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Problems and Solutions in Urban Construction Logistics

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Master thesis

Problems and solutions in urban construction logistics and transport in Sweden

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Abstract

The construction industry's world is very complex, competitive and challenging. That means that everyone who is involved needs to be constantly updated and follow the latest technological trends and ideas to be able to work on a viable project by minimizing the problems. Nevertheless, there are always different complications that arise mainly because there is not much attention given to logistics and logistics solutions. The purpose of this thesis is to identify the major problems in the Swedish construction industry as well as their corresponding logistics solutions applied by different companies. Moreover, this research will try to investigate how the use of the fairly new concept of Construction Consolidation Centers can improve the situation primarily with the material transportation. The current thesis was conducted by investigating the relevant literature and arranging interviews with a few of the many consultant companies working in the construction industry. The outcomes from both investigations are analyzed and compared showing that there are important differences between the theory (literature review) and the reality (interviews) as some of the main problems in real projects do not appear in the current literature. It is also clearly exposed that Construction Consolidation Centers are a game changer to this kind of projects and such a solution is suggested from both sides, while there is high necessity from the companies to emphasize on the logistics and invest more on their logistics solutions.

Key words: Construction Consolidation Centers, Third-Party Logistics, city logistics, transportation in construction site, logistics solutions

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1. Introduction

During the last years, it has been noticed that more and more people have decided to live in urban areas. In Europe, the percentage of people who live in urban areas is about 80% (Carlsson et al., 2012). Thus, these areas are growing faster compared with other areas such as rural. Mobility of people and goods is needed for a smooth and functional economy. Thereby, good transportation and deliveries are essential in order to service people in their everyday life (Lindholm, 2012). In order to meet people's demands and needs, construction industries have focused on building new or refurbishing old buildings (Janné, 2016). However, there is limited space in urban environments and the transportation of goods and personnel to, from and around the construction sites cause negative impacts to the local environment (ERA-NET, 2016). Moreover, the different stakeholders who take part or have been influenced directly or indirectly have their own requirements for such projects. These requirements for example, can be for environmental protection against pollution, noise and emissions (Landqvist and Rowland, 2014). For that reason, construction industries have to take into consideration many aspects, and incorporate more efficient and smarter techniques in logistics and material flows in development projects (Janné, 2016), in order to have a successful outcome with the fewest problems possible.

Due to the fact that construction projects consist of many phases and many participants take part in each phase, it directly makes it one of the most complex industries (Matouzko and Methanivesana, 2012; Matouzko, 2015). Different studies have shown that construction industries have to adopt new strategies, working practices and focus more on logistics, in order to improve the production efficiency, safety and material flows and of course decrease the building time and overall costs (Janné, 2016; Matouzko and Methanivesana, 2012). Moreover, proper management of the construction supply chain can help the industry to improve productivity and decrease production costs. In order to do that, the construction industries should focus on the supply chain management (SCM), which is the vigorous management of supply chain activities (Rudberg, 2016). However, it is difficult to manage the construction supply chain properly, because it consists of many elements. One of the most important elements is that the target product (houses, block of apartments, offices etc.) is produced and assembled in the construction site from the incoming materials. According to Vrijhoef and Koskela (2000), there are four roles of SCM in construction that can make the collaboration better and increase the productivity on site. These roles that focus on the supply chain, the construction site or both are: focus on the interface between the supply chain and the construction site; focus on the supply chain; focus on transferring activities from the construction site to the supply chain and finally, focus on the integrated management of the supply chain and the construction site.

As mentioned before, there is a big demand for new houses/apartments, businesses and transport infrastructure, so the construction industry has to manage its logistics properly, since it has a key role in the construction projects. However, a major problem with the construction industries is to manage the everyday deliveries. The deliveries contain different kind of materials, such as concrete, bricks, sand and other materials and resources, which are necessary for all the different types of constructions. For that reason, in some construction projects there is a construction consolidation center, which enhances the 'just-in-time' deliveries and helps to decrease the

congestion, pollution, noise and road accidents around the construction site. Moreover, these centers can reduce the amount of deliveries to the construction site by more than 70% (Transport for London, 2016).

Logistics in construction projects also suffer from unnecessary on-site activities (Matouzko, 2015). The problem with these activities, from the customer's point of view, is that they do not add value to the final product (Matouzko and Methanivesana, 2012; Matouzko, 2015). According to Womack and Jones (1996), waste is defined as any activities that soak up the available resources, but do not produce value. These activities can be for example, the waiting time between activities, activities that are not compulsory and inactive workers during working hours (Josephson and Saukkoripi, 2007). Poor logistics in construction projects may favor idle time and there is a higher risk for injuries to personnel while they are trying to reach the targets (Matouzko, 2015). The production cost can be reduced by taking into consideration and refining these unnecessary on-site activities Earlier studies have shown that by minimizing the total amount of waste, it is possible to decrease the production costs by 30-35%. (Matouzko and Methanivesana, 2012; Matouzko, 2015).

It is clear that the construction industry is suffering from many problems, and so the correct application of logistics solutions plays a vital role. Every project has different complications depending on its size and its location and so it has its own problems and solutions. For these reasons, it is important that different stakeholders and contractors collaborate in a healthy and efficient way and do their best for the project.

1.1 Purpose

Many papers have been written about the construction logistics, but most of them focus and analyze a specific area. There has not been so much attention and effort to combine an extended and detailed literature review with an up-to-date contemporary feedback from various consultant companies in order to make a comparison between the theory and practice, to obtain a wider, more complete view of logistics. Thus, the purpose of this master thesis is to map and investigate the current state within urban construction logistics. This will be done by analyzing the relevant literature, having interviews with consultant companies, studying the state of the art construction logistics solutions, and identifying their targets, major problems and possible solutions.

1.2 Research questions

Most construction projects have to deal with various crucial problems that can change the plan of the project and increase its total cost. These problems are delays in transportation, incorrect orders, lack of correct information and several others that will be discussed later in this thesis. Thus, the research questions of this thesis are:

1. What are the main problems faced in urban construction projects?
2. What are the main construction logistics solutions used in Sweden?
3. Which solution matches which problem?

1.3 Delimitations

There are two main delimitations in this master thesis. The first one is that the study is based on the Swedish construction practices. Moreover, the interviews took place with only four different construction consultant companies. This means that there are limitations to the range of scientific papers reviewed and the feedback from the actual construction industry.

1.4 Outline

This master thesis is structured as follows. Section 2 introduces the main definitions important to an understanding of the current research. The next section describes the methodology that was followed in order to collect and analyze the literature data and the way that the interviews were performed. Section 4 investigates and sums up the findings of the literature study. Section 5 contains an overview of the interviews, which will be later used for the comparison to the outcome of the previous section while Section 6 has the comparison between the literature review and the interviews. Finally, Section 7 presents the discussion of the findings, while Section 8 contains the conclusion of the thesis.

2. Definitions

Before moving forward with the report, there are some definitions and concepts which need to be clear. From the introduction, it is obvious that logistics, construction logistics and the construction consolidation centers will have the main part in this report.

2.1 Logistics

There are many definitions for logistics, but the most commonly used is CSCMP's definition. According to CSCMP, logistics is defined as: *"That part of supply chain management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements."* (CSCMP, 2016)

Logistics can be considered as a framework for material handling, information and capital flow. Its main goal is to manage a project in an effective way. It refers to many activities like planning, purchase, control, coordination, forecast, warehousing, transportation, inventory management and customer service. All these activities help the companies to maximize their profits. Therefore, logistics is linked to all activities that have to do with the movement of goods and services from their origin to consumption. Hence, in the construction area, logistics can be considered as the planning of supplying the construction area with the right materials, machineries and correct information, according to the customers' orders, in order to meet the customers' requirements (Shigute and Nasirian, 2014).

2.2 Third-Party Logistics

Nowadays, some companies choose to outsource some or all their logistics activities by using Third-Party Logistics (TPL) providers to get financial benefits. The TPL provider is a firm that acts as a middleman and outsources the logistics activities but does not take the ownership of the products (Janné and Fredriksson, 2017). The TPL provider focuses on logistics issues that take place at the first steps of the planning process. The main target of the TPL provider is to deliver a safe, efficient workplace with well-planned logistics. In this way, contractors and subcontractors do not need to spend extra time to transport their materials within the construction site (Matouzko and Methanivesana, 2012; Matouzko, 2015). Some of the activities that can be outsourced are the warehousing, packaging, transportation, distribution and inventory management. It should be mentioned that the relationship between the company and the TPL provider is based on mutual trust while it is generally accepted that their collaboration is strengthened under long-term periods (Janné and Fredriksson, 2017).

According to Papadopoulou (2001), TPL is defined as: *"Indented companies providing single or multiple logistics services to a purchasing company. Third party logistics providers, although they do not hold ownership of the product for distribution, are legally bound and responsible to perform the requested logistics activities of the purchasing company. The relationship between the two parties is long-term and beneficial."* (Papadopoulou, 2001)

2.3 City Logistics

The objective of city logistics is to increase the efficiency in the city and at the same time reduce the negative consequences of logistics activities (Tadic et al., 2015). City logistics is responsible for the deliveries of materials such as building materials, wastes and consumption goods into the city. It uses urban freight transportation, because it plays a vital role keeping the city activities at normal levels (Erdinch and Huahg, 2014). The traffic flow for goods transport has increased due to the fact that the population in urban areas also has increased. In Europe, 34% of the total freight transport has been completed by urban freight transport (Tadic et al., 2015). These types of transport cause many problems in urban areas such as traffic jams, air and noise pollution and road accidents. These factors have a huge impact on the quality of life and decrease the competitiveness of the local economy (Tseng et al, 2005). Moreover, city logistics is important to control the logistics costs in packaging, transportation and inventory.

Ooishi et al., (1999) defined city logistics as: *"The process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of market economy."* There are four key stakeholders who take part in and influence city logistics: shippers, freight operators, customers and authorities. Since each one of them try to maximize their benefit and have special requirements, sometimes there are conflicts between stakeholders (Landqvist et al., 2014; Erdinch and Huahg, 2014). The main target of city logistics is to decrease the costs that are related to material transport, optimize logistics systems, reduce the environmental impacts from the trucks (CO_2 emissions) and increase the efficiency in the city (Erdinch and Huahg, 2014).

