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Construction logistics in dense urban areas

A qualitative study on the challenges and solutions for construction logistics in dense areas

Master's thesis in Design Construction Project Management

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DEPARTMENT OF Architecture and Civil Engineering

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ABSTRACT

Population growth is one of the emerging issues of the world, this growth increases the demand for constructing new buildings. Likewise, there is also a significant increased interest in living in urban areas. As a result of these two factors, building in dense urban areas becomes more difficult and complex, thereby affecting construction logistics within the projects. In dense urban areas, construction sites face numerous challenges, such as lack of space, traffic congestion, transportation (off-site issues) among many others. The difficulties regarding construction logistics within dense areas has a large negative impact on the stakeholders involved, but it is also the least managed. Thus, the aim of this thesis is to understand the off-site logistical challenges, and the corresponding solutions for those challenges, and offer future perspectives.

In order to achieve the aim of this thesis a qualitative study has been deployed based on semi-structured interviews with managers responsible for logistics. Prior to the empirical work, a literature review conducted to frame the theoretical background of this research. Seven construction projects have been selected to be included in the empirical data. The projects are all located within the dense parts of Gothenburg and are all commercial buildings.

The findings indicate that there are commonalities and similarities among the projects, as well as some project-specific challenges. The most common challenges identified during the interviews were a lack of on-site space, consideration of nearby stakeholders, and transportation to the site. According to the interviewees, the most frequently launched solutions to these challenges were the use of a digital planning system (DPS). While the literature advocated for three other solutions to help with the arising challenges, such as construction consolidation centers (CCC), third-party logistics (TPL), and construction logistics plan (CLP). Nonetheless, empirical data show that the selection of logistical solutions is influenced by the logistics managers knowledge and experience, the magnitude of the project, and the location of the project. The respondents were all advocating for increased use of digital tools to improve construction logistics, while no further elaboration was provided, all of the interviewees agreed that additional digital tool implementations are required. Additionally, intangible factors such as increased communication, collaboration, and transfer of gained experience from prior projects were also identified as a means to improve construction logistics.

Keywords: Construction logistics, densification, off-site, construction consolidation centers, third-party logistics, construction logistics plan, digital planning system

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Preface

This master's thesis represents the culmination of our Master of Science in Civil Engineering studies at Chalmers University of Technology in Gothenburg. The thesis was completed as part of the master's program in Design and Construction Project Management. The paper was written in collaboration with the Department of Construction Management at Chalmers, whereas only the interviewees has been conducted with external actors.

We would like to thank our supervisor Dilek Ulutas Duman at the Department of Construction management for her assistance and guidance from the beginning to the end of this study. We would also like to thank all the interviewees for taking the time to speak with us, this thesis wouldn't be possible without them.

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Notations

CCC: Construction Consolidation Centre

CLP: Construction Logistics Plan

TLP: Third-Party Logistics

DPS: Digital Planning System

RSFD: Rest stops for deliveries

LM: Logistics Manager

1 Introduction

This chapter provides an overview of the background of construction logistics in dense urban areas. This is followed by articulation of the research problem. It, then, introduces the aim and research questions, limitations, and the outline of the thesis.

1.1 Construction logistics within dense environments

Growing population is one of the emerging problems worldwide, which in turn puts pressure on developing buildings in order to meet this growth. Moreover, according to United Nations (2015) the urban population exceeded the global rural population in 2007 for the first time in history. In 2018, approximately 75% of Europe's population lived in urban regions, with 87% of the people in Sweden living in urban areas at the same time (United Nations, 2019). Furthermore, it's also predicted that the urban population in Sweden will rise to approximately 93 percent by 2050, according to the United Nations (2019). Such growing interest to live in urban areas creates challenges to the construction sector. Increasing population requires more apartments, offices, schools, houses and urban areas are needed to accommodate the growing population within the cities. This implies that the number of construction projects within urban areas will increase considerably. On the other hand, Lundesjö (2015) emphasizes that such increased demand for construction gives rise to logistics problems, hence, this will result in construction logistics facing difficulties in terms of conducting work in urban areas. Construction activities in urban areas creates challenges such as transportation problems, environmental demands from municipalities, lack of space, demands from neighboring buildings, such as residents and business owners regarding accessibility and noise (Dablanc, 2007). The arising challenges of construction logistics within dense urban areas puts pressure on the off-site logistics, i.e., the flow of materials to site. The transportation of materials and equipment to the site is a procedure that frequently has a large negative impact on the stakeholders involved, but it is also the least managed and sometimes disregarded part of the logistics process. (Sullivan et., 2010).

Furthermore, Sullivan et al (2010) also states that, if the challenges of construction logistics are not regarded and acted upon, it could consequently lead to delays and cost overruns, which would lead to the failure of a project. To combat this, the construction industry has seen an increase in logistics methods, however, their use has remained limited (Tetik et al, 2022). Nevertheless, Tetik et al. (2022) argues that despite multiple successful case studies, the construction industry's use of logistical methods lags behind those of other industries. He, further, argues the reasons of such lack are the absence of pre-planning, overly high logistics costs, the fragmented nature of the industry and the lack of competence regarding construction logistics. Given the growing demand for construction in urban areas, overcoming logistical challenges will be crucial. One way to address the rising challenges of urban construction projects is by using different types of construction logistics solutions (logistical tools), such as construction consolidations centers, third-party logistics, construction logistics plan, digital arrival schedules etc. (Janné & Fredriksson, 2018; Ekeskär and Rudberg, 2016; Transport for London, 2013). These solutions are offered to alleviate the growing logistical challenges that urban construction projects face.

1.2 Aim and purpose

The aim of this thesis is to understand the off-site logistical challenges faced in the construction projects located in dense urban areas, identify the solutions adapted to cope with such challenges and understand future expectations. Numerous articles have been produced on building logistics. However, there has not been as much attention and effort paid to combining a detailed literature review with an empirical analysis consisting of various ongoing construction projects. Thus, obtaining a broader, more comprehensive view of the challenges and solutions for construction logistics in dense areas. The aim will be accomplished by the following research questions:

- What are the most difficult off-site logistical issues confronting construction projects in dense areas?
- What construction logistics solutions are used to cope with the issues associated with the off-site challenges?
- What are the future expectations regarding construction logistics, according to the logistics managers?

1.3 Limitations

For the purpose of this thesis, only construction projects taking place in densely populated regions in the city of Gothenburg will be included and analyzed. Additionally, only commercial buildings, such as offices and hotels, have been considered due to the commonality of developing such projects in densely populated areas. Moreover, regarding construction logistics, only off-site logistics will be considered because construction in dense urban areas mostly affects the off-site logistics. Nevertheless, because of the interdependencies between on-site and off-site logistics, on-site logistics will also be regarded but to a lesser extent.

1.4 Outline of the thesis

This thesis consists of seven chapters, namely the following:

Chapter one – Introduction: This chapter introduces the aim and research questions, highlights the limitations, and also gives a background to the thesis.

Chapter two – Method: This chapter will present the methodical approach, which includes the research approach, research process, literature search, data gathering process, and a section on ethical and sustainable aspects.

Chapter three – Theory: In this chapter an review of the currently available construction logistics research will be presented, which gives a background to construction logistics and also works as a framework on which to base the discussion.

Chapter four – Interviews: This chapter presents the seven interviews that has been conducted.

Chapter five – Analysis: In this chapter the results from the interviews are analyzed and discussed based on the areas, namely, challenges, solutions, and future expectations.

Chapter six – Discussion: In this chapter a discussion is presented based on the research questions, hence, this chapter is divided into three parts. Each part discussing and comparing the empirical data with the literature.

Chapter seven – Conclusion: A short and concise answer will be provided for the three research questions in this chapter, together with a reflection on improvements and future research.

2 Methodology

This section presents the research design and methodology that were employed in this thesis. It begins with an overview of the research approach and then goes on to detail the research process. Following that, the literature review and data collecting procedures that were employed in the thesis are discussed in detail. The chapter closes with ethics and sustainability aspects.

2.1 Research approach

This thesis adopts a qualitative approach. As stated by Bryman and Bell (2011), qualitative research is a research approach that places a strong emphasis on words and meanings rather than numbers while collecting and analyzing information. In contrast to quantitative research, where a natural scientific model is used, the central concern of qualitative approach is the social phenomena through an investigation of how its participants interpret it (Bryman & Bell, 2011). The goal is to fully grasp a participant's interpretations and recognize that people's interpretations of their own experiences might differ. Furthermore, the vast bulk of qualitative research makes no promise to be generalizable, instead, it just claims to represent the people studied (Vanderstoep & Johnston, 2009). Thus, the answers from the respondents do not necessarily reflect the whole industry.

Bryman and Bell (2011) also note that there are two ways in which research influences theory: either the obtained data can be compared to pre-existing ideas, or the collected data can be used to develop new theories. The first of these relationships is known as deductive theory, while the second is known as inductive theory. However, there is a third type of research methodology that can be used in an academic paper: the abductive methodology. In an abductive investigation, the initial question may change as a result of empirical discoveries and emerging theoretical concepts from the data (Dubois and Gadde, 2002a). Hence, this approach starts with an incomplete collection of information and does the best it can with the knowledge at hand. Whereas an iteration stems from the gained data from the interviewees and in turn helps to form the thesis. As a result of these descriptions of the various approaches, an abductive approach was chosen for this thesis, because of its characterizations.

2.2 Research process

The topic of the thesis was inspired in part by real-life observations of the construction industry, particularly in Gothenburg, where it is expanding in densely populated areas. And partly from a construction logistics and supply chain management course taken a year ago. After combining real-life observations with what has been learned in class, the idea of looking into building logistics emerged. We were particularly intrigued by how it worked in "real-world" projects, which increased our interest even further. We wanted to know how difficult it would be to build large-scale projects in densely populated area in Gothenburg, and how difficult it would be for construction companies to manage the logistics of such projects.

The preliminary topic of this thesis was registered in January 2022, and the initial work began in early February 2022. The thesis topic was further developed and

refined throughout the first few weeks of work, and the purpose and research questions were revised and rewritten with direction from the supervisor and as a result of gaining more knowledge from reading related literature on the subject. Early on in the process, a general examination of the literature on the chosen topic was conducted, together with a decision on which research approach that should be utilized. This was a strategy to obtain a better understanding of the research area, and when combined with the preparation of the thesis proposal, it served as a strong starting point for the project.

After reaching a certain clarity on the research problem, a detailed literature review process was conducted. As the research focus moved to off-site logistics, an initial interview conducted with Svensk Bygglogistik was undertaken. The aim of this initial interview with a company specialized in logistics was to understand which parts of the literature might be useful to read in detail and how the research questions should be framed. This is referred to as a pilot study which provides a preliminary knowledge concerning the research topic. The primary goal of a pilot study is to give a better understanding of how the research should be conducted in order to reach the aim of the thesis. This can be done by confirming the selected path with a specialist within the area of topic, validating the accuracy of the interview questions etc. Additionally, a pilot study also helps in the selection of the data acquired, and rejects information not relevant to the topic of research (Dzwigol, 2020).

Following this, a number of projects in citycenter of Gothenburg were identified, and the people in charge of each project were contacted. Subsequently, the person in charge of each project sent us to the principal employee in charge of the projects' logistics. One manager from each project was interviewed as the interviewees stated that they have the main responsibility for the whole logistics and no other representative can give more detailed answers regarding logistics.

In the end seven projects were included in the thesis. The seven interviews were done at the same time as the literature review and the analysis of the empirical findings. After completing the first draft of the literature review, the data collection for the empirical part begun in mid-March 2022. Thereafter, work on the concluding parts, namely, analysis, discussion and conclusion began. As more information and observations came to light, new and summarizing sections were added to both the theoretical chapter and the empirical data to show these changes.

2.3 Literature search

The primary objective of the literature review was to provide a theoretical background for the thesis. In order to provide relevant literature for the purpose of the study, conference papers, scientific articles, books etc., were explored. These materials came about as a result of articles being discovered and key terms being searched for in databases such as the Chalmers library, Scopus, Google Scholar, ResearchGate, ScienceDirect, and others. Some of the key words used in the initial literature search was "Construction logistic", "Construction logistics in dense areas", "Construction Consolidation center", "Third-Party logistics", "Supply Chain Management", "Off-site logistics", "On-site logistics" etc. Subsequently, when better understanding of the topic was gained additional literature was searched for, by using phrases such as,

“logistics manager”, “digital solutions for logistics”, “innovation within construction logistics”, “densification” etc.

Additionally, new sources were discovered by a more in-depth search among the references of relevant papers. In order to assure validity, the authors attempted to discover many sources that addressed the same issue. When it came to further evaluating the relevance of the articles, the abstract was read first, followed by the introduction and conclusion, and then the whole text, if it was found to be relevant.

2.4 Interviews

As stated this thesis adopts a qualitative approach, whereas the interviews has been conducted in a semi structured manner for gathering the empirical data. This implies that the questions were framed in a way that allowed the respondents to be free and more reflective. As a result, the replies may reveal information about the topic that the interviewee did not consider while formulating the question and that would have been overlooked if the interview had been conducted using a more organized interview format. However, the interviewer still has a framework of broad questions to draw upon in order to steer the discussion in the appropriate direction. The interview questions were separated into two sections: one for general questions and another for project-specific questions. The general part consisted of questions regarding general knowledge of construction logistics. The more specific sections included questions about the project and how they've overcome obstacles encountered for the project, as well as how they apply solutions for each project. As a result, dividing the interview questions into two parts gave us the opportunity to gather more information, and made the interview more structured and easier to conduct. In addition, despite the fact that the study is in English, the interviews were performed in Swedish. This was done in order to benefit from the additional information they might provide in a language they are more comfortable with.

