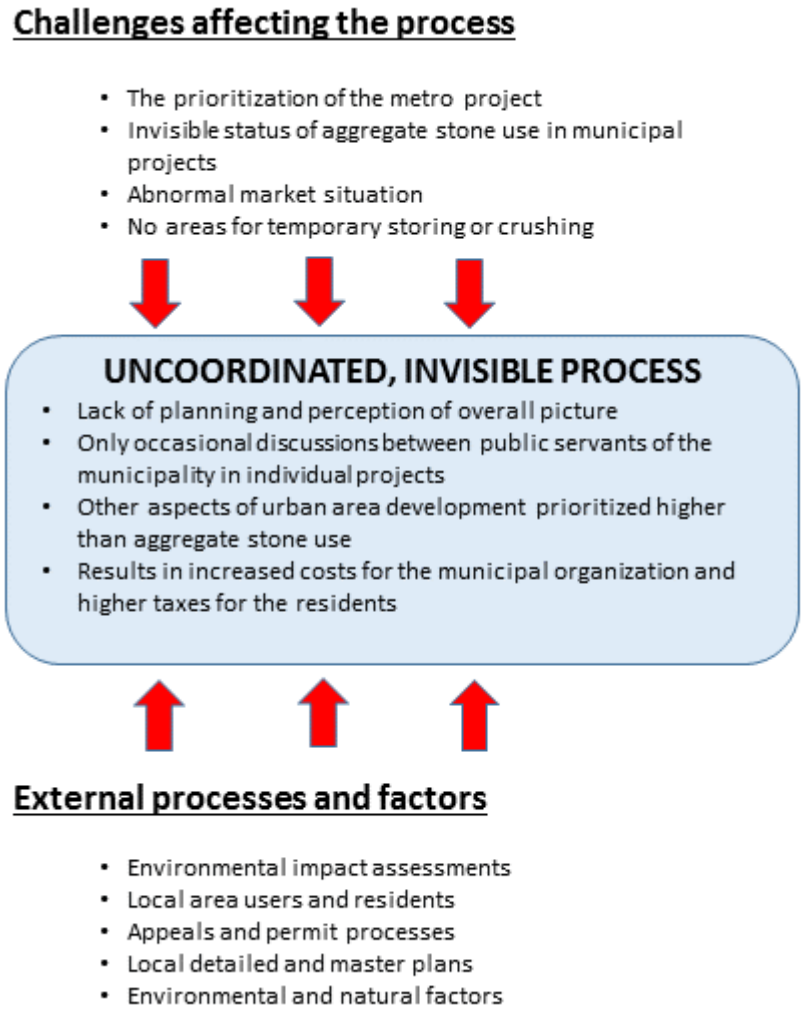

Figure 6: Current aggregate stone use process in the Finnoo development project

Currently, there is not a clear process of resource-efficient aggregate stone use in the Finnoo development project. The overall situation can be described with lack of planning and perception of the bigger picture. The questions regarding aggregate stone use are only occasionally discussed in individual projects of the municipality among the officials. No one is responsible for coordinating the supplies and demands of stone aggregates between different municipal projects. A lot of money and resources could be saved with more efficient aggregate stone use, but different challenges and factors have affected the lead-up to the current situation. The metro project was prioritized heavily in the decision-making of the municipality. This meant that the other related processes, such as the partial master plan process of Finnoo, were not ready for the sudden supply of blasted stone aggregate from the metro project. The usual way of working in the municipality regarding stone aggregate use in projects did not support

the coordination of the aggregate stone masses from the metro project to other municipal projects. Also, the amount of blasted aggregate stone from the metro project is so huge, that it makes the market situation abnormal. Usually, the supply and demand for stone aggregates are much closer to each other, but the blasted stone aggregate from the metro project makes the supply exceed the demand by a lot. Finally, the lack of areas for temporary storing or crushing of the stone aggregates makes it even harder to utilize the blasted stone aggregates from the metro project.