2.4 Logistics Centers/ Construction Consolidation Centers

According to Europlatforms, a logistics center is defined as: *"The hub of a specific area where all the activities relating to the transport, logistics and goods distribution – both for national and international transit – are carried out, on a commercial basis, by various operators."* (Europlatforms, 2004)

Construction companies suffer from long lead times, high logistics costs and uncertainties regarding deliveries. They therefore look for ways to solve these problems. Thus, the need for logistics centers is increasing. Logistics centers carry materials and deliver them to the construction sites when the order is placed. They play a key role and promise benefits to the constructions companies (Farook et al., 2007).

The same concept applies to the Construction Consolidation Centers (CCC). These centers provide efficient and safe material flows from all the suppliers to the construction sites (Matouzko and Methanivesana, 2012). In practice, construction consolidation centers are temporary warehouses which contain all the appropriate equipment for efficient material handling, and they are large enough to permit vehicles to upload and download the supplies (Matouzko, 2015). These centers distribute materials to the construction sites on the right time, to the right place and in the right quantity and quality (Matouzko and Methanivesana, 2012).

2.5 The connection between the concepts

Figure 1 shows the relationship between the concepts described previously. It shows that Construction Logistics is the concept which encompasses City Logistics, Third-Party Logistics and Construction Consolidation Centers. Construction Logistics includes the activities that are important for the material management and information flow in order to satisfy the end customer. The rest of the concepts use logistics as a base while they are connected to each other. Each one of them needs the other concepts to work correctly to produce the desired results. CCC uses logistics to handle the transportations in the most efficient way and to avoid or eliminate problems, such as delays and order mix-ups, which are common in such projects.

Moreover, some companies use TPL providers to handle the transportation or warehousing and inventory activities. Thus, the TPL providers collaborate with the CCC to transport the right materials on site. Additionally, city logistics contributes to that part, because it uses the urban freight transportation to transport the materials. With the help of logistics, it organizes all the transport activities in an effective way. Consequently, it is clear how these concepts are related to each other and how important the logistics are in their collaboration and organization.

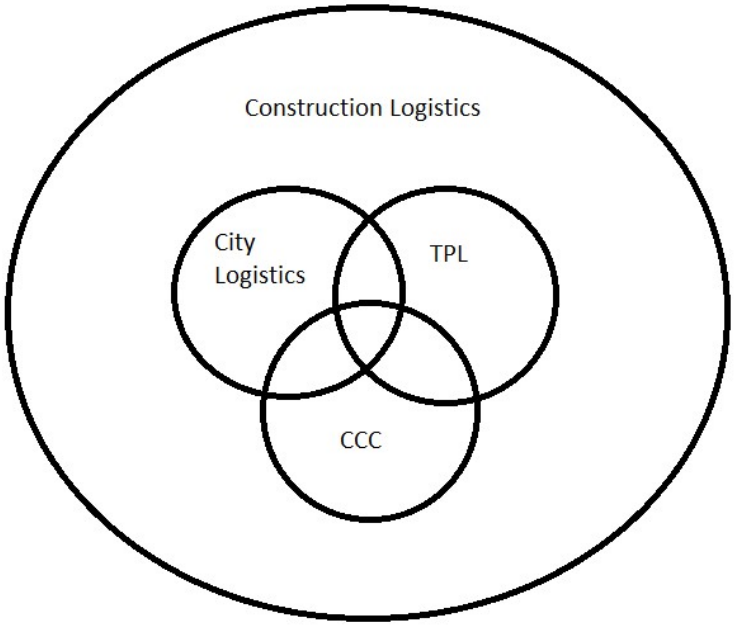

FIGURE 1: THE CONNECTION BETWEEN THE CONCEPTS

3. Methodology

3.1 General

Construction projects consist of many different parts. The combination and the collaboration of all these parts with each other is difficult to achieve and many problems arise. The first step in understanding how the construction industry works and collecting the data for the problems that arise in different phases, is to review the relevant literature. The following methodology and the way that the literature review has been carried out are based on the book “Doing Your Literature Review” (Jesson et al., 2011). The second step is the interviews with the consultant companies which are related to the construction projects. Understanding Steps 1 and 2 will give a clear picture on how the construction materials get transported and reach the construction site, what kind of materials are used, what transport modes are used, what happens in the unloading area and finally what problems arise in the different phases and what their solutions may be. The data from the interviews will then be analyzed and compared to the theory. The discussion will be based on this comparison.

3.2 Methodology theory

This section describes all the processes and techniques that were used to search, select, study and analyze all the relevant information about construction logistics. This was done firstly in order for the author to obtain a better understanding of the topic of the thesis and to give the readers an opportunity to evaluate the validity and reliability of this study. This section answers three important questions about this thesis.

- How were the scientific papers for the literature review collected?
- How were the interviews performed?
- How were the interviews analyzed?

There are two main ways to collect data for a literature review. The first one is by searching relevant books at academic libraries and the second way is via the web. For the online search, the keywords play an important role. The keywords enable the online database to search for the papers which are relevant to these words. In that way, the range of the papers is limited to the ones that interest the searcher. In order to save time and have a general picture about the papers, it is good to keep a record of the searches made and their corresponding results. The next step is to read the papers and decide which of them should be kept for the research according to their relativity to the research. A good practice is to keep the most recent papers and papers which are relevant to the geographic area that you are interested (Jesson et al. 2011).

The first step to holding a good interview with acceptable results is by determining the purpose of the research. In that way, it will be easier to determine who will be the interviewee and how the research will be written. In order to create the best questions, the writer should know the history and the background of the topic. This can be done by searching online, reading books or reading other interviews with a similar topic. In that way, the writer will have a better and more complete view of the topic. During the interview, apart from the recording devices (with

permission), the interviewer should take notes. This will be useful later when the outcomes of the interviews are being organized. The final step in achieving a successful interview is to decide the format of the interview. There are three types of format; a narrative format, where the interviewee presents his/her work in the form of a story, a conversational format, where the interviewee presents his/her work by discussing with the interviewer, and a question and answer format, where the interviewer poses the questions and the interviewee answers them (Bright Hub Education, 2015).

The data analysis was based on some questions that should always be posed when qualitative data is to be analyzed. These questions are:

- Can any patterns be identified in specific parts of the data?
- What are the most important parts from the patterns identified?
- Do any collected data report that more data should be gathered?
- Are all the questions answered?

When all or most of the above questioned are answered, the data are then grouped according to a common point and then further described in a more user-friendly way (The Pell Institute, 2017).

3.3 Research procedure

This thesis is composed of two main parts: the literature review and the interviews with consultant companies in the construction area. The research approach, the analysis of academic papers and the creation of the interview protocol are based on the previous section. For the literature review the main source was the Internet, more precisely Google scholar and LiU's library where someone can find full articles from scholarly literature, conference papers, dissertations and technical reports. Table 1 shows the key words that were used to find the appropriate literature for construction logistics. It is obvious that the key words are relevant to logistics and the concepts that were previously described in the Definitions section.

TABLE 1: KEY WORDS USED DURING MATERIAL COLLECTION

Source	**Key Words**
Google scholar	Construction Consolidation Centers
	Construction Logistics Centers
	Construction Logistics Solutions
	Urban Freight Transportation
	City Logistics
	Third Party Logistics
	Stakeholders in Construction Industry
LiU Library	Logistics
	Improving Construction Logistics
	Material Flow
	Construction Industry

After the selection of the relevant literature, the decision is taken about which of the academic papers should be kept for analysis. The research is based on the Swedish practices in construction area and thus the papers that were relevant to Swedish logistics were selected. Moreover, because construction logistics change rapidly and new methods and techniques are used to solve the problems, the most recent literature, that is, from the past ten years, was chosen.

The review is based on literature dealing with the most important concepts of construction logistics, like logistics, city logistics, CCC and TPL providers. Thus, the parts of the papers that were relevant with these concepts were chosen. These parts were examined and a summary was created for each one of them so that the reader has the best possible understanding. Table 4 contains the problems of and solutions to the construction problems that were identified during the literature review. Some problems are marked in blue text, which indicates that these problems are the most important and have a big influence on the project. This separation/choice was made since these problems were mentioned multiple times by the different authors, who emphasized that these problems have a great impact on construction projects.

The interviews with the consultant companies are based on an interview protocol. The interview protocol was created based on the literature and the concepts relevant to construction logistics. After each paper was read, new questions were posed about how the concept/phenomenon/process investigated in the paper works in reality. Thus, the interview protocol covered almost all the theoretical concepts and practices found in the papers. Appendix 1 presents the interview protocol. At the end of the chapter where each interview is presented, there is a summary of all the interviews. Table 6 contains the problems and the logistics solutions that were mentioned from the interviewees. The blue color of the text indicates those problems that are of greater importance, meaning which problems were mentioned by more than one interviewee or which specific problems have, according to the interviewees, a high impact on the projects.

The two summaries present the findings in a different way. The former summarizes the four concepts (Logistics in construction industry, Construction Consolidation Center, Third Party Logistics, Transportation in construction sites) and gives emphasis to the positive results from the application of these concepts on the construction projects. On the other hand, the latter emphasizes on the most important problems that the interviewees faced during their projects, as well as the logistics solutions they applied. Tables 4 and 6 were used for the analysis chapter. Only the problems marked in blue text because of their high importance were compared and analyzed. Moreover, the solutions presented on the tables were used for answering the second and third research questions.

Four interviews with different consultant companies were conducted for this thesis. One representative from each consultant company was interviewed. The interviews were conducted in two ways; three of them with a physical appearance of the interviewee and one via Skype. A list of various questions was sent to each individual some days before the interview in order to give them time to prepare some answers or gather any relevant material. Based on the interview protocol, all the interviews took the form of a discussion, each one in a different way. In two out of the four interviews, the individuals presented a map of the construction site, pointing out and explaining the processes and rules followed for their specific project. On the 3rd, the interviewee

used a whiteboard to draw and describe the methods used by his company while the last interview was performed via Skype in a form of discussion only. During all the interviews, additional questions were posed when something was unclear or needed further explanation.

3.4 Research quality – Validity and Reliability

In a research project, if the outcome is to be usable, it has to be reliable and valid.

A reliable result or else the reliability of the project ensure that the results would be the same if the research were to be done again by someone else. On the other hand, validity refers to how genuine the results can be considered to be and is generally separated into two aspects, the internal and the external. The former refers to whether or not the actions used measured or did not measure what they had to, while the latter to whether the findings could be transferred to other groups. Finally, the fact that a project work is reliable does not necessarily mean that is also valid (Handley, 2017).

This project work, as already mentioned, is separated into the literature review and the interviews with the consultant companies. The outcome of this thesis can be considered as reliable since the results would remain the same if the project was to be carried out by someone else. The literature review was based on the literature relevant to the project and all the findings were presented as is. Regarding the interviews, all the information gathered at the time that the interviews were conducted is reliable. Of course, there might be changes in the future since all the projects are on-going but that doesn't make the outcome of this thesis work unreliable.

