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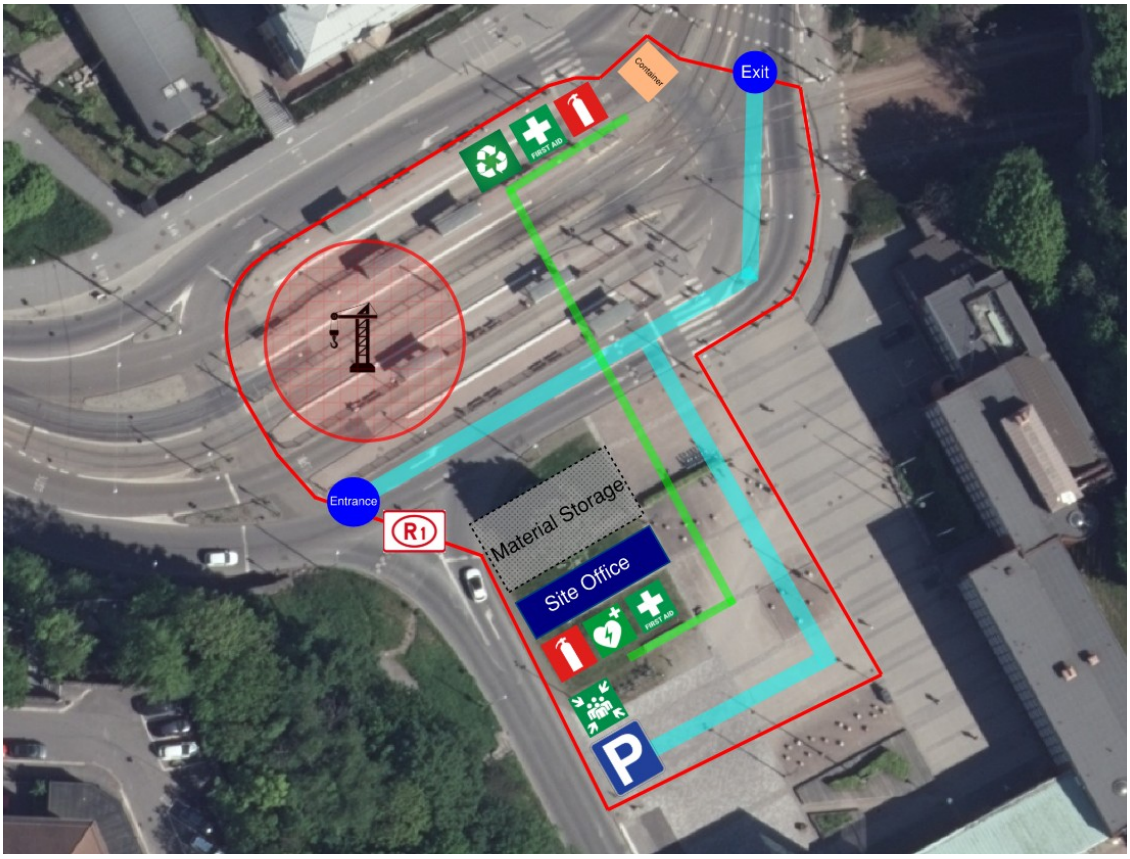

Structuring Construction Site Layout Planning in Urban Infrastructure Projects

A Checklist for Practical Implementation

Master's thesis in Design and Construction Project Management

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Gothenburg, Sweden 2026
www.chalmers.se

MASTER'S THESIS ACEX30

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Cover: Site layout plan of the Chalmers tram and bus stop, developed by the authors in Bluebeam.