A variety of external factors and processes affect the current state of stone aggregate stone use in the case study context. The master plans and local detailed plans approved by the municipality have a lot of impact on the use and storage of stone aggregates. The planning processes are participatory in their nature and involve the relevant stakeholders. Appeals can be made about the plans and if there are appeals, they need to be handled in a court of law. The same goes for the environmental and water permits, both of which are needed in the Finnoo urban area development project. The Finnoo area residents and users form a relevant factor, which needs to be considered. They are affected by the plans and permits in the case study example, and they can affect the planning and permit processes through appeals. Environmental and natural values of the case area must be considered when making plans and permit applications. Environmental impact assessments need to be done to sufficiently investigate all the impacts on the local environment. It is crucial to properly investigate all the environmental impacts, so that the plans and permits are more likely to hold up in court, if there are appeals. These external factors and processes cannot be dismissed, if the process of resource-efficient aggregate stone use is to be developed further. They are external to the organizational context of the municipality, but must be considered when planning resource-efficient aggregate stone use. These external factors and processes, especially the appeals, are seen in a very negative light according to the data.

The empirical data revealed a clear understanding of the current problems and future improvement possibilities among different stakeholder. The problems were well-known among the interviewees and most of the process simulation participants. Other factors, goals and duties take priority over the coordination and planning of aggregate stone use since it is not managed by anyone. Therefore, no one can be said to be responsible for the present situation. However, many improvements were perceived that could help in avoiding situations like this in the future. Figure 7 summarizes the

development ideas for the improved process of aggregate stone use and thus, answers the research question 1.2: what are the development ideas for the current combined process?

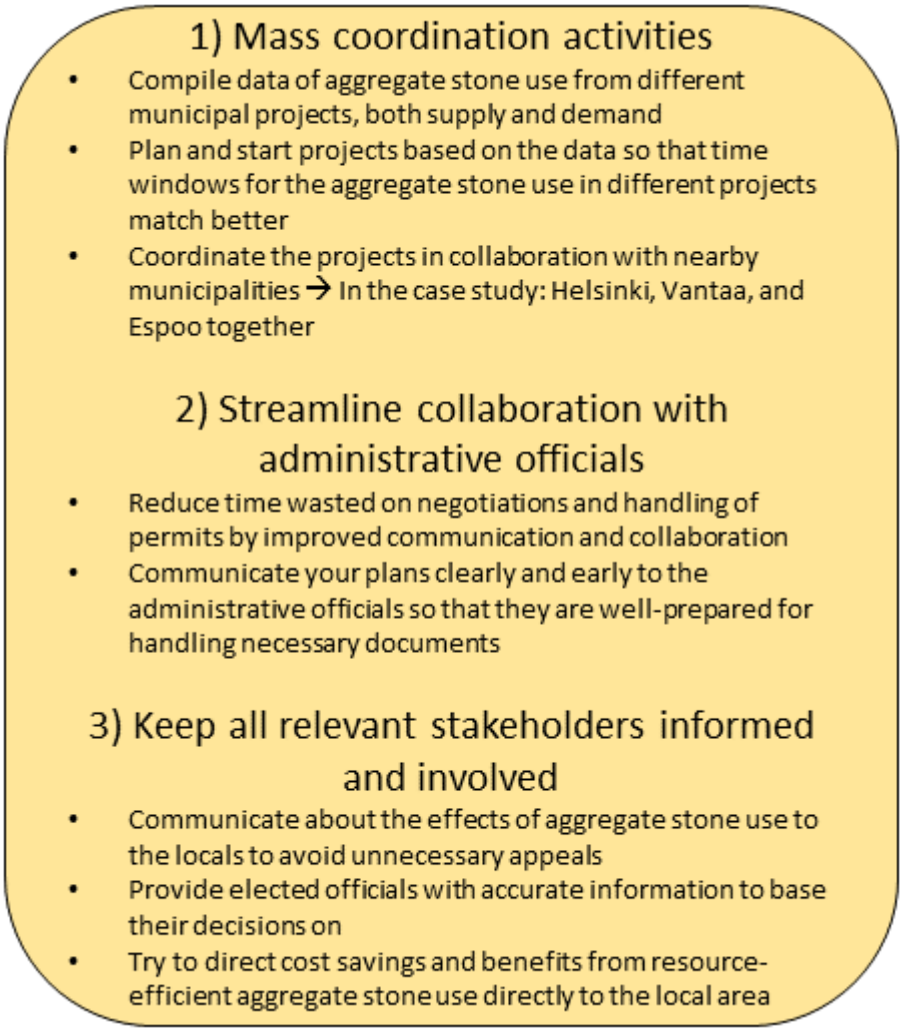

Figure 7: Summary of the development ideas for the improved process of aggregate stone use