Moreover, a thematic analysis was utilized for dissecting the gathered empirical data from the conducted interviews. This approach is the most frequently used method for analyzing qualitative data according to Bryman & Bell (2011). The method is a technique for discovering, analyzing, and reporting data patterns, it helps to organize and define data in detail (Braun & Clarke, 2006). Furthermore, in contrast to other accessible analytic methodologies, this one lacks a recognizable lineage and has not been described in terms of a separate cluster of procedures (Bryman & Bell, 2011). Using this method, common themes in the collected data were identified. Similarities and relationships between distinct data pieces have been identified and grouped so that similar data can be categorized together.

2.4.1 Selecting interviews

We started identifying complex case-projects located in the dense areas of Gothenburg. After finding projects we contacted several different people from the different construction projects. They were contacted throughout the interview part of the thesis, with the majority of the contacts coming from phone calls to those in charge of the projects. We selected these projects after conducting an analysis of construction projects that have just initiated or completed construction in Gothenburg and that are specifically located in densely populated areas. This was done to ensure

that the results of the interviews were comparable across all the projects. After that, we discussed their significance and importance in relation to concerns pertaining to building logistics. In addition, a questionnaire template (see appendix) was sent in ahead of time to provide an early overview of the interview process.

It was decided that the respondents for the thesis would come from a variety of construction companies and businesses so that the results could be presented from a variety of perspectives in the industry. The responders who were chosen were from well-established construction companies, and we also questioned a representative from a third-party logistics company at the outset. We interviewed representatives from both small and large construction enterprises in Sweden in order to compare different points of view on similar challenges.

Furthermore, the interviews were conducted with seven different managers who are the key personnel managing logistics issues for their respective projects. The individuals in charge of the logistics for each project played a variety of roles throughout the project; some were logistics managers (LM), while others were site managers, and block managers. A description of each of the projects, as well as the logistical issues they encountered and the solutions that were adopted, will be presented, as well as some comments from the interviewees on potential future solutions or innovations, will be offered. In addition, Table 1 also contains more specific details about each interview.

Company	Position of the interviewee	Project	Project status
PEAB	Logistics manager	Platinan	Finished
Veidekke	Logistics manager	Strömshuset	On-going
NCC	Block manager	Kvarter Johanna	On-going
Skanska	Logistics manager	Citygate	On-going
PEAB	Logistics manager	Gårda Vesta	Finished
K21	- Site manager - Logistics manager	Hotell Draken	On-going
NCC	Site manager	- Brick Studios - Vågshuset	On-going

Table 1, information about the interviews

2.5 Ethical & Sustainability aspects

In this section both the ethical and sustainability aspects will be presented.

2.5.1 Ethical

According to Bryman and Bell (2011), trustworthiness is made up of four criteria, namely, credibility, transferability, dependability, and confirmability. Credibility essentially refers to whether the results obtained, in this case, through interviews are reliable. Hence, the question is if the gained data is trustworthy. The measures that have been taken in order to achieve credibility in the results are that the interviews

have been recorded, transcribed, and saved. A high level of transferability can be obtained by aiming to obtain rich details of the qualitative study. Bryman and Bell (2011) call this a "thick description", which strives to make the thesis's findings useful to future investigations. Due to a lack of time, the number of interviews was kept to a relatively small number. Thus, not giving rise to a broad generalization of the studied subject, therefore, the transferability has been regarded to a lesser extent. Bryman and Bell (2011) continue by stating that research should use an auditing approach to their work. This requires ensuring that comprehensive records of all phases of the research process are retained in an accessible way. Hence, by keeping a record of all phases of the thesis, such as the process of the thesis, transcripts, data analysis choices, etc., a high degree of dependability was obtained. Confirmability assures that the thesis was created objectively and was not influenced by personal views or theoretical tendencies to impact the conduct of the study (Bryman and Bell, 2011). This was accomplished by both authors approaching the research with little prior understanding of the subject and hence with a generally objective perspective.

Several steps were taken to guarantee that the thesis was written in line with research ethics and the trustworthiness. All interviewees were informed about the aim and scope of this study and asked whether they are willing to participate. Furthermore, before the interview, the interviewees were asked whether they would be willing to have their interviews recorded in order for the writers to listen back to the interviews and ensure that no information was lost. Furthermore, the interview questions were sent to the interviewees ahead of time so that the respondents could be better prepared, thus both parties could benefit from the interaction. An example of the interview questions has been included in the appendix.

2.5.2 Sustainability

The Brundtland report, published in 1987, established the concept of sustainability. The idea is to address immediate needs without jeopardizing future generations' ability to meet their own. The concept has evolved over time to include three dimensions, namely, social, economic, and environmental. (Kuhlman & Farrington, 2010). To achieve long-term sustainability, organizations must meet all three characteristics at the same time. Because the three dimensions are connected, they can have a variety of effects on one another. (Dyllick & Hockerts, 2002).

Nonetheless, within the scope of this thesis, one of the dimensions of sustainability, specifically the environmental dimension, has received some consideration. Improving off-site logistics management is offered as a critical action for improving efficiency regarding environmental concerns.

3 Theory

This chapter aims at providing a theoretical framework related to construction logistics. It begins with a description of the characterizations of the construction industry, followed by an explanation on logistics, construction logistics, the importance of a logistics manager, and a comparison between on-site and off-site logistics. Furthermore, the concept of supply chain management is also presented in order to give more depth into the supply of materials for construction projects. A section on densification and challenges regarding off-site logistics has been included. The final section proposes three different construction logistical solutions, and the entire chapter concludes with a section on construction logistics improvements.

3.1 Characteristics of the construction industry

The construction sector has been around for a long time and can be classified by a variety of characterizations, namely, temporary based organizations (project-based), market fragmentation, conservative i.e., slow to change. The industry is based on temporary organizations and collaboration of different actors. Each project requires a different combination of contractors, subcontractors, consultants, builders' merchants, and logistics operators must be bid on and procured, making long-term partnerships with them difficult to create (Sullivan et al., 2010). In order to meet demand of the project-based work as efficiently as possible, the construction industry, as previously mentioned, relies heavily on temporary network structures due to the industry being project based. As a result, construction project organizations frequently become separated from the corporate level, making them difficult to manage and integrate throughout the process, from initial drawings through completed construction (Janné, 2018). This means that each stakeholder and activity inside a project is dependent on the success of the others. Tasks are usually completed sequentially, and if one activity is delayed, all future activities are also postponed. The management of construction projects is outsourced to the project organization, with the parent firm having little influence on the day-to-day operations of the project. Given that each project is different, the management team responsible for managing that particular project on site has the greatest amount of authority compared to the management of the construction firm. Additionally, personnel and installers require materials, and if deliveries are delayed, the entire process could be stalled. As a result, to move the project forward at the stated pace, there is a demand for good communication between project stakeholders within the project (Dubios & Gadde 2002).

Furthermore, as stated prior, the construction sector is usually labelled as slow to change (Janné, 2018). One of the key reasons for this is linked to the high interdependencies that exist between activities, components, and firms (Bankvall et al., 2010). Nevertheless, even though the construction industry is labelled as slow it is also noted by the author (Janné, 2018) that the industry has encountered substantial modifications as a result of mergers and acquisitions. Due to the growth of large major contractor organizations, subcontractors, suppliers, and builders' merchants have been obliged to imitate their business practices in order to retain a consistent stream of work. The substantial modifications have led to communication between the different actors becoming stronger and the steam of work better. This in turn results in

improvements to all of the aspects of the construction industry, including logistics, which will be discussed further in the following sections.

3.2 Logistics & Construction logistics

Logistics essentially entails the process of delivering resources to their destination. The relevant literature offers several different definitions on logistics, the reason for such an extensive number of definitions on the concept according to Straka (2017) is because its ever-changing nature, implying that logistics has a tendency as like everything else to change according to its external dependencies. Thus, the description of logistics varies according to the period in which it was developed, and the understanding of what logistics is vary considerably from person to person (Straka, 2017). Nevertheless, according to the literature logistics is usually defined by using the seven Rs. The seven Rs aims:

“...to deliver the “right product”, in the “right quantity”, in the “right quality”, at the “right place”, at the “right time” for the “right customer” and at the “right cost”
(Teoman, 2020).

The seven R's is familiar within logistics and has been a way to describe the essence of logistics. Despite the use of the seven R's two definitions have also been selected in order to give more context to logistics. Whereas the latter definition also incorporates supply chain management (SCM), which briefly can be explained as the supply of materials between actors, further elaboration on the concept will be presented in the coming section. The European committee of Standardization defines logistics as follows:

“Logistic comprises planning, organizing and control of flows of goods from their purchase, through processing to distribution to the end user, in order to fulfil market requirements and by minimal cost and capital engagement”
(Sobotka & Czarnigowska, 2005, p. 74).

This definition gives a more basic explanation of logistics and does not incorporate the concept of supply chain management. Whilst the Council of Supply Chain Management Professionals incorporates logistics and supply chain management (CSCMP), and defines logistics such as:

“Logistics management is the component of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information to meet the needs of customers between the points of origin and consumption.”
(CSCMP, N/A).

This definition stresses the importance of logistics for the entire supply chain from point of origin to point of consumption, and it presents logistics as a component of the overall flow of goods along the supply chain. It also highlights that logistics is not only about the flow of materials.

Furthermore, moving on to construction logistics. According to Ying & Tookey (2014) logistics in the construction industry refers to the process of planning,

organizing, coordinating, and controlling the flow of materials from the extraction of raw materials through their integration into the completed project. Alternatively, Janné (2018) defines construction logistics as:

“...supplying the right materials to the correct customer and construction site to meet customers’ requirements.”
(Janné, 2018, p. 9).

Regardless of the various definitions of logistics and construction logistics presented, it is important to remember that it can be divided into two parts: on-site logistics and off-site logistics.

3.2.1 On-site and off-site logistics

As it has been demonstrated, construction logistics has significant importance in achieving a better project process and involves several distinct activities. In order to provide a better understanding of its activities and how they affect logistics, construction logistics can be divided into two parts: on-site logistics and off-site logistics. On-site logistics refers to the logistics that take place at the construction site, while off-site logistics refers to the logistics that occur away from the construction site. This has also been illustrated in figure 1, where it clearly demonstrates the differences between the two parts.

Off-site logistics involves a vast number of providers, including manufacturers, distributors, transporters, and logistics firms, i.e., concerns everything that is not on-site (Sullivan et al., 2010). While on-site activities can for example consist of materials tracking, planning, waste management and inbound storage (Ying et al., 2018). Furthermore, Sundquist et al. (2018) acknowledged that the integration of on-site and off-site logistics is crucial to the efficiency and effectiveness of a construction project. Hence, implying that it’s important to recognize that off-site logistics depends upon on-site logistics, and vice versa.

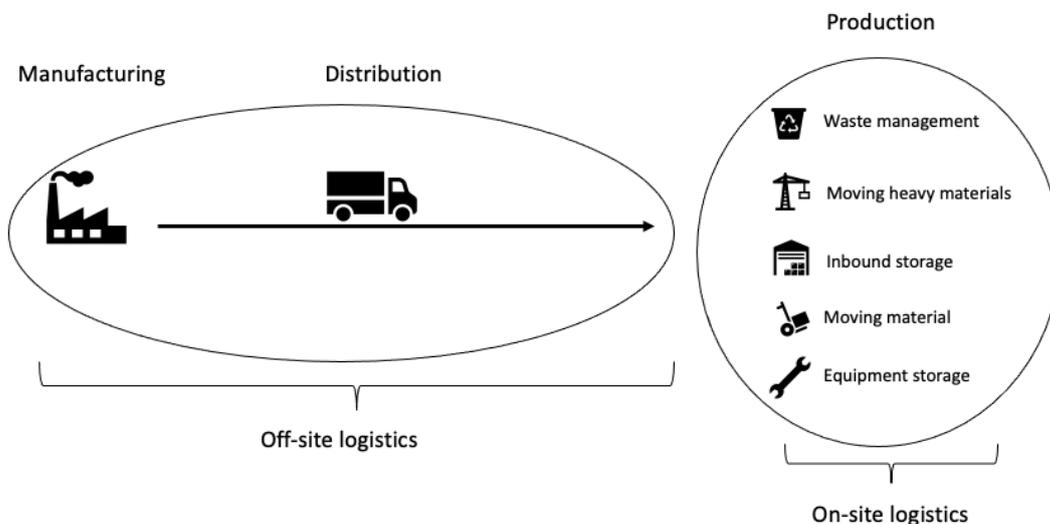


Figure 1, the two parts of construction logistics: off-site and on-site logistics (own figure).

Moreover, Sobotka & Czarnigowska (2005), highlight that experience has shown that careful planning and well-developed logistic ideas may lead to more efficient project execution and a lower overall project cost, as well as an increase in project quality and value (Sobotka & Czarnigowska, 2005). Thus, for the logistics within a construction project to be handled in the right manner a responsible person must be in charge of planning all activities i.e., a logistics manager.