Typeset in LaTeX
Printed by Chalmers Reproservice
Gothenburg, Sweden, 2026

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Abstract

Construction Site Layout Planning (CSLP) plays an important role in how construction projects are carried out, especially in urban environments with limited space. Despite this, site layout plans are often treated as static, and planning tends to be reactive rather than based on systematic understanding of movement flow and their impact on productivity. The aim of this study is to analyze how the planning and design of site layout plans in urban infrastructure projects affect productivity in terms of time losses and costs. The study also aims to develop a checklist that can support a more structured approach to CSLP. The study was conducted using a qualitative approach where a review of previous research was combined with interviews and a document analysis of site layout plans. The findings show that CSLP is influenced by several factors, such as surrounding environment, space constraints, project-specific conditions and safety requirements. In addition, the design of the construction site has a clear impact on productivity through time losses related to unnecessary movement, rework and relocation of temporary facilities. The findings further indicate that CSLP is largely based on experience. To address this, a checklist was developed aimed to support a more structured and systematic approach to CSLP by highlighting important aspects.

Keywords: construction site layout planning, infrastructure, urban environment, productivity, time losses, checklist

Acknowledgement

First of all, we would like to thank our supervisor, Ahmet Anil Sezer from Chalmers University of Technology, for his support and guidance throughout the thesis. We would also like to thank our Skanska supervisor, Björn Krook, for helping us identify relevant projects for the study and assisting us in contacting interviewees. Furthermore, we would like to thank all interviewees who took the time to participate in the interviews and share their experience and knowledge with us. Finally, we would also like to thank our opponents, Tilda Cronsell and Alice Westberg, for their valuable feedback on our work.

Benjamin Bladh and Ella Sjöberg, Gothenburg, June 2026

List of Acronyms

Below is the list of acronyms that have been used throughout this thesis listed in alphabetical order:

AI	Artificial Intelligence
BIM	Building Information Modeling
CAD	Computer-Aided Design
CSLP	Construction Site Layout Planning
DSLP	Dynamic Site Layout Planning
NVAA	Non-Value-Adding Activity
TF	Temporary Facilities
TMP	Traffic Management Plan

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1
Introduction

The following chapter presents the foundation upon which the study is based. It begins with a background to the research area followed by a problem formulation that clarifies the study's point of departure. The chapter then outlines the aim and research questions, and concludes with a description of the delimitations that define the scope of the study.

1.1 Background

Urbanization is reshaping the conditions under which construction projects are planned and executed. Global patterns of urban expansion indicate that cities are becoming denser and that new development increasingly takes place within already built environments rather than on undeveloped land (Angel, 2023). As a result, infrastructure projects are more often embedded in complex urban contexts, where construction activities must coexist with traffic, residents, businesses, and ongoing urban functions (Dainty et al., 2017). In such settings, the construction site becomes a temporary yet high-intensity production environment situated within a spatially constrained context. Urban construction sites are characterized by severe space limitations and continuous interaction with surrounding urban functions, which puts substantial pressure on how activities, flows, and Temporary Facilities (TFs) are organized (Tsegay et al., 2023). These sites are urban, dynamic and shaped by limited space and high external demands.

The construction industry is particularly challenged by these conditions due to its organizational and operational characteristics. Despite significant technological and managerial developments in recent decades, unlike manufacturing, the construction industry is organized around temporary, project-based arrangements in which a unique configuration of actors, competencies, and contractual relationships is assembled for each project (Gann & Salter, 2000). Production is decentralized, work is highly interdependent, and activities are carried out under continuously changing conditions. Multiple trades, subcontractors, and suppliers must coordinate their work in time and space, often with incomplete information and under tight schedules (Vrijhoef & Koskela, 2000). Consequently, construction production rarely resembles a controlled factory environment. Instead, it unfolds in a mobile and uncertain setting where disturbances and variability are inherent features of everyday work.

Within this context, the construction site itself can be understood as a production system in which people, materials, equipment, and information must interact efficiently in both time and space for value to be created. The spatial configuration on the site, its layout, plays a central role in shaping how these interactions occur. Decisions regarding the placement of TFs, storage areas, access routes, and work zones influence how far workers must walk, how materials are transported, and how different activities intersect (Zouein & Tommelein, 1999). According to Ballard and Howell (2003), even seemingly minor layout choices can have significant consequences for movement patterns, safety conditions, and the overall workflow. They also state that site layout is not an administrative detail but a core component of the production system that directly affects operational performance.