Mass coordination is a future improvement idea identified by the interviewees and the process simulation participants to tackle the problems of the current situation. Mass coordination refers to coordinating the demands and supplies of stone aggregates from different municipal projects. The coordination should happen between the different functions of the municipality and their projects. Compilation of data from all municipal projects about their aggregate stone use helps in matching the supplies and needs of stone aggregates between projects. In addition, the nearby municipalities should be involved in collaboration regarding mass coordination since the distances

to nearby municipalities or cities can sometimes be shorter than to other parts of the own municipality. Thus, it can be more resource-efficient to use aggregate stone coming from another municipality's project.

Another improvement idea is streamlining the collaboration with administrative officials. Communicating the project plans and schedules that involve aggregate stone use to the administrative officials is important so that they can give accurate information to the public servants about all needed documents and assessments, and better prepare for the upcoming necessary permit processes. Collaboration and communication with the administrative officials reduces the time wasted on negotiations and handling of the permits.

Finally, all the relevant stakeholders should be kept informed and involved in issues regarding aggregate stone use. Local area users and residents should be informed of the effects of aggregate stone use to avoid unnecessary appeals. Elected officials of the municipality should receive accurate information about the effects of aggregate stone use to be used in their political decision making. These effects include both changes to the local environment as well as the cost savings acquired through resource-efficient use of stone aggregates. With mass coordination activities, a lot of money and resources could be saved. Directing the cost savings appropriately, for example towards local area infrastructure and residents, could help avoid appeals from stakeholders whose living environments and interests are affected by mass coordination activities.

IV DISCUSSION AND CONCLUSIONS

This final part of the thesis concludes it by first interpreting the empirical findings through the theoretical lenses of lean thinking in chapter 9. The key characteristics of a generic resource-efficient aggregate stone use process are derived based on the chapter's analysis. Chapter 10 evaluates the research conducted in this master's thesis and finally, chapter 11 presents the implications of the study.

9. INTERPRETING THE FINDINGS THROUGH LEAN THINKING

This chapter applies lean thinking to interpreting the development ideas for the aggregate stone use process found in the empirical study (Figure 7, p. 71). The three development ideas are further refined to be used in the creation of the key characteristics for a generic resource-efficient aggregate stone use process (Figure 8).

Mass coordination activities

Lean thinking aims to identify and optimize all value adding activities and remove all redundant activities or waste from the value creation process. This core mentality of lean thinking about removing waste and creating value is applicable to the mass coordination activities. The transportation and temporary storing of stone aggregates are wastes that can be reduced with mass coordination. It creates savings and value for the municipal organization, when the aggregate stone resources of different municipal projects are used resource-efficiently. Matching the time windows of projects can reduce the amount of stone aggregates bought from outside sources and it helps with the problems of finding storage areas for stone aggregates since they are not needed as often.

However, the current situation of aggregate stone use in the case study context is that it is an uncoordinated, invisible process that occurs in discussions between public servants. According to the theoretical synthesis, the starting point of lean implementation is that there is a process that needs development. In this case, the process should be first defined so that it can be developed with lean thinking principles. An owner should be assigned to the mass coordination process and the owner is responsible for developing the process further. The mass coordination activities, though, should not only happen in the municipal organization but rather

between the nearby municipalities. This makes the context inter-organizational which according to the theoretical synthesis means that a collaborative atmosphere and contextual understanding need to be achieved as prerequisites for lean implementation. One of the municipalities or a joint inter-municipal organization should be in charge of the lean implementation, as inter-organizational lean implementation requires a focal organization that is in charge of the process development. Once the prerequisites are achieved, application of lean through waste elimination, partnering, and structuring the context can start. The continuous improvement mindset of lean should also be implemented throughout the inter-organizational process.

Streamlining the collaboration with administrative officials

Application of lean thinking to the external processes with administrative officials is not possible. The permit application and plan approval processes are defined in law, and therefore lean thinking cannot be applied to them. Lean thinking can only be applied to the parts of these processes that happen inside the municipal organization such as the preparation of the permit applications and plans. The needs for plans and permits for the realization of municipal projects should be clarified early in the projects so that the public servants can start preparing all the necessary documents early enough. Otherwise, a lot of time, money, and resources are wasted when the projects are delayed due to missing permits or plans.