Regarding the validity of the project, we could say that the project is internally valid but not externally. That is because all the methods used for reviewing the literature and conducting the interviews gave the requested outcome without any complications. On the other hand, this specific research mainly focuses on companies and establishments based in Sweden and thus the results cannot be taken for granted for companies in the rest of the world.

4. Literature review

As mentioned before, one main part of the current thesis includes analysis of the research presented in scientific papers on construction logistics. This section extensively reviews this information from the literature.

4.1 Logistics in construction industry

Logistics in the construction industry plays an important role. It is that part of the supply chain management which is used to supply construction sites with the correct materials, in the right quantity, quality and time (Janné, 2016). According to Samuelsson and Ahmetasevic (2014), companies use logistics as a tool, in order to create an economic advantage, since the modern era requires new and innovative buildings. Logistics has to do with the flow of materials, services, resources and information to, in and out of the construction companies (Matouzko, 2015). For example, Behrends (2009) mentions that the transportation of materials is one of the most important activities within logistics. The materials move from the suppliers to the construction sites in a specific order so that they meet the customers' demand. After the materials have reached the site, they are unloaded then stored to protect them from the weather or from theft (Matouzko, 2015). Rudberg (2016) mentions that, to deal effectively with such processes as the ones described above, the companies have to acquire the best knowledge on how the supply chain works to find the best logistics solutions possible and overcome the problems in the most efficient way. In order to manage the whole construction project, the construction company should understand how the supply chain management works (Ekeskär and Rudberg, 2016). In that way, they can find better logistics solutions and solve the problems in an efficient way for the company. That will also give them the possibility to keep up with the continuous demand for more and higher quality projects. Moreover, in Transport for London (2016) it is mentioned that, when the company manages the logistics properly, it can keep up with the demand for new homes, offices and other buildings in a safe and efficient way.

In many cases logistics management has been characterized as poor, because of the many problems that arise during the projects. For example, there can be many unnecessary production costs, high waiting time for the materials and accidentally damaged materials that are thrown away before they are even used. That clearly shows that poor logistics weakens the way a construction industry is perceived by others (Ekeskär and Rudberg, 2016; Matouzko and Methanivesana, 2012; Matouzko, 2015). Moreover, Salvén (2013) says that, the construction environment is unforeseeable and the forecast of needed materials is hard - which means that good logistics is a must. For that reason, the author mentions that the just-in-time deliveries are not very widespread in the construction industry and that can cause shortages in construction materials and delays. In many construction projects, the construction companies do not pay the appropriate attention to logistics (Matouzko and Methanivesana, 2012; Matouzko, 2015) and that lack of attention creates many problems and conflicts between the different parties during the project's timeline. According to Ekeskär and Rudberg (2016), the planners set the budget and the time plan for the project during its first phases. However, due to the ineffective logistics solutions, the contractors during the construction process exceed the budget and the time plan (Ekeskär and Rudberg, 2016; Matouzko, 2015). Additionally, according to Salvén (2013), the

main reasons for the problems in construction industry are that the planning in the first stage is insufficient and there are many last-minute changes.

According to Rudberg (2016), logistics is a part of the supply chain and the construction companies should manage effectively all its parts. They have to pay more attention to logistics management in order to increase productivity and to avoid decreasing profits. It has been observed that workers on construction projects experience more stress and have less confidence on-site if the logistics are poor. This happens when the working place is limited due to the way that the materials are stored, causing space inconsistencies on site (Salvén, 2013). Salven adds that workers spend almost 14% of their time replacing the materials on site. Replacement can be divided into three activities: moving the materials to the storage area; moving the materials from place to place on the construction site and, finally, moving the materials from the storage area to the area where they will be used (Salvén, 2013). These actions originate from lack of knowledge regarding the materials' logistics. That results in stopping production and increasing the number of non-value adding activities (Matouzko, 2015). However, Salvén (2013) believes that there can be economic advantages if the companies focus on material handling at the first stage of the project planning. However, this is difficult to achieve, because such planning is difficult to carry out since changes in the construction industry occur very quickly.

Matouzko and Methanivesana, (2012) mention that, in order to reduce unnecessary activities on the construction site, construction companies should improve their logistics. One way to make this improvement is to improve collaboration and coordination between parties. For example, contractors should communicate with their suppliers properly and continuously feed them with the right information regarding which materials should be on site and when. Also, logistics managers can share different resources with other managers such as vehicles, knowledge and facilities (Rose et al., 2015). Additionally, according to Samuelsson and Ahmetasevic (2014), the continuous education of all parties about the improvements and new techniques in the construction industry can be a good solution.

4.2 Transportation to construction sites

Transportation is that part of logistics that is responsible for the movement of the construction materials in the supply chain, from the suppliers to the construction site. It adds to the materials value and utility since the materials from their point of origin have a small value, while in the construction site their value increases (Behrends, 2009). Transport for London (2013) mentions that the supply chain controls all the freight transportation, from the beginning of a journey to the arrival at the construction site. Also, it covers the waste that arises from the construction process.

For the material transportation, different types of vehicles are used. These vehicles have an impact on the traffic and on the environment. According to Carlsson et al. (2012), a very high percentage of CO_2 emissions comes from inner-city transportation while almost 70% of the car accidents are caused by these transports. Erdinch and Huahg 2014, stated that city logistics has as a target to decrease these impacts from the transportation and increase the city's efficiency.

Landqvist and Rowland (2014) say that, in order to avoid the traffic congestion, accidents and noise, in some urban areas the transportation of materials is not permitted during the day and rush hours, but instead take place during the evening. This also reinforces the deliveries to be on

time at the site, something that can decrease the delays and increase the productivity. The need for just-in-time deliveries becomes more important, since the unloading areas at the construction sites are narrow. In that way, the congestion on site can be avoided (Landqvist and Rowland, 2014). Moreover, according to Transport for London (2013), another way to decrease congestion is with the coordination of vehicles that are used for the transportation of materials to and from the construction site, and with an effective transport management. Also, loading and unloading near the public highway should be avoided to reduce the risk of car accidents and congestion (Transport for London, 2013).

According to Behrends (2009), the reduction of the congestion in the urban areas has an impact on the health of people who live in the area. Congestion can cause many health problems like stress, heart rate alternation and high blood pressure. Also, the noise from the trucks can influence the sleep's quality and focus.

Transport for London (2013), suggests a tool called Construction Logistics Plan (CLP), which helps in the reduction of negative effects from the transportation in a construction industry. With CLP, planners can plan the transport routes and movements to and from construction sites effectively. Also, it suggests the way the materials can reach and leave the site. In that way, the developers can be almost sure that they follow the best routes. Since the CPL enables fewer transports which means fewer vehicles on the road, the congestion, pollution, road accidents and noise can be reduced, which is something that has a positive impact on the environment (Landqvist and Rowland, 2014; Transport for London, 2013).

According to the Transport for London (2013), many construction companies want to know where the vehicles with the materials are and when they will arrive on site. In order to do that, they use a tracking system and they book their deliveries online. In that way, they can control the deliveries during the day and the materials can be on site on time. By doing that, the work on the site continues without interruptions. Moreover, the booking slots minimize the chance to have more than a specific allowed number of vehicles on site at the same time while it reduces the chance that materials arrive later than expected.

4.3 Construction Consolidation Centers

The purpose of the CCC is to supply the construction sites with the construction materials and equipment in a just-in-time basis. Its target is to decrease the number of vehicles going directly from the suppliers to the construction site (Transport for London, 2008; Matouzko and Methanivesana, 2012; Lundesjo, 2011; Shigute and Nasirian, 2014; Janné and Fredriksson, 2017). This has a multi-sided beneficial result leading to traffic reduction, especially when the site is close to the city center, which in turn increases the overall safety and finally reduces the emissions and noise (Transport for London, 2016). To achieve all these plus a safe and efficient way of delivery handling, the CCC should have a very close partnership with the contractors and the project managers as the Transport for London (2008) refers. Moreover, Lundesjo (2011) says that, the above-mentioned processes in construction projects are in many cases enhanced by logistics specialists, who offer their experience to improve the resource productivity of such projects.

The CCC operates according to the following steps. Firstly, the orders are placed by the contractors who work in the construction site, requesting from the suppliers the construction materials that they need. As a next step, the suppliers send the orders to the CCC and not directly to the construction site. However, in cases where the materials are bulky and there are no vehicles available, there can be some direct deliveries. When the materials reach the CCC, a notification is sent to the contractors informing them that their orders are in the CCC. Then the contractors place an order to the CCC for the required materials. Then, the materials are loaded on the trucks and are delivered to the construction site. Approximately 60% of the deliveries should be on the site in less than 24 hours from the time the order was placed. This means that the just-in-time deliveries are important for the CCC (Transport for London, 2008). Figure 2 shows this process.

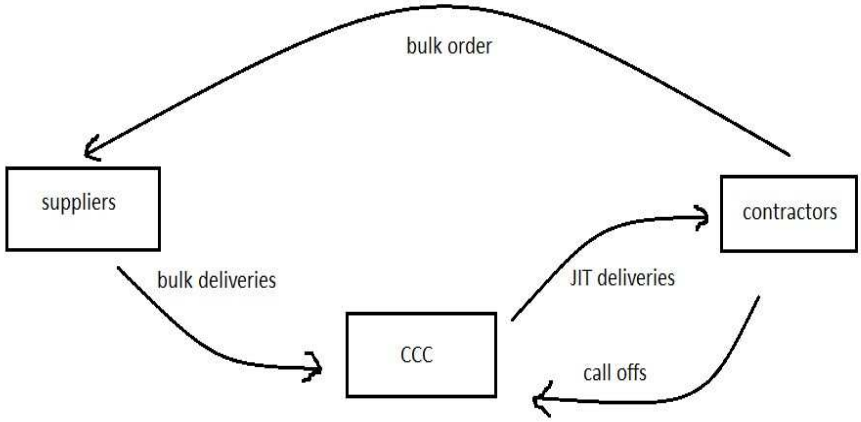

FIGURE 2: SUPPLY CHAIN CONFIGURATION FOR THE CCC [TRANSPORT FOR LONDON, 2008]

Figure 3 shows the operations of the CCC along with the suppliers and the construction area in more detail than Figure 2, based on the studied literature. As shown, the main part is the CCC which directly relates to the other parts. The continuous arrows indicate the trucks' "movement", while the dashed arrows the information "movement". The contractors send their orders to the suppliers and the suppliers transport the materials to the CCC. However, there is a possibility of direct deliveries to the construction site when and if it is required. The CCC performs just-in-time deliveries to multiple construction sites, which is something that decreases the number of trucks needed. When the vehicles reach their destination, they unload the materials on specific unloading areas while the same trucks are used to transport the waste from the construction sites back to the CCC. The parties (suppliers, CCC and construction site) exchange the appropriate information regularly to ensure a smooth transport to the construction site (Transport for London, 2016).

