UNIVERSITY OF GOTHENBURG

SCHOOL OF BUSINESS, ECONOMICS AND LAW

Construction logistics planning in Sweden:

The role of public and private sectors in logistics management

Authors: Immad Uddin and Annisa Ramadhianty Broström

Supervisor: Michael Browne

Master's thesis in Logistics and Transport Management

Spring 2024

Graduate School, School of Business, Economics, and Law

University of Gothenburg, Sweden

Acknowledgments

We would like to thank everyone who has supported us throughout the journey of this thesis. First and foremost, we are highly grateful to our supervisor Professor Michael Browne, who continuously guided us. His enthusiasm, dedication, and constructive feedback have greatly enriched this work. During the data collection process, we faced several difficulties which delayed our work, however, his support and encouragement remained a great source of motivation for us.

We would also like to express our deepest gratitude to Julia Hope, a former Arbetsledare Logistics at Serneke, who extended her valuable support in providing information about Serneke. Her support was remarkable in steering this thesis forward. Additionally, we would like to extend our thanks to Anna Fredriksson from Linköping University, who provided her guidance at the beginning of this work. In this connection, we would also appreciate the time given by Alexandra Bakosch, a Project Manager at the city of Gothenburg, Urban Environment Department. Lastly, the feedback and comments of our opponent and discussion group proved substantially beneficial in refining this thesis.

Immad Uddin Annisa Ramadhianty Broström

Abstract

The construction industry has an ample contribution to Sweden's economy. The industry has been expanding with an increase in urbanization. Resultantly, there is a rising demand for efficient management of construction logistics which has several impacts on the construction projects and population. However, efficiency in logistics operations calls for proper rules and regulations under which they are carried out to complete construction projects. Because construction logistics is a complex phenomenon, therefore it has multifaceted challenges, especially in large-scale projects. In Sweden, there exists a written constitution which governs all aspects of building construction, and it is mandatory for all stakeholders to follow it. But there is currently a lack of proper regulatory structure in written form which clearly defines the way construction logistics is to be carried out in urban areas.

This thesis explores the existence of rules and regulations governing construction logistics in the city of Gothenburg and the role of public-private sectors in logistics management. To fulfill the purpose of the thesis, a case study of a large-scale project, Karlatornet, was selected. Qualitative methods were applied, and semi-structured interviews were conducted with people from Gothenburg city and Serneke. The results revealed that the city of Gothenburg lacks a formal regulatory structure for construction logistics and their role is limited to transportation and land-use. The results also revealed that private companies are responsible for self-regulating their logistics activities in construction projects.

Keywords*:* *Construction Logistics, Construction Logistics Planning, Rules, and Regulations, Karlatornet, Construction Logistics Management, Logistics Challenges*

Table of contents

Table of figures

Table of tables

List of abbreviations

CCC – Construction Consolidation Center

CLC – Construction Logistics Center

CLP – Construction Logistics Plan

CSC – Construction Supply Chain

CSCM – Construction Supply Chain Management

CSCMP – Council of Supply Chain Management Professionals

EIA – Environmental Impact Assessment

EU – European Union

JIT – Just-In-Time

RL – Reverse Logistics

SC – Supply Chain

SCM – Supply Chain Management

SKR – Sveriges Kommuner och Regioner

1. Introduction

The first chapter starts with an introduction to the thesis in which a background for expanding construction industry and the need for logistics management has been discussed. It continues by stating the problem discussion and gives the purpose behind studying construction logistics. Research questions have been formulated in this chapter to plan the direction of the thesis. The chapter ends with delimitations which were made to complete this study.

1.1 Background description

The construction industry plays a vital role in the Swedish economy. Overall, the industry accounts for about 12 percent of Sweden's Gross Domestic Product (Fischel, 2024). Over the last four decades, the population in suburban areas has significantly increased by 70 %, which resulted in increased housing construction (Boverket, 2016). At present 89 percent of the Swedish population is living in urban areas, which requires a vigorous construction sector to demonstrate optimal performance by providing homes and other infrastructure to the urban dwellings (O'Neill, 2024). However, this optimal performance is achieved after facing several challenges by the construction industry, like cost efficiency and productivity particularly (Vrijhoef & Koskela, 2000), which in turn heavily depends upon successful execution of construction logistics operations (Carlsson et al., 2022). Agapiou et al., 1998 defines construction logistics as “for construction industry, logistics comprise planning, organization, coordination, and control of material flow from the extraction of raw materials to the incorporation into the finished building”. Because the construction industry continues to experience substantial waste and unnecessary costs due to poor handling of materials and tools (Agapiou et al., 1998), therefore, enhancing logistics activities can improve the performance of construction projects (Carlsson et al., 2022). Many construction projects experience inefficiencies due to unnecessary on-site activities, emphasizing the necessity of enhancing logistics operations. Of the several logistics activities involved in a construction process, the most important are transport of material to and from the construction site, and storage/handling of material on site (Matouzko, 2015). It is estimated that

of the total material ordered for a construction project, 10 to 15 percent go unused and waste away, which can be significantly reduced by the implementation of efficient logistics practices (Harker et al., 2007).

In Sweden, the construction process involves several stakeholders, for instance, the state, municipalities, project developers, contractors, logistics service providers, and property owners (Boverket, 2023). A construction project comprises numerous complicated tasks distributed among these stakeholders. It is also important to make thorough planning at each stage of the building process to ensure the allocation of concerned tasks to the stakeholders, followed by meeting deadlines and staying within budget (Bomb & Haraldsdottir, 2017). This is because the distinctive features of the construction industry can result in delays, raising disputes among the stakeholders which may in turn add complexity to the project (Hossam et al., 2021). Construction process is more challenging in urban areas particularly, the logistics process used in supplying material to the construction site, adding to congestion and environmental disruptions (Bomb & Haraldsdottir, 2017). To cope with these negative externalities of the construction industry, it is important to make a transition towards efficient construction logistic methods, which is essential in achieving the goal of high performance in construction projects.

1.2 Problem Discussion

"Construction logistics is a very challenging area" (Browne, 2015) which requires an effective administration of the whole construction project keeping in view the various constraints, and for a successful completion of a project, logistics management is crucially important (Usman & Ibrahim, 2015). Understanding the importance of construction logistics in the construction industry and the vital role it plays in the economy is a hard yet important task (Foulkes & Ruddock, 2008). Because construction is causing space limitations, environmental degradation, and reduced accessibility, the demand for construction logistics solutions is rising. Moreover, the dynamic nature of the urban environment further exacerbates the problem, as construction activities interact with existing infrastructure, transportation networks, and the daily lives of residents (Janné & Fredriksson, 2021). Additionally, in dense urban areas, the implementation of high-performing logistics becomes more challenging due to heavy traffic flow around the project and limited space at the construction site (Carlsson et al., 2022). Therefore, logistics solutions are essentially needed in projects within the urban areas (Janné & Fredriksson, 2019), especially

large-scale projects. Similarly, there must be rules and regulations which govern construction logistics in cities to cope with the negative impacts of the construction work.

It is also pertinent to mention here that the incorporation of logistics solutions in the construction industry is a recent phenomenon (Janné & Fredriksson, 2019). With an increase in urbanization and infrastructure projects, the significance of construction logistics has amplified, however, despite being an important part of city logistics, it is typically managed by the construction industry itself (Janné & Fredriksson, 2021). Resultantly, owing to the limited exchange of knowledge between city logistics and the construction industry, a repetition in logistical challenges and self-regulation of the logistics operations by the industry can be witnessed.

Previous research has addressed different perspectives of construction logistics. For instance, suggestions for improving construction logistics focusing on supply chain, performance, and coordination of stakeholders, on-site and off-site logistics, exclusive focus on logistics solution in terms of Construction Logistics Center, and labor force productivity (Carlsson et al., 2022). There is limited work done on the rules and regulations being implemented by the city authorities in Sweden to influence the way logistics activities are carried out in construction projects. There are also lesser insights on the role of private companies in managing logistics activities in large construction projects.

1.3 Purpose and research questions

In light of the above discussion, this thesis will investigate the existence of rules and regulations necessary for governing construction logistics. As construction logistics seems a complex phenomenon encompassing many activities, there must be some rules and regulations under which logistics operations are carried out. Hence, the purpose of the study is to find out what kind of regulations have been made by city authorities to control logistics operations in Gothenburg. For the sake of more clarity and better results, a case study of Karlatornet has been selected. The project being built by Serneke along with many other stakeholders is an ongoing large-scale construction project in Gothenburg. The purpose behind the case study is to see what kind of strategies Serneke implemented to manage its logistics operations and what role did municipality or other institutions play in governing construction logistics in the project because high-rising buildings like Karlatornet have many logistical challenges. Thus, the main objective of the study

is to find the role of both public and private sectors in regulating construction logistics operations.

Keeping in view the purpose of this study, the following research questions have been formulated to steer the investigation properly:

RQ1: *What kind of rules and regulations have been implemented by the city of Gothenburg to influence the way logistics activities are carried out in construction projects?*

In the first question, the study will find out rules and regulations about construction logistics being implemented by the city authorities to control logistics activities in Gothenburg. As already stated, to keep construction activities on track, the presence of proper rules and regulations is essential, especially in Gothenburg, where many construction projects are currently in progress. In this case, both primary and secondary data will be collected by a thorough scrutiny of literature and semi-structured interviews from the city municipality, Boverket and other related stakeholders. Official websites of the concerned departments will also be accessed to have a better understanding of the results.

It will address the following main points:

- Existence of regulations about construction logistics in Gothenburg
- Impacts of these regulations on logistics operations in the city

RQ2: *Which type of logistical challenges Serneke faced during the construction of Karlatornet and what strategies were adopted to optimize logistics operations in the project?*

The second question will address the challenges faced by Serneke during the construction phase. The main challenges would be demonstrated and would investigate the nature of strategies being followed by Serneke to achieve efficient logistics operations in building Karlatornet. Hence, it will go deeper into understanding the logistical challenges being faced by Serneke and the solutions sorted out to tackle them. It will also shed light on the role of municipality and other institutions in influencing its logistics operations.

It will address the following two main points:

- Investigating the various logistical challenges faced by Serneke during the construction process of Karlatornet.
- Investigating the nature of strategies being followed by Serneke to achieve efficiency in construction logistics.

1.4 Delimitations of the study

The study is mainly focusing on the city of Gothenburg, specifically examining the current rules and regulations applied to construction logistics and any old practices or changes over time are not within the primary focus. The study will find the role of city authorities in regulating logistics activities in Gothenburg and its impact on logistics operations. It is investigating a single case study, Karlatornet, which is a large-scale construction project, and the role of Serneke in managing their logistics activities. It does not go deeper into investing in any regulatory structures on national level. Key on-site and off-site logistics activities like transportation, material handling, storage places, and waste management will be discussed and any other logistics aspects like technological innovations will be considered only if they are directly relevant to the case study. Finally, the research is limited to qualitative methods and findings will be descriptive and exploratory, providing a basis for further research.

2. Literature review

In this part, the literature review starts by elaborating construction logistics and its associated challenges. It will further elaborate construction logistics management and will discuss the effects that arise from construction logistics in terms of economic, environmental, and social impacts. It will continue by elaborating on the ways to enhance the performance of construction logistics. Then it is leading to the discussion of construction supply chain management and later on, the study will briefly explain the importance of regulations for construction logistics. Lastly, the study will discuss construction industry in Gothenburg, after that the summary of the literature review will be presented.

2.1 Construction Logistics

In addition to the definition given in the introduction section, construction logistics can also be defined as "all activities dealing with supplying the right materials and resources to the correct customer and construction site to meet the customer's requirements" (Janné & Fredriksson, 2019). There are two categories in construction logistics, first is off-site material logistics and second is on-site material logistics (Ghanem et al., 2018). All logistics activities on the construction site are categorized as on-site logistics, and logistics activities that encompass procurement, and transporting resources and materials outside construction sites are included in off-site logistics (Ghanem et al., 2018). The construction industry is heavily dependent on construction logistics, specifically on road transport. During the construction projects, large volumes of construction materials and other resources need to be transported to, from and within construction sites (Venås et al., 2020). The transport activities that are related to individual construction sites are generally extensive (Dubois et al., 2017), and a large number of heavy vehicles are essentially needed in construction industry (Anwar et al., 2022).

Even though construction logistics plays a vital role in urban development, it also has environmental impact as Fredriksson & Huge-Brodin (2020) highlighted that construction transport has a severe impact on the environment. Sezer and Fredriksson (2021) defined "construction transport as the delivery of materials, machinery, and equipment to construction sites, as well as the transportation of waste, soil, and rock masses away from the sites". The success of the construction projects greatly depends on the coordination of both the on-site and off-site logistics (Ying et al., 2014). Browne (2015) argued that there are certain factors that

influence logistics activities, which are volume-to-weight ratio, value-to-weight ratio, special characteristics, time issues, key transport and storage considerations for products, and control of the supply chain. Browne (2015) grouped three main challenges in construction logistics, which are the challenge of place, the challenge of complexity, and the challenge of achieving higher levels of sustainability.

1. The challenge of place

According to Janné (2018), with the ongoing increase in urbanization trend, a large proportion of transport is taking place in the complex urban transport system. The traffic in urban areas is generally dense, where the challenge of place in construction logistics is influencing the construction project itself. Kooragamage (2015) stated that in congested cities or confined land space, construction projects have various additional problems when compared to construction projects in greenfield rural areas. Janné & Fredriksson (2019) argued that in order to reduce the impact on all stakeholder groups and to ensure the efficiency of construction project, construction materials deliveries to construction sites in urban areas need to be coordinated and managed properly and correctly. Therefore, to achieve good coordination of construction logistics and increase the performance of supply chain in projects located in densely populated areas, logistics activities need to be managed correctly. An effective construction logistics aims to provide a system framework that embrace appropriate trade-offs between cost and service in the supply chain, and other various factors that have impact on vehicle movements at construction sites, and it can be classified as cost-related and service-related factors (Ying et al., 2014).

2. The challenge of complexity

The second challenge in construction logistics is complexity. Gidado (1996) highlighted the continuous demands in construction industry such as cost and quality control, safety at workplace, deterrence of conflicts, advancement in technology, liberalization of economies, environmental impacts, and fragmentation of construction industry have resulted in a spiral and quick increase in the complexity of construction logistics processes. There are many stakeholders in construction industry. The engagement of different stakeholders within the construction supply chain makes the construction logistics operations more complex and not easy to handle. Bilgin et al., (2022) argued that the level of complexity is increased when there are many stakeholders

involved in a project, such as contractors, sub-contractors, sponsors, government, investors, suppliers, and funding agencies.

Kardes et al., (2013) highlighted that the structure of supply chain gets more complicated with myriad international suppliers, or a partnership that may include investors whether private and public from different countries as well as with diverse cultures. The complexity in construction projects is related to interdependencies in the midst of a large number of activities that are conducted by many different actors employing large sets of resources (Dubois et al., 2018). Fredriksson et al., (2021) pointed out that the current problem in cities is not the transport of construction materials as such, yet the problem is how to ensure accessibility and mobility for all stakeholders during the construction projects period. Therefore, it is important to understand complexity of construction logistics in a project, and how it is managed (Baccarini, 1996).