Keep all relevant stakeholders informed and involved

Lean thinking is not applicable to the processes involving external stakeholders such as elected officials and local area residents or users. The elected officials have their own legally defined decision making processes which means they cannot be modified according to lean principles. However, the elected officials can be accurately informed of resource-efficient aggregate stone use and its effects. This can promote lean thinking, if the elected officials have information of the cost savings that are achievable with lean, resource-efficient aggregate stone use. The local area users and residents can delay the plan approval and permit application processes through appeals. These delays in large municipal projects always inflict more costs and therefore they can be considered as waste. It is impossible to manage the intentions of local area users and residents about submitting appeals, but the municipal organization can try to reduce the number of appeals with open and honest communication. This

means informing the local area residents and users about the effects of resource-efficient aggregate stone use to their livelihoods and interests. The municipal organization can try to direct the cost savings and other benefits achieved with resource-efficient aggregate stone use to the development of the area affected by it.

In conclusion, lean thinking can be applied to the development of the mass coordination activities of the municipal organization. Lean thinking, though, cannot be applied to streamlining the collaboration with administrative officials or to the involvement of relevant stakeholders in the process since the processes move outside the organization's boundaries and they are therefore not controllable. The results of this chapter's analysis were used to derive the key characteristics of a generic resource-efficient aggregate stone use process, which are depicted in Figure 8. The figure answers the second research question (RQ2) of this master's thesis: what are the key characteristics of a generic resource-efficient aggregate stone use process?