3.2.2 Logistics manager

In order to give further context to the empirical part of this thesis, a definition and the role of a logistics manager will be given. According to Dobroszek et al. (2018), logistics managers are responsible for organizing, controlling logistics activities, planning, and integrating in order to supply markets more effectively and at a lower cost. Furthermore, while construction logistics operations have been around for a while, the role of a logistics manager is arguably the most recently recognized within the construction industry. Despite the fact that the demand has always existed, it has traditionally been met by different team members rather than being assigned to a specific position and handled by one person (Lundesjö, 2015). The role was born due to the ever-increasing construction projects within dense cities and the constraints that came along with them and will continue to increase in the future (Dobroszek et al., 2018).

3.3 Supply Chain management

As stated in the previous section regarding logistics, the second definition entails that logistics is part of supply chain management. As a result, a more detailed explanation of the concept is required. The phenomenon of supply chain management was first introduced by consultants in the early 1980s and has since gained a lot of attraction (Lambert & Cooper, 2000). According to Koskela and Vrijhoef (2000), the concept began and prospered in the manufacturing industry, with the first sign of use in the JIT system, which was part of the Toyota production system. Moreover, according to the Council of Supply Chain Management Professionals (CSCMP) supply chain management can be defined as the following:

“Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies.”
(CSCMP, N/A).

The above definition clearly states that SCM includes the handling of physical supplies i.e., logistics. However, Larson and Halldorsson (2004) claim that there is a lack of agreement on how SCM is connected to logistics. They introduced four different views on the connection between SCM and logistics. Figure 2 tries to illustrate the four different views, the first one being the traditionalist view, which entails that SCM is a part of logistics, i.e., SCM is only a limited part of logistics. While on the opposite, the unionist perspective views logistics as a part of SCM, in this case logistics is only one part of the concept of SCM. The third type of view, re-

labeling, means in this context that logistics is now instead known as solely SCM, it simply renames logistics, what was logistics before is now SCM. The last perspective is named intersectionist, where logistics and SCM are two separate entities in this definition with some overlap (Larson & Halldorsson, 2004). However, Larson and Halldorsson (2004) also state that despite an expanding body of research and practical experience, there seems to be no consensus on the relationship between logistics and supply chain management. Whilst the authors (Larson & Halldorsson, 2004) have put forward various perspectives on the relationship between logistics and SCM, based on the found literature the intersectionist view seems the most common one. Whereas SCM and logistics supplements each other, and they co-exist with each other.

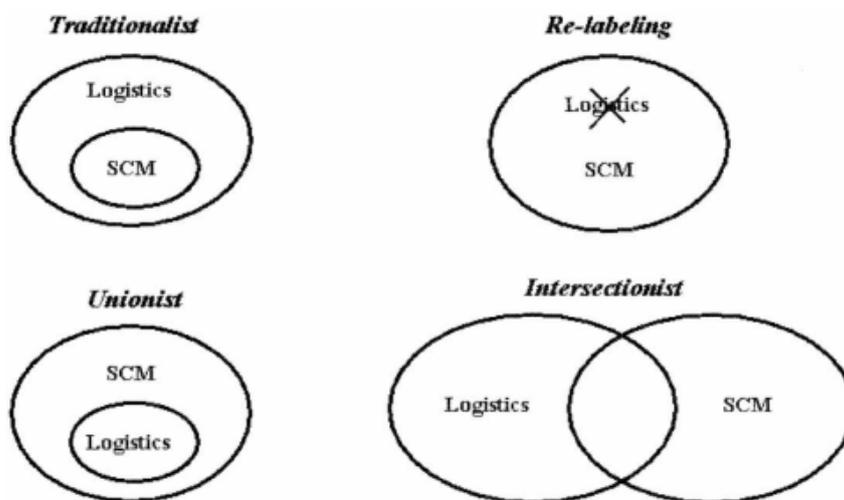


Figure 2, four views on SCM and logistics (Larson & Halldorsson, 2004).

3.3.1 Construction supply chain management

As mentioned above SCM is a concept that is used in various industries, and is not only made for construction, thus the concept has to be adjusted to its environment and be adopted accordingly. Koskela and Vrijhoef (2000), characterizes supply chain in construction by using three elements. Firstly, in the construction industry all the materials all directed towards one single product e.g., a building. Secondly, the supply chain is temporary due to the project-based nature of the industry. They argued that - this results in instability and fragmentation. Lastly, there is little to no repetition between different projects, all projects are unique in their own way. Koskela and Vrijhoef (2000), further, have distinguished four different roles of SCM in construction, which has been illustrated in figure 3. The four different roles highlights where the focus on supply chain is aimed at in the construction industry, and what the outcome of each role entails. Role 1 focuses on the impact of the material supply chain on building site operations, with the objective of lowering costs and shortening construction time. It's mostly about ensuring material supply security in order to avoid production delays. There is an added focus on the supply chain in role 2, Logistics, lead time, and warehousing are the primary concerns in this situation. The third role aims to decrease production disruptions or increase coordination across activities, the focus is on shifting operations from the building site to the supply chain. The major aim is to lower the total cost as well as the amount of time it takes. Lastly, the fourth role, the holistic perspective, supply chain, and construction site are seen as a coherent

system where the whole system is analyzed to achieve improvements (Koskela and Vrijhoef, 2000). Each one of these roles have their own drawback and benefits, it's up to the responsible personnel at every firm to decide which one will benefit them in order to be successful.

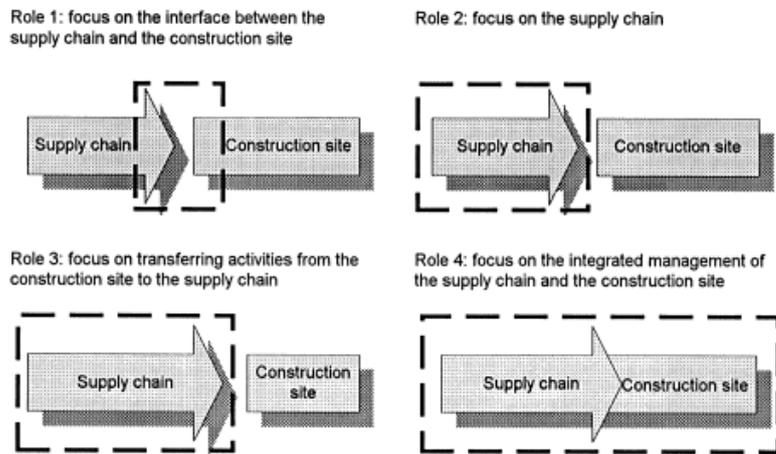


Figure 3, four roles of SCM in construction (Koskela and Vrijhoef, 2000)

Construction logistics is made considerably more difficult when construction sites are located in crowded urban areas with a variety of restrictions imposed by many stakeholders on the construction site (Dubois et al., 2018). Therefore, the next section will focus on densification in urban areas due to the urbanization.

3.4 Increased densification

A considerable worldwide urbanization trend is now under progress. According to the United Nations (2015), the urban population surpassed the rural population for the first time in the world in 2007, while in Europe, almost 75% of the people lived in urban regions as recently as 2018 (United Nations, 2019). This urbanization will have an effect on supply chains and logistics. Construction activity will increase in numerous cities as a result of this. Simultaneously, the push for a more sustainable approach to urban logistics, particularly freight transit, will increase the pressure on everyone involved in managing commercial supply chains. This is especially true for the construction industry (Lundesjö, 2015). In Sweden, a similar statistic was about to 86 percent, and by 2050, it is expected that the urban population in Sweden would exceed 90 percent (United Nations, 2019). Thus, there is a need for city development, which includes the construction of houses and apartment complexes, as well as the construction of office buildings, hospitals, schools, and infrastructure in cities and urban regions (Janné, 2020). Not only large cities are undergoing change; at least half of urban expansion in the future decades is expected to occur in the numerous smaller cities. Additionally, many various parties are affected by city growth, including construction businesses (contractors, subcontractors, installers, etc), developers, suppliers, transporters, municipalities, residents, and medical personnel, among others. These stakeholders frequently have an opinion on construction projects and how they are carried out, which adds to the organizational complexity of projects as various stakeholders enter and depart projects at different times (Janné, 2020). However, as urbanization continues, the issue of construction logistics management is

becoming more tangible, as an increasing number of projects are constructed and supplied throughout dense urban areas. Since densification is becoming greater across the world, off-site logistics gets even a more important role in construction projects. It is estimated that construction deliveries account for around 20% of all cargo km traveled in Sweden (Sveriges Byggindustrier, 2010).

3.4.1 Challenges regarding off-site logistics

Construction logistics also known as off-site logistics are faced with urban transportation problems, such as, space constraints, municipal demands to reduce environmental impact, and demands from residents and business owners regarding accessibility and noise restrictions (Dablanc, 2007). Therefore, construction material deliveries to work sites must be organized and managed in such a manner that their impact on the urban transportation system is minimized while at the same time guaranteeing that construction may progress without losing productivity on the job site as a result of missed or delayed material deliveries (Janné, 2018).

Moreover, Janné (2018) states that, building in urban areas is plagued by two problems: the difficulty of urban transportation and the challenge of coordinating the efforts of a large number of different construction parties. Furthermore, Janné (2018) continues by elaborating that it is possible to alleviate these issues by implementing construction logistical solutions, such as, consolidations centers, third-party logistics and construction logistics plan, which will be further explained. These solutions have the same goal of controlling and coordinating construction shipments, but they accomplish this goal in a different way.

Economically, the expenses spent by congestion affect both residents and businesses (Bretzke, 2013), and this is the root of the fundamental problem with the urban transportation system; it is a complicated transportation system in which both good-transport and people share a restricted infrastructure (Dablanc, 2007). Aside from that, the transportation system is comprised of a diverse range of vehicle types and road users, increasing the likelihood of an accident (Russo and Comi, 2010). As previously stated, an efficient goods transportation system is critical for the urban economy (Lindholm, 2012) and should be a top priority for cities, residents, and businesses (Lindholm, 2012).

Regardless of whether it is products or persons being moved, urban transportation networks are subject to an excess of rules (Ballantyne et al., 2013). Goods transportation and logistics have traditionally been viewed as an issue that must be solved by the logistics sector (Ballantyne, et al., 2013). According to Janné (2018), the lack of transparency and a narrow focus on goods transportation add to the difficulties of the urban transportation system.

The management of logistics and material delivery is, of course, impacted by these considerations as well. For example, various stakeholders may have varying requests and considerations about how construction logistics should be carried out. Managing

projects in these complex environments are challenging owing to the high amount of unpredictability and the diversity of companies.

3.5 Construction logistics solutions for dense environments

In this section three different construction logistics methods will be presented. These methods can be used in order to combat the challenges which could appear for construction projects located in dense areas, the solutions are namely, construction consolidation center (CCC), third-party logistics (TPL) and construction logistics plan (CPL).

3.5.1 Construction consolidation centre

Construction projects generate the final product at the place of consumption, which necessitates the timely delivery and removal of various materials and resources to and from each site. This results in increased traffic flows and congestion on current urban infrastructure. Consolidating items from different suppliers into one shipment to lessen the volume of goods moving in cities is a common recommendation for lowering the effect of urban goods transportation (Janné & Fredriksson, 2018), in other words, the use of Construction Consolidation Centre (CCC). According to Sullivan et.al. (2010) the retail and industrial sectors were the first to use the Consolidation Centre (CC) concept. CCs, unlike warehouses, are essentially buffer storage facilities that hold materials or items for a short period until they are needed by a retail shop or a location. Consolidation centers are frequently built near highways or railroads to make distribution and the acquisition of huge amounts of materials and commodities easier. Between the period 1970 and 2010, 114 consolidations centers were identified throughout the world, but only seven of them were related to construction projects (Muerza & Guerlain, 2021). Implying that the concept still has a long road ahead for it to be recognized for its potential to lower the number of transportations to the construction site. A CCC may be launched by a variety of stakeholders, such as the developer or the municipality (Janné & Fredriksson, 2018).

Moreover, the objective of a CCC is mainly to arrange delivers to multiple construction sites within an urban area (Janné & Fredriksson, 2018; Muerza & Guerlain, 2021). The usual process entails different suppliers to deliver materials to the CCC, where they subsequently are received, registered, controlled and stored (Janné & Fredriksson, 2018). Figure 4 depicts the different process that a CCC calls for, firstly, the materials from the suppliers are unloaded at the warehouse (CCC), then the responsible staff at site has the opportunity to place an order from the warehouse to the site, the return trips may include waste from the site. The figure also shows that some materials, however, should be taken directly to the site, this includes very large items, such as steel work and heavy plant (Lundesjo, 2011). The registration of the delivered material can be done by using a simple spreadsheet or on a warehouse management system, the materials are now also placed in a secure location in order to erase the risk for theft and damage (Lundesjo, 2011). When a construction site orders supplies, they are picked up and delivered. Workers at the CCC choose and assemble consolidated loads before delivering them to the job site on a just-in-time basis. This allows entire truck loads to be delivered to several contractors in one delivery without giving excessive amounts to any one contractor (Janné & Fredriksson, 2018; Lundesjo, 2011).