3. The challenge of achieving higher levels of sustainability

Construction logistics is heavily relied on large vehicles to transport deliveries to and from construction sites. As Brusselaers et al., (2022) argued that construction is heavily relied on logistics activities, therefore the environmental factor cannot be denied. Muerza and Guerlain (2021) argued that construction transport is responsible for up to 30% of freight movement in cities, with impacts in terms of emissions. Transportation is one of a major activity within logistics operations that have the biggest environmental impact, and construction transport is directly influenced by the way logistics is managed, organized, and handled in a construction project (Fredriksson & Huge-Brodin, 2022). Browne (2015) argued that it is possible to see how smaller vehicles will be able to reduce emissions by using alternative fuels, by means of electric vans for instance, however it is more complicated for large vehicles. The aim to achieve sustainable construction logistics is mandatory in order to minimize its associated risks.

2.2 Construction Logistics Management

Ghanem et al., (2018) defined construction logistics management as “the management of the process of delivering materials and resources required at a construction site in a productive way”. Productivity is one of the most important elements in managing construction logistics, which can be improved by adopting new technologies such as mobile-based application, materials management, and labor motivation, etc., (Almohsen & Ruwanpura, 2011). Management

of construction projects requires an integrated process that ensures that these integrated processes are completed on time, within budget and according to the specification of contract (Usman & Ibrahim, 2015). The collaboration and integration between multiple stakeholders in construction industry, such as contractors, architects, third-party logistics companies, governmental institutions, and financial institutions will result in creating an efficient logistics plan (Sobotka & Czarnigowska, 2005).

2.3 The effects that arise from construction logistics

The effects that arise from construction logistics are categorized as economic, environmental, and social effects. These effects might be good or bad for the economy, environment, and society. 30% of freight movements in cities and even more in terms of pollutant emissions is derived from transport of materials for construction projects (Guerlain et al., 2019). According to the report of Construction Logistics Group (2005), there are several consequences that are generated from a failure in managing construction logistics, important of which are:

- Creating unnecessary costs,
- Creating a poor image of construction developers,
- Inferior quality in construction,
- Prolonging the duration of construction projects,
- Increasing the risk to health and safety.

(Lundesjö, 2015).

2.3.1 Economic effects

From an economic perspective, construction logistics can bring positive effects when it is planned, coordinated, and managed correctly. Coordinated construction logistics can increase a construction company's profit margins (Byggföretagen, 2023), increase efficiency, innovation, productivity, and reduce costs (Bengtsson, 2019). Construction logistics can lead to economic losses as well if it is planned, coordinated, and managed incorrectly. For instance, if the construction material does not arrive on the construction site as it is scheduled, it will disrupt the project, and poor time utilization will result, the workers will not be able to work, which means it will lead to big losses for the construction developer. The workflow variability that resulted from difficulties in planning construction projects causes inefficiency in downstream processes that

will lead to delays and additional costs (Panova & Hilletofth, 2018). Delays issues in construction industry are caused by various factors which affect the whole construction project (Khoiry et al., 2018). When construction project is predicted to be delayed, decision-makers for the construction project have to analyze additional costs that need to be allocated to add more resources to prevent the predicted delays, to finish the project as it is planned (Lee, 2023).

Stockholding too many construction materials for a long time on the construction site will lead to high costs, leading to deterioration, damage, and waste, thereby creating losses for the construction developer. The developer has to reorder new construction materials to continue working, which will ultimately create additional costs. As Horman and Thomas, (2005) pointed out that material stockpiles can obstruct the performance in ways such as slowing problem detecting, hindering fast reconfiguration, and incurring storage costs.

However, these economic losses yielded from construction can be prevented by managing deliveries correctly, implementation of Just-In-Time (JIT) delivery concept, when delivering construction materials. The concept of JIT aims to ensure the supply of right materials in right quantity, in right place and at right time (Zhongfu & Jianshuang, 2008). In order to successfully manage a JIT strategy, the use of delivery management system can be applied, to monitor and control the flows of material and the use of available resources (Waddell, 2015).

2.3.2 Environmental effects

Brusselaers et al., (2020) argued that a large share of total traffic in urban areas is yielded from construction. The material deliveries to and from the construction site, if not coordinated and managed correctly, will result in various problems for the environment. From an environmental perspective, construction logistics yield emissions such as pollutants, greenhouse gas emissions, and material waste. Tao et al., (2022), argued that plenty of construction activities generate fine particles, and it is severely threatening to the physical health of construction workers. Sezer and Fredriksson (2021) emphasized that the activities from construction logistics become a source of significant environmental hazard if it is not managed appropriately. Renault, Guerlain & Ferreo (2019) argued that all the distribution that is related to the construction activities is often creating significant disturbances to daily life of residents, for instance, congestion, safety hazard, pollution, and noise.

It is very important that the environmental effects generated from construction logistics need to be reduced. Tischer et al., (2013) found that reducing environmental impacts in construction logistics can be achieved through implementing waste management plan which specifically leads to increase disposal logistics efficiency. Bengtsson (2019) stated that construction logistics is recommended as a means to enhance efficiency in transportation, reduce the use of material, and coordinate health and safety on-site.

2.3.3 Social effects

Fredriksson et al., (2021) argued that in urban areas, construction transport affects various stakeholders, such as residents, freight transporters, municipalities, shop owners, tourists, and businesses. Furthermore, it also creates social effects such as inconvenience to nearby residents and citizens, noise disturbance, noise vibration, disturbance in aesthetics generated from the new unnecessary traffic signs, limited public space for the residents and citizens, health risks, and safety risks, etc. Venås et al., (2020) pointed out that disturbances are the results of noise, vibration, and traffic density while road capacity is diminished due to road closures and redirections of traffic.

Gilchrist and Allouche (2004) discussed impacts and social costs associated with construction projects as below:

- "Traffic - (prolonged roads closure, detours, loss of parking space, additional fuel consumption, travel delay, increased traffic accident rate, accelerated deterioration of roads, and road rage).
- Economic activities - (loss of income, productivity reduction, loss of tax revenues, property damage).
- Pollution - (noise, dust, vibration, air/water pollution).
- Ecological/ social/ health - (surface/ subsurface disturbance, damage to recreational facilities, treating compromised physical/ mental health, reduced quality of life, restoration costs)"

According to Ebekozien et al., (2023), the engagement of various stakeholders in construction projects will indeed improve inclusiveness in decision making, sustainability of construction,

sustainable development, and team collaboration, as well as expediting transformation of integrated project delivery that leads to productivity and performance optimization.

2.4 Enhancing the performance of construction logistics

Almohsen and Ruwanpura (2011) argued that increasing productivity of labor force can be achieved through increasing overall productivity, and then construction companies would gain many more benefits from the projects. In order to reduce the negative externalities derived from construction logistics and aim to achieve effectiveness and efficiencies in the process, there are several ways to enhance the performance of construction logistics. Browne (2015) argued that two methods have been implemented in the UK, which are Construction Logistics Plans (CLP), and Construction Consolidation Centers (CCC).

2.4.1 Construction Logistics Plans (CLP)

The logistics planning in construction projects involves the movements of various materials and equipment from multiple sources to multiple consumption points in the manner of cost-effectiveness (Choudhari & Tindwani, 2017). As urban areas are evolving, the activities of construction logistics are also increasing. In order to manage material deliveries to construction sites in urban areas, there is a need to improve the control, coordination, and execution of construction logistics (Janné, 2018). Browne (2015) pointed out that CLP provides a framework to better manage all types of freight vehicle movements to, from, and within construction sites. Robbins (2015) defined Construction Logistics Plans as "a Construction Logistics Plan (CLP) is a document produced by the principal contractor that considers project constraints, identifies opportunities, and defines a management strategy for the logistics function".

Brown (2015) argued that there are several objectives of a CLP, which are as follow:

- CLP presents procurement of construction materials. These construction material resources are ordered from construction suppliers and delivered to construction sites,
- It presents waste generated from construction site and delivered to waste landfills,
- It helps in reducing the traffic congestion,
- It reduces unnecessary costs that might emerge from the construction project,
- It reduces bad environmental impacts,

- It identifies if the delivery hours can be shortened, or whether it needs to use construction consolidation center instead,
- It enhances the reliability of the performance of construction industry.

CLPs consider barriers associated with the location and physical layout of the site and is the most efficient method to manage the logistics functions (Robbins, 2015). However, if the planning for construction logistics is not planned and coordinated correctly, it will create disturbance for the workflow of construction projects. According to Voigtmann (2010), poor and insufficiently planned and non-coordinated processes in logistics are the consequence and reasons for the high number of unproductive actions and indeed it is going to disturb workflow on construction sites.

2.4.2 Construction Consolidation Centre (CCC)

Construction Consolidation Centre (CCC) is an advanced method in the construction industry, where they are used to manage the flow of construction materials to the construction sites and provide benefits to multiple stakeholders. According to Guerlain et al., (2019), a CCC is "an innovative approach, which aims at increasing the efficiency and effectiveness of logistics processes by reducing the number of deliveries". Browne (2015) defined CCC as "a distribution facility through which material deliveries are channeled to construction sites". When there are a large number of deliveries to construction sites, CCC are usually used to better organize and manage the flow of materials from suppliers to construction sites. Muerza & Guerlain (2021) also defined CCC as "CCC is a logistics solution that improves the performance of construction logistics and reduces the negative socio-economic and environmental impacts of urban deliveries, by reducing the congestion, energy use, and emissions and improving the working environment".

Lundesjö (2019) stated that during an ongoing construction project, there are a large number of material deliveries, therefore, CCC should be used:

- The construction materials transported to construction sites are of different types and volumes, transported in various heavy vehicles and derived from various suppliers.
- Many heavy vehicles that are transporting construction materials arrive in less than a truckload.

· Lack of coordination or even there is no coordination between deliveries, and suppliers, which are not keeping the time, which can lead to traffic congestion, and increases the queuing time to enter the gate to unload the materials.

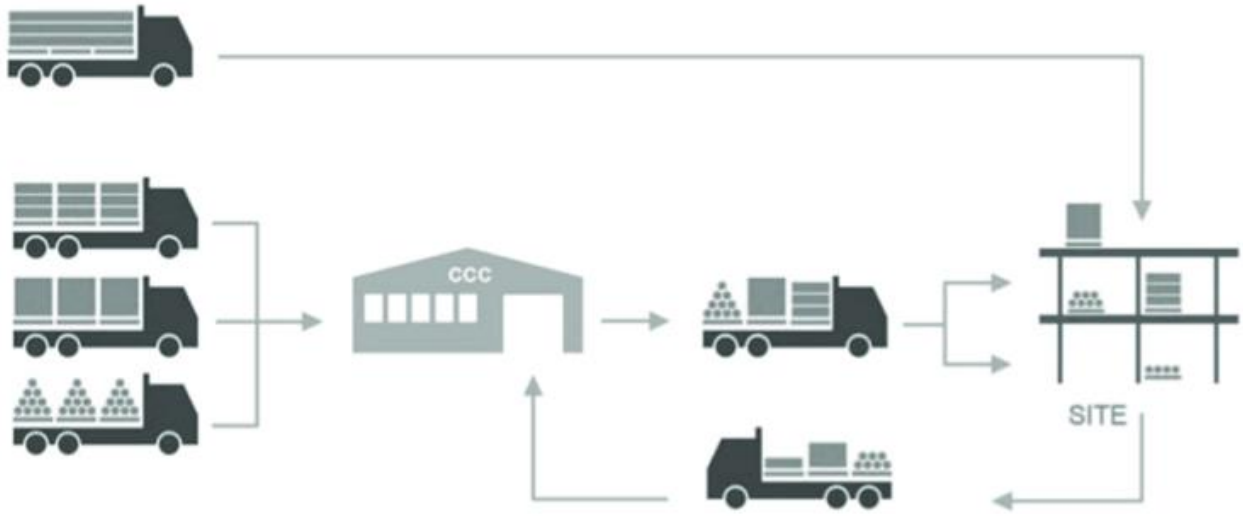
· Many heavy vehicles that depart from CCC with empty loads means that the capacity of the vehicles is optimized to manage reverse logistics.

· Generally, the material deliveries are often on a large volume, and it needs more storage space (not on construction site) for a long time.

· It is highly time consuming when different heavy vehicles unload construction materials using different types of equipment.

· The construction materials are derived from different suppliers, and it is often that the main contractor has low coordination over the large number of deliveries.

Figure 2.1: The concept of CCC



Source: (Muerza & Guerlain, 2021)

The picture above illustrates the implementation of CCC in construction industry. Materials are first transported to CCC by different suppliers where they are consolidated and from there, they are sent to the construction site. Some materials can also go back to CCC from the site. It helps in reducing traffic congestion, and negative environmental impacts.

The benefits of CCC as elaborated by Lundesjö (2015) are summarized in the table below:

Table 2.1: Benefits of Construction Consolidation Center

Number	Benefits of Construction Consolidation Center
1	Reduces traffic congestion around the sites, and in urban areas.
2	Easier to manage the material deliveries.
3	Reduces environmental impacts generated from the construction logistics.
4	Facilitates the rise of managing and handling reverse logistics.
5	Enhancing productivity
6	Increasing health and safety
7	Reduces the risks of accidents.
8	Reliability of deliveries increase.

Source: Authors generated.

The benefits of the use of CCC can be perceived by all stakeholders, and need to be located in the right location, which implies that there should be good access for delivering materials from suppliers. All the risks that might arise from the construction project can be reduced by implementing CCC.

2.5 Construction Supply Chain Management

As an essential part of Construction Supply Chain Management (CSCM), construction logistics is for both project management and cost aspects (Ying et al., 2016). Francart et al., (2019) stated that regarding buildings in particular, Swedish municipalities are responsible for all phases of planning in urban areas, including land attribution and building permits. The practice of SCM in the construction industry is needed. The Council of Supply Chain Management Professionals (CSCMP) defines supply chain management as “The planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities”. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies”.

From the definition of supply chain management by the Council of Supply Chain Management Professionals, supply chain management integrates processes, materials, services as well as information, from one supplier to another supplier, then to the focal company that produces a product and services for the customers, and supply chain management is also about managing the coordination of forward and reverse logistics flow in the business. Supply, operations, logistics and integration are the foundational elements in supply chain management (Wisner, Tan, Leong, 2019). Persson et al., (2010) argued that supply chain in the construction industry is different from supply chain in the manufacturing industry, in which the raw material is transported to production site, then it is processed into a finished product and later distributed to the customers. In the connection of supply chain management with the construction industry, SCM affects the construction industry.

Xue et al., (2007) discussed construction supply chain management (CSCM), as "Construction Supply Chain Management (CSCM) is the integration of key construction business process, from the demands of client, design to construction, and key members of construction supply chain, including client/ owner, designer, contractor, subcontractor, and supplier. CSCM focuses on how firms utilize their suppliers' processes, technology, and capability to enhance competitive advantage". Aloini et al., (2012) defined CSCM as "the coordination and the integration of key construction business both processes and members involved in CSC, extending traditional intra-enterprise activities in a management philosophy by bringing together partners who have the common goals of optimization and efficiency so establishing long-term, win/win, and cooperative relationships between stakeholders in a systematic perspective".