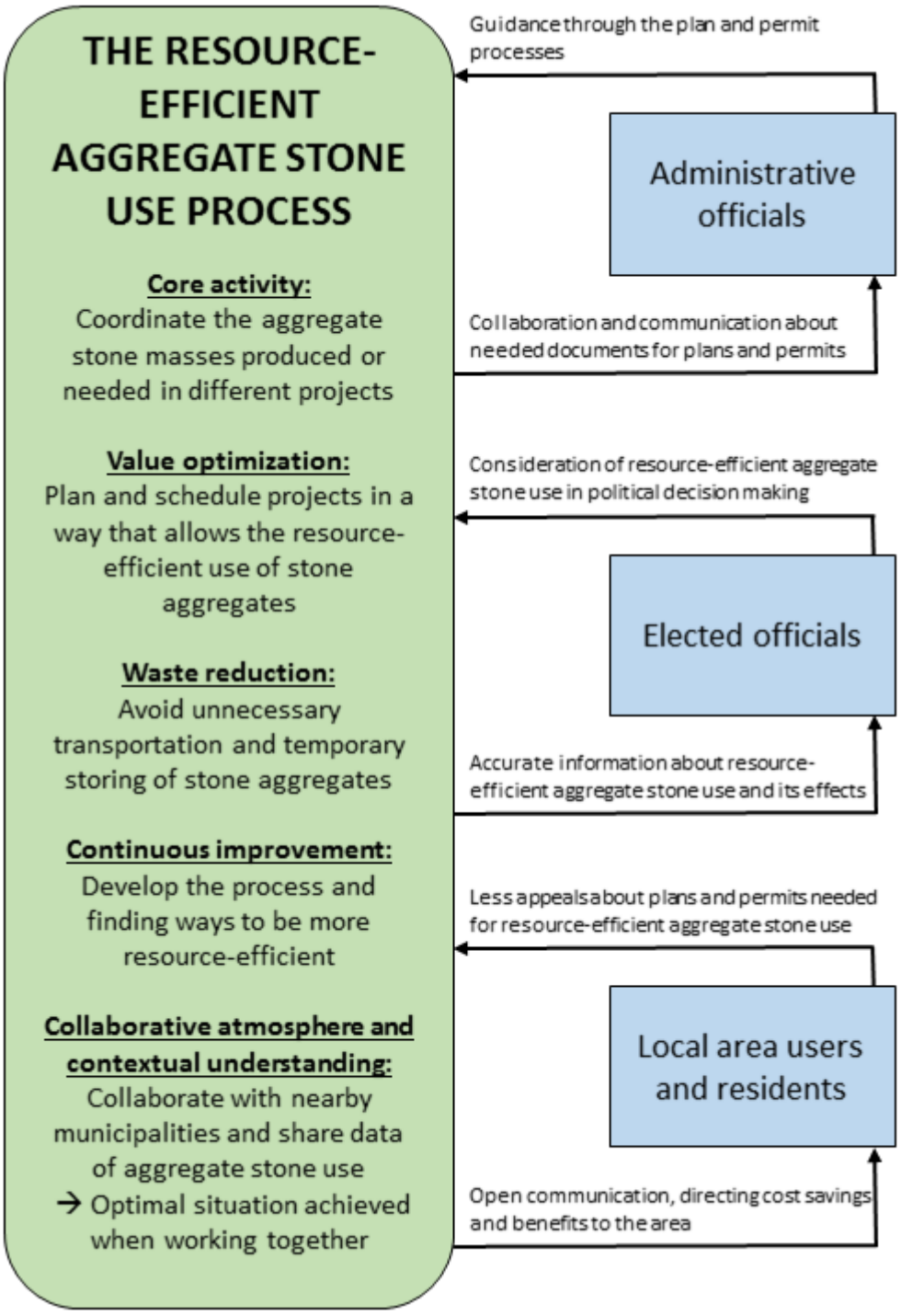

Figure 8: The key characteristics of a generic resource-efficient aggregate stone use process

10. EVALUATION OF THE RESEARCH

Lincoln and Guba (1985) use trustworthiness as a measure to evaluate qualitative studies. It is appropriate to use trustworthiness to evaluate this master's thesis since it features a qualitative research approach. Trustworthiness can be evaluated with the four criteria of credibility, transferability, dependability, and confirmability (Lincoln and Guba, 1985).

The credibility of a study refers to the degree of which the results are credible or believable (Lincoln and Guba, 1985). In this master's thesis, credibility was built by interviewing relevant people from many different backgrounds and organizations, thus providing a believable set of data. In addition, the author of this thesis conducted preliminary interviews to better understand the research context and to therefore achieve more credible results.

Transferability refers to the possibility of transferring or generalizing the results of the research to other contexts or settings (Lincoln and Guba, 1985). The results of this master's thesis are context specific since a single case study was used as a research method. Therefore, the results are not easily transferable to other contexts or settings. However, transferability of this thesis has been established by describing the research context and the research process in a detailed fashion. In the end, the responsibility of judging the transferability is on the person who wishes to transfer the results of the study (Lincoln and Guba, 1985).

Dependability refers to the reliability of the study, whereas confirmability refers to the ability of other researchers to confirm or corroborate the results of the study (Lincoln and Guba 1985). Both dependability and confirmability of this master's thesis have been established by describing the data collection and analysis processes as well as the research process.

In the initial phases of conducting this master's thesis, two objectives were set:

- To understand the process of resource-efficient aggregate stone use in a case study
- To develop a generic model of a resource-efficient aggregate stone use process by applying lean thinking

The first objective was certainly achieved. The process of resource-efficient aggregate stone use was not first found in the case study. The Finnoo urban area development

project was modelled and the current situation of aggregate stone use in the case study context was examined. It was evident from the empirical data, that the current process of aggregate stone use, which was described as an uncoordinated and invisible process, was not a resource-efficient process. Therefore, the key characteristics of a generic resource-efficient aggregate stone use process, presented in Figure 8 (p. 69), were derived based on the development ideas from the empirical data and the application of the theoretical synthesis of lean thinking to the ideas. Thus, also the second objective of the thesis was achieved.

11. IMPLICATIONS OF THE STUDY

The implications of this master's thesis are presented in this chapter by first describing the practical contributions in chapter 11.1, and then presenting the theoretical implications and future research suggestions in chapter 11.2.

11.1. PRACTICAL CONTRIBUTIONS

The empirical study of this thesis combined with the theoretical findings provide valuable information about the possibilities and issues of resource-efficiency in aggregate stone use. The municipal organization from the case study and practitioners in the aggregate stone industry can make use of the following practical contributions and recommendations that this master's thesis provides:

- The process model of the urban area development project helps people involved in the project understand how their work affect others and how it is connected to the use of stone aggregates.
- The empirical findings of the study provide elected officials accurate information about the use of stone aggregates. They can better take the possibilities and issues of aggregate stone use into account in their decision-making processes.
- The process of aggregate stone use should be brought into better attention in the municipal organization and developed according to the key characteristics of a resource-efficient aggregate stone use process presented in Figure 8 (p. 69).
- The municipalities in the metropolitan area of Finland should start collaborating and using the stone aggregates of the area in a resource-efficient manner.
- The resource-efficient aggregate stone use process requires systematic, long-term planning based on data from construction projects of the municipality or municipalities in the area about the uses and needs of stone aggregates.
- Frequent communication and collaboration between municipal organizations and administrative officials is a crucial part of the resource-efficient aggregate stone use process. Other stakeholders, including elected officials, local area users, and residents, should be kept informed and involved in the process as well.