In addition to its impact on productivity, site layout planning is also closely linked to sustainability which has become increasingly important in today's society (Bajdor & Bhambri, 2024). Through efficiently designed layouts, transport distances can be minimized, leading to reduced emissions and lower environmental impact (Galieroková & Sosedová, 2016). From an economic perspective, effective site layouts can contribute to cost savings and reduced time losses (Elebeltagi et al., 2004). A well-organized construction site can also provide safer working conditions which is a central aspect of social sustainability (Muthu, 2025).

In urban construction projects, challenges related to site layout are common. Limited space combined with changing project conditions, can result in unclear movement flows, clashes between different actors, and recurring relocations of TFs (Tsegay et al., 2023). This may lead to unnecessary movement and interruptions in daily operations, affecting both productivity and safety while also reducing overall project predictability (Choi et al., 2014). Although such issues are frequently recognized in practice, they are not always addressed in a structured manner within conventional planning processes.

Despite its substantial impact on daily operations, construction site layout is frequently treated at a superficial level. In many projects, layout planning is concentrated in early stages and materialized in static drawings that are seldom revisited as conditions change (Tommelein & Zouein, 1993). Therefore, structured approaches for analyzing movement flows, evaluating alternative configurations, or systematically linking layout decisions to productivity and safety outcomes are often lacking in practice. This gap becomes particularly evident in urban environments, where spatial constraints and external interfaces make layout decisions both more complex and more consequential (Said & El-Rayes, 2011).

In the Swedish context, these challenges are especially pronounced in urban infrastructure projects. High levels of urban density, regulatory frameworks, and strong societal expectations regarding safety, accessibility, and disturbance create demanding conditions for site establishment (Marcano Pina & Sadeghpour, 2023). Construction activities must be coordinated not only internally but also in relation to municipal authorities, traffic management, and surrounding stakeholders

(Fredriksson et al., 2025). TFs and logistics areas are often confined to narrow corridors or fragmented plots, leaving limited room for error. At the same time, Swedish projects are subject to stringent requirements regarding work environment and safety, further constraining how sites can be organized (Arbetsmiljöverket, n.d.).

Within this setting, the way construction sites are planned and continuously adapted becomes a critical determinant of both operational efficiency and project legitimacy. Yet, practitioners often rely on experience-based judgment and ad hoc adjustments rather than on structured, principle-based methods for layout planning (Singh et al., 2020). This creates a need to better understand how site layout influences work in urban projects and how planning can be supported through more systematic approaches. Addressing this need requires bridging the gap between the everyday realities of construction sites and the analytical tools available for understanding and improving spatial organization. This study responds to that need by focusing on construction site layout and logistics in urban projects, with particular attention to productivity in terms of time losses and costs.

1.2 Problem Formulation

In many construction projects, site layout plans are developed in an early stage and subsequently seen as largely fixed artifacts, even though site conditions and production needs evolve continuously (Zouein & Tommelein, 1999). As a consequence, layout changes are often made in a reactive manner, driven by immediate constraints, regulatory demands, and personal experience rather than by a systematic understanding of movement flows and their cumulative effects on productivity (Said & El-Rayes, 2011).

This creates a gap between the acknowledged importance of site layout and the practical means available to manage it. Although research demonstrates that spatial organization influences coordination, time use, and operational efficiency, this knowledge is rarely transformed into accessible principles or tools that can support everyday planning on site (Choi et al., 2017). In urban infrastructure projects, where space is severely constrained, this lack of guidance becomes particularly evident, as practitioners must balance safety requirements, regulatory frameworks, and production efficiency within very narrow margins (Tsegay et al., 2023).

The core problem addressed in this study is therefore the absence of a practical and structured approach to site layout planning that explicitly integrates movement flows, time, and cost considerations. Without such an approach, site layout risks remaining a reactive activity rather than a proactive instrument for improving performance in constrained urban environments.

1.3 Aim and Research Questions

The aim of the study is to analyze how the planning and design of site layout plans in urban infrastructure projects affect productivity in terms of time losses and costs. Particular emphasis is placed on the movement of personnel, materials, and equipment within the construction site, as these flows constitute a significant part of everyday production and are strongly shaped by layout decisions.