Vrijhoef and Koskela (2000) argued that there are four roles of SCM in the construction industry, which are:

Role 1: Increasing the connection between activities on site and the supply chain.

Role 2: Enhancing the supply chain.

Role 3: Transferring the activities derived from the construction site to the construction supply chain.

Role 4: Integration between construction site and supply chain.

It can be concluded that the coordination, collaboration, and management of construction stakeholders with construction companies and construction employees surely require the implementation of SCM. It is needed in the construction industry to reduce inefficiency and ineffectiveness on the construction site. The construction companies and construction employees are expected to conduct their work efficiently and effectively, and without generating disturbances to residents, pedestrians, and other stakeholders.

2.5.1 Characteristics of construction supply chain

The Supply chain in the construction industry has its characteristics. Vrijhoef and Koskela (2000) argued that the supply chain in the construction industry is characterized by several elements, which are:

- It is a converging supply chain that directs all construction materials to the construction site, and then on the construction site the incoming material is assembled into object. In construction supply chain, the factory of construction is set up around a single product.
- A temporary SC produces one construction project, and it has been through repetitive reconfiguration of project organizations. Which in result, CSC is represented by fragmentation and instability, specifically the separation or gap between the architecture design and the construction building object.
- It is particularly make-to-order supply chain, together with every single project that creates a new product. The level of repetition is low; however, the process could be similar for particular projects.

From the characteristics of the supply chain in the construction industry discussed by Vrijhoef and Koskela (2000), we can grasp that these characteristics have their function to improve the performance of the supply chain in the construction industry. In order to achieve short-term and long-term goals, improving collaboration and performance of construction supply chain is mandatory (Eriksson, 2010).

2.6 The importance of rules and regulations for construction logistics

To set the stage for studying the rules and regulations that should govern construction logistics, first it is important to define both the terms. Because for any rules and regulations there must be

some regulatory structure in written form. “In the field of public policy, regulations refer to the promulgation of targeted rules, typically accompanied by some authoritative mechanism for monitoring and enforcing compliance” (Britannica, 2024). According to Cambridge English Dictionary, regulation is “an offcial rule or the act of controlling something” (Cambridge English Dictionary, 2024). From both the definitions it can be deduced that rules come under the defintion of regulations which can be any guidelines that shows the way things are to be done. Hence, regulations for construction logistics can be simply defined as those rules that govern the various logistic activities on and off a construction site. It can be a written document from the national or state governments which elaborates the various rules for different logistics activities to be carried out in that proper way.

As stated earlier, construction is a multifaceted process that requires substantial investments and the contribution of several stakeholders throughout the lifecycle of the project. Due to the presence of many stakeholders, it is obvious that there would be many obstacles in the operation of logistic activities.

Smart Construction Logistics (2020) divides these obstacles into five main categories:

“Awareness: Proper awareness is mandatory in order to understand how innovation can be achieved in construction logistics.

Understanding: To transform construction logistics, for the decision-makers it is essential to understand the changes that are required and their implications. However, limited knowledge about innovation in construction logistics can lead to uncertainties.

Willingness: In construction logistics, conflicting objectives among the multiple stakeholders limit the drive to reach innovation

Ability: Insufficient financial and poor skill levels of human resources may lead to failure in the ability to transform construction logistics. For instance, failure to secure permits or acquiring low-emission vehicles can restrict the changes.

Implementation: At the execution stage, construction logistics is impeded by the lack of coordination at the municipal level and insufficient customer demand. For example, supply chain partners are involved too late in the planning process and thus they miss the opportunity to be innovative in the supply chain strategy”.

Therefore, the presence of a proper governance mechanism or a thorough set of regulations is indispensable for construction logistics activities. This governance mechanism differs from country to country as well as in cities. For instance, Stockholm uses a Construction Logistics Center (CLC) with a logistics coordinator on the top to coordinate and administer all logistic activities on and off the construction site. Proper rules govern the transport and storage of materials, loading and unloading zones are identified, and a contractor is held responsible for logistics planning to book all the shipments in an LC's IT system (Smart Construction Logistics, 2020). Similarly, the city of Vienna governs the logistics process with an Environmental Impact Assessment (EIA) which is mandatory for all big projects. Introduced by the European Commission, EIA deals with tackling the negative environmental effects of construction logistics. Likewise, Amsterdam has a different set of tools to govern construction logistics. In this case, before awarding a tender, the contractor is responsible for presenting a construction logistics plan which must be approved by the municipality. After approval, a permit is issued to the contractor for using public space and transporting materials to the construction site (Smart Construction Logistics, 2020).

Nevertheless, it is pertinent to mention here that the vision of good or improved construction logistics is lacking at the strategic level. In the above-mentioned examples, the adopted strategies exist for specific projects and do not form a part of the bigger decision-making process at the state level which is seemingly an overwhelming hurdle in good construction logistics. It is therefore important to create a shared vision of good construction logistics at the policy-making level to achieve efficiency, sustainability, and overall safety (Smart Construction Logistics, 2020).

2.6.1 The existence of regulations for the Construction industry in Gothenburg

In this part, the existence of a regulatory structure for the construction sector in the city of Gothenburg will be discussed.

The main regulations that are governing the building construction in Gothenburg are Boverket's building regulations (2011:6). They work under a constitution which contains regulations and general advice for the Planning and Building Act (2010:900), PBL, and the Planning and Building Ordinance (2011:338), PBF (Boverket, 2020). These regulations apply to both the construction of new buildings as well as the demolition of old ones. The Housing Authority's

regulations and general advice (2011:10) contain rules about load-bearing capacity, statute, and durability of load-bearing constructions, whereas regulations regarding lifts, escalators, motorized gates, and devices for waste are found in the same text under section (2011:12). Similarly, the Housing Agency's regulations and general advice (2011:16) contains provisions about ventilation system and provisions regarding broadband connection can be found under section (2017:1) (Boverket, 2020). Moreover, there are two authorities other than the Housing Authority which are responsible for the notification of the design of buildings. They are the Swedish Work Environment Agency and the Swedish Agricultural Agency.

Under some special circumstances in this constitution, the Building Board may allow minor deviations from the regulations. In this case, the board first examines the building permit and whether any change in the requirements can affect the technical satisfaction of the project. If the deviation is technically satisfactory, the board issues a clarification notice of acceptance. Additionally, materials and products used in a building must meet the requirements of these regulations which the client may itself choose as long as they fulfill an economically reasonable lifespan according to law (Boverket, 2020).

According to section (BFS 2011:26), construction or demolition sites must have special arrangements that deny access to unauthorized persons, and make sure that the site is protected against dust, noise, and any unusual situation like fire. The section also requires them to take measures that ensure the protection of residents against accidents when heavy machinery, vehicles, or materials are being transported to the site. The Swedish Environmental Protection Agency issues rules on noise reduction, whereas the Work Environment Agency issues rules on ill health and accidents during the ongoing construction. To make certain that both the design and execution are satisfying the current regulations, it is of vital importance for the developer at the beginning of construction to allocate each task to relevant competence, as a basis for the control plan. (BFS 2011:26) also covers rules about the crucial work of blasting (if required) and emphasizes that a blasting plan and a blasting journal are mandatory before a blasting work, which must specify times, risks, and protective measures. The plan should also provide information about the nature of explosive materials, drilling work, and the methods of covering and cordoning off. It is pertinent to mention here that rules on blasting are issued by the Swedish

Environment Authority. The constitution also comprehensively contains special regulations regarding people with reduced mobility (Boverket, 2020).

Table 2.2: Regulations related to construction industry in Gothenburg.

No.	Regulations related to construction industry in Gothenburg
1.	Boverket's building regulations (2011:6)
2.	Planning and Building Act (2010:900)
3.	Planning and Building Ordinance (2011:338)
4.	The Housing Authority's regulations and general advice (2011:10)
5.	The Housing Authority's regulations and general advice (2011:12)
6.	The Housing Agency's regulations and general advice (2011:16)
7.	BFS 2011:26
8.	BFS 2011:26

Source: Authors generated.

2.6.2 Stakeholders in Construction Industry

There is a high engagement and interaction of stakeholders to increase and improve the effectiveness of governance in the construction industry. Governance refers to a category of social facts, namely the processes of interaction and decision-making among the actors involved in a collective problem that led to the creation, reinforcement, or reproduction of social norms and institutions (Hufty, 2011). In construction industry many stakeholders are involved, each playing their role with an aim to achieve sustainable construction logistics. Fredriksson et al., (2021) pointed out that construction stakeholders can be internal or external to the project, internal stakeholders are those who are directly involved in construction projects and external stakeholders those who are affected by construction activities significantly (for instance, residents, road users, tourists, neighbors, local authorities), yet they are not part of the construction project. In this part, we are going to elaborate internal stakeholders that are directly involved in construction projects in Gothenburg. Multiple stakeholders that are involved in construction logistics focusing on Gothenburg, are Boverket, Gothenburg municipality, Gothenburg city, Västra Götaland län, Västtrafik, residents, constructions employees, subcontractors, construction material suppliers, logistics service providers, Sveriges Kommuner

och Regioner, Skatteverket, Recycling stations, Lantmäteriet, Länsstyrelsen Västra Götaland, etc.

Table 2.3: Important Stakeholders in construction industry in Gothenburg

Stakeholders	**Explanation**
Boverket	Swedish National Board of Housing, Building, Constructions and Planning urban development.
Göteborg stad	Develops planning for the city.
Lantmäteriet	Land surveyor which maps the country.
Sveriges Kommuner och Regioner (SKR)	An organization which gathers all municipalities and regions in Sweden.
Västtrafik	Coordinates public transportation.
Trafikverket	Responsible for road infrastructure.
Göteborgs kommun	Responsible for development of Gothenburg municipality.
Logistics Service Providers	Outsourcing companies providing transport services
Contractors	Main developers often divide work among several contractors

Source: Author generated

2.7 Summary of Literature Review

The literature review starts by discussing the importance of construction logistics and explores the role of construction logistics in urban development keeping in view its importance, challenges, and implications. Firstly, it identifies that construction logistics is an important component of a massive construction industry, involving complex set of activities such as material supply, storage of material on site, and waste handling etc. The complex nature of managing logistics activities both on and off construction sites has been explained by making distinction between on-site and off-site logistics. The study also investigates factors affecting

logistics activities by discussing variables such as volume-to-weight ratio, value-to-weight ratio, as well as key transport and storage considerations.

Secondly, the study acknowledges the importance of supply chain management in the construction industry, which can prove vital in enhancing the overall efficiency of construction logistics. It has been discussed that the implementation of SCM is aimed at improving efficiency in construction and fostering collaboration among the various stakeholders. The study further explores the various economic, environmental, and social impacts of logistics activities, particularly associated with transportation of material.

Afterwards, the literature review investigates two prominent approaches implemented for the purpose of enhancing the performance of construction logistics, i.e., Construction Logistics Plan (CLP) and Construction Consolidation Centers (CCC). Both these strategies have been tested in mega projects to streamline logistics operations for reducing the negative impacts such as congestion and costs. In order to ensure efficient and sustainable logistics operations, the literature emphasizes the importance of proper rules and regulations for construction logistics. In Sweden, Boverket's building regulations govern the construction industry, however, other authorities such as Swedish Environmental Protection Agency and Swedish Work Environment Agency are also responsible for issuing regulations related to noise reduction, health, and safety during construction activities. Similarly, the role of important stakeholders in the construction sector has also been highlighted. Lastly, the study sheds light on the construction industry in Gothenburg and important stakeholders.

The following table illustrates the summary of literature review

Table 2.4: Summary of literature review

Headings	Authors	Results
Construction logistics and its challenges	Ghanem et al., (2018) Dubois et al., (2017) Browne (2015) Sezer and Fredriksson (2021) Janné (2018) Janné & Fredriksson (2019) Gidado (1996) Bilgin et al., (2022) Kardes et al., (2013) Dubois et al., (2018) Fredriksson et al., (2021) Brusselaers et al., (2022) Muerza and Guerlain (2021) Fredriksson & Huge-Brodin (2022)	The challenge of place The challenge of complexity The challenge of sustainability
Construction Logistics Management	Ghanem et al., (2018) Almohsen & Ruwanpura (2011) Usman & Ibrahim (2015) Sobotka & Czarnigowska (2005)	Material delivery in a productive way Requires integrated processes Collaboration between stakeholders is necessary

Effects arising from Construction Logistics	Guerlain et al., (2019) Construction Logistics Group (2005) Lundesjö (2015) Panova & Hilletofth, (2018). Bengtsson, (2019) Horman and Thomas (2005) Zhongfu & Jianshuang (2008). Waddell (2015) Brusselaers et al., (2020) Tao et al., (2022) Sezer and Fredriksson (2021) Renault, Guerlain & Ferreo (2019) Venås et al., (2020) Gilchrist and Allouche (2004) Gilchrist and Allouche (2004)	Economic effects Environmental effects Social effects

Enhancing the performance of construction logistics	Almohsen and Ruwanpura (2011) Browne (2015) Choudhari & Tindwani (2017) Janné (2018) Robbins (2015) Voigtmann (2010) Guerlain et al., (2019) Muerza & Guerlain (2021) Lundesjö (2019)	Increasing overall productivity Construction Logistics Plan Construction Consolidation Center
Construction Supply Chain Management	Ying et al., (2016) Francart et al., (2019) Wisner, Tan, Leong (2019) Persson et al., (2010) Xue et al., (2007) Aloini et al., (2012) Vrijhoef and Koskela (2000)	Planning and management of all logistics activities Coordination and collaboration with channel partners Management of reverse logistics
Importance of Regulations for Construction Logistics	(Britannica, 2024) (Cambridge English Dictionary, 2024) Smart Construction Logistics (2020)	Promulgation of targeted rules to ensure compliance Five categories of obstacles in logistics operations Presence of a proper governance mechanism is essential

Regulations for construction industry in Gothenburg	Hufty (2011) Boverket (2020)	Boverket's building regulations Housing agency's regulations and general advice The Swedish Environmental Protection Agency's Regulations Work Environment Agency's rules

Source: Authors generated.

3. Methodology

This chapter accounts for the methodology used that how this thesis is conducted and the reason why the authors are using such methodologies. The chapter includes a case study selected for this thesis. The aim of this chapter is to provide an understanding for the readers of the process of conducting this thesis.

3.1 Research Philosophy

When conducting thesis, methodology is needed to help how to construct and conduct the thesis. In research methodology, a research paradigm is generally required to help construct the thesis. Collis and Hussey (2013) defined a research paradigm as a framework that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge. There are two research paradigms that have been implemented in many research works, first is positivism and second is interpretivism.