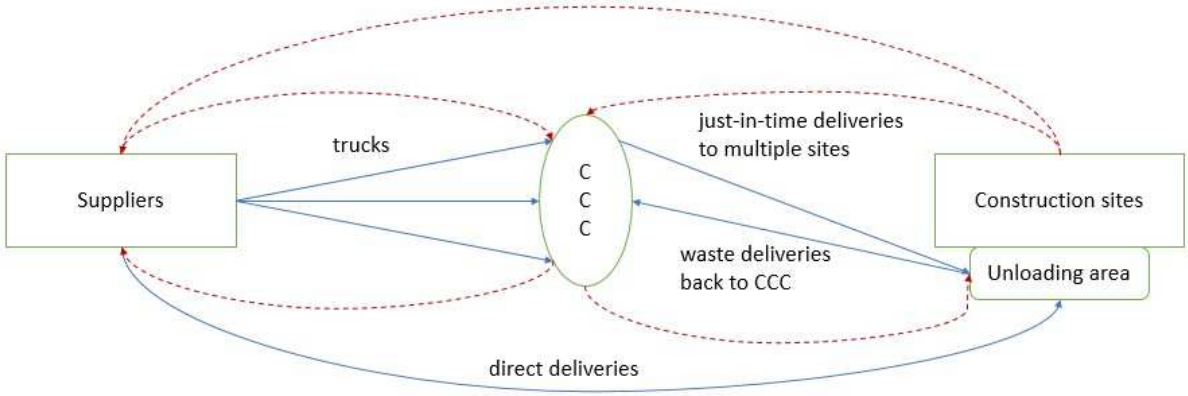

FIGURE 3: THE OPERATION OF THE CCC [TRANSPORT FOR LONDON, 2016]

In order to reduce the number of deliveries from the CCC to the construction site, it is possible that each vehicle carries many orders from the contractors. This means that one vehicle can deliver materials to more than one construction site (Transport for London, 2008). Moreover, Salvén (2013) says that this reduction happens because a CCC combines deliveries from different suppliers. If there is no need for direct deliveries then, the suppliers can send their deliveries to the CCC. The logistics managers understood that the CCC offers many advantages for construction sites that are difficult to be reached, like the ones in the center of the city where there is a lot of traffic and many pedestrians (Salvén, 2013).

Transport for London (2008) states that, depending on the nature and the size of the materials, different types of vehicles are used in the CCC. For example, materials like electronic devices, furniture and insulation parts, should be kept dry during the deliveries. The materials that are bulky, such as wood and iron bars, require vehicles that are flat in order to be in a horizontal position, when it is required. Using different types of vehicles effectively and according to the needs, the CCC decreases the cost. It is important to mention that the main costs for a CCC according to Salvén (2013), are the administration cost, labor cost, warehouse cost, delivery cost and land cost. Sometimes, the CCC uses a tracing system to create live and historic tracking. That system helps the CCC to manage the fleet successfully (Transport for London, 2008).

The use of a CCC brings many benefits to the construction area. According to the London Construction Consolidation Center project, after the implementation of a CCC, there was a significant reduction in the number of vehicles that reached the construction site (Transport for London, 2008; Transport for London, 2016; Salvén, 2013). That reduction was up to 40%, something that was obvious especially during the congestion hours (Transport for London, 2008). Moreover, Lundesjo (2011) says that, the reduction in the number of vehicles can bring cost reduction for the suppliers, contractors and clients. Also, the just-in-time deliveries benefit the carriers and improve the workers' productivity and the project's integrity. Furthermore, the delivery reliability is increased. The goods were received at site on time, and that had as a result to increase the workers' productivity, since they did not spend time waiting for the materials. Thus, the project's efficiency increased, as the workers were spending less time receiving and managing the deliveries (Transport for London, 2008). The delivery reliability in London's project was approximately 97% and the materials were in the construction area within 15 minutes

in the correct type, quality and quantity. Also, with the use of the CCC the drivers were saving up to 20% of their shift. According to Transport for London (2008), the saved hours can be used for transporting other freights something that will increase the transport's efficiency.

The CCC offers a secure storage and a reliable delivery of goods that decreases the possibility of the construction materials being unintentionally damaged, stolen or lost (Transport for London, 2016). That has resulted in a reduction of the wastes in the construction site, which according to Lundesjo (2011) can be approximately 7-15%. This reduction can lead the workers to spend less time on material handling, which according to Salvén (2013) takes about 14% of their working time. However, a construction site will always have wastes and for that reason the vehicles that carry materials to the site, are also used to take materials from it in order to be reused or recycled. Moreover, many times there are materials, pallets and packaging items that can be reused that also return to the CCC (Lundesjo, 2011). In that way, according to the Transport for London (2008), vehicle utilization increases and the total journeys for the waste transport are reduced.

The use of the CCC has also a positive impact on the environment (Transport for London, 2016). As mentioned before, the deliveries to the construction site are reduced by 40% and along with the just-in-time-deliveries have as a result the reduction in the CO_2 emissions originating from the transport vehicles (Transport for London, 2008). Moreover, the reduction of the number of vehicles decreased the congestion, traffic accidents and noise, especially in the city center (Transport for London, 2008; Lundesjo, 2011). The just-in-time deliveries help in the reduction of the CO_2 emissions also. According to Lundesjo (2011), for the vehicles to be on site in less than 30 minutes, the location of the CCC plays a vital role. It should be close to the motorway network to reduce the impact on the local roads and have easy access to the construction site.

On the other hand, according to the Transport for London (2008), the use of the CCC creates some problems for the construction projects for example, the time it takes for the materials to be delivered to the construction site from when the order is placed has increased. With the use of a CCC two more phases have been added in the material delivery process. The first phase is the constructor that should wait for a report from the CCC that the materials are there. The second phase is that after the report the constructor has to place an order to the CCC for the materials to be delivered. Thus, these two phases increase the time it takes for the materials to reach the site (Transport for London, 2008). In addition, there are cases where workers do not have the correct knowledge for all the products stored in the CCC and thus some components are incorrectly sent to the construction sites. That has as a result the loss of valuable time since the incorrect materials are sent back again to the CCC and a new order is placed for the correct material (Transport for London, 2008).

4.4 Third-Party Logistics

During the last years in the construction industry, a new phenomenon has emerged in the form of a TPL provider (Rudberg 2016; Ekeskär 2016). TPL is an external company that is hired by the construction company to accomplish some or all the logistics functions (Ekeskär and Rudberg, 2016; Rudberg, 2016, Janné and Fredriksson, 2017). Ekeskär and Rudberg, (2016) say that the services that are offered by the TPL provider, are usually several and not just isolated services

like warehousing and inventory management. The services that a TPL provider provides to the construction company are the warehousing, transport of materials, inventory management, value-adding activities and the design of the supply chain (Ekeskär and Rudberg, 2016; Rudberg, 2016). The authors mention that it should be clear that the TPL is a part of the supply chain and not an activity on its own. It affects and is affected by the multiple supply chain actors who take part in a construction project (Ekeskär and Rudberg, 2016).

According to Wang and Gong (2014), there are four types of TPL providers: standard TPL provider, service developer, customer adapter and customer developer. The first type is the most common provider and provides logistics activities like packaging, transportation and inventory. The second type provides value-adding activities to the customers, like special packaging and tracking of materials. The third type gives emphasis to the customers' requests and gets the power of their logistics activities. The last type is in charge of all the logistics activities that have to do with the customers. Figure 4 shows the classification of the TLP providers.

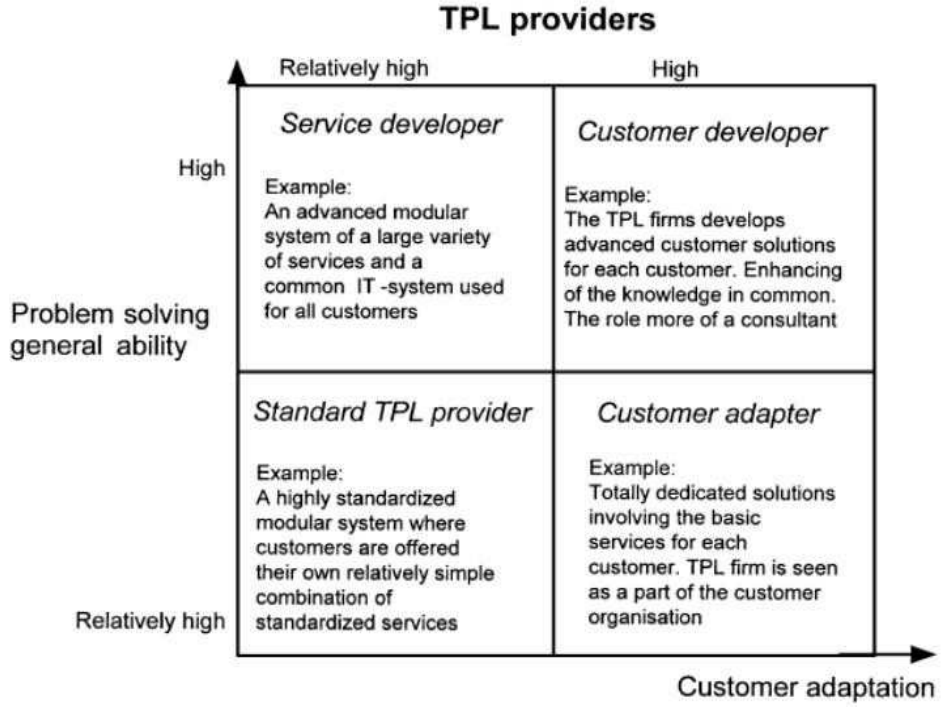

FIGURE 4: CLASSIFICATION OF THE TPL PROVIDERS (WANG & GONG, 2014)

According to Ekeskär and Rudberg (2016), the case study of the hospital project in Linköping showed that the TPL solution is an effective help for the construction, because it has many helpful effects on construction logistics. Some of the effects are the customer's satisfaction, lower costs, the reduction of capital assets and inventory levels, enhancement of the flexibility in changes and more (Selviaridis and Spring, 2007). Moreover, Ekeskär (2016) mentions that, with the use of a TPL provider for the planning of logistics and the material handling, the logistics procedure is more efficient and the total cost is less in comparison to the non-use of a TPL. However, it should be used in the right way to deal with different barriers that appear during such

a project. This is maybe why there is an increase in the number of construction companies that use the TPL providers in order to handle their logistics processes (Ekeskär and Rudberg, 2016).