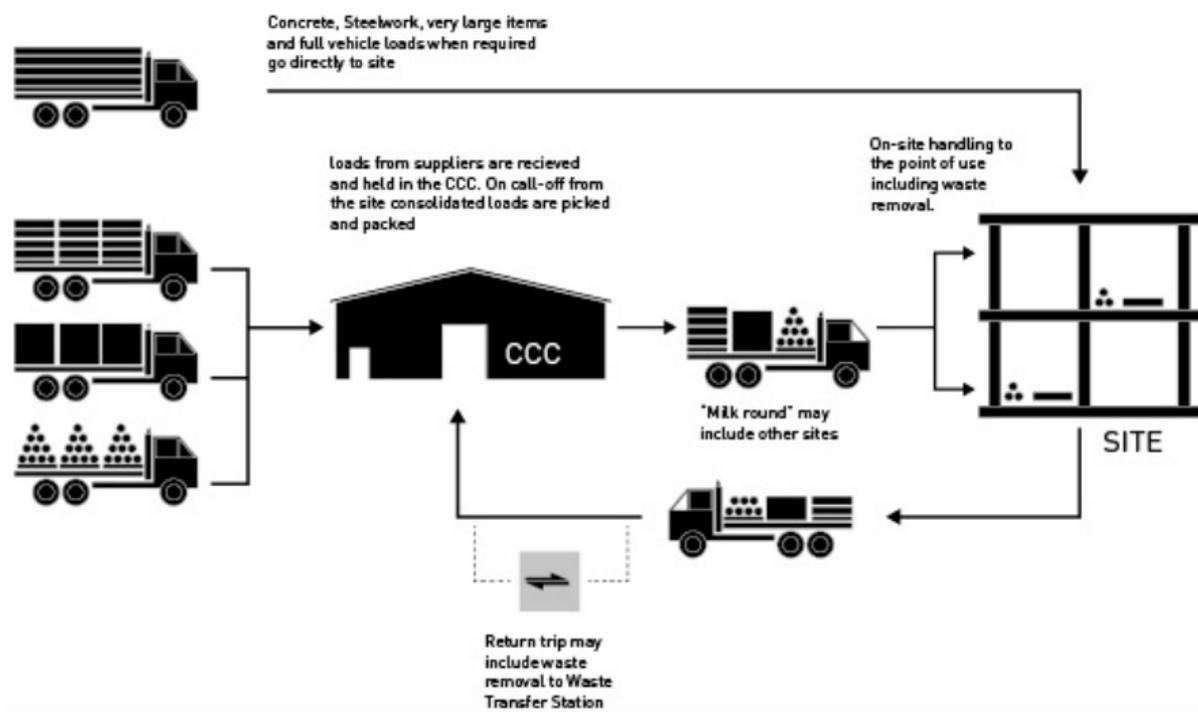


Figure 4, The principle of a CCC (Lundesjo, 2011).

According to Muerza & Guerlain (2021), the benefits of utilizing CCC for construction projects could be:

“(i) a reduction in construction traffic; (ii) environmental effects, including a reduction in congestion, noise pollution, carbon emissions and waste; (iii) social effects related to health and safety with a reduction of disruptions on-site as a result of lower stocks, fewer vehicles, and reduced material handling; and (iv) productivity and programme certainty effects, regarding the reduction of on-site handling, which supposes an increased productivity of the labour force (up to 30 min per day), and fewer shortages”

(Muerza & Guerlain, 2021, p. 3).

Furthermore, some value-adding services can also be utilized by using a CCC, such as for example the coordination of reservations using shared IT systems. As a result, contractors must schedule their material flows based on when they need the supplies. The primary contractors may concentrate on their operations rather than establishing relationships and arranging delivery with several additional contractors within the same construction region by using the CCC as a coordinating contact point (Janné & Fredriksson, 2018).

3.5.2 Third-party logistics

Third-party logistics (TPL), or also referred to as logistics outsourcing, has in the recent years gained considerable amount of attention from various logistics scholars (Marasco, 2008; Ekeskär and Rudberg, 2016). There has also been a steady increase in the number of organizations using TPL providers to handle all or part of their

logistics operations across the industry sector according to Ekeskär & Rudberg (2016). Moreover, Ekeskär (2016) states that neglect from both the clients and contractors to strengthen their relationship with suppliers and subcontractors, together with a lack of knowledge on SCM and logistics in general from the responsible parties has created a niche for TPL within the construction industry. However, according to Marasco (2008) the concept still lacks a single consistent definition, and notes that TPL is sometimes used to as conventional transportation and/or warehouse sourcing, while other times it refers to a more complicated outsourcing that may include the full logistics process.

Nevertheless, Marasco (2008) highlights those existing interpretations may help to illustrate the concept, such as from Lieb (1992, p. 29), which states that TPL involves:

“...the use of external companies to perform logistics functions that have traditionally been performed within an organization. The functions performed by the third party can encompass the entire logistics process or selected activities within that process”.

Agreeing with the statement from Marasco (2008), which highlighted that TPL can encompass both selective activities or the whole logistical process.

Furthermore, TPL solutions in the construction sector are available in a variety of configurations, which vary based on the client, the contractor, the TPL provider, the suppliers etc (Ekeskär, 2016). Some examples of these services according to Ekeskär (2016) could be, information related activities (e.g., tracing and tracking of materials/packages, planning for distribution of materials), transport, value adding activities (e.g., installation of materials), warehousing and inventory management (e.g., repackaging, handling of materials).

Ekeskär & Rudberg (2016) identified several factors for implementing TPL and potential barriers for it in their paper. The identified factors were later combined with the findings from their case study (The case of a large hospital project), and together formed a comprehensive list on driving forces and concerns for utilizing TPL in the construction industry. Some of the driving forces for TPL in the construction industry were, increased possibility to focus on core activities, lower costs, improved delivery service, enhanced customer satisfaction etc. Whilst some of the concerns were, TPL has to be included in the early planning, the position of the TPL provider, fear over an unreasonable fee structure, inability of the TPL to provide certain services etc., (Ekeskär & Rudberg, 2016). Nonetheless, Ekeskär & Rudberg (2016) concludes that a TPL solution is not a means to an end for construction logistics, rather, it is a tool that, when utilized appropriately, may assist in resolving some of the construction industry's logistical challenges.

3.5.3 CLP – Construction logistics plan

The Transport for London (2013) has created a construction logistics plan (CLP) in order to assist construction projects to plan and coordinate vehicle movements in a way to mitigate negative impacts on the surrounding environment. Moreover, according to the Transport for London (2013) the building phase of a construction project will have an influence on the public safety, environment and traffic congestion on the road network as well as the local community. Additionally, the implications

may vary depending on the size, timeframe, and location of the development (Transport for London, 2013). This creates a need for an effective delivery plan for the transportation of both materials and waste to and from the construction site. In a case analyzed by the authors Ying & Tookey (2014) it was discovered that there was a lack of coordination between the subcontractors and their site workers when it came to material delivery and unloading. It was also observed that suppliers seldom provided input to the site staff on whether or not they were able to supply the items requested. Materials were often brought to the job site with as little as ten minutes' notice in advance. This caused tremendous disruption and lost time as management had to form an ad hoc crew to dump and receive the supplies. Unplanned delivery caused scheduling issues and inefficient loading (Ying & Tookey, 2014).

Furthermore, Sezer and Fredriksson (2021) introduces the term “turnaround times”, which is defined as the time spent by the truck and its driver at the construction site for loading and unloading activities, from the moment it arrives at the gate until it drives out of the gate again. Hence, the longer the turnaround time, i.e., the longer a vehicle is on site, the greater the likelihood that there will still be another vehicle on site, increasing the likelihood of congestion, which raises the danger of accidents and delays (Sezer and Fredriksson, 2021). The authors (Ying & Tookey, 2014; Sezer & Fredriksson, 2021) highlights that one of the causes for poor delivery plans within the industry is due to a lack of planning, more specifically a lack of planning the deliveries.

However, the transport for London (2013) have introduced a solution for this, called construction logistics plan (CLP). It can be defined as the following:

“A CLP provides the framework for understanding and managing construction vehicle activity into and out of a proposed development, encouraging modal shift and reducing overall vehicle numbers.”
(Transport for London, 2013).

The CLP is a document that outlines the anticipated and complete logistical activities of a construction project. It should describe how material deliveries will be scheduled and controlled throughout a building project, and it is becoming a necessity. It is a tool to educate local stakeholders about the extent to which the project would interfere with their everyday lives. It is used by the primary contractor and other project participants to better plan and coordinate logistics operations, to guarantee safety on and off-site, and to better plan and coordinate logistics activities. Through improved planning, the CLP framework may assist in reducing local congestion (Transport for London, 2013).

3.6 Innovation within construction logistics

The term "innovation" refers to the practice of making substantial alterations and enhancements to an existing process, which in turn makes that process seem novel to the person or group that is responsible for starting and creating the change (Havensid et al., 2019). Moreover, according to Bengtsson (2018), a typical categorization derived from manufacturing research separates product innovation from process innovation. Whereas process innovation is applicable to changes made in construction

processes because it implies creating innovative methods for existing activities or tools (Bengtsson, 2018).

Furthermore, the use of building information modeling (BIM) for construction logistics has been classified as a tool for improving construction logistics. BIM is a method of operation including the creation of a model that is a virtual representation of reality. The BIM model may include a great deal of information, from the building's characteristics in general to the qualities of individual components (Elias, 2020). When additional information is added into the BIM model, users are able to progress to higher levels within BIM. Whereas, the basic level of BIM is 3D BIM, and 4D BIM (next level) is the adding of time to BIM by tying model properties to a building schedule (Magill et al., 2020). In the context of construction logistics, BIM can offer:

“...tools to develop plans for erosion control mitigation, crane logistics, material staging areas, vehicular traffic/access, material hoists, equipment, scaffolding, and safety”

(Brad & McCool, 2015, p. 188).

Moreover, according to Whitlock et al. (2021), with the use of BIM data, the burden of materials management on building sites may be decreased, therefore reducing the danger of theft and damage, and optimizing site operations. The authors (Whitlock et al., 2021) continue to highlight that the incorporation of supply chain management methods with 4D model data allows the supply chain process to be visualized and material flow to be monitored. Hence, implying that BIM, or more specifically 4D BIM, has the potential to facilitate for construction logistics. Nevertheless, Magill et al. (2020) argue that despite the widespread use of BIM at different levels, 4D BIM within construction logistics is underutilized, mainly due to lack of strategy, perceived IT expenses and required training.

Hulthén and Sundquist (2019) devote a chapter in the book “The Connectivity of Innovation in the Construction Industry” to construction logistics innovation and used a Swedish logistics actor as an illustration of innovation within construction logistics (Havenvid et al., 2019). The authors emphasized that activity interdependencies are innovation facilitators for developing a new construction logistics process. Identifying that when activities were re-organized and coordinated in different ways gave rise to innovative solutions, and new methods of working (Hulthén & Sundquist, 2019). Thus, implying that innovation does not necessarily imply the creation of new processes, products, tools etc., but can simply refer to new methods of working. Which can be done by:

“...increase in connectivity in the form of more intense interaction and stronger interdependencies among not only activities, but also resources and actors.”

(Hulthén & Sundquist, 2019, p. 18).

The quote also emphasizes the fact that collaboration can help to propel the industry forward, thereby improving all aspects of the industry, including construction logistics.

4 Interviews

This section presents the interviews that have been conducted with seven different managers who are the key personnel managing logistics issues for their respective projects. The ones in charge of the logistics for each project had different roles in the project; some were logistics managers (LM), site managers, block managers etc. A description of each of the projects will be presented, along with the logistical challenges they faced and the solutions that were implemented, but also some thoughts from the interviewees on future solutions or innovations. All of the projects that were selected are located in the dense parts of Gothenburg, in order to have the same prerequisites when analyzing the results from the interviews. The interviews will be presented in the order they were conducted. Table 2 presents some detailed information about the interviews, such as, the role of the interviewee, project name, what type of project, and the status of the project.

Company	Position of the interviewee	Project	Type of project	Project status
PEAB	Logistics manager	Platinan (Project A)	New construction	Finished
Veidekke	Logistics manager	Strömshuset (Project B)	Remodeling	On-going
NCC	Block manager	Kvarter Johanna (Project C)	Remodeling/new construction	On-going
Skanska	Logistics manager	Citygate (Project D)	New construction	On-going
PEAB	Logistics manager	Gårda Vesta (Project E)	New construction	Finished
K21	- Site manager - Logistics manager	Hotell Draken (Project F)	New construction	On-going
NCC	Site manager	- Brick Studios (Project G) - Våghuset (Project G)	New construction	On-going

Table 2, information about the interviews & projects

4.1 Platinan - PEAB

Peab is the main contractor for this project, and they are building it for Vasakronan, who is the client. The building has an unusual profile with a floor size of 60,000 square meters distributed over 18 levels, all of which are covered by glass and green terraces. The building has a variety of facilities like hotels, offices, coworking spaces, conference rooms, restaurants, and stores. The project started in 2016 and will be ready for the users during spring of 2022. The building is located next to the newly constructed bridge, Hisingsbron. According to the interviewee, one of the reasons this project is unique is because of its location and the projects that were conducted concurrently around Platinan, such as Hisingsbron and E45:an. These factors played a big role in the logistical challenges that the project faced, which will be elaborated further.

4.1.1 Logistical challenges

As mentioned above, the project is situated in a very dense and compact area of the city, along with two infrastructure projects being under progress during the construction phase of the project. The interviewee stated that a great deal of coordination was required between Skanska which built the bridge (Hisingsbron) and PEAB (infrastructure), which was working on the E45. The interviewee also highlighted that:

“Just because both we and those who built the E45 wear same PEAB jacket does not mean that we have it easy to work together”.