"Positivism is a paradigm that originated in the natural sciences. It rests on the assumption that social reality is singular and objective and is not affected by the act of investigating it. The research involves a deductive process with a view to provide explanatory theories to understand social phenomena" (Collis and Hussey, 2013). Since the origin of positivism is from natural sciences, positivism is generally implemented in quantitative research, which is based on statistical analysis from the data collection for quantitative research. "Interpretivism is a paradigm that emerged in response to criticisms of positivism. It rests on the assumption that social reality is in our minds and is subjective and multiple. Therefore, social reality is affected by the act of investigating it. The research involves an inductive process with a view to provide interpretive understanding of social phenomena within a particular context" (Collis and Hussey, 2013).

In 2020, Alharahsheh and Pius argue that "The interpretivism would enable researchers to treat the context of the research and its situation as unique considering the given circumstances associated as well as participants involved". Interpretivism paradigm is often used in qualitative research methods, where the data collection of qualitative research is interpreted and analyzed.

Table 3.1: Approaches within positivism and interpretivism

Positivism	**Interpretivism**
Quantitative	Qualitative
Objective	Subjective
Scientific	Humanist
Traditionalist	Phenomenological

Source: Collis and Hussey (2013)

The paradigm that is most relevant to this thesis can be argued to be interpretivism, as the data collection and analysis of this thesis is based on qualitative approach. The authors conducted interviews with the interviewees which have been contributing to construction industry in Sweden. The authors also aim to obtain a social dimension to the situation of construction logistics in Sweden, and to view our interviewees experiences and point of view and as well as perception about construction logistics in Sweden, aligned with the interpretivism paradigm. Despite the paradigm that is most suitable for this thesis is interpretivism, the positivist paradigm in this thesis cannot be ignored, as this thesis applies scientific journals that previously have been studied.

3.2 Research Process

Qualitative research methodology is applied for this thesis. A qualitative research methodology emphasizes data collection from interviews, focus groups, and participant observation and analyzing the collected data. Qualitative research aims to generate deep insights concerning particular topics, and it does this through a considered engagement with places and social actors (Bryman et al., 2021).

This thesis consists of several theoretical frameworks that are based on scientific journals, reports, research, and books. The use of search engines through Google, google scholar, Goteborg's universitetsbibliotek, and a case study of Karlatornet in Gothenburg, also have contributions for this master thesis. When searching for information keywords used for this thesis, such as construction industry, construction logistics, construction logistics plans, construction consolidation centers, supply chain management, construction logistics

management, boverket, etc. The literature review in chapter 2, provides knowledge of the theoretical frameworks that are relevant for the construction logistics.

When the authors gained knowledge about the main topic concerning construction logistics, then the data collection part began. The data collection for is conducted through collecting both primary and secondary data. Valuable information from the primary and secondary data is gained and this valuable information contributes to this thesis.

3.3 Research approach

This master thesis applies qualitative research method. The literature review together with the findings of data collection were continuously contributing to the development of the study in construction logistics as well as during the whole process of writing this thesis. The main objective of this study is to find answers to the following research questions:

RQ1: *What kind of rules and regulations have been implemented by the city of Gothenburg to influence the way logistics activities are carried out in construction projects?*

RQ2: *Which type of logistical challenges Serneke faced during the construction of Karlatornet and what strategies were adopted to optimize logistics operations in the project?*

This research will mainly focus on the construction logistics in Gothenburg. As stated earlier, most of the previous research has been conducted on construction logistics solutions, the ambition of this study is to find if there is any gap which is to be studied. Therefore, a new area of study was selected which are the regulations governing construction logistics and the role they can play in efficient logistics management. The city of Gothenburg was selected to see the existence of regulations and their impacts on the logistics operations. Moreover, a case study of a large-scale construction project called Karlatornet has been added to get more insights about its logistics operations and the associated impacts. The reason behind such a selection is to find the role of both public and private sectors in controlling logistics operations in the city.

Though the research will be based on both primary and secondary data. However, a major portion of the research will be based on primary data. For this purpose, semi-structured interviews will be designed with various stakeholders, important of them are Boverket, Gothenburg municipality, Developers, Contractors, and Transport providers. A semi-structured interview will be designed, and questions will be asked from concerned people. These interviews will only focus on the

existence of regulations for construction logistics in Gothenburg. The interviews will explore whether any regulations about construction logistics exist in Gothenburg. Then the implications of these regulations will be explored. Similarly, interviews will be conducted with responsible people from Serneke, which is the main developer of the project. The interviews will then be analyzed to get the results of the study.

3.4 Case study research

A Case study is chosen to conduct this thesis, which is an in-depth analysis case study. The aim of case study is to obtain a holistic comprehension of the complexity of construction logistics in Gothenburg. Case studies are generally applied in different disciplines, such as economics, business, sociology, medicine, and psychology. Collis and Hussey defined a case study as "methodology that is used to explore a single phenomenon (the case) in natural setting using a variety of methods to obtain in-depth knowledge". Case study research that is used for this thesis is focusing on a prominent construction project in Gothenburg called Karlatornet. The methodology used for case study research for this thesis are semi-structured interviews, reports, qualitative data, and observations. Abebe (2023) argues that there are five types of case study, which are: illustrative case studies, explanatory case studies, exploratory case studies, longitudinal case studies, and comparative case studies. A type of case study that is suitable for this thesis is exploratory case studies, it is because:

- This thesis explores and elaborates a complex issue of construction logistics in Gothenburg city and Karlatornet by defining the roles of public and private sectors.
- In-depth analysis to comprehend the challenges and the underlying factors of the complex issues or phenomenon.

3.5 Data collection

Data collection method is very important in writing thesis. It is because data collection is about how the information is collected for the thesis, and how the collected data will be used for analysis. Paradis et al., (2016) stated that in qualitative research method, there are five types of data collection methods, which are:

- Surveys,
- Interviews,

- Focus groups,
- Observations,
- Textual or content analysis.

The authors chose interviews for the data collection method for this thesis. Collis and Hussey (2013) defined “an interview as a method for collecting primary data in which a sample of interviewees are asked questions to find out what they think, do, or feel”. To collect data for this thesis, the authors used both primary data and secondary data. The primary data is collected through interviews, emails, phone calls and company visits. The interviews conducted were semi-structured interviews.

The following table shows the primary data collection that authors have collected via emails, video call meetings, phone calls etc.,

Table 3.2: List of people contacted.

Company	**Name of contact person**	**Position**	**Contact type**	**Date**
University of Gothenburg	Emil Gurbani	Responsible for overall project management of the new building at Handelshögskolan Gothenburg	Email, phone, and Teams	8-03-2024 11-03-2024
Stadsmiljo Gothenburg	Carina Abrahamsson	--------	Email	15-03-2024
Linkoping University	Anna Fredriksson	Professor in Construction Logistics	Zoom meeting	18-03-2024
Serneke	Viktor Thun	Project manager for construction of the new building at Handelshögskolan Gothenburg	Email	18-03-2024 22-03-2024
Serneke	Martin Andersson	Blockchef logistics	Email	19-03-2024
Bygglogistik	Emil Jonasson	VD	Email	25-03-2024
Serneke	Julia Hope	Ex- Arbetsledare Logistics, Serneke	Zoom	02-05-2024
Stadsbyggnad	Maria Riknar	Kund service	Email	26-03-2024
Gothenburg, Urban Environment Department, Urban Freight and Waterways	Alexandra Bakosch	Project Manager, Transport of Goods	Email	04-04-2024
Bygglogistik	Patrik Lindgren	Project manager	Email	10-04-2024

Source: Authors generated.

Secondary data collected as well for writing this thesis. Collis and Hussey (2013) defined secondary data as “data collected from an existing source, such as publications, databases and internal records”. The secondary data is collected through scientific journals, books, business topics in professional business journals, data from the related companies or institutions in construction industry in Gothenburg.

3.6 Validity and Reliability

There are factors that influence the quality of the study, which are validity and reliability. This section elaborates the validity and reliability for research. Collis and Hussey (2013) argue that “Validity is the extent to which a text measures what the researcher wants it to measure, and the results reflect the phenomena under study”. The authors need to measure if there are any research errors, poor samples that can mislead the accuracy of validity. In business research, a term of construct validity is crucial. Construct validity refers to problems that are not able to be directly observed, such as motivation, satisfaction, or dissatisfaction, driven, worriedness, anxiety, etc. Collis and Hussey (2013) defined reliability, “reliability refers to the accuracy and precision of the measurement and the absence of differences if the research were repeated”. Reliability is important in research, because reliability can assess whether the future research can reproduce the similar results by applying the same theoretical frameworks and methods.

3.7 Ethical conduct and trustworthiness of the study

This master thesis is conducted ethically. Authors approached all interviewees via phone calls or emails. Authors informed all the interviewees that the interviews will be used as primary data collection for this thesis. In qualitative research method, trustworthiness of the study is applied. The trustworthiness of the study is required to evaluate the quality of the study or research. In the mid-1980s, Guba and Lincoln proposed the concept of trustworthiness for qualitative research method. Guba and Lincoln presented five criteria to develop trustworthiness in qualitative study, which are credibility, dependability, confirmability, transferability, and authenticity.

“To develop trustworthiness in qualitative research, Lincoln and Guba (1985) initially presented four criteria: credibility, dependability, confirmability, and transferability. In 1994, Guba and Lincoln added a fifth criterion, authenticity” (Cope, G.D., 2014).

Credibility refers to the validity of data collected for the research. “Credibility is enhanced by the researcher describing his or her experiences as a researcher and verifying the research findings with the participants” (Cope, G.D., 2014). Dependability refers to the persistency of the data in a likely situation. The data in similar circumstances should be consistent. Confirmability refers to the researcher’s ability to confirm that the data collected for the research is as the representation of the responses from interviewees / participants, and not researcher’s point of view. Authenticity refers to the ability of researchers to interpret and expresses participants’ expressions and feelings in a truthful way. Transferability refers to empirical findings that enable it to be reapplied to other conditions.

Trustworthiness is a very crucial aspect in qualitative research methods. Without trustworthiness, it will be hard to assess the quality of a qualitative study. Adler (2022) argues that “Regardless of the approach of the researcher, the key to trustworthiness of a qualitative study is transparency, and by transparency, I mean that not only should the research techniques be precisely spelled out, but also that the epistemological and theoretical bases of the work must be made explicitly apparent”.

4. Empirical Findings

This chapter presents the empirical findings obtained from the interviews and related literature. For the sake of clarity and better understanding the chapter has been divided into two parts. The first part focuses on the case of Gothenburg and the second part explains the case study of Karlatornet. In the first part the role of Gothenburg city has been discussed in devising and implementing rules and regulations for construction logistics activities. The second part explains the logistical challenges faced and the strategies implemented by Serneke in Karlatornet to optimize construction logistics operations. Thus, the chapter finds out the role of both private and public sectors in managing construction logistics.

4.1 Empirical findings about regulations in Gothenburg

This part illustrates the existence of regulations about construction logistics in the city of Gothenburg. The findings show the role Gothenburg city plays in regulating construction logistics activities.

4.1.1 Regulations about land use

Keeping in view the importance of an effective management of construction logistics, it is essential that a set of regulations must exist in the city of Gothenburg. Fredriksson (2024) emphasizes that it is difficult to say that a whole set of regulations is currently existing in written form like a constitution which govern construction logistics in Gothenburg, however, the city gives directives related to certain activities like traffic shutdown. Earlier, in the literature review it can be seen that there is a proper constitution containing sections and sub-sections about regulations which are made by Boverket for construction of buildings. All stakeholders such as developers, contractors, and transporters must follow the rules written in the constitution prior to start working on a project. If regulations can be seen in the form of a written document like the one mentioned above, then city authorities do not have any such written rules for construction logistics. However, Fredriksson (2024) says that there are certain rules and regulations about logistics activities, which are developed by the authorities to manage construction logistics.

According to Bakosch (2024), regulations mainly depend on land ownership, for instance, if the city/municipality owns the land, then regulations can be enforced through land use instructions.

These instructions serve to guide and control the use of land to ensure that construction activities match urban planning objectives. He further explains that the City Development Administration (Exploateringförvaltningen) is responsible for the Municipality's land and its use. It is also responsible to ensure the development of land in a way that encourages sustainable expansion of Gothenburg in the long run. On the other hand, if the land is privately owned, then the city has no authority over logistics operations. Bakosch (2024) explains that this diverse ownership structure features the most difficult challenges in regulating construction logistics in Gothenburg. He adds that it can be seen in all big projects that most of the initiatives have been taken privately by construction companies to regulate logistics activities. A notable example in this regard is the construction of Karlatornet in Gothenburg, where a Construction Consolidation Hub (bygglogistikcentra) was established by Serneke, a private company, for consolidation of material flows. This type of initiative represents a practical approach by private companies like Serneke to streamline transportation and reduce environmental footprints associated with logistics operations.

4.1.2 Regulations about transport

The city intervenes in the logistics of a construction project only if it is disrupting the traffic network. It is the responsibility of the production manager to explain the traffic plan before the initiation of the project that how they are going to re-direct transport routes like pedestrians, cyclists, and public/private transport throughout the construction process, which must be approved by the city (Bomb & Haraldsdottir, 2017). Furthermore, in case of any major re-routing of public transport, the city has made it mandatory for the project to inform public transport operators eighteen months prior to the beginning of construction work to avoid any inconvenience. The city has also made a special task force known as System och Trafikföringsprinciper (SOT) whose sole responsibility is to facilitate communication between different construction projects (Bomb & Haraldsdottir, 2017). Due to the absence of formal regulations, there are a multitude of inherent challenges in managing construction logistics. For instance, there are concerns about vehicle movement to and from the construction site impacting the urban environment and population, therefore, the city administration is currently looking into limiting vehicle movements. This can possibly be achieved through a high level of consolidation

and fill rates per vehicle, optimizing routing to minimize unnecessary trips, and establishing central hubs for material distribution (Bakosch, 2024).

Janné (2024) explains, "*there are some passages on construction logistics in the municipal freight plans, but mosty the issue is pushed towards the contractors to solve".* He further describes that there were some construction logistics plans in Stockholm for certain areas like Södermalm, and Norra Djurgårdsstaden, however, it wasn't encompassing all of Stockholm or even the central parts of the city. He is of the view that the city mostly forgets about construction transport when they introduce freight transport measures. Julia Hope, a former Arbitsledare logistics at Serneke also confirmed that during the construction of Karlatornet, the city municipality had no specified role to play except that they were contacted whenever there was a need for traffic shutdown. In that case it was compulsory to inform municipality first (Hope, 2024). This stance was also validated by Emil Gurbani who was responsible for the project management of the new building of Handelshögskolan. According to Gurbani (2024), the decisions about routes that should be taken to access the construction site, safety, and working time are usually handled by the building company and the property owner**.**

4.1.3 Upcoming plans of the city administration to enhance construction logistics

Bakosch (2024) highlights that the city of Gothenburg is deeply committed to advancing sustainability and addressing climate change through various initiatives. In line with national and international goals, Gothenburg has signed agreements like The Paris Agreement, and Agenda 2030 whose key objective is the transition towards climate neutrality by 2030. In pursuit of these goals the city considers construction logistics as an integral part of the policymaking in the future. The city is keen on contemplating over optimization of construction logistics given its significant impact on environment and waste generation. By prioritizing initiatives like Construction Logistics Hubs (Bygglogistikcentra), Gothenburg aims to streamline material flows, minimize transportation-related emissions, and reduce wastes in construction process (Bakosch, 2024).