Building on the identified gap between the recognized importance of site layout and the lack of structured support in practice, the research seeks to move beyond descriptive accounts of inefficiencies. Instead, it aims to develop a structured form of decision support aimed at systematizing layout planning in order to reduce unnecessary movement, improve resource efficiency, and support productive site operations. This support is intended to provide practitioners with a clear and accessible alternative to complex and often difficult-to-use mathematical optimization algorithms for site layout planning.

Based on the aim and problem formulation, the study strives to answer the following research questions:

RQ1: Which factors influence the design of site layout plans in urban infrastructure projects?

RQ2: How do different designs of site layout plans affect project productivity in terms of time losses and costs?

RQ3: How can a checklist be structured to support effective site layout planning?

1.4 Scope and Delimitations

The study focuses mainly on infrastructure projects within *Skanska Väg och Anläggning* and on site layout planning and movement flows during the production stage. However, perspectives from other companies and divisions have also been considered in the study. It is restricted to urban-area projects, where space is often constrained and logistical challenges are more likely to arise.

The study further examines site layout planning in relation to productivity, particularly regarding potential impacts on time losses and project costs. However, no quantitative time studies or cost calculations are conducted within the scope of this research.

2
Literature Study

This chapter presents a review of previous literature related to construction site layout planning and its connection to project productivity. First, an introduction to site layout planning is given, followed by its key components. Then factors influencing site layout planning are presented, followed by an overview of the relationship between layout planning and productivity. Finally, existing methods and tools for site layout planning are presented.

2.1 Construction Site Layout Planning

Construction Site Layout Planning (CSLP) is a process where TFs for a construction project are identified and strategically placed within the site boundaries (Zouein et al., 2002). The CSLP process involves identifying the TFs required for the specific project and determining their required sizes based on the project scope. Finally, the locations of the TFs are analyzed and optimized within the construction site in order to ensure a high level of efficiency in the project execution (Abdelalim et al., 2025).

Poorly located TFs affect the efficiency of construction activities (Olugboyega & Wemimo, 2018). Effective CSLP has been shown to reduce both costs and time, while also improving safety at site (Salah et al., 2021). The planning of TFs focuses on minimizing unnecessary movements, shortening transport distances and reducing repeated material handling (Salah et al., 2024). For many decades, researchers have explored multiple mathematical optimization methods to improve site layout planning (Elbeltagi et al., 2021). These techniques and formulas are often complex and require expertise, sufficient time and input that is not always available (Sjøbakk & Skjelstad, 2015).

2.1.1 Components of CSLP

There are several components involved in CSLP. As mentioned above, TFs are an important component in the site layout planning. TFs refer to the things required to execute the project, but do not become a permanent part of the finished project (Hansen, 2024). The TFs needed at the construction site differ between projects and are dependent on the project characteristics. However, some of the most common ones are offices, cranes, equipment and material storage, transport routes

(Abune'Meh et al., 2016; Fathy et al., 2016; Zouein et al., 2002).

Planning of movement patterns is another part of site layout design. According to Kannimuthu (2025), site access routes should be planned in an appropriate way to enable vehicles and pedestrians to access the construction site in a safe and easy way. Pathways for transportation of vehicles, personnel, materials and equipment should also be planned to minimize travel distances. Elbeltagi et al. (2004) argue that safety zones should be established around constructions, machinery and storage areas to reduce the risk of injuries caused by falls, falling objects and machine accidents.

2.1.2 Dynamic Site Layout Planning

Traditional CSLP is static, meaning that the plan is established at the beginning of the projects and then remains largely the same throughout the project (Al Hawarneh et al., 2021). Dynamic Site Layout Planning (DSLP), on the other hand, takes into account the changes and stages that occur during production. Layouts are therefore optimized for specific project stages and are continuously changed throughout the construction process (Tommelein & Zouein, 1993). According to Andayesh and Sadeghpour (2014), static CSLP often results in over-allocation of space and less efficient use of the project area compared to DSLP. They also argue that DSLP can be divided into phased and dynamic layout planning. Phased layout planning divides the project into different stages and optimizes each stage layout separately. TFs that remain on the site between phases are not moved but the remaining space can be reused in the new stage. However, within a stage no reuse of space is allowed. Dynamic layout planning, on the other hand, considers the entire project duration as a continuous process. The same space can be used by different TFs at different times, making the area more efficient.