According to Rudberg (2016), during the last years, many different types of TPL providers have entered the construction industry, varying according to the structure, the type of services and the level of customization that they offer. There are two main ways to categorize them. The first one is according to the infrastructure they offer and the second is the degree of their customization.

Matouzko and Methanivesana, (2012) mention that, TPL companies realized that if the construction companies give the appropriate attention in the planning stage to the issues that have to do with the logistics, they will have huge financial advantages. The services that the TPL companies offer create a workplace that is safe, clean and effective not only for the contractors but also for the workers. With that working environment, the skilled workers can spend more time in value-adding activities, achieving a more efficient production.

The long-term agreements between the TPL and the construction companies give benefits to the TPL providers, because they can enhance their performance and at the same time they have the chance to decrease the concerns and the problems that are identified during a construction project (Ekeskär and Rudberg, 2016).

According to Ekeskär and Rudberg (2016), many of the issues that appear to the SCM can be detected by the TPL companies. These issues can be the management of components and the relationships in the supply chain. However, a TPL solution cannot be substituted for the necessity for the SCM in construction. The construction industry is complex and fragmented, thus the requirements on SCM are special. For that reason, the supply chain in construction is complex too, and there are many relations between the numbers of stakeholder who take part in the construction industry (Ekeskär, 2016).

According to Papadopoulou (2001), the main reasons why a construction company prefers to outsource its logistics functions are to acquire an expert in logistics solutions, focus on the basic competencies and improve the customer services. Moreover, Ekeskär (2016) says that, the need for someone with knowledge about SCM and logistics solutions is created because the contractors and the clients do not give the appropriate attention to improving the collaboration with the suppliers and subcontractors, but they prefer to focus on how to secure and improve their contracts. According to Papadopoulou (2001), there are many criteria for a construction company to choose the appropriate TPL provider. Some of them are the experience, the technology used, the quality of their services, the reputation, the delivery accuracy and the cost.

Many authors believe that the TPL providers can offer effective solutions for the construction companies (Ekeskär and Rudberg, 2016; Rudberg, 2016). Also, the TPL providers can start an interface between the supply chain and the construction sites (Selviaridis and Spring, 2007), which can have a positive impact on the construction projects. Moreover, these kinds of solutions can increase the productivity on the site and the utilization of resources, while at the same time can decrease the total cost (Ekeskär and Rudberg, 2016). Ekeskär (2016) says that this reduction in cost can arise from the decrease of transports on site and when the storage of the materials on site does not take too much space.

4.5 Summary of the Literature Review

The purpose of this section is to make a summary of the literature review and emphasize its most important parts. It presents how the previous concepts of the literature review are connected to provide a better picture of the construction industry to the reader.

The correct application of the logistics solutions such as the collaboration and communication between parties, the right exchange of information, the sharing of resources and the continuous education give many advantages to the construction area. Some of the advantages could be the reduction of the total cost, a decrease in lead times, the improvement of the whole project's performance, the increase in safety while being in the workplace, the productivity and the workers' satisfaction. Moreover, the transportation of materials has less impact on the environment and can be done in a much safer way which in turn means less waste.

On the other hand, logistics in the construction area has been characterized as poor because of the many problems that may arise during the project's lifetime. Some of the problems are the waiting time for the materials, unnecessary production costs, time spent for replacing the materials and unreasonable material damage. These problems create conflicts between parties, increase the workers' stress and make the time plan to exceed its initial schedule. To avoid or eliminate such problems, construction companies should understand that logistics is a main part of the supply chain and should give emphasis to manage the entire supply chain properly.

The CCC's purpose is to supply the sites with the construction material in a just-in-time basis. Moreover, CCC tries to reduce the number of trucks arriving at the site. The decrease on the number of the trucks has a positive impact on the environment and that in turn also means less road traffic, pollution, noise and road accidents. The trucks can also be fully loaded and visit more than one construction sites in one route. The productivity on the site increases, because the reliability of the deliveries increases. This means that the workers spend more time in value adding activities and increase the project's efficiency. Additionally, CCC offers protection to the materials, which means less waste by accidental damages. Moreover, the trucks carry the waste from the construction sites back to the CCC, something that increases the utilization of the vehicles.

However, the use of the CCC encompasses some problems. Sometimes, the workers in the CCC are not well trained to handle different types of materials and make mistakes with the orders. Moreover, the total time from the order placement until the materials reach the site increases and that is because the materials should pass by the CCC first and then be on the site.

The TPL is a company that performs some or all the logistics activities for the construction company. These kinds of companies have experience in the logistics sector and can handle activities such as the packaging, warehousing and transportation. The effects from the use of TPL providers are the lower costs such as the labor cost, the customers' satisfaction, the reduction of inventory levels and capital assets and more. Moreover, they offer a safe and clean workplace, something that makes the workers to have more confidence and spend more time in value adding activities. TPL providers believe that more emphasis should be given on the planning stage in order to achieve more financial advantages. A long-time agreement between the TPL providers

and the construction companies has advantages such as better communication and collaboration that results in fewer problems and better results.

Transportation is a logistics activity and is responsible for the transport of materials from the supplies to the CCC and to the construction sites. Different types of vehicles are used for the transportation of materials according to the materials' type. In some cases, the transportation takes place during the evening or night to avoid congestion. Transportation is one of the activities that enhance the negative effects in the environment. For that reason, companies try to reduce the number of deliveries and use the same vehicles to supply different sites. Thus, the right planning of transportation is important and can decrease these effects. The planners try to choose the best routes and reduce the transports. Finally, some companies book their deliveries online and use live tracking systems to observe the vehicles and in that way, avoid possible interruptions and ensure the materials are at the site on time.

After presenting all the concepts, it is clear that logistics plays a key role in the construction industry. Understanding logistics and applying it correctly, together with the proper planning in the first stages of a construction project, are key elements for a project to be finished on time by avoiding most of the problems.

Table 2 shows the problems faced in different construction areas around Sweden and the corresponding reference where each one was found, while Table 3 shows the solutions that the construction industries apply nowadays, also with their matching references.

The tables below (2,3) state some references that were not found in the literature review but in other parts of this thesis research.

TABLE 2: PROBLEMS IN THE CONSTRUCTION AREA WITH THE CORRESPONDING REFERENCES

Problems	References
Poor logistics	Ekeskär & Rudberg 2016, Matouzko 2015, Matouzko & Methanivesana 2012, Rudberg 2016, Salvén 2013
Unnecessary production costs	Ekeskär & Rudberg 2016, Matouzko 2015, Matouzko & Methanivesana 2012
High waiting time for the materials	Ekeskär & Rudberg 2016, Matouzko 2015, Matouzko & Methanivesana 2012, Josephson & Saukkoripi 2007, Womack & Jones 1996
Damaged materials / waste	Ekeskär & Rudberg 2016, Matouzko 2015, Matouzko & Methanivesana 2012
Difficult forecast for the needed materials	Salvén 2013
Conflicts between parties / bad collaboration	Ekeskär 2016, Ekeskär & Rudberg 2016, Erdinch & Huahg 2014, Landqvist & Rowland 2014, Matouzko 2015
Surplus the budget and the time plan	Ekeskär & Rudberg 2016, Rudberg 2016
Reduced productivity	Rudberg 2016

Workers have stress and less confidence	Salvén 2013
Health problems from congestion	Behrends 2009
Big number of vehicles going to the site	Transport for London 2008, Transport for London 2013, Transport for London 2016, Shigute & Nasirian 2014
Traffic, noise, emissions	Carlsson et al. 2012, ERA-NET 2016, Landqvist & Rowland 2014, Tseng et al. 2005
Difficulties with the planning	Salvén 2013, Transport for London 2013
Difficulties with the management of the SC	Ekeskär & Rudberg 2016
Vehicles tracking	Transport for London 2013
Lack of knowledge	Matouzko 2015, Rudberg 2016, Transport for London 2008

TABLE 3: SOLUTIONS WITH THE CORRESPONDING REFERENCES

Solutions	References
Good work with logistics	Janné 2016, Rudberg 2016, Salvén 2013
Good communication between parties	Matouzko & Methanivesana 2012, Transport for London 2008
Use of a CCC	Farook et al. 2007, Lundesjo 2011, Matouzko 2015, Matouzko & Methanivesana 2012, Salvén 2013, Transport for London 2008, Transport for London 2016, Shigute & Nasirian 2014, Janné & Fredriksson 2017,
Use of the TPL provider	Ekeskär 2016, Ekeskär & Rudberg 2016, Janné & Fredriksson 2017, Matouzko 2015, Matouzko & Methanivesana 2012, Papadopoulou 2001, Selviaridis & Spring 2007, Wang & Gong 2014
City logistics	Erdinch & Huahg 2014, Tadic et al. 2015, Tseng et al. 2005
Just-in-time deliveries	Landqvist & Rowland 2014, Transport for London 2008, Transport for London 2016
Better handling of materials	Salvén 2013
Transports during evening	Landqvist & Rowland 2014
Vehicles can deliver more than one site	Transport for London 2008, Salvén 2013
Book deliveries online	Transport for London 2013

Use of a CLP	Landqvist & Rowland 2014, Transport for London 2013
Share of resources	Rose et al. 2015
Tracking system	Transport for London 2008, Transport for London 2013
Education	Samuelsson & Ahmetasevic 2014

Table 4 shows which solutions match which problem from the literature review. For some of the problems there are several logistics solutions. This table is the result of the union of Tables 2 and 3 to make it clear which solution matches which problem. It is clear that all the problems that are in Table 2 also appear in Table 4, apart from the "Poor logistics" problem, since it is encapsulated into the other problems presented in Table 4. The same occurs with the solutions' table. All the solutions that are presented in Table 3 are also presented in Table 4. Thus, the reader can have a clearer picture of the problems and their solutions. The problems marked in blue color are those that are the most important and, according to the studies in the literature review, have a big influence on the project's development.