He further adds that the City Administration is currently working on exploring strategies to enhance various aspects of construction logistics like creation of a depo or a central hub to consolidate materials and the City's responsibility in this regard. One key aspect of their strategy

is to look into the potential for sharing masses between projects. This approach mainly aims to minimize the need for transporting materials to and from the hubs to reduce costs and environmental impacts associated with logistics operations. The emphasis on creating mass sharing reflects a forward-thinking approach to address logistical challenges in construction as the reuse of materials across different multiple projects will optimize resource utilization. Additionally, the strategy also promotes circular economy principles within the construction sector. However, there is no evidence of Gothenburg city working in collaboration with construction companies to achieve efficient construction logistics unlike the city of Stockholm, where a CCC was established on public-owned land.

The key stakeholders in construction logistics which mainly include the construction companies, and transporters are agreed upon the fact that managing construction logistics is highly needed in today's world, however, less tangible actions have been seen so far in Gothenburg. This has so far only prompted the establishment of a "Construction Logistics Group" in Gothenburg in the wake of acknowledging the necessity to manage construction logistics and the challenges it is posing within the industry. The Construction Logistics Group consists of various stakeholders who will exchange their insights and expertise aimed at enhancing knowledge and practices in construction logistics. As the industry is keenly considering the climate and sustainability issues, the group has a strong focus on addressing these pressing concerns. By prioritizing discussions related to digitalization, electrification, and reuse in relation to construction logistics, the group is making collaborative efforts to efficiently utilize modern technology and practices to minimize negative externalities and promote efficiency throughout the construction process (Bakosch, 2024).

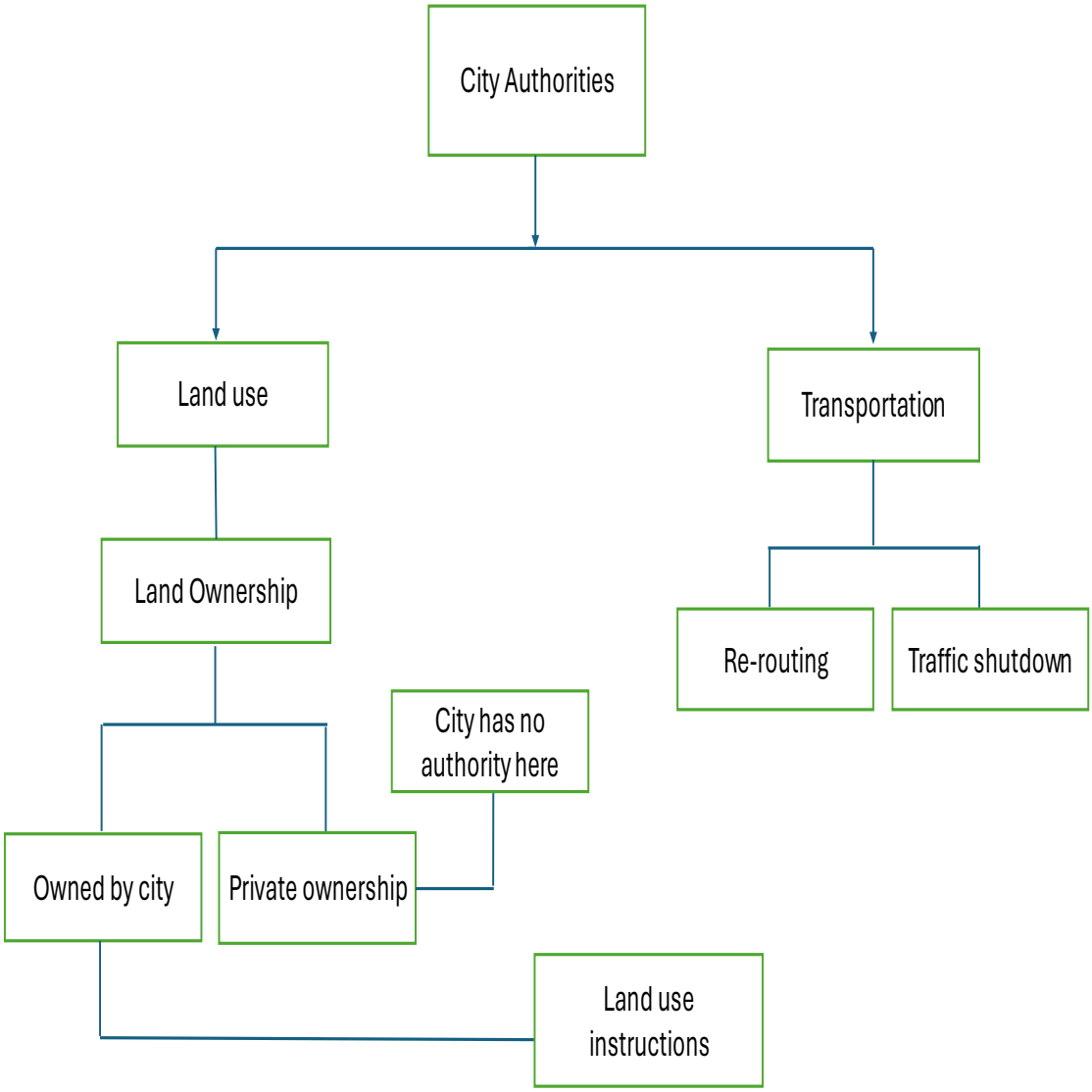
4.1.4 Summary of empirical findings about Gothenburg

The findings of this section can be summarized as follow:

- The city of Gothenburg lacks a formal structure in written form describing the rules and regulations governing construction logistics.
- The city relies on certain directives specifically related to land use and traffic management. Land use depends on land ownership, where the city plays a role only if it owns the land.

- City intervenes in the process when construction disrupts traffic.
- Gothenburg city is committed to sustainability and is exploring strategies to enhance construction logistics.
- The city is thinking about creating central hubs.
- Major initiative till now is making of Construction Logistics Group.

Figure 4.1: Summary of the role of city authorities in regulating construction logistics.



Source: Authors generated

4.2 Case study: Karlatornet

In this section, empirical findings about construction logistics in Karlatornet are presented. The rationale behind selecting this case study is that large-scale projects like Karlatornet need some unique actions for accomplishing the logistics tasks involved in the construction process. Secondly, from the empirical findings in the case of Gothenburg, it was revealed that building companies themselves are solely responsible for devising and implementing rules about construction logistics. Therefore, this project was chosen to see the logistical challenges faced by Serneke and the rules and regulations implemented to tackle them.

4.2.1 The development of Karlatornet

In 2017, Serneke aimed at securing a building permit for what would become the tallest structure in Scandinavia, situated in Lindholmen, Gothenburg. The building is planned to have 74 floors consisting mainly of residential apartments. A unique characteristic of the building is that it undergoes a twist from the 48th to the 68th floor, resulting in slight variations in the fourth plan (Andersson & Månsson, 2017). It has a height of 246 meters, containing 611 apartments, hotels, offices, and sky bars. With the construction of Karlatornet, a new district called Karlastaden came into existence (Serneke, 2023).

Table 4.1: Timeline for the development of Karlatornet

Year	**Accomplishment**
2004	First real estate acquisition was made for the establishment of Karlastaden.
2007	The plan for the new district of Karlastaden was presented.
2014	The architectural competition was won by Skidmore, Owings, and Merrill (SOM) to design the new tallest building of Scandinavia at Lindholmen, Gothenburg.
2016	Sales of the apartments started
2017	The plan of a new district got a legal force.
2018	Piling and foundation work started.
2020	By gaining 50 percent shares, Balder AB became a partner with Serneke in the project.
2022	Karlatornet reached 60 floors with a height of 193 meters.
2023	Many apartments are ready to move in
2024	The project is almost in the completion stage

Source: (Serneke, 2023)

4.2.2 Logistical challenges and implemented regulations

In building a tall structure like Karlatornet, logistics play a crucial role in the construction process. The reason is that logistics activities are simpler if the building is lying flat, however, the vertical nature of the high-rise construction adds complexity due to the density of space in height (Andersson & Månsson, 2017). Moreover, the location of Karlatornet, which is at a short distance from the city center adds another challenge, as traffic congestion becomes a significant constraint for deliveries. Hence, from the onset of the project, logistics was identified as a significant challenge in project planning (Serneke, 2023). The following key challenges were identified by the logistics department of Serneke, and regulations were made accordingly to tackle them.

4.2.3 High-rise construction and impacts of weather

According to Azad (2020), the problem with high-rise buildings is that weather affects the logistics activities severely. In high-rise building projects like Karlatornet, weather conditions play a crucial role in affecting the production time, because wind and logistics have severe impacts on all parts of the project (Azad, 2020). Additionally, heavy machinery like cranes and lifts are able to properly work in a certain wind strength because the more the height in the tower, the windier it becomes. This was considered at the top of agenda in the planning due to the fact that after a certain height cranes or lifts cannot be used. To tackle this challenge, a study was conducted to analyze the weather statistics spanning fifty years. This enabled Serneke to anticipate potential weather-related challenges that could be a hurdle in logistics operations (Serneke, 2021). The collected data was utilized to dimension essential elements such as cranes, lifts, and other logistical needs. Moreover, study visits were conducted to places like London, which shares similarities with Gothenburg in terms of weather, wind, and high-rise building in dense urban environment to seek inspirations and insights (Hope, 2024). The study visits provided ample insights into understanding the challenge of weather effects on construction logistics. For this purpose, special machinery was manufactured to avoid any mishap in the construction process. The picture below shows the height of the building.

Source: picture taken by authors

4.2.4 The making of logistics appendix

To tackle the logistical challenges, a comprehensive logistics appendix was developed early in the process. It is a contract document which serves as a guideline for suppliers dealing with the supply of materials. To establish an efficient supply chain and to ensure smooth logistics operations, it is of vital importance to make unified efforts to prevent delivery conflicts (Serneke, 2023). This appendix was communicated at every kick-off meeting in which important problems and their solutions were discussed (Hope, 2024).

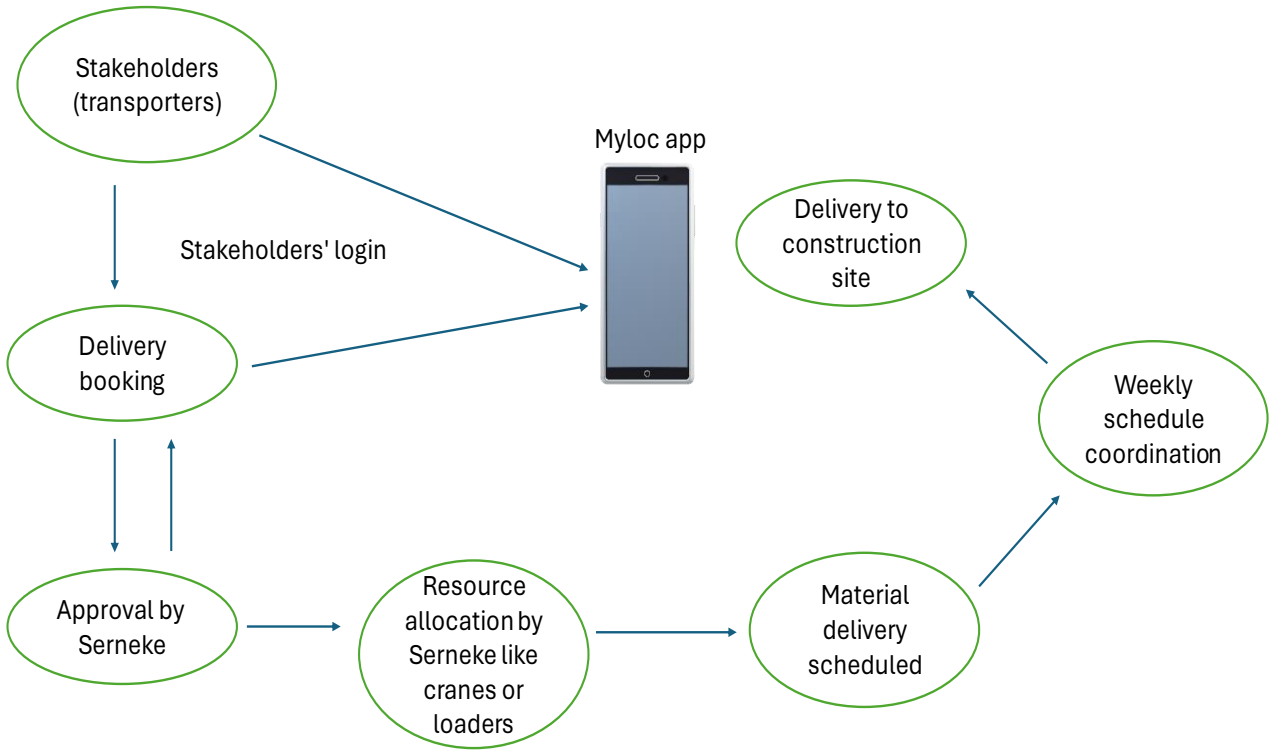
4.2.5 Development of Myloc construction App

According to Hope (2024), the development of Myloc construction app was an important step taken by Serneke to streamline its material supply. All stakeholders, for instance, suppliers,

employees, subcontractors etc., would receive a login to a delivery booking system, called Myloc Construction, for the purpose of following the same plan in the logistics appendix. It is an app designed by Myloc AB, specifically made for this project to control the complicated processes involved in the logistics chain. It works on the concept of activity-based logistics to streamline the supply chain and efficiently manage the logistics operations (myloc, 2024). For instance, if a contractor had to make a delivery, it was to be put in the calendar and Serneke would approve it. After approval by Serneke, the contractor would complete its material delivery. The deliveries were coordinated in such a way that one day was allocated to each item, for example, paints were to be delivered on Mondays, panel sheets on Tuesdays, and so on. Based on this Serneke would set up a weekly schedule for all deliveries to make sure that there is no overlapping in transport of materials. In addition to this, the system was used to see what resources are needed at the workplace to unload material, for example, if the unloading requires a crane handling, wheel loaders or in certain cases if hauling is needed. All these were constantly overviewed to avoid any clash in the booking (Hope, 2024).

The construction went in a way that one floor was to be completed in nine days before transitioning to the next. Hope (2024) identified it as a big challenge because it was essential to coordinate delivery of materials over this nine-day period. The delivery booking program was used to disseminate information about which material would arrive at what time and which resources would be used to handle material on the site (Hope, 2024). This helped in material deliveries and transportation to the construction site in a scheduled manner and no overlapping was observed during the entire construction process. It also played a vital role in the information flow between the various stakeholders. For instance, transporters had a known schedule, and they would not have to worry about mismanagement in their delivery time. Every delivery would reach the construction site at the right time and to the right place.