DSLP is particularly useful for projects with limited space and long construction durations (Al Kulabi & Al Zahid, 2020). According to Hansen (2024), wider construction sites tend to have more static layout planning, whereas more confined construction sites rely more on dynamic planning. Hansen (2024) also state that small-scale projects should have a minimum of two site layout plans and large-scale projects should have at least three. Collins et al. (2017) argue that projects costing less than $5 million and/or lasting under 12 months are typically classified as small projects, while those exceeding these cost and duration thresholds are considered large projects.

2.2 Factors Influencing CSLP

The design of site layout plans is shaped by several different factors. While theoretical approaches to CSLP often focus on optimizing distances and space use, the actual design of site layouts is influenced by regulatory requirements and project-specific conditions (Marcano Pina & Sadeghpour, 2023; Aaltonen & Kujala, 2016). Particularly in urban projects, layout decisions must consider spatial constraints (Tsegay et al., 2023). This section will explain these factors further and how they influence site layout design.

2.2.1 Regulatory and Safety Requirements

Marcano Pina and Sadeghpour (2023) have identified seven categories of regulations applicable to CSLP: client requirements, safety, environmental, public regulations, transportation policies, codes and permits, and territorial. These categories are further divided into four subcategories: project-related, federal, provincial and municipal, depending on the origin of the regulations.

There is no specific legal requirement to establish a site layout document in construction projects. Nevertheless, site layout plans are commonly used because they are an effective tool for fulfilling the requirements set by the Swedish Work Environment Authority (Arbetsmiljöverket). According to AFS 2023:3, every construction project must organize the construction site, but does not necessarily have to be executed through a site layout plan. However, a site layout plan serves as a practical instrument for ensuring that these regulatory requirements are met (BAMS AB, 2025). This highlights that regulatory requirements do not only constrain layout design but also actively shape how space, flows and activities are organized in practice.

Due to the Swedish Work Environment Act (Arbetsmiljölagen, AML), the work environment must be adapted to workers and designed to prevent ill health and accidents (AML, Chapter 2, Sections 1-2). In construction projects, where multiple actors operate within a shared workplace, this is further reinforced by statutory requirements for coordination (AML, Chapter 3, Section 6). Together, these provisions provide a clear legal basis for the need for structured and well thought out site layout planning.

2.2.2 Spatial Constraints in Urban Areas

In urban construction projects, the work space is often limited, which creates fundamentally different conditions for how to organize the workplace in comparison to projects outside the urban area. Olugboyega and Wemimo (2018) show that the placement of TFs becomes particularly critical in such areas. Minor misplacement can lead to inefficiencies across the entire production system. On work sites with lack of space, it becomes difficult to separate functions such as storage, transport routes and work areas, resulting in overlapping activities and increased operational complexity (Olugboyega & Wemimo, 2018).

Tsegay et al. (2023) stresses that inner-city construction sites are shaped by structural lack of space and that limited access to space is combined with high demands on accessibility, safety and consideration of the surrounding environment. They point out that current practices are often fragmented and driven by short-term decisions regarding TFs. This leads to tight working conditions and frequent relocation of site resources. The same authors argue that lack of space should not only be understood as a physical constraint, but also as a systematic condition that influences the production logic on site. Further, they stress that categorizing space requirements into micro-space, macro-space and paths helps to illustrate how different parts of the construction site are interconnected. Micro-space can be understood as the immediate areas where work is carried out, such as spaces for crews, equipment and safety zones. In contrast, macro-space refers to larger areas on site used for functions like material storage, TFs and overall logistics.

Several researches indicate that limited space often leads to extended travel distances, recurrent relocation of site facilities and materials, and difficulties in establishing clear safety zones (Zouein et al., 2002; Elbeltagi et al., 2004). In case of a lack of space for permanent solutions, project teams are often forced into short-term, reactive decisions where immediate operational needs dominate. As a result, the site often evolves gradually and fragmented rather than through a coherent planning process (Tsegay et al., 2023).