TABLE 4: THE SOLUTIONS WHICH MATCH WITH THE PROBLEMS FROM THE LITERATURE REVIEW

Problems	Solutions
Unnecessary production costs	Emphasize on logistics / share of resources / TPL provider
High waiting time for the materials	Good communication between contractors and suppliers / just-in-time deliveries/ improve logistics
Damaged materials / waste	Emphasize on logistics / CCC
Difficult forecast for the needed materials	Improve logistics / education
Conflicts between parties	Emphasize on logistics / improve their communication
Surplus the budget and the time plan	Emphasize on logistics
Reduced productivity	Attention in the logistics management / TPL provider
Workers have stress and less confidence	Better handling of materials
Health problems from congestion	Use of a CCC / transports during evening
Big number of vehicles going to the site	Use of a CCC / vehicles can deliver more than one site / use of a CLP
Traffic, noise, emissions	Use of a CCC / just-in-time deliveries / transports during evening / city logistics
Difficulties with the planning	Emphasize on logistics / TPL provider / use of a CLP
Difficulties with the management of the SC	Use of the TPL provider
Vehicles tracking	Tracking system / book deliveries online
Lack of knowledge	Education

5. Interviews

This section presents and analyses the interviews that were conducted with four different specialists from the construction industry area. It describes their projects, the problems they faced and how they managed to solve them. The interviews are presented in the order they were conducted in a problem/issue-solution style. That means that each paragraph presents the problem-issue faced and the solution or the actions taken directly after. Table 5 shows some basic information about the interviewees and their projects.

TABLE 5: INFORMATION ABOUT THE INTERVIEWS

Company	Project	Location	Project status	Duration
Sweco	Vallastaden 2017	Linköping	Finished	2 hours
Brimacon	Uppsala's construction logistics project	Uppsala	Start-up phase	2 hours
Schenker	Mall of Scandinavia	Solna	Finished	1,5 hours
Servistik	Urban Escape	Stockholm	In progress	1 hour

5.1 Interview with Sweco

Sweco takes part in the project "Vallastaden 2017" which is located in Linköping close to the university. The initial discussions about the project started in 2013 and the construction started the same year. The firsts apartments were ready during 2015 and some families already live there. According to the schedule, around 1000 new apartments would be ready until July 2017. The project is bigger than originally thought by the municipality because the number of clients, 38 in total, was not originally known. The contractors were required to finish the buildings that are on the side of the main road by February 2017 since the municipality is responsible for them. In case of a delay the contractors would have to pay a penalty and give a reason for the delay but the municipality moved that deadline to the 1st of April 2017.

One problem encountered is related to who is going to build the roads around the project area and keep them clean and who takes care of the waste disposal. The land for the construction belongs to the municipality and thus it is responsible for building the roads around the area and keeping them clean from the snow. Sweco, together with the construction manager, have agreed with the municipality to take care of the safety on the main streets by observing if the streets are dirty, if anything blocks them or if the fences next to them have any problems. As a result, the roads are always open and the transportation of materials rolls smoothly.

However, many logistics problems occurred and created difficulties in the material transportation. The developers needed to find a solution as fast as possible. However, they did not want to take risks so they collaborated with Sweco to take over this part. Sweco cooperated

with a new TPL provider without previous experience in construction logistics solutions which forced them to wait for up to 8 months for the right person with the right experience to undertake the situation. The person who took over the situation managed to minimize the transportation problems.

Keeping up with the project updates and dealing with the material delays was also crucial. That is why the three coordinators have a weekly meeting discussing the problems or the improvements that have been done until that point. If there are delays from the suppliers' side, then the contractors re-negotiate their agreements.

An initial requirement was a fee to the TPL provider from the contractors and tenants. The contractors should pay to the TPL provider 132 kr. per gross floor area. Gross floor area is all the m^2 that have been built. That amount of money provides them a "package" that contains security, a booking system for the transportations, gates, cameras, and fences while there are some services that the contractors could pay extra for, such as a site establishment and recycling services. Additionally, each family that builds its own house in the area pays a one-time invoice of 10000 kr. to the TPL provider for their safety measures during the project.

The gate controls on who enters and exits the area and a booking system for the deliveries had also to be established. Consequently, in the construction area, gates with surveillance cameras that control who and what enters and exits the area were installed. When a truck reaches the gate, the driver calls a number and identifies himself and the purpose of his transportation and the gate opens automatically. The contractors make an online booking before their transportation in order to confirm it. The TPL provider then organizes the transport on site and is responsible to handle the materials.

One of the main misunderstandings among the contractors was about the height of the cranes that was initially wrong. Thus, new cranes were ordered, triggering extra delays and cost but, on the other hand, the cooperation between the contractors became better after the incident.

As in most projects, a target goal was to be able to save time and money on future defects. Therefore, the municipality created underground tunnels for the electricity cables and the waste pipes so that in future there will be no need to dig and destroy the roads but instead the municipal employees will be able to directly spot the location that has the problem.

The need for a parking place big enough to be used by the trucks had also to be resolved in the best way possible. As a result, a parking place was created where the truck drivers are offered rest rooms and coffee-making facilities while they wait to enter the site. Moreover, there are some limited parking spaces for the workers and while the entrance to the area is free they will have to pay a penalty if they park their car on the wrong place.

Sweco faced a security information problem as well right in the beginning of the project. To deal with similar future scenarios a weekly security information meeting was established with all the contractors in order to discuss and analyze the current status and the future difficulties.

The optimization of the material handling, transportation and the reduction of the truck number in the construction area was also a challenge that had to be solved. A combined solution of a checkpoint and a CCC was established to manage those issues. The area was not the most

optimal choice but since it was empty and close to the construction site it was selected. This type of solution brought many advantages to the project. A checkpoint is easier to manage, has lower costs and it regulates the transport on site. On the other hand, with the use of a CCC there are better warehouse possibilities on site and better handling of materials due to the fact that there are fewer deliveries directly to it. Also, more transport is handled which means less work on site due to the fact that the main activities have been done on the CCC thus decreasing the cost for the construction companies. In the CCC the first five days for material storage are for free but then the companies pay according to the amount of time that each company wants to store their products.

5.2 Interview with Brimacon

The interviewee owns a construction consultant company named Brimacon and is working as a strategic advisor for Uppsala's project. They try to avoid problems that have been identified in other construction projects, like the low use of a CCC, because the materials were sent from the suppliers directly to the construction area. For example, the use of a CCC for a specific project was estimated at approximately only 15%. Thus, in order to avoid problems like these, there were initial discussions about the need for a logistics center and the need for new and different construction logistics solutions.

As in most projects the land belongs to the municipality and thus the municipality decides which part of the land will be used for which purpose. The area that was finally chosen for the CCC is close to the highway, making it optimal for the project. The proximity to the highway allows for easier transports to the CCC and it reduces the amount of heavy traffic through the city. This CCC can be used in the future for warehousing purposes if there are space problems with future projects. Currently, construction companies avoid using a CCC because they want to deliver directly to the site. That is why a business solution is investigated to increase the use of the CCC.

In Uppsala, before the construction companies sign the land agreements with the municipality, they sign a contract with the CCC that includes many different services such as transport and consolidation. Although the developers believe that this solution costs a lot of money, it is strongly believed that this solution can bring many advantages to them in the future.

Another logistics solution that is tried on this project is to separate the logistics operator from the planning system. That means that if the contractors realize that the planning system is not functional for a CCC solution, they can change the system and keep the operator if the operator is good enough. If the system is working properly but the operator is not good enough, they can switch operators but keep the system. The logistics operator books a slot time at the construction site. That means that the contractors know when the logistics operator will unload the goods which are consolidated at the CCC.

Another action attempted is to give the construction companies the power to plan their own deliveries in order for them to have full control by operating their own unloading areas in the site via an online planning system. This system will "talk" to the gate and the gate will open for the trucks to enter. There are two gates on the site from the start, an entrance and an exit. In that way, there will be no transportation problems and collisions with the trucks. The gates can act as a checkpoint for the direct deliveries from the suppliers. Moreover, this system can offer many

different types of information to the companies such as what type of trucks have entered the area, where they are in the area, when and what type of materials will be unloaded and more. Furthermore, the cameras in the gates will recognize the truck's number plate and will inform the contractors about which unloading area is going to be full in near future and it will be faster and easier for the transporters to enter the gate. Their aim is to not have people to operate the gates, but only have this standalone system, which is controlled by the construction companies. Thus, when there is a change in the schedule the system will be automatically updated.

There is also the necessity for each construction company to have their own unloading areas on site. If the construction companies do not use their own private unloading areas there is a penalty of approximately 10000 kronors. The construction companies will be informed about the available space on site to avoid misunderstandings. Moreover, for more information, the companies can download and read a brochure that contains questions and answers to various important subjects. The phase planner is responsible for taking care that the rules are followed in the whole area, such as the trucks' movement and the fact that each company uses its own unloading area.

Another requirement has to do with the fact that each construction company should have and handle its own waste system. The companies are then responsible to deliver the waste directly to the responsible companies. It is easier and costs less to transport the waste directly to the waste companies in Uppsala in comparison to transporting them to the CCC and then to the waste companies. As a result, the CCC will only set the rules on how this system has to work and it does not take part in the handling of the waste. Moreover, the project takes into consideration the environmental issues by reducing as much as possible the pollution from the site and protecting the river that is nearby by decreasing for example the number of trucks that reach the site.

One of the most important issues in the project is the available parking space. There are only a few paid places and these are for those workers who have to drive to the site because they carry special equipment for their work. There is a bus stop close to the site, which connects the city with the train station, thus the workers can reach the site quite easily.

There is a huge difficulty identifying all the possible problems at the beginning of a project and the same is for this project. The construction process should be ongoing in order to observe and classify the problems and find the corresponding solutions. The contractors wait to run the project and then identify the complications that will arise.

The contractors want to know beforehand all the rules and legislations of how they will act to construct their buildings in order to avoid problems and work according to specific rules. These rules come from the government, the municipality, the CCC, the developers etc. Each one of them sets its rules and explains how the contractors should work to avoid problems.

Finally, the interviewer mentioned that the TPL provider does not need to be a specialized construction logistics company in order to offer its services. However, if the TPL provider has a construction background, it can offer extra services to the project like warehousing, transporting of materials on site and material handing on site.

5.3 Interview with Schenker

The interviewee has experience from different set ups regarding construction logistics. Now, he is working for a consultancy company named Schenker Consulting. The interviewee has experience from Ragn-Sells which sold the service of "clean construction", where they offered a person in the construction site, who sorted the waste in an effective way and thereby took care of the waste on site for the construction company and kept the site clean. Moreover, the person was responsible to go to different buildings and put the waste into containers to be moved away. Some years ago, construction companies realized that it was very costly to take care themselves of the waste.