Figure 4.2: The use of Myloc construction app



Source: Authors generated

4.2.6 The making of logistics terminal and rules for material flow

Hope (2024) describes the importance of logistics terminal made by Serneke in addition to Myloc construction app to streamline material deliveries. For large-scale construction projects like Karlatornet the flow of materials is an important challenge in timely completion of the project. Because of the congestion and environmental disruptions created by the transportation vehicles, it is essential to manage delivery of materials. To address this challenge, a logistic terminal (Construction Consolidation Center) was established specifically for the project. Run by Ahlsell, a TPL partner of Serneke, situated at a distance of approximately 20 minutes (17 km) from the site at, the terminal served as a central hub for receiving, storing, and distributing materials. According to Hope (2024), on a daily basis, roughly 20 tons of material were transported to the construction site from the terminal. Ahlsell was responsible for transportation of materials which

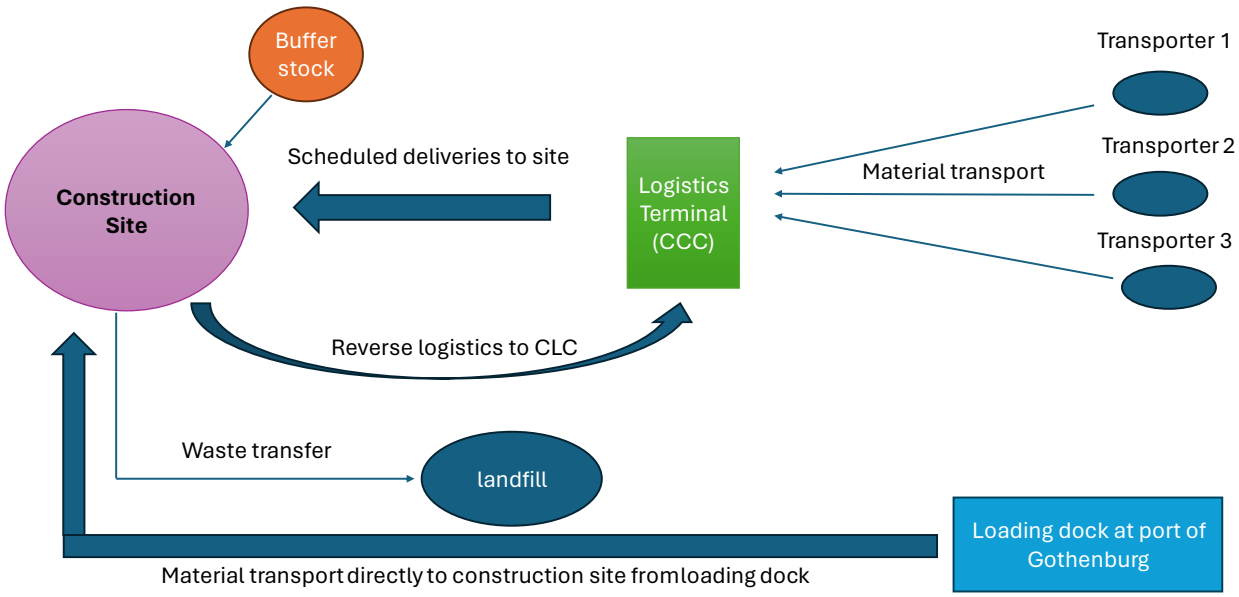
were distributed among approximately 40 contractors to supply them to the construction site from the central hub. This allowed a smooth flow of material to the site and timely completion of each floor without creating congestion. Furthermore, the project also had a temporary loading dock at the port of Gothenburg, where some ready-made elements transported from China and other countries were stored, thus avoiding transportation to the logistics center and instead carried them directly to the construction site (Azad, 2020).

Materials were supplied to the logistics center during working hours in the day and deliveries to the construction site were made after 4pm in the off-hours. Moreover, 20 to 30 shipments were to be received at the logistic terminal on daily basis where they were gathered, repackaged, and sent to the project site (Azad, 2020). Around 90 percent of the material required for construction was processed through this terminal, where they were consolidated before dispatching to the site. This consolidation process helped in reducing traffic congestion by 65 percent. Approximately 40 individuals would work at the construction site to handle transported materials and remove waste. They were responsible for efficient transport of material to the construction site and simultaneously managing waste disposal operations (Serneke, 2023). The waste resulting from the project was handled by company “Renova” on a daily basis (Hope, 2024). Another rule essential to follow was the lead time at the construction logistics center. It was mandatory for the material to arrive no later than 24 hours before reaching the construction site and no earlier than four days before. This was done to ensure that material does not remain in the construction center for several days. Additionally, a buffer stock was created at or near the project, which contained material necessary for construction so that the risk of shortage may be overcome to avoid delays or stoppage in work. Greater attention was paid to the protection of material in the logistics center and deliveries were made Just-in-Time to protect them from damage by rain or harsh weather (Azad, 2020).

One of the most important regulations was that all materials were to be transported on EU palette so that they can be moved with forklifts in order to improve efficiency along with safe handling and storage. It is pertinent to mention here that there were a lot of disagreements between Serneke, its TPL partner, and contractors about these regulations (Hope, 2024). However, these disagreements were removed through logistics appendix which was to be signed by all stakeholders before the initiation of the project. This appendix would consist of some set rules

for materials delivery which were to be strictly followed by all contractors. Though it was pretty hard to get through all these regulations, Serneke handsomely managed it by making proper planning beforehand.

Figure 4.3: The use of Logistics Terminal at Karlatornet



Source: Authors generated

4.2.7 Rules to handle vertical logistics operations

As stated earlier, the biggest challenge in building Karlatornet was its big height and the associated vertical logistics operations. This challenge was mainly tackled by taking information from study visits to various cities, especially London, which share similarities with Gothenburg in aspects like weather and urban environment. Solutions were derived by studying the previous examples and the best of them were applied in the project. For instance, to set the rules, 5 lifts were installed on the tower, two of them were exclusively designated for transporting workers and three for transport of materials. Similarly, three cranes were used in the project in which one was used for the tower and two for the podium.

The cranes used in this project were completely different from the ones used in a lot of projects in Sweden. The cranes which were used in Karlatornet were inspired from projects in London, which have been designed in such a way that the arms of the cranes are wide to the extent that they cannot crash into the building. Before using these types of cranes which they call “The London styled cranes”, it was discussed with the crane operators because it was a little difficult to operate. Furthermore, the elevators used in the project were bought from the company “Alimak Sweden”, in which two were high speed elevators. These high-speed elevators are said to be used for the first time in Sweden because of the height of the project. Similarly, one elevator was the biggest in its kind which was called “The Mammoth Elevator”. This was the slowest one used to carry bulky materials.

Construction logistics for Karlatornet was divided into eight logistics functions, which were construction logistics center, transport, checkpoint, unloading, carrying in, waste management, elevators, and logistics tents. These logistics functions served as a tool to work in line with Just-in-Time concept and to ensure proper functioning of all logistics activities in and outside the construction site. Serneke followed strict regulations about material delivery and its repackaging at the central hub.

4.2.8 The role of city authorities

Finally, it is worth mentioning here that a whole new area (District) was in making, so there would obviously be some role of the Gothenburg Municipality to play. The interviews revealed that the city had less or no role to play in the project or making any regulations for construction logistics. Municipality was contacted to name the newly built streets in the area, which comes under their jurisdiction. Furthermore, they were only contacted in case of traffic shutdown at Lindholmen *salen.* From a logistics point of view, there was no contact with the municipality and it was controlled wholly by Serneke itself (Hope, 2024).

4.2.9 Summary of empirical findings about Karlatornet

Project overview

- **Initiation:** Began in 2017 by Serneke, located in Lindholmen, Gothenburg.
- **Structure:** Tallest building in Scandinavia with 74 floor and 246 meters height.

- **Facilities:** 611 apartments, offices, hotels, sky bars.

Logistical Challenges and Solutions:

- **Weather Impact:** Collected data about weather spanning 50 years and used special machinery.
- **Logistics Appendix:** A contract document to prevent delivery conflicts.
- **Myloc Construction App:** Made to streamline material supply.
- **Logistics Terminal:** A central hub created and managed by Ahlsell to consolidate material supply.
- **Vertical Logistics:** Lifts and cranes specially made for the project
- **Logistics Functions:** Divided into eight basic functions for smooth running of the project.

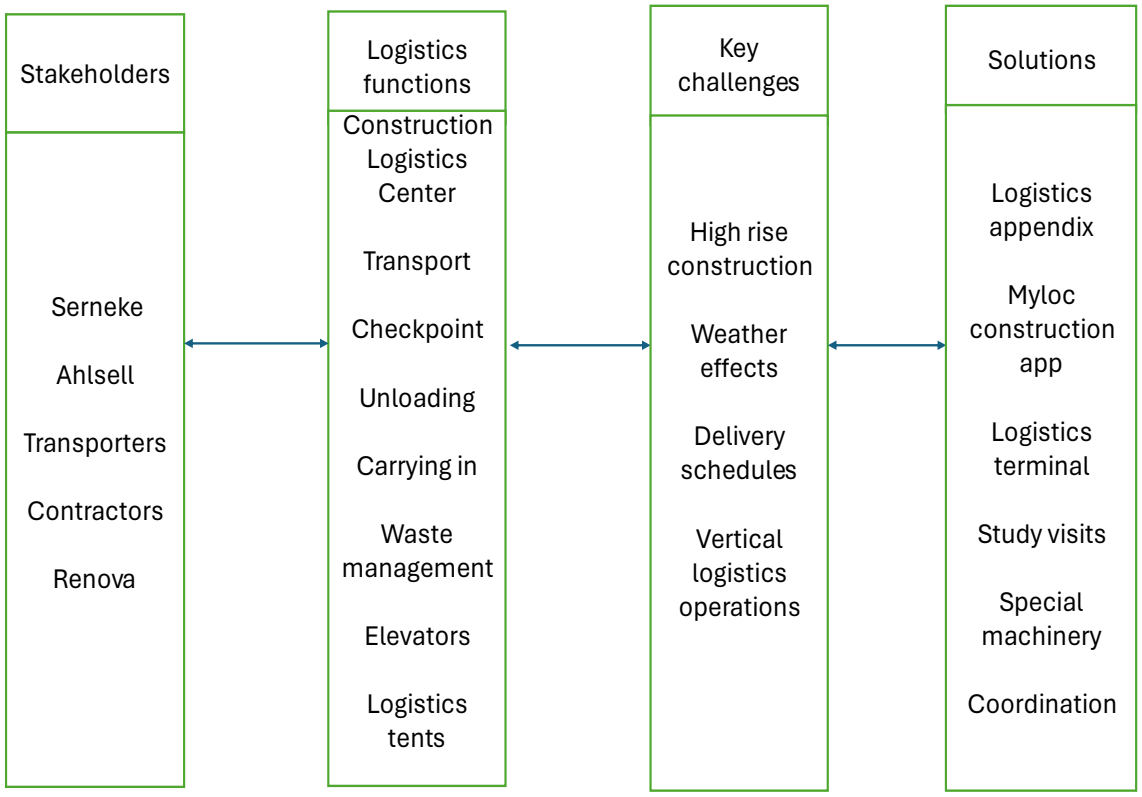
Key Measures:

- **Delivery Timing:** Fixed delivery timings.
- **EU Palettes:** Used for safe and efficient handling of material.
- **Study Visits:** Gathered insights from study visits in London.

Collaboration and Regulations:

- **Stakeholders Agreement:** Logistics appendix to be signed by all stakeholders to ensure compliance.
- **Environmental Focus:** Measures to reduce traffic congestion during material transport.

Figure 4.4: Summary of logistics activities at Karlatornet.



Source: Authors generated

5. Analysis

This chapter makes interpretation of key findings in terms of purpose and research question as well as in terms of theoretical framework. To make it clearer, first it will discuss the findings about Gothenburg city followed by the case study of Karlatornet.

5.1 Interpretation of findings in terms of purpose and research question

As stated earlier, the purpose of the study is to investigate the existence of rules and regulations made to govern construction logistics in the city of Gothenburg and the role of public-private sectors in this regard. The study is particularly focusing on a large-scale project of Karlatornet with the primary aim of understanding the type of logistical challenges faced by the project and the strategies implemented by Serneke to tackle those challenges.

5.1.1 Existence and nature of rules and regulations in Gothenburg

The essence of first research question is to find the existence of rules and regulations under which construction logistics activities are performed in Gothenburg city. As Fredriksson (2024) explained that Gothenburg city lacks a formal set of rules and regulations in written form which is currently governing construction logistics. Instead of a comprehensive set of regulations like a constitution containing sections and subsections about every aspect of construction logistics, the city authorities rely on directives and guidelines related to certain activities. It is evident from the literature and studied case that logistics play a crucial role in urban development. The literature identifies key logistical challenges like transportation, material storage, and the need for making rules and regulations to tackle its associated impacts. Since the literature identifies transportation as one the main challenges in logistics operations, the findings of the study also reveal that the city authorities are exclusively responsible for controlling transport related to construction logistics. It is the sole responsibility of city authorities to devise and implement rules and regulations to manage traffic flow like rerouting and shutdown.

In addition to transportation, a new finding was revealed in the interviews, i.e., the use of land. It is evident from the findings that regulations about land use are based on ownership structure. For instance, if the land is owned by the municipality, the city enforces regulations in the form of land use instructions (Bakosch, 2024). This means that enforcement of regulations about land use

is aimed at ensuring alignment with urban planning objectives. These instructions are specifically designed to ensure that logistics operations comply with urban planning goals like sustainability, traffic control, and reduction in environmental footprint. The regulations do not follow uniformity because they vary depending on whether the land is owned by municipality or is privately owned. In contrast to the above scenario, if the land is privately owned, then the city's authority to implement logistics regulations are limited. As a matter of fact, the findings deny the city authorities' role in privately owned land except matters related to transportation. This complexity in ownership structure is bound to create a dual system in which types of regulations differ significantly. This is why the type of ownership structure currently in existence often leads to a reliance on private sector to self-regulate logistics operations.

This complexity in ownership structure may have its pros and cons. For instance, if construction is going to be started on municipal land, the building companies in that case must be ready to adhere to possible stricter regulations to line up with the logistics plans of the city authorities. They have to make good coordination with city authorities to attain their objectives. On the other hand, on a privately owned land, the building companies may enjoy more autonomy because they have to self-regulate logistics operations according to their own devised planning. In this case the companies will have to ensure that their logistics operations are carried out efficiently to reduce negative environmental impacts.

5.1.2 Potential for policy development

The results of the study emphasize the importance of construction logistics strategies for the relevant stakeholders and identify the interdependence of logistics functions to improve coordination and optimize utilization of the available resources. Keeping in view the above discussion, the city of Gothenburg has the potential to develop policy because the current dichotomy between municipality and private land regulations emphasizes the need for a more integrated regulatory structure. An important policy in this regard may involve development of standards for construction logistics which would apply to the whole city regardless of land ownership. Such a framework could include regulations for all types of construction projects whether they are small or large-scale. Such a framework could benefit Gothenburg in promoting sustainability and efficiency across all projects.