Kannimuthu (2025) argues that spatial constraints in practice tend to neglect logistical considerations because of favoring immediate production demands. By prioritizing production demands it often results in inefficient movement patterns and places additional workload on both workers and equipment. Research within site layout efficiency further shows that such conditions not only affect productivity but also safety as tight environments limit the possibility of creating safety zones between people, machinery, and materials (Abune'Meh et al., 2016).

These findings mean that lack of space should be understood as a structural condition that shapes the logic of production on site rather than only as a physical limitation. The need for deliberate and systematic layout planning is reinforced in urban projects where each square meter is important and seen as a resource that must be allocated with regard to both efficiency and safety (Salah et al., 2021; Salah et al., 2024).

2.2.3 Project Specific Factors

Other than regulatory requirements and spatial constraints, site layout design is also shaped by conditions that are specific to each individual project. Construction projects are often carried out in environments where many actors operate simultaneously, project objectives may shift over time, and uncertainty forms a natural part of execution. This affects how space can be allocated, where TFs are located, and how transportation routes and movement patterns are organized within the site (Aaltonen & Kujala, 2016).

The complexity of the project is one factor that is often highlighted. When the scale of a project increases, the number of parties involved and the number of ongoing activities typically increase as well, leading to more coordination challenges. This means that the dependencies between different work elements become more and more apparent, placing higher demands on the planning of the workplace (Rajhans & Modh 2024). Decisions about workspace, material locations, or site access can have consequences that go beyond one single activity. If multiple professional groups must share the same area, competition may occur for space, which in turn can interfere with workflows and productivity (Bygballe & Swärd, 2019). Careful site planning therefore becomes an important prerequisite for maintaining stability in production.

At the same time, it is important to highlight that spatial requirements rarely remain constant throughout the entire project. Early phases often require larger continuous areas for heavy machinery, material storage and logistics functions. In later stages the situation often shifts when more specialized groups perform parallel tasks meaning that the area must be shared between several activities (Andayesh & Sadeghpour, 2014). Since the project requirements becomes clearer during execution, a layout that initially was well-adapted can later on show to be less suitable as activities begin to overlap. Site layout is an evolving component of the production system, rather than a plan established once and not intended to change (Mesa et al., 2016).

The need to maintain a well-functioning production flow further underlines the importance of adapting site layout planning to project conditions. Construction processes depend heavily on the coordinated progression of tasks, and limited workspace availability may result in disruptions such as waiting times, detours or temporary adjustments (Lai et al., 2020). In projects where work areas shift over time, or where the progression of activities changes, it requires spatial arrangements that can be adjusted as the project advances in order to reduce bottlenecks and interruptions (Lappalainen et al., 2021).

2.2.4 The Planning Gap in Urban Construction

Previous research shows that there is a clear gap between long-term urban planning and practical conditions during construction (Fredriksson et al., 2025). In this context, it is important to distinguish between different types of planning related to construction. Temporary traffic solutions are often managed through Traffic Management Plans (TMPs) which regulate how public space and streets can be used or restricted during construction (Fredriksson et al., 2025). In contrast, site layout plans focus on the entire construction area and a broader logistical flow on the work site, not only the traffic (Andayesh & Sadeghpour 2014). Although these planning tools address different aspects of the construction process, they are closely related as they together shape how the flows of materials, equipment, and personnel are managed (Fredriksson et al., 2025).

This distinction also shows a broader challenge in how the construction phase is handled within planning processes. While planning processes mainly focus on how the final built city should function, the temporary situation during construction is often given less attention (Chou et al., 2025). This means that logistics, traffic arrangements and site organization tend to be handled more reactively rather than in a proactive and systematic way. This has been described as a planning gap where the production phase is not fully integrated with the urban and transport planning (Fredriksson et al., 2025; Eriksson & Fredriksson, 2025).