- Permit application and plan approval processes have a significant impact on the resource-efficient use of stone aggregates. The administrative officials should try to find ways to speed up and ease these processes for the applicants to promote the resource-efficient use of stone aggregates.
- This master's thesis sheds light on the environmental, social, and economic impacts of resource-efficiency in the use of stone aggregates.
- The literature review of lean thinking and the theoretical synthesis provide guidelines for lean implementation in intra-, and inter-organizational settings.
- Adapting lean thinking principles is recommended for the municipal organization of the case study as a good starting point for shifting towards the resource-efficient aggregate stone use process.

11.2. THEORETICAL IMPLICATIONS AND FUTURE RESEARCH

Lean thinking has not been researched before in a complex, municipal context in which the empirical study of this master's thesis took place. The full-fledged application of lean thinking in the context of this thesis proved to be difficult since lean thinking could not be applied to all the parts of the resource-efficient aggregate stone use process. Lean thinking could not be applied to the processes that were external to the municipal organization and outside its control. These included the permit application and plan approval processes, which have been defined in law, and the involvement of elected officials, local area users, and residents. However, lean thinking could be applied to the parts of the process that occur inside the organization. The current processes regarding the use of stone aggregates in the municipal organization produce a lot of waste and are not optimized per lean thinking principles.

The results of this master's thesis are limited to the case study context. More research in similar contexts would be beneficial to deepen and enrich the findings and results of this master's thesis. The applicability of the model of a generic resource-efficient aggregate stone use process, which is only a hypothesis, should be investigated in other urban area development projects. The key characteristics of a resource-efficient aggregate stone use process could be confirmed and refined after more research in the area.

Following future research topics are suggested by the author of this master's thesis:

- The implementation of the generic resource-efficient aggregate stone use process. How to start its implementation in the municipal organization? How to organize the collaboration between the nearby municipalities, the administrative officials, and other stakeholders?
- The applicability of the generic model of resource-efficient aggregate stone use process in other settings. How applicable is the model in other urban area development projects or in other growth centers and cities of Finland?
- The measurement of the environmental, social, and economic impacts of the resource-efficient aggregate stone use process. How can these impacts be measured and how big are they?
- Lean thinking in complex contexts. How to implement lean into new, complex contexts? What are the prerequisites of lean implementation in such settings?

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APPENDIX 1: INTERVIEW TEMPLATE

Odotukset haastattelulle

Olemme valmistelemassa REKI-hankkeeseen liittyvää työpajaa Aalto yliopiston SimLabiin. Työpajan teemana on lähikiviaineksen käyttö kaupunkisuunnittelussa. Esimerkkikohteena on Länsimetron Finnoon aseman tunnelilouhe ja sen hyödyntämismahdollisuudet Finnoon alueen kehittämisessä ja rakentamisessa. Työpajaa varten haastattelemme mahdollisimman laajasti eri toimijoiden suhtautumista, odotuksia ja ajatuksia tästä aiheesta. Haastatteluja käytetään myös Artti Kaipaisen diplomityön empiriaosuuden keräämiseen. Haastattelu on jaettu kahteen osaan. Ensimmäinen osa keskittyy Finnoon metroaseman louhimiseen ja kiviaineksen käyttöön. Haastattelun toisessa osassa pohdimme tarkemmin tunnelin louhinnasta syntyvän jätteen teemaa.

Nauhoitamme vastauksenne tutkimustarkoituksiin. Niitä käytetään aina niin, että vastaaja ei ole tunnistettavissa. Ensin kysymme taustatiedot.

Haastateltavan esittäytyminen

- Kuka olet?
- Missä organisaatiossa työskentelet ja mitkä ovat työtehtäväsi?
- Kuinka kauan olet työskennellyt kyseisessä organisaatiossa?
- Miten työtehtäväsi liittyvät Finnoon alueen kehittämiseen ja siihen liittyvään Länsimetron tunnelilouhintaan? Mitä hyötyjä ja haittoja siitä on teidän organisaationne kannalta?