In the area where the interviewer was working, there were 7 construction sites on-going, each one for a different purpose. Due to the fact that there were a lot of different parties cooperating it was extremely difficult to transfer information among them. However, since the communication was crucial for the project to be completed on time, more meetings and regular discussions were established in a frequent basis.

There were some thoughts, requirements set and problems that should be solved on site. Some of them were: initial pre-construction draws of the logistic areas during the different stages of the project to check if a checkpoint is needed, a way to organize the trucks, a central control of the transport on site, regular checks for incorrectly parked trucks, wrongly unloaded materials and waste that was not handled properly. A checkpoint was set on site to organize the trucks for the different contractors for all the project's stages. The checkpoint organizes the trucks, sets up the lanes and the paths that the trucks should use to transfer the materials and unload them safely according to the contractors' need. Bicyclists were checking, taking pictures and reporting people that had parked on the wrong parking places, materials that were unloaded in the wrong space and waste that was not taken care of. Finally, there were a lot of follow up meetings with the contractors to check whether or not the things mentioned above were working as planned and if something had to be changed to make things run smoother. Another issue faced was that the parking space was inadequate and a good organization was needed to serve all the trucks in such a limited space. That is why a person was assigned to observe and guide the trucks (that could be up to 250 in one day) in the different queue lines. Finally, there was a question about the CCC and why it was not selected in that project. They did not have a CCC because everyone was running his own logistics on site. However, the interviewee mentioned that a CCC would have been a benefit to the project so that the deliveries could have been handled in a more efficient way.

For the pre-construction logistics phase, the interviewee mentioned that they made drawings on how to plan their logistics areas during the different stages and see what type of solution is needed based on the deliveries that arrive at different stages and then the contractors decide which areas should be used as storage and where the materials should finally go. One of the reasons that you need such a solution is when there are many contractors in the same area and the area is too tight. Another reason is when there is a need to change the surroundings, for example in cases where you have to make new ways for the ambulances in order for them to reach the area fast and safely.

5.4 Interview with Servistik

The interviewee is working for a project called Urban Escape, which is in the heart of Stockholm's city. This company is responsible for handling the materials from the factory directly (or all the way) to the construction site. There is too much planning for the daily deliveries, because they should catch up with the delivery schedule so that the materials are on site on time. Also, the planning includes the planning for the suppliers in an earlier stage, thus in that way the unnecessary mishaps can be avoided. Moreover, they perform the study for the construction before it actually starts. The planning for this project started with the external planning and then they continued with the internal planning. The planning system that they used was based on another planning system that includes what deliveries were made every day and what kind of materials they included. Also, it included information about the cranes, such as their sizes and heights. The system was available to stakeholders for information about the deliveries.

An initial problem that was faced in that project was how the trucks should move in the construction site without causing delays, where to safely unload the materials and where the crane positions should be and at what height. So, the contractors used consultant experts to create the routes for the trucks in the construction site. They tried to make the routes as efficient as possible in order to unload with safety. Moreover, they plotted the positions and height for the cranes. It was very important for the contractors to be careful with the size of the materials, because their dimensions are restricted according to the crane's size.

Finding a good logistics solution for the deliveries was crucial to avoid problems with the contractors. In this project, the property owner takes a big chunk of the delivery cost from the CCC to the project and tries to divide the cost between the contractors. He invests in a safer solution to have a safer transport. In that way, the contractors are satisfied, observe that the solution works very well and is effective and they do not want to look for other logistics solutions.

The material deliveries are very important for a construction project and thus should run efficiently all the time. To do that, the contractors inform the suppliers about when they want the materials to be available. Some of the suppliers are really keen on delivering at a good pace but others are not. The latter creates many problems and delays since the contractors do not have what they need to continue the project.

For the project not to fall behind schedule, everything has to be planned from a very early stage. Logistics is something that should be planned long before the project starts. When there is an actual plan on how the project is to be developed, it is a good time for the logistics expert to join the project. That gives the logistics expert the chance to organize his work better, avoid future complications because he/she has the time to form a better picture of the project and what are its requirements.

Apart from the problems faced and the actions taken to solve them, the interviewee shared also some thoughts regarding the construction industry and how it can be compared with other industries, the future of construction logistics and his thoughts about the CCC solution.

He made a small comparison between the construction industry and Volvo. Volvo has more standardized collaborations, which means that they can work more effectively with the materials

and the supply chain planning. On the other hand, in the construction industry the logistics provider must collaborate with different companies and stakeholders in each project. Most of the time the project is the first collaboration between them, which can create communication problems until a solution is finally found.

About the future, the interviewer expects the construction logistics to be more standardized. The logistics will take place in earlier phases to catch up with the "feeling" and the requirements of the project. The number of stakeholders will increase to get a better solution. All involved in the construction project will have a better picture of the solution and will be able to act faster than before. Moreover, the construction projects will utilize the resources better than they do today and working methods will be much more effective. Finally, the contractors will have the chance to use the specific applications on the Internet to order their materials easier and faster.

A CCC is a good solution when there are many projects in the area since it can service multiple construction sites simultaneously while decreasing the number of trucks. Furthermore, with the use of a CCC the transports can be more flexible in comparison to a checkpoint. With the latter, the contractors do not have the chance to make changes in their deliveries when there is a delay in the schedule or if there are other obstacles in the construction state.

5.5 Summary of the interviews

The purpose of this section is to make a summary of the four interviews and emphasize their most important parts. It presents the most crucial problems one or more interviewees faced during their projects as well as the actions taken and the logistics solutions finally applied. In that way, the reader will have a comprehensive view of the interviews.

The interviewees noted many and diverse problems that they faced during their construction projects. Some of the problems are the transportation of the materials, the parking space for the trucks close to the gates, the delays with the suppliers and more. Some of them required more complicated actions or a combination of actions, while others needed a simpler solution. Some problems were encountered by more than one interviewee while others were encountered by only one. Table 6 presents all the problems that the interviewees raised. As we can see, for the same problem different solutions were found. It is clear how each company acts for each problem. The last column presents the name of the company of the interviewee and the second column his/her corresponding solution. Finally, the problems marked with blue are the most important described in this section.

TABLE 6: THE PROBLEMS WITH THEIR LOGISTICS SOLUTIONS FROM THE INTERVIEWS

Problems	Solutions	Company
Transportation problems and queues in the gate	Use a person from TPL with experience - Combination of check point and CCC Online planning system Check point	Sweco Brimacon Schenker
Traffic problems and delays	Consultant experts to create paths - Use of a CCC	Servistik

Poor planning system	Separate logistics operator from planning system	Brimacon
Delays with suppliers	Re-negotiation of agreements between contractors and suppliers Use of a CCC	Sweco Servistik
Material orders	Use of the internet	Servistik
Big number of trucks on site	Use of a CCC	Servistik
The building is not ready on time	Contractors should pay a penalty	Sweco
Delivery cost	Divide the cost between the contractors	Servistik
Contractors use wrong unloading areas	Inform them detailed - Pay penalty	Brimacon
Problems with collaboration and communication between parties	More meetings and improve the communication	Sweco Schenker
Suppliers do not use logistics solutions correct	Contractors inform the suppliers about the solutions	Servistik
Many contractors in a tight area	Use of a checkpoint	Schenker
Parking	Limited space with facilities for the drivers Parking for the trucks close to the gate A person to keep track of the lanes	Sweco Brimacon Schenker
Security information problem	Weekly security information meeting	Sweco
Catch up the feeling and the requirements of the project	Logistics should take place in earlier phase	Servistik
Waste	Follow the rules - Contractors should transport them to waste companies Bicyclists on site	Brimacon Schenker
Environment issues	Reduce the number of vehicle with the use of CCC	Brimacon

6. Analysis

In this chapter the three research questions of this thesis are answered based on Tables 4 and 6.

6.1 Analysis of the research questions

This section presents the three research questions presented in the first chapter. Tables 4 and 6 are used to answer them (only the highlighted problems). Each answer is structured like this: the common problems are discussed first, then the problems discovered in the literature review and finally the problems mentioned in the interviews.

RQ1: What are the main problems faced in urban construction projects?

Only four of the many problems are common in both tables. The first one is **the high number of the trucks** on site. In the literature review many authors referred to this problem to emphasize the many consequences that this creates. On the other hand, only one of the interviewees mentioned that the high number of trucks created problems on site. Another serious problem is the **conflicts and the poor collaboration between the parties**. That problem is mentioned many times in both the literature and the interviews, because the problem of poor collaboration and communication is quite common in a project. Moreover, some of the authors stated that the **workers spend a lot of time waiting for the materials**. That means that the workers "sacrifice" valuable working time waiting, thus not contributing value-adding activities to the project. The same problem was faced by two of the interviewees in their projects, when there were delays from the suppliers. The last problem that was commonly identified is the large amount of **damaged materials and the waste**. Many authors mentioned that this problem is due to the poor logistics and sometimes causes delays to the project. Additionally, two of the interviewees stated that as a problem.

From the literature review some problems have been acknowledged which were not identified during the interviews. One of them is the **unnecessary production costs** like the cost for the materials' movement. These costs burden the budget of the project and sometimes surpass it. Other authors mentioned that a construction project causes **traffic** which means noise, accidents and emissions in the surrounding area. Finally, a few of the authors stated that there are some **difficulties with the planning** during the first phase which means that there will be problems later on the project.

In the interviews' summary only three problems were not identified during the literature review. The first one is the **transportation problem,** which causes queues at the gate and which in turn causes delays in the construction process. This problem is mentioned by most of the interviewees. Another big issue that three out of the four interviewees mentioned is the **parking space** for the trucks. In most of the projects there is not enough space for all the trucks and that creates delays with the material handling. Finally, the unfair division of the **delivery cost among the contractors** creates tension and problems in their cooperation.

Table 7 presents a comprehensive view about which problem corresponds to which case.

TABLE 7: THE MOST IMPORTANT PROBLEMS FOR THE BOTH CASES

Problems	Literature's summary	Interview's summary
The high number of trucks on site	X	X
Poor collaboration between the parties	X	X
Workers spend time waiting for materials	X	X
Damaged materials and waste	X	X
Unnecessary production cost	X	
Traffic	X	
Difficulties with the planning	X	
Transportation problem		X
Parking space		X
Delivery cost among the contractors		X

RQ2- RQ3: What are the main construction logistics solutions used in Sweden and which solution matches which problem?

These questions can be answered together since the second encapsulates the first. Regarding this question, the second columns from the two tables are used with a reference to the first columns. The solutions that will be presented in this section follow the same presentation order as the problems in the previous section. The first two paragraphs present the solutions for the common problems identified from the literature review and the interviews, the third presents the solutions from the literature review problems and the last one, the solutions for the problems stated during the interviews.