Implying that although they work for the same company they still work on different projects, with different timelines, budgets, expectations etc. Furthermore, the LM at Platinan identified transportation to the site as the most difficult challenge and stated that on-site (material handling at site) logistics were not a problem. There was no option to drive around the building, meaning that they just have one drive in for the load and unload place. All the transport was made through Gullbergs strandgatan. The interviewee stated that they had already thought of most of the logistical challenges which the project faced. However, if something came up, it usually had to do with the neighboring projects. An example is when the bridge was delayed which consequently affected the flow of the traffic. The LM continued to highlight that it's almost impossible to plan for everything, there will be challenges which will occur during the construction phase, and it's important to deal with those challenges from a logical point of view. But the interviewee did emphasize the fact that the neighboring projects had a significant effect on the construction process for Platinan, hence impacting the logistical part of the project.

4.1.2 Logistical solutions

As the project's logistical challenges were discovered, the corresponding solutions were identified by the logistical manager and the team. As mentioned, the most significant logistical challenge for this project was the lack of space. The solution that was implemented for this was a delivery planning system, in order to facilitate the transport to the building. The responsible personnel could book the different unloading areas in the right order. In this way every delivery could be booked

beforehand in order to avoid any further congestion on the already dense site. Furthermore, when questioned about deliveries being late or too early, the interviewee stated that ad hoc solutions were used in those cases. For example, if there is a delay in delivery of frame material, they try to solve this in the most flexible way. But if a delivery comes too early, for example, if delivery 6 comes before delivery 5, then they try to stop this by guiding them to rest areas around town. Solutions from the literature was also mentioned to the interviewee, however he stated that only a “hybrid” form of a TPL was used for this project i.e., they have rented some services from different companies, but Peab was determined to have all the control of the logistics for Platinan. He also admitted that, while they did not use a CCC for this project, it could have certainly aided in delivery.

4.1.3 Future expectations

According to the interviewee, digital tools are the future of logistics. During his time on this project, he has witnessed significant changes in digitization, from printing fewer drawings to using applications such as Dalux for reporting. He stated that he is especially looking forward to the day when you can simply click on a drawing and order the material for a specific surface, and the entire ordering and bearing chain is complete.

4.2 Strömshuset - Veidekke

It is a new construction on an existing building in the heart of central Gothenburg. Veidekke is contractor for Vasakronan. The lack of a defined section in the existing structure that distinguishes the two properties that are built into each other. As a result, there is no clearly defined workplace in most buildings, resulting in more complicated logistics having a negative effect on the pedestrians and cyclists being directed "directly" into the workplace. The interviewee stated that they used glulam as a frame to build facades, windows, and a three-story extension on one of the properties.

4.2.1 Logistical challenges

The fact that the location is "open" to the general public is a significant challenge. The interviewee mentioned that they sealed off a section of Strandgatan to create a delivery zone, as well as a waste management area. However, it is not large in comparison to the amount of material that must be drained out. It's a 130-square-meter cargo zone where everything should take place, including all inbound and outbound transportation. Since this is an existing building, one can't knock down the facade, which complicates transportation routes to the property, as you must utilize terraces and the like, which requires lifting with a crane that the company also had within the property. All the way down to the basement, there's constant forging. There was also Christmas shopping in the centre of town, as well as other considerations with a large number of people. The client and municipalities want one to cause as little disruption as possible. Of course, the fact that it was residents in the building throughout the entire construction time has had an effect. As a result, there was several unique circumstances.

Then there's waste management, where there's no specific location, and the only place according to the interviewee one could put a container was in the loading zone, where one handle deliveries, so the solutions was to do things like have containers and then the trucks are allowed to drive in and then back out and drive around the loading zones.

4.2.2 Logistical solutions

According to the interviewee, a digital planning system for deliveries and in general activities in the zones that was available had been a critical component of the entire process. According to him it has been an extremely useful tool because when something happens frequently and there are so many different parties involved, it was extremely difficult to keep track of everything in the head or to keep it organized if one has a lot of paper everywhere; therefore, a digital system with good visualization was extremely beneficial! He also stated the benefit of specialized workers that have been tasked with lifting and similar tasks. The interviewee highlighted the company's view of ensuring that always work with the same staff. Especially in this case, where they are working directly on, and where a mistake can have serious effects. He also mentioned they work at a fast pace, so it's critical that you work with people you know and trust.

4.2.3 Future expectations

The interviewee stated that there will be a significant growth in the use of digital tools in the future. He also thought that it was unfortunately, it is impossible to predict how quickly it will progress. Digital tools, he would absolutely recommend them, especially when it comes to delivery services, as an illustration. He even stated that integration is also vital; make every effort to guarantee that information shared between various parties is passed on to the next party. Communication between suppliers, contractors, supervisors, carriers, and other parties is essential to business success.

4.3 Citygate- Skanska

The construction of the project, Citygate, started in 2018, and is anticipated to be finished by the end of 2022. When completed, it will be the highest office skyscraper in the Nordic area, standing at a height of 144 meters and consisting of 36 floors, with an area of 42, 000 square meters. The building will consist of restaurants, office spaces, cafés, etc. Citygate is located in Gårda, a strategically well-placed area in Gothenburg, where it's right beside the highway. However, the benefits of the location have in turn brought challenges to the construction of the project, specifically logistical challenges due to a lack of space.

4.3.1 Logistical challenges

As mentioned, the project is located in Gårda, which is an area with constant traffic flows, and is connected to the highway. Besides that, the largest fire station in Gothenburg is based across the project. Thus, the interviewee stated that it's very

important to be cautious not to interfere with the traffic flow. The logistical manager put a lot of emphasize on the fact that it's crucial that the traffic can't be affected in any way. Apart from the traffic flow, there is also lack of spaces around the project for deliveries of materials, as the interviewee highlighted, "The surface around the house is almost non-existing.". Furthermore, although the logistical challenges can be categorized as off-site complications i.e., traffic flows, lack of space, delivery challenges etc., on-site obstacles was also identified as challenges for this project due to its height. However, in essence, the main logistical challenges were, lack of space around the project and to not disturb surrounding traffic.

4.3.2 Logistical solutions

Due to the lack of space around the building, a CCC was one of the logistical tools that were implemented for this project. According to the interviewee, the choice to use a CCC for this project was inevitable, especially due to the lack of space around the building, and as stated before, the importance of not interfering with the traffic flow. In addition, because of the building's height, it was difficult to designate the material to the right place easily; everything had to be planned beforehand. Hence, the use of a CCC would give the logistical manager better control of the material flow to the site and in turn lead to less congestion and disturbance at the site. Besides the implementation of a CCC, the LM mentioned that they had been using several different digital solutions for the logistics part of this project, such as a warehouse program called "Myloc", which basically works as some form of a stock balance, where they have control over the number of materials. When asked about solutions that has been used for the unpredictable problems arising during the production phase, the LM said:

"In the construction industry, we are quite good at solving things. We solve it, but we usually solve it when it happens here and now."

Above quote is a good example to discuss the tendency to use ad hoc solutions was used when a problem arose during the construction. What was going on in the available zones was an important part of the overall process. Furthermore, the LM frequently emphasized that, aside from all of the implemented solutions, the most important factor was that he had control and worked with his own team. Everything that can be done in-house, should be according to the LM, that would lead to a more efficient building process.

4.3.3 Future expectations

Digital solutions were according to the interviewee the future solutions for logistics. Although they are already using plenty of different digital programs for the logistic part, there is still room for improvement. However, the interviewee continued to state that, "Of course you want new things, but we must not forget that we have to work with them as well.". Thus, there has to be a limit to the number of new programs introduced, it's not very wise to just implement new solutions, they have to make the work more efficient.

4.4 Kvarter Johanna - NCC

Kvarter Johanna is in central Gothenburg, close to Brunnsparken. The project began in early 2022. NCC is the primary contractor, and Huvudstaden is the client. There are currently five properties. The plan is to construct a house on a plot that no longer contains a building due to a fire. As well, they have three existing properties where building expansion is planned. One of the buildings, however, will be demolished. The third will be constructed above with one floor. They will add three floors to the tallest building. So, in total, it's a combination of renovation, reconstruction, and story extension.

4.4.1 Logistical challenges

The interviewee stated it is always difficult when you take on older buildings. The combination of here with going into old houses without knowing the conditions while using new prefab elements are exciting. Everything should be put together and feel like a unit when it's done. However, the technical disadvantage pales in comparison to the requirements for accessing the material. As it is now, it is mainly planned as two off-loading zones, one of which is Östra Larmgatan, which was easily closed off. The other one the interviewee had in mind is that hope to get a small area is on Södra Hamngatan, but here is the issue the tram traffic. And that's coming at peak time a tram in 17 seconds, which makes it much more difficult.. According to the interviewee, they have looked at when fewer trams run, for example they could work at night but then the problem is that there are 5 hotels around that like to sleep at night. They don't want the noise disturbance, that makes logistics by far the most challenging thing about the project. The logistics manager's main challenge is determining how to get materials here and how to dispose of demolished materials.

4.4.2 Logistical solutions

The interviewee stated that they are still in the early stages of development, so they are currently using their own tool as an unloading calendar. It's simply a drop calendar where you make reservations when you have deliveries to create. According to the interviewee, a winning solution was to use a CCC for all materials so that the site would have more control over the flow of materials that arrive at the site due to the location and bookings from the site to the terminal. She also mentioned the possibility of transferring things from here to the terminal that are going somewhere else, so they're considering whether they should create another digital tool to help with that. This project is being handled by a logistics specialist at NCC. The LM coordinates booking confirmations; the LM collects the information from the subcontractors, who handle materials and delivery dates. This results in greater control when the material arrives. The terminal will be 1.8 kilometers away, in Marieholm.

4.4.3 Future expectations

The interviewee think that the technologies come a long way just that she has worked on from drawing on pen and paper, to starting to use more calendars, scales, more efficiently. And that's only going to continue to give the industry more innovations in

terms of digital tools and the possibilities to see in everything in 3D-model. She stated in the future maybe one will be able broadcasts onsite so one could see it in the 3d-model “live”. She thought people are starting to see the benefit of that at least in the bigger cities.

4.5 Gårda Vesta - PEAB

The Gårda Vesta office property has been built on behalf of Platzer fastigheter by Peab. The project started in 2017, however, the official first sod for the project was taken in January 2019. Skatteverket moved in during the autumn of 2020, during the first half of 2021 additional tenants moved in on an ongoing basis and the project as a whole was handed over in September 2021 (Peab, N/A). The project is located in Gårda, just like Citygate, which is a rather dense part in Gothenburg with a lot of traffic coming from the highway nearby. However, although both the buildings faced roughly the same logistical challenges, the implemented solutions differ, which will be further elaborated in the coming sections. Moreover, the building consists of two “bodies” with 25 and 14 floors, respectively, which are connected by a lower building, the tallest body is roughly equal to 97 meters. The property mainly houses offices but also a restaurant and a large terrace. According to the interviewee, Gårda Vesta was the first “tall” building constructed in the area, since then more high buildings have been added to Gårda.

4.5.1 Logistical challenges

When asked about the logistical challenges for Gårda Vesta, the interviewee started off by mentioning that the main logistical obstacles for this project were following an environmental protocol and the logistics of the staff on site. This project aimed at achieving an environmental certification, and in order to accomplish this objective the logistic staff had to collect data every month for three years. Examples of collected data was, follow up on transportation, CO₂-emissions and waste management. This was one of the most time consuming and difficult tasks for the logistics team during the course of project. The interviewee also stated that the moving around of staff members was a big challenge. Mostly, because everything had to be coordinated and planned in advance with a lot of care. Sheds had to be relocated, consequently leading to cranes and other equipment’s being used for purposes not connected to the actual construction of the building, thus halting the production. The team was aware of the fact that the logistics of the staff would be a challenge beforehand but was surprised that it was more difficult than anticipated. Furthermore, the lack of space around the property was also yet another issue for the logistics, as mentioned in the previous interview with Skanska (Citygate), both this building and Citygate are located in an area with constant traffic flow and near the highway. Hence leading to transportation difficulties to and from the site.

4.5.2 Logistical solutions

A digital delivery calendar was one of the solutions used for this project, the suppliers had to adjust to Peab’s demands on booking when the deliveries would arrive to the site. This demand was also included in the contract with the subcontractors and suppliers according to the interviewee. Furthermore, several delivery sites had been prepared beforehand in order to mitigate the risk of collisions around the site. They

avoided using CCC, instead they utilized the just-in time concept. It was done by guiding the trucks (deliveries) to specific rest areas for trucks within the vicinity of the site, and the trucks waited at the rest place until it was their time to arrive at the site. Flag guards was also a tool that was introduced to the project, but this solution was not planned beforehand, it was something that the logistics team implemented during the construction phase. They took them in because it did not work out on site and they needed someone who might hold the deliveries harder for them to come out on time and go in on time. Regarding the solutions for the unplanned challenges that occurred during the project, the interviewee stated that, the workers at Peab in general are very solutions-oriented, they have no problem with dealing with upcoming obstacles.

4.5.3 Future expectations

The interviewee stated that the responsible personnel working with logistics at the office informs the logistics managers at Peab regarding new methods of working. In this case the interviewee mentioned a colleague at Peab that is very interested in developments within construction logistics, and he always tries to keep the employees up to date with new solutions. In addition, the interviewee also believes that in order for the industry to prevail and reach new heights of productivity and efficiency it needs to adapt digitalization and use its benefits.

4.6 Hotell Draken - K21

The hotel is located in a dense- and highly populated area by Järntorget in central Gothenburg. It consists of a building with 474 hotel rooms on 35 floors, of which one floor is an area of 26,000 square meters. The construction itself started in November 2019 and is expected to be completed in 2023. The client are Fastighets Balder and the hotel will be tallest hotel in whole of Gothenburg becoming a landmark in the city.