5.2 Interpretation of findings about construction logistics – the case of Karlatornet

The second research question was formulated to know the logistical challenges faced by Serneke during the construction process of Karlatornet and the strategies adopted to tackle them. Findings of the study reveal that due to a lack of proper regulations governing construction logistics in Gothenburg, the big companies like Serneke are responsible for controlling construction logistics operations. Though the city of Gothenburg administration is keen in planning to explore strategies aimed at enhancing construction logistics, there has been fewer tangible actions seen so far (Bakosch, 2024). Private initiatives like the one seen in the case study of the Karlatornet project demonstrate the responsibility of the private companies to address logistics challenges. These challenges are mainly related to place, complexity, and the challenges of achieving higher levels of sustainability (Browne, 2015).

5.2.1 Construction Logistics Management at Karlatornet

The development of logistics appendix shows Serneke's active approach to construction logistics management. Building a high-rise structure like Karlatornet requires the construction process to run smoothly, therefore implementation of Construction Logistics Management (CLM) is needed, in order to transport construction materials and resources to the construction site in a productive way. This is possible only when the logistics chain functions smoothly because the timely completion of the project and the associated costs are directly dependent upon construction logistics (Azad, 2020). When the implementation of CLM is conducted successfully, the lead time will not be prolonged, disruption can be prevented, and productivity will increase. In other words, efficient logistics operations are fundamental to a construction project and collaboration of all stakeholders is mandatory to achieve success in the project. In this background, the development of logistics appendix at the beginning of the project indicates that logistics was a main priority for Serneke. As the results revealed that it was a contract document, Serneke bound all stakeholders to follow the established rules mentioned in the appendix. Hope (2024) explained that all stakeholders were legally bound to follow it, resultantly, it helped in reducing ambiguities which lead to a more steadfast logistics operations. Moreover, it also shows that collaboration among stakeholders is necessary to prevent delivery conflicts. The regular communication of logistics appendix in the kick-off meeting demonstrates an effective approach to problem solving,

because it helped Serneke to adapt to any unforseen issues effectively and timely, therefore, reducing the chances of disruption in the project timeline**.**

5.2.2 Construction Logistics Plan

For every construction project, the most important phase is the planning, in which all aspects of the project are overviewed, especially logistics activities, which are crucial for both the project and the surroundings. The success of a project depends on devising a successful plan first. CLP is needed in order to enhance the performance of construction logistics. Both Robbins (2015) and Browne (2015) support the aim of the concept of CLP, which is to increase the performance of construction logistics, and CLP aims to reduce environmental impacts that arise from construction logistics. In the case of Karlatornet, it is evident that effective planning was made before the initiation of the construction work. This was also validated by Hope (2024) that the logistical challenges were at the top of agenda in planning for constructing Karlatornet. She added that a sound planning for the project was the fundamental reason to achieve success. The project could have otherwise met with delays and costs would have been raised.

Hope (2024) explained that the economic effects arising from construction logistics, such as the increasing costs, had to be prevented only through devising efficient logistics plan. This is the reason that prior to building Karlatornet, Serneke conducted study visits and got to know the complexities of vertical logistics. It would have been very difficult to tackle vertical logistics challenges in Karlatornet, had the logistics organization not collected information beforehand, particularly when the building is going higher and higher. The case study also revealed that the flow of construction material as well as workers was the biggest challenge due to the wind effects and big height. The study visits were particularly useful in making targeted strategies to address these challenges.

Compared to lifts and elevators, cranes are more vulnerable to wind because they are more exposed to wind than lifts (Azad, 2020). Building a high-rise project requires stronger and bigger construction lifts to ease the flow of material as the construction goes higher. Therefore, the more the number of elevators, the timelier would be the flow of materials. Similarly, cranes need to be stronger to avoid any mishap due to strong winds. For this purpose, stronger, high-speed, and bigger elevators and cranes were used in Karlatornet to avoid any bottleneck in the construction

process. This also ensured the timely flow of workers because some of the elevators were exclusively used to carry workers. Additionally, Serneke built lunchrooms and toilets on designated floors to provide ease to workers during lunch and avoid wasting time in going up and down unnecessarily. Hope (2024) emphasized that the rules to operate elevators and cranes were to be strictly followed by the operators as a minor mistake could have resulted in big losses.

This shows how Serneke planned to manage logistics activities effectively to achieve a successfully result-oriented project. The most important decision made by Serneke was the outsourcing of logistics activities to a TPL "Ahlsell" (Azad, 2020). The biggest advantage of this decision was that Serneke concentrated on its core competencies in building the project and Ahlsell provided all transportation services related to construction logistics. It is also pertinent to mention here that Serneke did not delegate the whole logistics work to Ahlsell, rather it continuously monitored the workflow and did not lose the control of construction logistics (Hope, 2024). Therefore, under the vigilant monitoring and control of Serneke, Ahlsell successfully managed to carry out logistics activities throughout the lifecycle of the project.

5.2.3 Complexity in construction logistics

As Ghanem et.al., (2018) argues that "construction logistics is divided into offsite and onsite material logistics". By studying both the off-site and on-site logistics activities, the complex nature of construction logistics has been discussed which highlights the complexity and scope of efficient logistics management throughout the lifecycle of a project. According to Azad, (2020), the complexity of construction logistics increases with an increase in the size of the project. For instance, large-scale projects require more deliveries and materials compared to small ones. This indicates that the volume and frequency of material transportation in large scale projects adds more complexity to construction logistics. Secondly, the importance of timely deliveries and precise location cannot be neglected in large-scale projects. The fact is that in the absence of efficient management of material supply and appropriate storage location, the project is again bound to meet delays leading to rising costs. Adding to this is the material sourced from global market through sea transport, making another layer of complexity in the logistics process. The reason is that they require longer lead time to reach the destination and call for careful coordination to harmonize material influx with the timeline of the project. In the case of Karlatornet, Ahlsell played important role in coordinating material supply at the logistics hub as

well as those received through sea transport. However, transporting construction material supply through sea transport is more sustainable than transporting it through air transport. From Karlatornet project, we can understand Serneke's attempts to reduce the emissions yielded from the project as much as possible, by transporting some of their construction materials (from suppliers) through sea transport.

The use of buffer stock was also a good idea developed by the logistics organization of Karlatornet because it is important to minimize risk of material shortage. Due to the availability of limited space at the construction site, which could accommodate all the tools and machinery, the establishment of a logistics hub and a temporary loading dock at port was significant decisions made by Serneke. These two strategies are vitally important for optimizing construction logistics. On one hand, it helped in minimizing material shortages and on the other reduced the unnecessary transport of vehicles to and from the construction site.

6: Conclusion

This chapter provides the conclusive remarks on the thesis and answers the research questions by summarizing the key findings.

6.1 Key findings about construction logistics regulations in Gothenburg city

The purpose of this thesis was to know the existence of certain rules and regulations for construction logistics in the city of Gothenburg and the role of public-private sectors. For this purpose, interviews were conducted, and literature was studied to reach the empirical findings. Furthermore, a case study was selected to deeply investigate the nature of construction logistics and to see what type of regulations were implemented by Serneke to complete Karlatornet and how these regulations proved beneficial in achieving efficiency in the project.

The first key finding of the thesis is that a set of formal regulations governing construction logistics cannot be found in written form in the Gothenburg city. Unlike a written constitution for regulating construction activities in buildings, the city in case of construction logistics activities issues some directives to construction projects but that directives are related to specific parts of logistics operation like transportation particularly. It has been found that the city has a diverse ownership structure related to land ownership which is a big challenge in devising rules for construction logistics.

The second key finding of the thesis is that most of the initiatives about construction logistics are being taken by private companies. They are responsible for making and implementing their own rules for logistics operations. The city does not interfere in the logistics activities of the project, however, the building company has to present its logistics plan to the city authorities prior to the initiation of the project. When the construction work is in progress, the city is only contacted when there is a need for a traffic shutdown. Else, there is a little role the city plays in regulating construction logistics.

6.2 Key findings about construction logistics regulations in Karlatornet

The first key finding of the case study is that logistics activities in high-rise buildings are more complex and require unique actions. In response to this complex nature of construction logistics

in Karlatornet, the development of a logistics appendix and Myloc construction app were important strategies made by Serneke. It had some set rules which were to be followed by all stakeholders.

The second key finding of the study is that materials were consolidated through a logistics hub made for the project. It helped in consolidating material flow before reaching the construction site and had a larger impact in optimizing logistics operations.

The third key finding is that the city authorities played a lesser role in optimization of construction logistics as the whole responsibility to handle construction logistics lay on Serneke, who was the main developer of the project.

6.3 Answering the research questions

The following research questions were formulated to fulfill the purpose of the thesis. The first question is related to the regulations about construction logistics in the city of Gothenburg and the second question is on rules and regulations implemented by Serneke in building Karlatornet. Thus, both questions are meant to investigate the role of public and private sectors in Gothenburg to manage construction logistics.

RQ1: *What kind of rules and regulations have been implemented by the city of Gothenburg to influence the way logistics activities are carried out in construction projects?*

Construction logistics is a complex process which involves management of material transport, storage, and resources to achieve efficiency in the construction project. The research shows that there exists an appropriate relationship between necessary regulations for logistics operations, tackling logistical challenges, and project success. This complexity in the nature of construction logistics is evident in the case of Gothenburg which has a diverse ownership structure and less control over logistics operations. By exploring the research question several insights have been uncovered which demonstrate a significant reliance of Gothenburg city/Municipality on private initiatives rather than producing a comprehensive set of regulations by itself to control construction logistics. The absence of a proper set of regulations in documented form in the city shows a lesser control of the city authorities over construction logistics, which is now thinking to come up with strategies like establishment of a central hub to manage logistics operations.

This lack of formal regulatory structure leads the study to the fact that the city authorities do not play a significant role in regulating logistics operations in the city. In densely populated urban areas, efficient logistics management plays an important role in enhancing safety on the construction site as well as in the surrounding by ensuring orderly movement of vehicles and machinery. Therefore, it is essential that the city offers its role in effective management of construction logistics which is ultimately a way to optimize resource utilization and reduce waste. However, the empirical findings also show some of its upcoming plans to enhance construction logistics in the city of Gothenburg like making of Construction Logistics Group, consisting of different stakeholders to prioritize discussion on electrification, digitalization, and reuse for the purpose of achieving sustainability goals and optimizing logistics operations. Also, its commitment to initiatives like the Paris Agreement and Agenda 2030 bears testimony to the fact that the city wants to incorporate construction logistics in policymaking to achieve climate neutrality and promote responsible urban development.

RQ2: *Which type of logistical challenges Serneke faced during the construction of Karlatornet and what strategies were adopted to optimize logistics operations in the project?*

As construction logistics has a direct impact on important aspects of a project like its timeline, costs, and quality, its importance cannot be neglected. Effective management of construction logistics helps in minimizing delays in the project while simultaneously optimizing resource utilization and reducing waste. Hence, construction logistics contributes significantly to the overall success of a project by streamlining the flow of materials and resources at the construction site. All these factors were taken into account before the initiation of construction work at Karlatornet because the journey of construction logistics begins with the initiation of the project from the planning stage and goes till the completion.

To enhance the logistics operations in Karlatornet, the findings of the study reveal that the use of logistics appendix and Myloc construction app proved valuable, which had two big advantages. First, material flow to the construction site was always scheduled therefore reducing the chances of overlapping deliveries. Furthermore, it also proved helpful in eliminating any disagreements raised among the stakeholders at any stage of the construction. Secondly, the establishment of a central hub was a fundamental rule to consolidate material flow to the construction site. Thirdly,

the use of unique machinery in the project required some unique actions which played a key role in the successful completion of the project.

Lastly, the thesis identifies the role of private initiatives in managing construction logistics like the one seen in the studied case of Karlatornet. It shows the practical approach by private companies like Serneke to address logistical challenges which has broader impacts on the project success. While the municipality has a lesser role to play in the process like in case of traffic shutdown or naming the newly built streets, the responsibility to handle construction logistics falls entirely on private companies.

6.4 Implications and future recommendations

With increased urbanization, the scope of construction logistics is increasing. The role of both public and private sectors is essentially important in regulating logistics activities to minimize its negative impacts. To streamline logistics operation efficiently, the following recommendations are made:

- The city of Gothenburg should develop a formal set of regulations governing construction logistics addressing all aspects of logistics. It would be more beneficial to involve all stakeholders in the drafting process of the regulations.
- The city should encourage the use of digital tools to enhance logistics planning and execution.
- Public-private partnership should be strengthened by creating platforms for regular interaction between city authorities and private developers to collaborate effectively in addressing logistical challenges.

Looking at the importance of rules and regulations in governing construction logistics, future research can be made by exploring important aspects of policy development in the city. The research may focus on drafting comprehensive regulations that provide clear guidelines for managing construction logistics.

References

Adler, R.H (2022). Trustworthiness in Qualitative Research. Journal of Human Lactation. Volume 38, Issue 4, November 2022, Pp. 598-602. https://doi-org.ezproxy.ub.gu.se/10.1177/08903344221116620

Agapiou , A. o.a., 1998. The role of logistics in the materials flow control process. *Construction Management & Economics,* 16(2), pp. 131-137.

Almohsen, A. and Ruwanpura, J., 2011. Logistics management in the construction industry In: Proceedings of the CIB W78-W102 2011, 26–28 October. Sophia Antipolis.

Aloini, D., Dulmin, R., Mininno, V., Ponticelli, S. 2012. Supply Chain Management: A Review of Implementation Risks in the Construction Industry. Business Process Management Journal. Vol. 18. No. 5. pp: 735-761. DOI 10.1108/14637151211270135

Andersson, O. & Månsson, S., 2017. Planning for Efficiency at Karlatornet. Gothenburg: Chalmers University.

Anwar, Q., Hanif, M., Shimotoku, D., Kobayashi, H.H. 2022. Driver awareness collision/ proximity detection system for heavy vehicles based on deep neural network. Journal of Physics: Conference Series. doi:10,1088/1742–6596/2330/1/012001

Azad, N., 2020. BYGGLOGISTIK FÖR SKYSKRAPOR, Logistikplanering för bygget av Karlatornet i Göteborg, Gothenburg: u.n.

Baccarini, D., 1996. The concept of project complexity – a review. International Journal of Project Management. Vol. 14. No. 4. pp. 201-204.

Bakosch, A., 2024. Existence of regulations for construction logistics in Gothenburg city. [Interview] (04 April 2024).

Bargstädt, H-J., Voigtmann, J., 2010. Construction Logistics Planning by Simulation. Proceedings of the 2010 Winter Simulation Conference B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan, eds.

Bengtsson, S.H., (2019), “Coordinated construction logistics: an innovative perspective”, Construction Management and Economics 2019, Vol 37, No. 5, pp. 294-307. https://doi.org/10.1080/01446193.2018.1528372

Bilgin, G., Erol, H., Atasoy, G., Dikmen, I., Birgonul, M.T. 2022. Exploring Pattern of Complexity in Mega Construction Projects. International Journal of Managing Projects in Business. Vol. 15, No. 7. pp. 1064-1090.

Bomb, A. & Haraldsdottir, H., 2017. *Four perspectives on urban construction logistics: Why it matters and how to make it a priority*. Gothenburg: University of Gothenburg.

Boverket, 2016. *Boverket. Vision for Sweden 2025.* [Online]
Available at: https://sverige2025.boverket.se/en-urbaniserad-varld.html
[Accessed 10 February 2024].