In practice, this is reflected in how temporary traffic solutions are developed under limited time and with restricted access to information and analytical tools. At the same time, construction activities increase pressure on the surrounding transport system through deliveries and heavy vehicles (Fredriksson et al., 2025). A key explanation to the planning gap is that responsibilities are distributed or divided across several different actors. Municipalities, clients and contractors all influence construction logistics but still have different goals and priorities. Clients often focus on project duration, contractors on production efficiency and costs, while municipalities often operate to minimize disturbances and impact on the surrounding. When these different views and perspectives are not coordinated sufficiently, decisions risk being optimized at a project level rather than from a broader system perspective (Fredriksson et al., 2025; Eriksson & Fredriksson, 2025).

The challenges are further reinforced in urban areas where multiple projects are ongoing simultaneously. Combined transport demands and road shutdowns can interact and lead to congestion, reduced accessibility and safety risks in the traffic system. This highlights how decisions within a single project can affect the wider urban system (Fredriksson et al., 2025; Eriksson & Fredriksson, 2025).

Another aspect is the weak connection between production planning and logistics planning. Even if construction activities are often planned in detail, deliveries and transports are not always as planned. This can lead to inefficiencies such as poorly timed deliveries or unnecessary movements on the construction site. (Fredriksson et al., 2025). Overall, the planning gap highlights the need for more structured approaches that better connect planning with on-site production, particularly in urban environments.

2.3 Productivity in Construction Projects

There is a clear link between CSLP and project productivity. Productivity in a project context is defined as the ratio between the output produced and the inputs used to produce it (Rathnayake & Middleton, 2023). Productivity can also serve as an indicator of the success of a project, which highlights its importance (Thulasi & Unnikrishnan, 2018). Construction labor productivity is a commonly used measure of productivity as labor costs often represent more than 30% of the total project cost (Tammy et al., 2019; Nurhendi et al., 2022). This means that the movements of workers on site play a critical role since they are paid for their time, and unnecessary movements will contribute to higher project costs.

Hasan et al. (2018) identified the most common factors that influence construction productivity. The factors are ranked according to their level of criticality, with the most critical listed first: material shortages, poor supervision, lack of skilled labor, lack of proper tools and equipment, incomplete drawings and specifications, ineffective communication, rework, unfavorable weather conditions, and design changes. Although poor site layout is not defined as one of the most critical factors, it remains an important aspect influencing productivity in construction projects. Despite this, Hansen (2024) argues that many project managers and site engineers tend to ignore this aspect.

2.3.1 Time Losses and Non-Value-Adding Activities

A significant part of time losses in construction projects can be traced to activities that do not directly contribute to value creation. These types of activities are often called Non-Value-Adding Activities (NVAAs) and consume resources without moving the project forward or failing to advance the project progress, leading to reduced overall productivity (Emuze & Smallwood, 2013). Ismail and Yusof (2016) indicate that such inefficiencies may represent a substantial part of the daily operations. For example, almost half of the time spent on construction activities has been connected to work that does not add value to the project. Common examples include waiting for materials or equipment, unnecessary movement, rework and defects, all of which interrupt workflow continuity and reduce the time spent on productive tasks (Ismail & Yusof, 2016).

At the same time, it is important to note that these activities tend to become normalized within project organizations and therefore risks remain unaddressed or not handled during planning stages. This suggests that time losses should be interpreted not only as operational shortcomings, but also as indicators of underlying organizational and spatial conditions that shape the production process (Yap & Tan 2021). From this perspective, it becomes central to pay increased attention to how the construction site is structured and coordinated, as decisions of this type are directly related to the possibility of reducing NVAAs (Ismail & Yusof, 2016).

2.3.2 Cost Implications of Inefficient Layouts

The time losses and NVAAs that arise in construction production do not only affect productivity but also have economic consequences. When work tasks take longer than anticipated, the consumption of resources increases, leading to increased project costs but also reinforces the close relationship between time performance and financial outcomes. Even smaller inefficiencies can, when repeated over time, have noticeable effects on the project's total costs (Josephson & Saukkoriipi, 2007).