4.6.1 Logistical challenges

A challenge was figuring out where the transportation should come from and how it gets into the construction site. At the site, there was only a passage for trucks to enter from one side, unload all their material, and exit the other. The question was, however, from which direction it would be most effective. Another issue was that the crane could not be used over the trucks that were co-loading in the narrow passage.

The lifts have also been difficult. It was determined early on that a large number of elevators were required. There were fewer good positions available now, but only four remain. But what they hadn't seen was how long the elevators remained stationary because they had to be raised every time a floor was built because they were picked up under elevators. They take a little longer than they anticipated, and then there are the gates that have opened, forcing you to raise the height. When the company was lying on the floor, the gates had to be moved five inches. Then they must be turned off as well.

4.6.2 Logistical solutions

The first solution to the problem of how the material would be transported was to drive into the east and out of the west directions. It is somewhat predetermined by the appearance of the streets and roads in the area. It was stated by the interviewee that the use of digital planning tools was essential in synchronizing the flow to site. According to the person who conducted the interview, JIT was given top priority at the site. In addition, the material should be delivered directly to the work area where it is needed. It was almost necessary to transport the material to the location where it would be used because there was only a small area for co-loading due to the limited space.

According to interviewee working at K21, the crane's movement was primarily a function of planning and consciousness. Even though being cautious and following the rules and regulations was a minor issue, they were able to get by with some ingenious solutions.

4.6.3 Future expectations

The interviewee stated the importance digital solutions in the future has an important role for logistics. However, he stated that digitalization is not always a key to good logistics success. Even if he emphasized the significance of using it.

4.7 Brick Studio & Våguset - NCC –

The last interview was conducted with a site manager for the projects, Brick Studios and Våguset. The interview was conducted with the LM that is responsible for both projects. The projects are constructed by NCC Building for their property development sector, NCC PD, which they later on will rent out to various companies. Both the projects will mainly be used as offices, both of them are located within the vicinity of Järntorget, not far away from Hotell Draken by K21. The number of floors is between 13 and 15, and both buildings are ready for access in 2022.

4.7.1 Logistical challenges

According to the interviewee, the project is at its most difficult stage right now regarding the logistics. The site is very crowded with limited space, which makes it difficult to handle the incoming materials. A lot of changes occur daily, and the team has to be prepared to solve anything that comes at them, stated as such by the interviewee:

“...and it is not possible to describe how much changes may occur several times a day...”

Implying that it's not possible to plan for everything in advance, problems will occur and it's important to know how to solve them. The site manager stated that archaeological findings and the progress of another contractor who no longer works on the project has given rise to the logistical challenges for this project.

4.7.2 Logistical solutions

The site manager was very precise with his answers, and just stated that the two main solutions used for these projects was increasing the space around the projects to facilitate for the materials, this was done by renting needed space from the city, and the use of a TPL was also implemented. Furthermore, the site manager stated that there are some aids and templates that NCC has and the logistics calendar before taking on a project. However, considering that it's a very crowded area that its built on and they are not the only project or company that builds here, there are many coordination meetings that required, at least one a week, sometimes there can be more. Moreover, the site manager was pleased with the outcome of their logistics approach and highlighted that they've done everything in their control. When asked about the unpredictable challenges arising during the construction phase, the site manager simply stated that they try to reach an agreement on how to solve the issue amongst themselves.

4.7.3 Future expectations

The site manager was both positive and skeptical about the increase in digital tools for construction logistics, he mentioned that the digital tools can facilitate the process but highlighted the importance of experience and knowledge by stating that "...it is out there that it happens and not in front of the computer." Furthermore, the company tries to stay up-to-date by having talks with other projects and exchanges ideas and smart solutions, or even cooperation to reduce transport, etc. He also stated that NCC as a company are not scared to try new solutions that have been introduced.

5 Data analysis

The purpose of this section is to present the findings from the analysis of the seven interviews conducted with the managers. The analysis enabled the researchers to understand the similarities and differences between the different projects in regards to challenges, solutions and future expectations related to off-site logistics. Table 3 illustrates the most significant logistical obstacles, the measures taken to combat those challenges and the future expectations for construction logistics briefly. It is followed by detailed explanation of each parameter identified in the analysis.

Table 3, summary of the challenges, solutions and future expectations for all of the projects

Projects	Challenges	Solutions	Future expectations
Platinan (Project A)	<ul style="list-style-type: none"> The project is situated in a very dense and compact area of the city → close to two infrastructure projects under progress. Transportation to the site Lack of transportation route on-site 	<ul style="list-style-type: none"> Digital planning system for deliveries Ad hoc solutions. Rest stops for delivery problems. Use of TPL, but Peab still had the overall control of the logistics 	<ul style="list-style-type: none"> Digital tools Use of Dalux Digital solutions for ordering
Strömhuset (Project B)	<ul style="list-style-type: none"> The fact that the location is "open area" to the general public Transportation to the site Lack of space on-site Lack of transportation route on-site Existing building Awareness of nearby neighbors 	<ul style="list-style-type: none"> Digital planning system for deliveries Specialized workers. 	<ul style="list-style-type: none"> Greater use of digital tools Integration: sharing acquired experience Communication between suppliers, contractors, supervisors, carriers, etc.

Citygate (Project C)	<ul style="list-style-type: none"> • The project is situated in a very dense and compact area of the city • The project site is close to highways and the largest fire station in Gothenburg • Transportation to the site • Lack of space on-site • Lack of transportation route on-site 	<ul style="list-style-type: none"> • CCC • Several digital solutions • Ad hoc solutions 	<ul style="list-style-type: none"> • Digital solutions
Kvarter Johanna (Project D)	<ul style="list-style-type: none"> • Existing older buildings • Lack of space on-site • Lack of transportation route on-site • Transportation to the site • Awareness of nearby neighbors 	<ul style="list-style-type: none"> • Digital planning system • CCC • Logistics employee responsible for bookings 	<ul style="list-style-type: none"> • Digital solutions • Use 3D-models to facilitate the work • Broadcast everything live
Gårda Vesta (Project E)	<ul style="list-style-type: none"> • Environmental protocol and the logistics of the staff on-site. • Sheds had to be relocated. • Lack of space on-site • Lack of transportation route on-site 	<ul style="list-style-type: none"> • Digital planning system for deliveries • Several delivery sites had been prepared beforehand • Just-in time concept. • Rest stops for deliveries. • Flag guards 	<ul style="list-style-type: none"> • Use of new developments from institutions such as Chalmers • Digital solutions

Hotell Draken (Project F)	<ul style="list-style-type: none"> • Lack of space on-site • Lack of transportation route on-site • Crane issues with co-loading 	<ul style="list-style-type: none"> • Having a fixed route for deliveries • Digital planning system for deliveries • Just-in time concept. 	<ul style="list-style-type: none"> • Digital solutions
Brick studio & Våguset (Project G)	<ul style="list-style-type: none"> • Crowded → Limited space • A lot of updates • Archeology 	<ul style="list-style-type: none"> • Increase space around the site • TPL 	<ul style="list-style-type: none"> • Digital solutions • Experience & Knowledge • Implementing new ideas

5.1 Analysing logistical challenges

Transportation to site

The majority of the interviewees identified transportation to the site as a significant logistical challenge. This is because Gothenburg has undergone extensive reconstruction, and all construction projects covered in this study takes place in densely populated areas within the city. For example, this was highly obvious for Project A, which was being built alongside two other major infrastructure projects at the same time, namely E45:an and Hisingsbron. The LM at project A stated:

” Given the surrounding projects, a great deal of coordination was required between Skanska, which built the bridge, and PEAB (facility), which was working on the E45.”

Highlighting that the surrounding projects being built simultaneously made the whole process more complex, and thus meant that stronger communication between the projects was required. He also continued to state that most of the faced challenges was due to the neighboring projects by saying that:

”Most of the challenges we had already thought of, if something came up it usually had to do with our neighboring projects. An example is when the bridge was delayed and traffic did not go through.”.

With project B and project D the delivery was hampered by trams and pedestrian streets on all sides. The interviewee for project D stated that:

”The most problematic aspect of the project is its routes to site. Especially for this project, we are in close contact with the traffic office to determine the optimal alternatives. Because they can evaluate the entire city and are aware of the processes planned for other nearby projects.”.

Due to its central location, it also posed a problem for accessing the city during periods of heavy traffic. Being in Brunnsparcken with offices and stores with a lot of

pedestrians nearby. Being in the heart of Gothenburg, with public transportation nearby. It is impossible to limit the space due to the importance of the location. That's the reason the interviewee stated the work close with the traffic office. Additionally, in project C, which is located across Gothenburg's largest fire station, the problem was emphasized as the challenges regarding to being close to a fire station and the mandate to keep the traffic open. The interviewee stated:

“The area around the building, is almost non-existent. There's barely enough room for a moving truck around the project. We also have Gothenburg's largest fire station across the street, which we must consider.”

This means that you must always be present and calculate when to withdraw, which results in trucks not able to arrive as they want. With the almost non-existent area at the site as the interviewee mentioned the transportation to site gets effected. The site had barely enough room for a truck, emphasizing the importance of on-site unloading challenges.

Other issues regarding transportation to site emerged as being too close to the highway. It was emphasized both as an advantage and disadvantage. Being so close to the highway had its advantages for the route to the site, but it also had its drawbacks due to the heavy traffic on nearby highways, which made it difficult for the off-site logistics. Project F, which is near to Järntorget, also has issues with public transportation routes including buses, trams, and pedestrians. Transportation issues are evident in most projects. The interviewee for project F stated:

“The challenge is not only the site itself, but also the surrounding area, traffic, pedestrians and other projects that must be considered”

As seen in the above quote, the projects located in dense urban areas face with logistical challenges as a result of the high volume both in transportation and pedestrian.

Lack of space on-site

Another common challenge was emerged as the lack of space on-site. One of the most common problems with the lack of space on-site is the design and allocation of the materials on the construction site, for example, interviewee D said:

“You could say that we have 130 square feet, and that is the amount that is on-site, and that is where everything should take place, including all in and out transportation.”

The above quotation emphasizes the difficulties that are faced due to the limited space at site. Considering the building density in the city center, limited space occurs a challenge impacting the logistical issues. All logistics rely on there being no disruptions in the flow of transportations in the restricted area through which the material passes. Making material handling critical for off-site transportation.

According to the interviewee in project C, due to the small size of the location, the trucks could not be emptied in any case. As a result, there was insufficient space for forklifts to enter and empty the trucks, necessitating the use of alternative methods.

He even mentioned that the project area is so small that only one truck could drive around it on site. Therefore, because there is lack of space on-site, and in this case, there is only enough space for a single route, materials cannot be transported in any way. This demonstrates that lack of space and lack of transportation on the site are interdependent.

Lack of space on site emerged as another challenge that almost all interviewees emphasized. For example, in Project A, the interviewee stated:

"All transport had to be brought in through Gullbergsstrandgatan, where we had to load and unload because we couldn't drive around the building, all the time. It was simply due to a lack of space."

It's stated that there is lack transportation route on-site, since they only have one transportation route on site due to lack of space on-site. Moreover, in project F this is also a challenge with the outcome being that the trucks arrive from one side and depart from the other.

Adding- and re-modeling buildings

Two of the projects included for the analysis differ from the others in that they both focus on renovating old projects and adding new buildings, which means they must be consider nearby buildings (shops, apartments, hotels, etc.). The projects are, D and B, which both also are located in the densest parts of Gothenburg. When working in such locations, the LM faces several challenges, one of which is the proximity of neighboring buildings, such as shops, hotels, restaurants, etc. These projects face all the challenges listed above, as well as this one, making it more difficult to execute. For example, the respondent at project D stated that:

"...they can work at night but then the problem is that there are 5 hotels around us who like to sleep at night. They do not want us to sound, that is by far the most unique thing about the project".

This quotation from the respondent demonstrates that the presence of nearby businesses complicates logistics. The business and construction site are negatively affected. Consequently, when planning the logistics, the solution must consider the needs of all parties involved. In addition the LM at project B stated that:

"Buildings do not have a demarcated workplace, but you have pedestrians and cyclists directly into the workplace, so to speak."

Considering that the project is located in the city, it is not possible to have construction site boundaries, which means that the site is open to the public, adding an additional element of challenge to the already existing ones.

The LM also mentioned that because there are no site boundaries, events such as Christmas shopping have an impact on the project, and that they have been told not to interfere with retailers and shoppers. This was said by the LM:

"There was Christmas shopping in the middle of town, as well as other such things to take into account. They want us to disturb as little as possible, of course. It's such a

thing. We also had tenants left in the building throughout the construction period. Of course, it is also something that affects.”.

The quote shows that the LM also recognizes that consideration for the tenants in the building is also a challenge which affects the project.

Other challenges

In addition to the logistical challenges that have been referred above, the interviewees also mentioned some other obstacles that they have faced. The LM at project E stated that fulfilling an environmental protocol and the moving of staff was the most challenging. The quote below exemplifies the complaints regarding the environmental protocol:

” You needed to collect the transport follow-up carbon dioxide emissions that you had in the project and therefore you had to select certain fragments (...) and then you got constantly collect this data every month for three years. To achieve this point, it was a big challenge...”.