Regarding the problem with the *high number of vehicles on site*, some of the authors mentioned **the use of a CCC** as a logistics solution. With the use of a CCC only the vehicles with the needed materials at a given time will be present on site. Moreover, the contractors can make **use of CLP** for the better organization of the vehicles. The interviewees' opinion on the same problem coincides with that of the authors, as they believe that a CCC can reduce the number of vehicles. To minimize the consequences of the *poor collaboration and communication between parties*, the authors believe that the construction industry should give **more emphasis to logistics**. Also, the stakeholders should focus on **improving their communication** with each other to avoid misunderstandings. The interviewees believe the same, saying that the key to a better collaboration is to **increase the number of meetings**.

In many projects, *the waiting time for the materials* is long. In the literature review the authors indicated three possible logistics solutions. The first one is the **good communication between the contractors and the suppliers** so that the suppliers are informed in time about the needed materials. Moreover, the **improvement of logistics** and the **just-in-time deliveries** have a great impact and helps so that the materials reach the site on time. On the other hand, the interviewees

mentioned that good logistics solutions could be at first the **re-negotiation of the agreements between the contractors and the suppliers** and secondly the **use of a CCC** so that the materials reach the site on time. For the *damaged materials and the waste* that comes from the construction process, the authors stated that the contractors should **emphasize logistics more** for the better material handling and make **use of a CCC** that can handle the waste. For the same problem, the interviewees believe that **the contractors should transport the waste directly to the waste companies**, if they are close to the site. Additionally, a good logistics solution mentioned **bicyclists to patrol around the site** and check if there are any wastes to inform the contractors so that they remove them on time.

Unnecessary production costs will always be part of such projects with the authors mentioning the following logistics solutions. The people who work on construction projects should place more **emphasis on logistics,** which will give them the chance to avoid extra costs since there will be better planning and management of the materials. Likewise, **a TPL provider** with the appropriate experience can be a good solution to handle the logistics issues and organize the construction site. Finally, the contractors can also **share resources** (trucks, cranes etc.) with other companies to decrease functional costs. *Traffic* jam created by trucks and its consequences such as the excessive noise, is a great problem for the people who live in the surrounding areas. Some of the authors mentioned that the solution for that problem could be the **use of a CCC**, the **just-in-time deliveries** and **transports made during the night**. This in turn means less traffic, noise, emissions and accidents. The last issue is the *planning problem during the first phase* of the project. Some solutions are the **good interaction with the logistics**, the use of an experienced **TPL provider** and the **use of a CLP** that contains detailed information about the project. That is how the organizers can have almost all the necessary information for a good plan that can then solve many future problems.

The problem mentioned by the interviewees and concerns the *material transportation* that causes queues at the gate can be solved with three logistics solutions according to them. The first one is to **use a TPL provider** to organize the transports effectively and a **CCC** close to the site for the transports and the material handling. Moreover, an **online planning system** for the deliveries and a **check point** on site can also regulate the transports to avoid delays. The *parking space* problem that was identified by the interviewees could be solved by having (if there is space) a **parking lot close to the gates** for the direct unloading of materials as well having some **facilities for the drivers** who have to wait many hours. Additionally, another solution could be **a person to manage the track of the lanes** for the trucks to avoid confusion for the drivers. Finally, regarding the *delivery cost for the contractors*, one of the interviewees stated that the property owner should **divide the delivery cost among the contractors** so that each one of them pays his\her corresponding cost.

Table 8 presents the problems with their logistics solutions from both the literature review and interviews.

TABLE 8: WHICH PROBLEM MATCHES WHICH SOLUTIONS FROM BOTH CASES

Problems	Solutions
The high number of trucks on site	Use of a CCC Use of a CLP
Poor collaboration between the parties	Emphasis on logistics Improve stakeholders their communication
Workers spend time waiting for materials	Good communication between the contractors and suppliers Improve the logistics Just in time deliveries Re-negotiation of the agreements between suppliers and contractors Use of a CCC
Damaged materials and waste	Give emphasis on logistics Use of a CCC Contractors transport the waste Bicyclists to patrol around the site
Unnecessary production cost	Emphasis on logistics Use of a TPL provider Share of resources
Traffic	Use of a CCC Just-in-time deliveries Deliveries during the night
Difficulties with the planning	Good interaction with the logistics Use of a TPL provider Use of a CLP
Transportation problem	Use of a TPL provider Online planning system Check point
Parking space	Parking close to the gate Facilities for the drivers A person to manage the track of the lanes
Delivery cost among the contractors	Division of the costs between the contractors

7. Discussion & Conclusion

This section presents the results from the analysis part. It helps the reader to move his/her understanding of the research that has emerged from this thesis.

As it was mentioned many times, the construction industry is complicated and consists of many phases and stakeholders. Due to the fact that changes in that area occur rapidly, it means that the logistics and the logistics experts have to follow that rhythm in order to catch up with the new data, be always informed and apply new techniques and ideas. However, in most of the cases there are many problems that arise from poor logistics, bad communication between parties and other causes that were analyzed in the previous chapters. Thus, it is not always easy for the logistics experts to follow that tempo of development.

This master thesis tried to identify the problems and the logistics solutions in the Swedish construction industry, through a literature review and interviews with different consultant companies. From the Analysis chapter, it is clear that there are many problems that appear in construction projects. Table 7 shows the problems that can be characterized as the most important or those that have a great influence on the different processes and phases of such projects. Only some of these were mentioned both in the literature and the interviews, some only in the literature review and some only in the interviewees' projects. As we can observe, only the 40% of the problems are common between both cases. Moreover, Table 8 shows the corresponding logistics solutions that were applied on the projects from both cases. The improvement of logistics, the use of a CCC and a TPL provider, the good communication between parties and the just-in-time deliveries, are some of the most common solutions appearing in this thesis. Many of these logistics solutions have been mentioned from both sides as we saw in the previous chapters.

Also, what we should focus from the Analysis chapter is that:

- *Reality is different to theory*. That result comes from the fact that the most important and basic problems that were identified from the interviews are not mentioned in the literature.
- *Reality and theory share some problems*. It was expected that the two cases would have some similar problems that influence the whole process. Three out of the four common problems are quite important for both.
- *A CCC and a TPL provider can solve many of the problems*. From both summaries, it is clear that an organized CCC close to the site and a TPL provider with experience in logistics can solve or eliminate many of the problems that arise in the construction industry.
- *Each project is unique and requires specific management*. In the interviews, the participants identified the fact that each project is different and demands different management even if there are cases where the same issues arise. Moreover, there are individual problems that occur in each project. That is because in each project the stakeholders, the area, the purpose, the time period and other important factors are different.

- *Emphasize logistics*. Both summaries indicate the fact that the construction industries should focus more on the logistics to improve the processes and the ways of working. Logistics solutions are the key to solving or eliminating most of the complications.

The findings are important for researchers and for those who work in the construction industry. The results, alongside with Tables 4 and 6 that contain the problems and their corresponding logistics solutions, can help anyone to get a deeper understanding of the problems and how to avoid or solve them. Moreover, the main part of this thesis focuses on the CCC and how it can help the construction industry with the transportation and the elimination of its known problems. From the findings, the use of a well-organized CCC can offer many advantages to the construction industry. Both the literature review and the interviewees mentioned the CCC as a "good tool" that helps the contractors with the organization of the construction site.

Finally, it is worth mentioning that, occasionally there were many researchers who investigated the construction industry and focused on a specific problem. This thesis tried to combine the theoretical point of view with the reality with four different cases from the Swedish construction industry and identify the main problems and their corresponding logistics solutions.

Further work can be done to extend the knowledge provided in this Master thesis since it seems as if the literature appears to be quite "weak" on extended research into the construction industry. More research should be done on what happens in the unloading areas when the materials have reached the site as well as on the parking space issues, which is a vital problem. Moreover, the literature should be enriched with research about the checkpoint option and how it works, as many of the projects seem to use it. Also, the knowledge gained by this thesis can be supplemented by the obtaining of more interviews, especially about projects that have been already completed. That is because a greater number of interviewees can provide a more comprehensive view about the problems faced as well as the logistics solutions used. Lastly, it would be informative to get the opinion and perspective of other parties like the suppliers, on how they organize the transports and how they solve the possible problems.

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9. Appendix

Appendix 1 – The interview protocol

Describing governance
What type of contract is used and how is the contract set up?
How is tendering conducted?
What is the policy for rewards and penalties?
How is knowledge transferred between construction projects regarding: a. Construction logistics b. Governance
What are the objectives of governance? What is important to achieve? How was the solution developed?
What are the challenges of governance? What makes it difficult?
What have been positive with the chosen solution?
What have been negative with the chosen solution?
How is the chosen solution working in comparison to other solutions that you know of?
Would alternative governance of and by stakeholders be possible in this project? If yes describe!
Would alternative logistics solutions be possible and why?
How do clients affect the logistics solution selected?
How do the logistics solution affect costs and construction efficiency?
What are the challenges with regards to governance? • Stakeholders • Resources • Activities • Material flows • In general
Collaboration/communication

Can you see any difference when you have a construction organization where you have long term collaboration versus a sort term collaboration regarding how they apply logistics solutions?
What do you do to improve cooperation between parties?
What type of information should they exchange to have a good collaboration? When and how they should exchange?
Does a better communication, collaboration, exchanging information and trust between parties improve the issues in construction industry?
TPL provider
Who can be a TPL provider?
Will it be beneficial for the construction industries if they outsource some of the logistics processes? If yes, what kind of processes?
Is the use of a TPL provider positive for the construction industry? If yes, in which ways?
Construction Consolidation Centers (CCC)
Tell me your opinion about CCC
Explain how it works
Can an implementation like that be beneficial for the city and for the construction project in general? In which ways?
General
What are the main logistics related problems with construction projects?
How is the urban freight transport connected or cooperating with the construction industry?
What do you do in order to reduce the congestion, noise and air pollution?
What are the JIT deliveries to you? What products do you want to come JIT?
What should be educated in to improve the previous problems?

Is the construction industry open in new strategies/innovations which may improve the whole situation?
Are there many unnecessary activities in the construction projects? What kind? How can that be solved?
How can the logistics solutions increase the efficiency in construction industry?
Is the lack of proper logistics planning a big problem? If yes, how can it be solved?
How big problem is the waste from a construction project? How can it be solved?
Which kind of information should a construction logistics plan contain and why is it important?
Why is city logistics important for the construction industry and which is the relationship with the urban freight transportation?