Boverket, 2020. *Boverket.* [Online]
Available at: https://www.boverket.se/sv/lag--ratt/forfattningssamling/gallande/bbr---bfs-20116/
[Accessed 18 February 2024].

Boverket, 2023. *Boverket.* [Online]
Available at: https://www.boverket.se/en/start/building-in-sweden/swedish-market/roles-and-responsibilities/
[Accessed 10 February 2024]

Brown, A (2015). The role of the construction logistics manager, in Supply chain management and logistics in construction, Lundesjo, G. (ed). Kogan Page, London. ISBN: 9780749472436.

Browne, M. (2015) The challenge of construction logistics, in Supply Chain Management and Logistics in Construction, Lundesjo, G. (ed). Kogan Page, London. ISBN: 9780749472436.

Brusselaers, N., Fufa, S.M., Mommens, K., 2022. A Sustainability Assessment Framework for on-site and off-site Construction Logistics. Sustainability 14, 8573.
http://doi.org/10.3390/su14148573

Brusselaers, N., Mommens, K., Janné, M., Fredriksson, A., Venås, C., Flyen, C., Fufa, S.M., Macharis, C. 2020. Economic, Social, and Environmental Impact Assessment for Off-Site Construction Logistics: The Data Availability Issue. IOP Conf. Series: Earth and Environmental Science 588 (2020) 032030. IOP Publishing. doi:10.1088/1755-1315/588/3/032030

Brusselaers, N., Mommens, K., Janné, M., Fredriksson, A., Venås, C., Flyen, C., Fufa, S.M., Macharis, C., 2020. Economic, social, and environmental impact assessment for off-site construction logistics: the data availability issue. *IOP Conf. Series: Earth and Environmental Science 588 (2020) 032030. IOP Publishing.*

Bryman, A., et.al (2021), Bryman's Social Research Methods. Oxford University Press. ISBN: 978-0-19-879605-3

Cambridge Business English Dictionary, 2024. *Regulations.* United Kingdom: Cambridge University Press and Assessment.

Carlsson, A., Nilsson, S. I. & Älvegran, A., 2022. *Mitigation strategies for challenges to achieving high performing on-site construction logistics.* Gothenburg: Chalmers University of Technology.

Choudhari, S., Tindwani, A., 2017. Logistics optimisation in road construction project. Construction Innovation.Vol. 17. No. 2. DOI 10.1108/CI-03-2016-0014

Cope, D.G (2014), Methods and Meanings: Credibility and Trustworthiness of Qualitative Research. Oncology Nursing Forum Vol. 41, No.1, January 2014.

Dubois, A., Hulthén, K., Sundquist, V. 2019. Organising logistics and transport activities in construction. The International Journal of Logistics Management. Vol. 30. No. 2. pp. 620-640. DOI 10.1108/IJLM-12-2017-0325

Ebekozien, A., Aigbavboa, C.O., Ramotshela, M. 2023. A qualitative approach to investigate stakeholders' engagement in construction projects. An International Journal. Vol. 31, No. 3. pp. 866-883. DOI 10.1108/BIJ-11-2021-0663

Eriksson, P.E. 2010. Improving construction supply chain collaboration and performance: a lean construction pilot project. Supply Chain Management: An International Journal. Vol. 15(5). pp. 394-403

Fischel, C., 2024. Forecast for the construction industry2024: Trends and challenges, Sweden: byggbranschen-blog.

Foulkes, A. & Ruddock, L., 2008. Defining The Scope of The Construction Sector. Salford UK: Salford Centre for Research and Innovation, the University of Salford, UK.

Francart, N., Larsson, M., Malmqvist, T., Erlandsson, M., Florell, J. 2019. Requirements set by Swedish municipalities to promote construction with low climate change impact. Journal of Cleaner Production 208. pp. 117-131.

http://doi.org/10.1016/j.jclepro.2018.10.053

Fredriksson, A., 2024. Existence of regulations for construction logistics in the city of Gothenburg [Interview] (18 March 2024).

Fredriksson, A., Huge-Brodin, M., (2022), "Green construction logistics – a multi-actor challenge", Research in Transportation Business & Management 45 (2022) 100830. http://doi.org/10.1016/j.rtbm.2022.100830

Fredriksson, A., Janné, M., Nolz, P., de Radiguès de Chennevière, P., Van Lier, T., Macharis, C. 2021. Creating stakeholder awareness in construction logistics by means of the MAMCA. City and Environment Interactions 11 (2021) 100067.

https://doi.org/10.1016/j.cacint.2021.100067

Fredriksson, A., Sezer, A.A., Angelakis, V., Gundlegård, D. 2021. Construction Related Urban Disturbances: Identification and Linking with and IoT-model. Automation in Construction 134 (2022) 104038. https://doi.org/10.1016/j.autcon.2021.104038

Ghanem, M., Hamzeh, F., Seppänen, O., Zankoul, E., 2018. "A new perspective of construction logistics and production control: An exploratory study". IGLC 2018 - Proceedings of the 26th

Annual Conference of the International Group for Lean Construction. https://doi.org/10.24928/2018/0540

Gidado, K.I., 1996. Project complexity: The focal point of construction production planning. Construction Management and Economics. Vol. 14. Pp. 213-225.

Gilchrist, A., Allouche, E.N. 2004. Quantification of social costs associated with construction projects: state-of-the-art review. Tunnelling and Underground Space Technology 20 (2005) 89-104. doi: 10.1016/j.tust.2004.04.003

Guerlain, C., Renault, S., Ferrero, F. 2019. Understanding Construction Logistics in Urban Areas and Lowering Its Environmental Impacts: A Focus on Construction Consolidation Centres, *Sustainability 2019*. http://doi:10.3390/su11216118

Gurbani, E., 2024. The role of city authorities in construction logistics [Interview] (11 March 2024).

Harker, A., Allcom, W. & Taylor, D., 2007. Material Logistics Plan Good Practice Guidance, UK: Waste and Resource Action Programme.

Hope, J., 2024. Regulations about construction logistics in Karlatornet [Interview] (02 May 2024).

Horman, M.J., Thomas, H.R., 2005. Role of Inventory Buffers in Construction Labor Performance. Journal of Construction Engineering and Management. Vol. 131, No. 7.

Hossam E, H., Ahmad H, I. & Abeer, E., 2021. Assessment of Construction Project Complexity. *The Open Civil Engineering Journal*, 15(1), pp. 414-423.

https://www.scb.se/en/finding-statistics/statistics-by-subject-area/population/population-composition/population-statistics/pong/tables-and-graphs/population-statistics---year/swedens-50-largest-municipalities-2022/

https://www-emerald-com.ezproxy.ub.gu.se/insight/content/doi/10.1108/IJPDLM-03-2019-0078/full/pdf?title=characterizing-third-party-logistics-setups-in-the-context-of-construction

Janné, M. & Fredriksson, A., 2019. Construction logistics governing guidelines in urban development projects. *construction innovation,* 19(1), p. 109.

Janné, M. & Fredriksson, A., 2021. Construction logistics in urban development projects – learning from, or repeating, past mistakes of city logistics. *The International Journal of logistics management,* 33(5), pp. 49-68.

Janné, M. 2018. Construction Logistics Solutions in Urban Areas. Linköping Studies in Science and Technology. Thesis No. 1806. Swedish Licentiate Thesis. ISBN: 978-91-7685-290-3.

Janné, M., 2024. Construction Logistics Plan in Sweden [Interview] (25 March 2024).

Janné, M., Fredriksson, A., Rudberg, M., (2021), "Characterizing third-party logistics setups in the context of construction", International Journal of Physical Distribution and Logistics Management, Vol: 51 No: 4, pp: 325-349.

Kardes, I., Ozturk, A., Cavusgil, S.T., Cavusgil, E. 2013. Managing global megaprojects: Complexity and risk management. International Business Review 22 (2013) pp. 905-917 http://dx.doi.org/10.1016/j.ibusrev.2013.01.003

Khoiry, M.A., Kalaisilven, S., Abdullah, A. 2018. A review of minimizing delay in construction industries. E3S Web of Conferences 65, 03004. http://doi.org/10.1051/e3sconf/20186503004

Kooragamage, R., 2015. Managing construction logistics for confined sites in urban areas. In: G. Lundesjö, ed. Supply chain management and logistics in construction: delivering tomorrow's-built environment. 1st ed. London, UK: Kogan Page.

Lee, C., 2023. Evaluating construction delays using productivity-based resource reallocation for economic feasibility. Engineering, Construction and Architectural Management. Vol. 30. No.4. pp. 1679-1696.

Lundesjö, G. (2015). Construction consolidation centre in construction logistics, in Supply Chain Management and Logistics in Construction, Lundesjö, G. Kogan Page, London. E-ISBN 978 0 7494 7243 6

Lundesjö, G. (2019). Consolidation centres in construction logistics, in Urban logistics: management, policy and innovation in a rapidly changing environment, Browne, M. et.al. (ed). Kogan Page, London. ISBN: 9780749478728.

Matouzko, Y., 2015. *Efficient Construction Logistics: A case study of an office block project.* Stockholm: KTH Architecture and the Built Environment, Department of Real Estate and Construction Management.

Muerza, V., Guerlain, C. 2021. Sustainable Construction Logistics in Urban Areas: A Framework for Assessing the Suitability of the Implementation of Construction Consolidation Centers. Sustainability 2021, 13, 7349. http://doi.org/10.3390/su13137349

myloc, 2024. *myloc.* [Online]
Available at: https://myloc.se/sv/start/
[Accessed 05 May 2024].

O'Neill, A., 2024. *Statista.* [Online]
Available at: https://www.statista.com/statistics/455935/urbanization-in-sweden/
[Accessed 06 February 2024].

Panova, Y., Hilletofth, P., 2018. Managing Supply Chain Risks and Delays in Construction Project. Industrial Management & Data Systems. Vol. 118, No. 7. Pp. 1413-1431. DOI 10.1108/IMDS-09-2017-0422

Persson, F., Bengtsson, J., Gustad, Ö. 2010. Construction Logistics Improvements Using the SCOR Model – Tornet case. IFIP International Federation for Information Processing. IFIP AICT 338. Pp. 211-218.

Robbins, S. 2015. Effective management of a construction project supply chain, in Supply chain management and logistics in construction, Lundesjo, G. (ed). Kogan Page, London. ISBN: 9780749472436.

Serneke, 2021. *Serneke.* [Online]
Available at: https://www.serneke.se/en/project/karlatornet/
[Accessed 25 April 2024].

Serneke, 2023. *Serneke.* [Online]
Available at: https://www.serneke.se/projekten/karlatornet/
[Accessed 15 May 2024].

Smart Construction Logistics (2020) CIVIC Project.

Sobotka, A., Czarnigowska, A. 2005. Analysis of supply system models for planning construction project logistics. Journal of civil engineering. Vol. XI, No. 1. Pp. 73-82. ISSN 1392–3730

Statistics Sweden, 2023. *Statistics Sweden.* [Online]
Available at: https://www.scb.se/en/
[Accessed 4 February 2024].

Tischer, A., Besiou, M., Graubner, C-A. 2013. Efficient waste management in construction logistics: a refurbishment case study. Logist. Res. Vol. 6. Pp. 159-171.

Usman, N. & Ibrahim, A. M., 2015. Efficient Management of Construction Logistics: A Challenge to both Conventional and Technological Systems in the Developing Nations, Jeddah, Saudi Arabia: Academia.edu.

Venås, C., Flyen, C., Fufa, M.S., Janne, M., Fredriksson, A., Brusselaers, N., Mommens, K., Macharis, C. 2020. No or low emission from construction logistics – Just a dream or future reality. Beyond 2020 – World Sustainable Built Environment conference. IOP Conf. Series: Earth and Environmental Science 588 (2020) 042003. doi:10.1088/1755-1315/588/4/042003

Vrijhoef, R., Koskela, L. (2000). "The four roles of supply chain management in construction". European Journal of Purchasing & Supply Management, 6(3-4), pp.169-178.

Waddell, M. 2015. Resource efficiency benefits of effective construction logistics. Lundesjö, G. (ed). pp.139-155. Kogan Page, London. ISBN: 9780749472436

Xue, X., Wang, Y., Shen, Q., Yu, X. 2007. Coordination Mechanism for Construction Supply Chain Management in the Internet Environment. International Journal of Project Management 25 (2007). Pp.150-157. doi: 10.1016/j.ijproman.2006.09.006

Ying, F., Tookey, J. Roberti, J., 2014. Addressing effective construction logistics through the lens of vehicle movements. Engineering, Construction, and Architectural Management. Vol.21. No. 3. Pp. 261-275. DOI 10.1108/ECAM-06-2013-0058

Ying, F., Tookey, J., Seadon, J., 2016. Measuring the invisible - A key performance indicator for managing construction logistics performance. An International Journal. Vol. 25. No. 6, pp. 1921-1934. DOI 10.1108/BIJ-11-2016-0176

Zhongfu, L., Jianshuang, F., 2008. Study on JIT distribution system based on web for the 3rd party logistics. 4th International Conference on Wireless Communications, Network and mobile computing. Pp. 1-4

Appendixes

Appendix 1- Interview questions about current regulatory structure for construction logistics in Gothenburg city

1. Can you provide insights into the current regulatory structure (if any) governing construction logistics in Gothenburg, and to what extent are they effective in managing construction logistics within the city?

2. Are there any specific regulations or policies (if any) that you believe have so far significantly impacted construction logistics in Gothenburg, either positively or negatively? For instance, example of a particular project completed under certain regulations.

3. In your experience, what are some of the direct impacts of construction logistics regulations on the local population, and how do they influence the overall urban environment of Gothenburg?

4. Could you describe any strategies or initiatives currently in place aimed at ensuring compliance with construction logistics regulations in Gothenburg, and what are the primary objectives of these strategies?

5. How do you believe stakeholders perceive the current strategies for managing construction logistics disruptions, and have they expressed any concern regarding the effectiveness of these strategies?

6. Are there any shortcomings in the current regulations for construction logistics that you have observed or encountered? If yes, how do they affect the effectiveness of the regulations in achieving their intended goals?

7. Are there any upcoming plans aimed at improving the regulatory structure for construction logistics in Gothenburg, and what are some of the major challenges that can be faced in complying with these regulations?

Note: If there are no regulations in existence, you can explain the directives for construction logistics provided by the City Planning Authority or the concerned department.

Appendix 2- Interview question about construction logistics at Karlatornet

1. Who is responsible for managing construction logistics at Karlatornet and what were the key solutions to regulate it?

2. How much distance is there between the construction site and the logistics center and what impact did it have in optimizing the logistics activities?

3. Who is the main transporter in the project and has the transport work been divided among other contractors also?

4. What were the main challenges in the logistics operation?

5. What role did the city of Gothenburg/Municipality play in regulating construction logistics in the project and what was their impact on different stakeholders?

6. What were the unique things in the construction logistics which differ from other projects in Sweden?

7. Did the main stakeholders like the main TPL partner and subcontractors have any concerns about regulations implemented by Serneke regarding construction logistics and how those disagreements were removed?

8. How effective the chosen solutions were in comparison to other solutions?