Furthermore, the LM also mentioned that sheds (barracks for the on-site workers, place for showers, eating etc.) and the workers had to be relocated a lot:

“I would probably say the logistics of staff on site. We moved on a number of times when we were there, so it was that we lived in sheds, and these sheds had to be relocated a couple of times during the different phases of the project”.

The quotation shows that the re-location of staff and sheds consequently led to cranes and other equipment's being used for purposes not connected to the actual construction of the building, thus halting the production. Because the cranes was used for moving the sheds, and was then used for other purposes than the actual moving of materials for the building. Project F was the only one to indicate difficulties with the use of the crane for the on-loading of supplies. This challenge would consequently led to other deliveries being affected and being late. To conclude, the majority of the projects faced the same kinds of difficulties, whilst there were also some more project specific problems.

5.2 Analysing logistical solutions

Digital planning system

The data analysis showed that the use of *digital planning system (DPS)* was the most common solution used in the projects reviewed within this study (except Project G). The site manager at project G did not mention the use of a DPS when asked about implemented solutions. Nevertheless, the utilization of a DPS helped to mitigate the logistical issues which was necessary given that all these projects were in dense urban areas that lacked sufficient space at site. This solution was the very first answer which the interviewees gave when asked about implemented methods for their faced problems. Even though the use of a DPS was viewed as the primary solution for most projects, the LM at project B emphasized that working with the same actors and personnel is more important than any other tool, stating:

"We work at a fast pace, so it is essential that you work with people you know and trust."

This quote from the LM is meant to highlight that although the use of a DPS was mentioned by most of the respondents, it is also crucial that the intangible factors are considered, such as working with people you trust. In addition, the LM at project E accentuated that the use of a DPS has been utilized by all of the involved parties in order for it to work properly, she said:

"...at that point, we introduced it (DPS) to everyone who came on site at an early stage that it is in the contract and that we use delivery calendar to make it work. And there it was, like the demand now."

Indicating that the use of a DPS is insufficient to meet logistical challenges if not utilized by all the involved actors. It should be used by subcontractors and suppliers for the solution to work and to make transportation to the worksite easier. This indicates the need for active collaboration among the various project stakeholders.

TPL, rest stops for deliveries (RSFD) and CCC

The interviewees also emphasized other logistical solutions, namely, the use of *TPL*, *rest stops for deliveries* (RSFD) and *CCC*. All three of these solutions were used the second most by the respondents, thus they all are presented together. For example, the interviewees from project A and G said that *TPL* has been used to manage logistics. The following was said by the LM at project A:

"...it is usually a combination, it is cheaper to hire a consultant than to have several people who are employed by the company."

Referring to the fact that instead of outsourcing the entire logistics process, the LM mentioned that they had rented a few services from various companies. Also concluding that it's always better to work with third parties regarding managing logistics rather than having inhouse employees managing logistics. Furthermore, the following was also referred to by the LM:

"... wanted it under its own control. But then, of course, we hired staff from Svensk bygglogistik, who was responsible for the transport."

Svensk Bygglogistik was one of third part in charge of all transportation to and from the site. But that the organization (Peab) was determined to handle the majority of logistical processes. Additionally, the site manager for project G did not elaborate on the specific services that the *TPL* provided for the project, making it difficult to compare project A and project G in terms of *TPL* usage.

The analysis illustrated that one of the large contracting companies, that has two projects reviewed in this study, referred to an alternative solution named *rest stops for deliveries* (RSFD). It was seen that RSFD were used for different purposes in each project. The LM in project A said that RSFD was used to manage delivery problems. As stated by him:

“For example, if there is a delay in delivery of frame material, then we try to solve this in the most flexible way. But if a delivery comes too early, for example, if delivery 6 comes before delivery 5, then we try to stop this by guiding them to rest areas around town.”.

On the other hand, the LM in project E stated that RSFD was used as a way to avoid using a CCC. They instead utilized the "just in time" concept. It was done by guiding the trucks (delivery's) to specific rest areas for trucks within the vicinity of the site, and the trucks waited at the rest area until it was their time to arrive at the site. The LM stated:

“We use regular rest areas for cars coming from different places. Now you can stand there until we call, you have to show up at this very time and then you had to stand there until it was okay to come.”.

Project A utilized RSFD as a solution for unforeseen obstacles that could arise during the construction process, whereas project E utilized it as a holding area for the trucks until it was time to deliver the materials to the site.

CCC was another method emphasized by two of the interviews, working in project C and D. The LM at project C stated that the suggestion of utilizing a CCC for the project was introduced in the initial stages of the logistical planning process. The logistics team was well aware of the complexity which the logistics would face at the site, resulting in the utilization of a CCC mainly to have control over the transportation to the site in order to not affect the already congested area. Additionally, the interviewee in project D said that CCC was used to cope with the lack of space and congested area. According to her, the decision of using a CCC was also made in the beginning stages of the project, she stated:

“We checked it very, very early, but it was also because we checked the neighborhood”.

Also concluding that it would've been very difficult to reach the completion date without the use of a CCC for this project due to its location.

Other solutions

In addition to the logistical solutions referred above, the interviewees also emphasized a few project specific methods. Some of the LMs did accentuate a few times that ad hoc solutions were frequently used when a problem was raised. The LM at project C stated:

“In the construction industry, we are quite good at solving things. We solve it, but we usually solve it when it happens here and now.”.

Insinuating that although there is a plan for the logistics, unforeseen problems may arise, and it is important to know how to solve them. Hence, the logistics team needs to consist of experienced workers which can deal with unforeseen challenges emerging during the phase of the project. Likewise, the majority of the interviewees emphasized that although there are several different methods that can be implemented, experience and knowledge will always be the most important factors.

Finally, the concept of “Just-in-time” (JIT) which hasn’t been discussed in this paper was used in both project E and F in order to cope with the complexity of dense areas. JIT is mostly used to cope the on-site challenges but this effects the un-loading of materials which is related to off-site.

5.3 Analysing future expectations for construction logistics.

The analysis of the empirical data showed that the use of digital tools and methods will increase in future. Some of the managers was stronger to emphasize their expectation towards digitalization of construction processes. For example, LM in Project A said:

”I especially look forward to the day when you can just click on a drawing and order the material for the specific surface, and then the whole chain of ordering and bearing is ready.”.

He also added that he has witnessed significant advancements in digitization, ranging from printing fewer drawings to the use of software tools, during the course of this project. He said:

“Only during my time for this project have I seen enormous changes in digitization, from printing fewer drawings to using applications.”

Likewise, the LM at project B stated that the current use of digital tools helps to facilitate the delivery of services and materials and concluded that the use will expand and become even better than it is now. However, he was also cautious about elaborating further on the topic and instead stated that it’s impossible to predict the future of digital tools within this sector. This was said by the LM:

” I definitely think a lot will happen, I think it will increase. But how fast it will go, it is unfortunately difficult to say”

Nevertheless, although the majority of the interviewees were on the same page regarding the importance of increasing the adaptation of digital tools, some of them looked at it from a more skeptical viewpoint. The LM at project C stated that:

“of course you want new things, but we must not forget that we have to work with them as well.”

Hence, implying that there has to be a limit to the amount of new digital tools adopted, it is not ideal to simply implement new tools, rather, they must improve the efficiency of the work performed. Whereas project Fs LM highlighted that digitalization is not necessarily the key to successful logistics. Likewise, the site manager for project G emphasized that digital tools certainly have the ability to facilitate the logistics process, but highlighted that the value of experience and knowledge is far more important by stating that:

“... it is out there that it happens and not in front of the computer.”

Besides the implementation of digital tools, some other important factors for the future of construction logistics were also mentioned by the interviewees. The LM at project B declared that integration and communication is very important for logistics, by mentioning that:

“Integration is also important, try to ensure that information between the various parties is passed on. Communication between suppliers, contractors, supervisors, carriers, etc.”.

Hence, implying that it's vital that knowledge and experience obtained at each project is passed on in the chain, and that improved communication is needed between the different stakeholders. Moreover, the LM at project E mentioned that they try to keep “up-to-date” by having close collaboration with institutions and universities, such as Chalmers for example. A dedicated department within Peab is responsible with working with these institutions and keep the employees up to date with emerging solutions. Close collaboration between different companies is also possible in order to develop and discover new solutions according to the LM for project G. In conclusion, the majority of the interviewees agree that the far most important factor for a greater construction logistics is the increase of digital tools within the industry. However, as highlighted, there are also other factors that can improve construction logistics, such as improved communication, knowledge recycling, collaboration with institutions and companies etc.

6 Discussion

In this chapter a discussion is presented based on the research questions, hence, this chapter is divided into three parts. Each part discussing and comparing the empirical data with the literature.

6.1 Off-site logistical challenges facing projects in dense urban areas

Research question 1: What are the most difficult logistical issues confronting construction projects in dense areas?

The literature addresses some of the challenges that could arise for projects in dense urban areas for construction logistics, such as, urban transportation problems, space constraints, municipal demands to reduce environmental impact, demands from residents and business owners regarding accessibility and noise restrictions (Dablan, 2007). These challenges are mostly related to off-site logistics, which is the focal point of this thesis, but as it has been mentioned in the literature on-site and off-site logistics are dependent on each other (Sundquist et al., 2018). The data from the empirical study supports the logistical challenges which the literature highlights for projects in dense urban areas. As a result, it can be said that the sector faces the same challenges that have been raised in the literature. As the analysis showed, working on projects in areas with a lot of people poses a number of similar challenges. However, it is clear that the theory, while mentioning these challenges, does not provide a more in-depth analysis of the challenges themselves. Rather, it focuses primarily on how these problems may arise and what solutions should be implemented in construction projects located in dense areas. In contrast, as discussed in the preceding chapter, the interviewees elaborated on the logistical obstacles faced by projects in dense areas. This means that, while the project will face numerous challenges, as long as they are identified in advance, the implemented solutions will be critical to achieving a successful logistics.

Furthermore, one of the consequences of logistical challenges is an increased likelihood of accidents due to the number of transportations to and from the site (Russo and Comi, 2010). When large trucks must share limited infrastructure with pedestrians, cars, trams, and other modes of transportation, the possibility of an accident increases. However, this consequence was not mentioned by the respondents. Instead, the entire focus was on how the actual project would be impacted in terms of time and money. One could argue that this issue should be managed purely by the responsible authority and imposed on the projects; but nevertheless, this may create additional logistical challenges. Even though authority would be in charge urban transportation is already subjected to an excess of regulations, making the planning of deliveries already difficult according to Ballantyne et al. (2013),

Moreover, this study shows that transportation to the site is one of the key challenges regarding off-site logistics. This is also considered a challenge that is shared by most of the projects that have been investigated. Further explanation on why exactly transportation is such a common challenge for projects in dense areas has not been presented in the literature. For these reasons, a discussion is not possible. However,

the respondents have elaborated based on their knowledge, which is presented in the preceding chapter. The lack of specifics in the literature regarding transportation challenges may be due to the characteristics of each project varying.

Hence, the empirical data shows that the challenges each project faces are different depending on the circumstances.

Space limitations were another of the most common challenges, as this was an issue in most of the projects we investigated. Congestion at site was seen as a huge problem because it affected other parts of the logistics process. Although this is primarily an on-site issue, it has a significant impact on the transportation of material to the site. As Ying & Tookey (2014) highlights, when materials are brought to the site with little notice in advance or unplanned deliveries it can cause scheduling issue and inefficient loading. Thus, affecting the whole process, and consequently affecting the outcome of the project. This was also addressed by Sezer and Fredriksson (2021) which stated that the longer it takes for a truck to load and unload increases the likelihood of congestions and delays. These challenges could of course be resolved with a large site, but due to the fact of building in dense areas, such issues are expected.

However, an aspect that is addressed by the theory, but which is not mentioned in the empirical data, is the demand placed by municipalities to reduce their negative effects on the environment (Dablanc, 2007). This is a challenge that is addressed by the theory, but it is not one that is directly mentioned by the interviews. Even though this challenge is not addressed directly by the people we interviewed, one can recognize patterns of compliance with this requirement embedded in their responses. It is mentioned that attention should be paid to the environment and that efforts should be made to reduce factors that have a destructive effect on the environment. However, it was not a challenge that immediately came to mind from the respondents, indicating to us that the industry still has a long way to go in order to acknowledge environmental issues.

On the other hand, when it comes to demands from residents and business owners regarding accessibility and noise restrictions, it is a challenge that is addressed by the empirical material as well as mentioned in the theory. These factors had an impact on three projects, but particularly projects D and B. Both projects involve the addition of new space to pre-existing buildings and are situated in and around the central district of Gothenburg. As stated previously, the literature we have reviewed only makes a passing reference to the challenges associated with constructing building projects in such environments, without providing any further information.

6.2 Construction logistics solutions for projects in dense urban areas

Research question 2: Which construction logistics solutions can reduce the issues associated with projects located in dense environments?

Based on the literature review that had been done prior to the interviews, three key solutions were identified for solving the problem of logistics for construction projects situated in dense areas or construction sites with limited space. The identified

solutions were CCC, TPL, and CLP.