Osa 1: Mahdollinen skenaario

Länsimetron Finnoon aseman rakentamisen myötä Espoo haluaa ottaa Finnoon alueen asuinrakentamisen kohteeksi. Alueen rakentamisessa voitaisiin hyödyntää Länsimetron tunneleista louhittavaa kalliokiviainesta. Tämä toisi merkittäviä kustannussäästöjä Espoon kaupungille, auttaisi Länsimetron rakentamisen aikataulussa pysymistä, ja säästäisi ympäristöä. Kiviainesta saataisiin läheltä eikä tarvittaisi pitkiä ja kalliita rekkakuljetuksia suuntaan ja toiseen. Kalliokiviainesta ei voi kuitenkaan hyödyntää rakentamisessa sellaisenaan, vaan sitä täytyy ensin murskata ja jatkojalostaa. Alueelle tarvittaisiin siis väliaikainen kiviaineksien murskauslaitos. Yksi mahdollisuus olisi rakentaa Finnoon merenrantaan tekosaari tunnelin louhinnasta syntyvää kalliokiviainesta hyödyntäen ja pystyttää väliaikainen

murskauslaitos alueen rakentamisen ajaksi tälle tekosaarelle. Murskaustoiminnan loputtua noin kymmenen vuoden kuluttua tekosaari voitaisiin ottaa asuin- ja virkistyskäyttöön.

- Mitä ajatuksia tällainen skenaario herättää?
    - Mitkä olisivat teidän näkökulmastanne sen hyviä puolia? Miksi?
    - Entä mitkä olisivat sen haittoja? Miksi?
    - Millä edellytyksillä tällainen skenaario voisi toteutua? Miksi?
- Mitkä toimijat olisivat keskeisessä roolissa tässä projektissa?
- Mikä teidän roolinne olisi siinä?
- Mitä tärkeitä vaiheita näkisitte tämän kaltaisessa projektissa?

Osa 2: Tunnelin louhinnasta syntyvä jäte

Nyt lähdetään purkamaan siihen metrotunnelin louhintaan liittyviä osa-alueita ja niiden tärkeyttä louhinnasta syntyvän jätteen näkökulmasta.

Minkälaista jätettä tai tuhlausta voi syntyä Finnoon metrotunnelin louhintaan liittyen?

Kuinka tärkeää olisi mainitsemiesi jätteiden ja tuhlauksen minimointi Finnoon rakentamisen kannalta?

Odotukset työpajalle

Työpajassamme 2.2. käsittelemme Finnoon alueen kehittämistä ja Länsimetron tunnelilouhinnasta syntyvän kiviaineksen hyödyntämistä sen osana.

- Mitä odotatte työpajalta?
- Mitkä olisivat hyviä tuloksia, joita työpajan avulla voitaisiin saavuttaa?
- Mitkä tahot pitäisi saada paikalle?
    - Entä keitä pitäisi haastatella tarpeellisen tiedon saamiseksi työpajan onnistumiseksi?

Haastattelun päättäminen

- Haluaisitteko kertoa vielä jotakin, mitä emme käsitelleet?
- Kiitos haastattelusta
- Toivottavasti pääsette itse mukaan työpajaan tiistaina 2. helmikuuta! Työpaja kestää koko päivän.

APPENDIX 2: FEEDBACK QUESTIONNAIRE TEMPLATE

Kyselylomake 2.2.2016

Lähikiviaines kaupunkisuunnittelussa -työpaja

Aalto-yliopiston perustieteiden korkeakoulu, tuotantotalouden laitos, SimLab

Ole hyvä ja vastaa seuraaviin kysymyksiin. Halutessasi voit jatkaa vastauksiasi paperin kääntöpuolelle. Kiitos vastauksistasi.

Vastaukset käsitellään anonyymisti.

Nimesi: _____

Lean-ajattelussa sujuvoitetaan prosesseja pyrkimällä kaikenlaisten hukkien vähentämiseen.

Minkälaisia hukkia Finnoon kehitysprosessissa syntyy lähikiviaineksen käyttöön liittyen?

Miten näitä hukkia voisi vähentää?