Furthermore, as mentioned, these three solutions have the potential to reduce the existing challenges for construction logistics, especially off-site logistics, which is the focal point of this thesis. The CCC can help to reduce the number of transportations to and from the site by having a consolidation center within the vicinity of the project (no more than 10 km away from the project). This solution would lead to the logistics managers at each project having better control over the deliveries of materials, and in turn lead to a decrease in congestion at the site, thus having less negative impact on the building process. Nonetheless, despite the fact that the solution has several advantages, it was underutilized in the examined projects, with only two of the seven projects using it, namely projects C and D. As it has been analyzed in the previous chapter both these projects were located in different parts of Gothenburg facing different challenges but deemed it necessary to use a CCC. Although the use of a CCC was deemed necessary by the LM at project C, the neighboring building, project E, did not see the benefits of using a CCC for their project. Instead, as stated in the data analysis, project E decided to use rest stops for their deliveries. This method would not have worked for project C due to the need for greater site transportation control. Despite the fact that both projects are located in the same area, project C has more factors to consider due to the proximity of the fire station, which makes the work more difficult because affecting the traffic would have a negative impact on the fire station.

Moreover, as it has been mentioned before, project D did also use a CCC, this project is located within the "heart" of Gothenburg, in a very dense area with pedestrians, trams, cars, shops etc. It is a prime example of a situation where a CCC is required due to its benefits, such as, for example, reducing construction traffic, reducing on-site material handling, hence effecting off-site logistics, increase of safety etc. (Muerza & Guerlain, 2021). Nevertheless, only two of the projects had decided to use a CCC considering all the benefits it provides to projects situated in congested areas, as it has been discussed in the literature. This reflection was brought up with some of the interviews, and they gave different answers. Some of them didn't see the actual benefits which the literature highlighted of using a CCC, others mentioned that they didn't have prior experience of working with a CCC, and for that reason did not implement it. These factors are consistent with the characterizations of the industry i.e., being slow to change, or not trying out new methods (Janné, 2018). In addition, the cost of implementing it was also highlighted as a reason for not using a CCC. Due to their lack of experience with CCCs, the cost-benefit ratio was unclear to some respondents. Although the literature does not elaborate on the cost for implementing a CCC, it is project specific, it all depends on the project. A need for studies regarding the cost-benefit ratio for implementing a CCC is needed in order to give concrete results.

According to the literature, TPL lacks a consistent definition, making it difficult to understand if an activity can be classified as usage of a TPL (Marasco, 2008). The concept can sometimes be referred to as conventional transportation and/or warehouse sourcing, and other times to more complex outsourcing that may encompass the whole logistics process. Hence, this consequently leads to confusion when interviewing the seven projects. Two of the projects, namely, projects A and G, used a TPL, whilst the other projects did not mention the use of a TPL. However, all the

projects still used activities that, according to the literature, encompass the definition of a TPL. Hence the data analysis supports the argument in the literature that TPL might refer multiple methods regarding logistics. It is found that TPL is not used only in two projects but emphasized as a method by only two interviewees. Therefore, whilst projects A and G agree that they have used a TPL, the other projects might as well have utilized it but do not consider that a TPL. For example, Ekeskär (2016) mentions in the literature that transportation is one of the several TPL services available for construction logistics. The respondent does not consider a TPL to have been used unless an external company planned and executed a significant portion of the logistics.

Another reason for the lack of TPL usage in projects could be that TPL must be included in the early planning, the position of the TPL provider, fear of an unreasonable fee structure, inability of the TPL to provide certain services, and so on (Ekeskär & Rudberg, 2016). These factors may deter potential TPL users from handling all or most of the logistics in-house.

A digital planning system (DPS) was emerged as the most referred method by the interviewees. However, this solution was not encountered during the literature review, none of the articles mentioned the use of a DPS as a solution for projects located in dense areas. The reason for this could be because this solution is viewed as a prerequisite for every project, and is therefore, not worth mentioning as a potential method of solving the issues of congested areas, or areas with lack of space. Especially considering that it was a solution utilized by most projects as a means of reducing site congestion and gaining greater control over the transportation of materials to the site.

Despite the absence of a DPS from the literature review, a CLP was included, which is essentially a plan for managing vehicle activities to and from the site. The CLP have been defined as the following:

“A CLP provides the framework for understanding and managing construction vehicle activity into and out of a proposed development, encouraging modal shift and reducing overall vehicle numbers.” (Transport for London, 2013).

One could argue that a CLP and DPS are identical, with the exception that a DPS is a digital solution and a CLP is a framework for logistics managers to plan transportation to the site. The objective of both proposed solutions is to reduce congestion at the site. Nonetheless, the CLP consists of several distinct activities, such as outlining the anticipated and/or complete logistical activities of a construction project, describing material flows, educating stakeholders on the impact of the construction, planning for road safety, etc., (Transport for London, 2013). Hence, demonstrating that a DPS is a component of a CLP and that a CLP is a much broader solution that considers a variety of factors for construction logistics. In addition to reducing congestion on-site, the purpose of the CLP is to make logistics planning easier for contractors. The framework highlights which parameters to consider and makes the responsible logistics manager to consider every aspect that might impact the overall environment. Even though DPS was not specifically mentioned in the literature, a close examination of the CLP framework reveals that if the framework's

parameters are considered, the use of a DPS will be unavoidable. Due to the fact that a DPS, for instance, can be utilized to reduce site congestion.

6.3 The future of construction logistics

Research question 3: What are the future expectations regarding construction logistics (from the perspective of logistic managers)?

As mentioned in the analysis, most of the interviewees agreed that digitalization is happening in the construction sector and digital tools are expected to improve the challenges regarding construction logistics. Another reason for the lack of TPL usage in projects could be that TPL must be included in the early planning, the position of the TPL provider, fear of an unreasonable fee structure, inability of the TPL to provide certain services, and so on (Ekeskär & Rudberg, 2016). These factors may deter potential TPL users from handling all or most of the logistics in-house.

However, even though the majority of interviewees stated that digitalization was an important factor for the future of construction logistics, they did not elaborate on specific tools that they currently use or might be using in the future. Only the interviewees from Projects A and C provided examples of digital tools currently in use for their respective projects (see table 3), namely Dalux (project A) and Myloc (project C). Likewise, there is a lack of published material concerning the use of digital tools for construction logistics.

Only literature regarding the potential use of BIM, or more specifically, BIM 4D, could be found on technologies for improving construction logistics. According to the literature, the use of BIM can facilitate construction logistics by:

"... offering tools to develop plans for erosion control mitigation, crane logistics, material staggering areas, vehicular traffic/access, material hoist, equipment, scaffolding, and safety" (Brad & McCool, 2015, p. 188).

However, as the quote highlights the use of BIM within construction logistics primarily focuses on how to improve on-site logistics and neglects off-site logistics. Nonetheless, given the industry's sequence-dependent nature, what happens on-site will definitely affect everything off-site. Thus, if it's possible to reduce the number of materials on-site that will in turn have a positive on the transportation to site, because the area will be less congested and there will be no delays. This has also been mentioned by Sezer and Fredriksson (2021) in the literature, where they introduce the word "turnaround times". Which is defined as the time spent by the truck and its driver at the construction site for loading and unloading activities, from the moment it arrives at the gate until it drives out of the gate again. Hence, the longer the turnaround time, i.e., the longer a vehicle is on site, the greater the likelihood that there will still be another vehicle on site, increasing the likelihood of congestion, which raises the danger of accidents and delays (Sezer and Fredriksson, 2021). Moreover, as several interviewees noted, the implementation of digital tools is irrelevant if they do not complement and facilitate the work. The LM at project C mentioned that they have tried several different digital tools, but at the end only one was successful and made the logistics easier. Moreover, according to Magill et al. (2020), the reasons for not implementing digital tools in general are a lack of strategy,

perceived IT costs, and required training. Therefore, when some interviewees express skepticism regarding the implementation of digital tools, it may be due to a lack of understanding of how to integrate them with existing processes or a lack of time to train personnel on something new. The lack of information about digital tools in both published research and interviewee responses may be attributable to the industry's reputation as a conservative sector that is slow to adopt new technologies and methods.

In addition to tangible factors like the use of digital technologies to improve construction logistics, the respondents also mentioned intangible factors like communication between different stakeholder groups, the reuse of knowledge, more collaboration, etc. The LM for Project B highlighted the significance of these intangible characteristics. Despite the fact that the use of digital solutions can make the job easier, if the staff lacks the necessary knowledge and experience, every accessible solution might be deployed without success. Hulthén and Sundquist also emphasized this in the literature. They stated that innovation in construction logistics does not always imply the creation of something new or the adoption of new technologies. Improving logistics can simply mean conducting tasks differently and increasing collaboration and communication between involved parties.

7 Conclusion

This thesis sought to identify and comprehend the logistical challenges that dense urban construction projects face. In addition, current construction logistics solutions and future logistics enhancements were examined. Two different ways to collect data were utilized to answer the research questions for this thesis, namely, a literature review and interviews. In this chapter, concluding comments will be presented with a following suggestions regarding limitations and recommendations for future research.

First, this research showed that the logistical challenges that are the most difficult to overcome in dense areas are a lack of space on-site, consider nearby stakeholders, and transportation to the site. The literature did not delve further into the difficulties; rather, the conclusions regarding the difficulties are primarily derived from the statements made by the interviewees. The challenges that have been highlighted are the most complex and generally discussed; other, less prevalent challenges have also been mentioned in this thesis.

Second, the literature and the interviewees had different answers regarding implemented solutions to mitigate the issues of logistics for construction projects in dense areas. The literature mainly highlighted three different solutions, namely, TPL, CCC and CLP. However, the interviewees mainly advocated for the use of a digital planning systems (DPS) in order to combat rising challenges of construction logistics. There are several ways to overcome the challenges of logistics in dense areas but based on the interviews the selection comes down to the knowledge and experience of the LM, the magnitude of the project, and the location of the project.

Lastly, increased utilization of digital tools was the primary factor for improving construction logistics according to the respondents. This was also highlighted in the literature, but to a lesser extent. Additionally, intangible factors such as communication, collaboration, and knowledge recycling were also cited as elements that could improve construction logistics. Thus, there is no one right answer to improve construction logistics, instead, there are multiple ways of which can help to enhance the logistics.

7.1 Limitations and suggestions for future research

Improvements

Several improvements have been identified that could have elevated this thesis even further. Firstly, conducting more interviews, it would have been advantageous to conduct more interviews within different projects allowing for a greater comparison and data analysis. Secondly, asking more project-specific questions, improvements to the interview questions could've resulted in more data gained from the respondents. Thirdly, another alternative that could have improved the work would have been to concentrate on a single case. This would have allowed for a greater level of exploration, leading to a better understanding of the difficulties that can arise at the site. Moreover, that would have led to a more comprehensive paper in which we could have followed the process of the work in one case. Finally, looking at logistics from a

broader perspective could have helped to improve this thesis. Where interviews with city planners and state actors could have been conducted to gain a better understanding of their perspectives on urbanization.

Future research

For future work, it would have been possible to concentrate on checking large logistics projects in various cities across Sweden and the rest of the world. This would have allowed for a comparison of how different countries work on projects. It would have been interesting to see how the logistical problems that different countries face is both the same and different. Additionally, it would have been possible to focus on the feasibility of achieving zero emissions for a project's logical transport to the construction site in order to improve the construction logistics effectively. This could be achieved through the use of fully electric trucks for logistics. To summarize, the future of logistics is bright as there is a significant amount of room for improvement, and additional research is needed.

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9 Appendix

9.1 Interview questions (in Swedish)

Generellt

- Berätta om din roll i företaget/projektet?

- Hur jobbar ni med bygglogistik?
 - Har ni en avledning som enbart jobbar med logistik frågor?
 - Hur tar ni an logistikfrågor inom företaget? Projektbaserat? Vem bestämmer?
 - Följer ni något företags protokoll när ni tar er an projektet kring logistiken?

- Hur mycket kunskap behövs inom logistik för ett projekt ska lyckas?
 - Stora- kontra små projekt?
 - Vad blir fördelarna med en planerad logistik?
 - Vad blir fördelarna med en välutförd logistik?

- Vad blir följderna inom logistiken på minde prioriterad projekt?
 - Utsätts även en logistik ansvarig på små lägenhetsprojekt? EX.

- Delar du tanken om att bygglogistik oftast är en mindre prioriterad del i ett projekt?
 - Om ja, vad tror du anledningarna till det är?
 - Vad bör industrin göra för att prioritera logistiken till en högre grad?
 - Hur jobbar ni för ständigt hålla er uppdaterade kring nya logistik innovationer?

Om projektet

- Beskriva kort om projektet, samt företagets roll i det hela?

- Vad skulle du säga är unikt med detta projektet?

- Vilka logistik utmaningar har ni stött på för detta projektet?
 - Har det varit förutsägbara utmaningar?
 - Vad har gett upphov till de utmaningarna?
 - Hade ni kunnat förbereda er bättre för dessa utmaningar?
 - Finns det moment som DU personligen hade velat göra på andra sätt?

- Vilka lösningar har implementerats för de förutsägbara logistikutmaningarna för projektet?
 - Vad har utfallet av lösningarna varit?

- Vilka lösningar har implementerats för det oförutsägbara utmaningarna som dykt upp under byggprocessen?
 - Hur går tankeprocessen för dig när ett hinder uppstår?
- Har företaget ett protokoll på lösningar till det ”Vanliga” problemen som KAN uppstå?
- Anser du att företagets lösningar kan skilja sig från exempelvis hur du hade velat göra?
- Hur jobbar ni för att vara i framkant med nya lösningar?
 - Applicerar ni lösningar från nya studier som görs? Hur håller ni er informerade?

Avslutande frågor

- Hur ser framtiden ut för logistik, nya lösningar, större användning av digitalt verktyg?
- Något annat du vill tillägga?
- Möjlighet att få prata med någon till som är insatt i logistik delen i projektet?