Singh et al. (2019) highlight that many of these costs are closely linked to the way the construction site is planned and organized. Decisions about the site layout influence transportation routes, material flows and accessibility to work areas, which shapes the logistical conditions where production takes place. Inadequate planning risks resulting in unnecessary transportation, repeated material handling and operational disruption (Aregbesola et al., 2024). These factors reduce both efficiency and increase the demand for labor and equipment. For example, longer travel distances do not only require additional work time but may also lead to higher usage of equipment and higher energy consumption, further amplifying cost impacts (Singh et al., 2019).

Since CSLP typically occurs in the early stages of a project, inefficient decision can be challenging and expensive to rectify once construction activities have started (Zavari et al., 2022). Making changes in later stages often requires the reallocation of resources or the implementation of temporary arrangements, resulting in additional costs. Furthermore, expenses related to site configuration often manifest as consequences of prior planning decisions rather than as standalone operational problems (Kim & Kim, 2025). This highlights the need to see layout planning as a strategic consideration with direct influence on a project's financial performance, not only as a matter of physical organization (Singh et al., 2019).

2.4 Tools for CSLP and Existing Methods

Several different methods and tools have been developed to support CSLP. These range from more traditional methods to digital tools and optimization algorithms (Marcano & Pina, 2023; Xu et al., 2020). Hansen (2024) also emphasizes lessons learned as an effective tool to improve future CSLP. Although no sites are completely similar, lessons learned remain important to transfer knowledge and avoid repeating previous mistakes.

2.4.1 CSLP Tools

Marcano and Pina (2023) have identified the tools that are currently used in the construction industry for CSLP. Table 2.1 summarizes the tools and their different functionalities.

Table 2.1: Existing tools in CSLP (Marcano & Pina, 2023)

Tools	**Function**
PDF Mark-Up	Draw, Write/Annotate
Pen and Paper	Draw, Write/Annotate
Whiteboard	Write/Annotate, Visualize Site Layout
Cardboard	Visualize Site Layout
BIM	Draw, Visualize Site Layout, Upload Information
CAD	Draw, Visualize Site Layout
Specialized Software	Share site layout, Upload Information
In-House Software	Upload information
Spreadsheets	Upload information, Save information
Satellite Map Tools	Visualize Site Layout, Upload Information, Save Information
UAV Imagine	Visualize Site Layout, Upload Information, Save Information
Image Viewing	Visualize Site Layout, Save Information

Table 2.1 illustrates that digital tools play a major role in CSLP. Traditional methods, such as manual sketches, have been significantly modernized through the adoption of digital tools. This shift allows for more dynamic, data-driven and efficient planning (Kannimuthu, 2025). Technological innovations like Computer-Aided Design (CAD), Building Information Modeling (BIM) and Geographic Information Systems (GIS) have significantly transformed CSLP. CAD enables the creation of digital 2D and 3D models, which increases accuracy and makes drawings easy to modify and adapt. Digital drawings also reduce the risk of errors and information loss compared to manual documentation. BIM represents the next level in digital planning with an integrated and data-driven approach, where 3D models also can include information such as time (4D) and cost (5D). GIS is a system that includes spatial data and can be used to identify optimal routes for the transportation of materials, equipment and personnel (Kannimuthu, 2025).

2.4.2 Optimization Algorithms

In recent years, many researchers have focused heavily on optimization algorithms in CSLP (Xu et al., 2020; Ning et al., 2010; Yao et al., 2023). These algorithms aim to identify optimal location of TFs by minimizing travel distances and safety risks (Nguyen et al, 2025; Zouein et al, 2002). From a theoretical perspective, these optimization algorithms have a high potential to improve site efficiency. However, it can be difficult to apply them in practice. Firstly, this is because the methods assume that the required space and resources are known in advance. In real construction projects, these may vary significantly and change over time (Shin et al., 2024). Secondly, the methods can be very comprehensive and difficult to understand, requiring expertise and time that smaller projects in particular may not have (Sjøbakk & Skjelstad, 2015).

This gap between advanced algorithms and practical applicable methods shows that there is a need for alternative approaches to CSLP. There is a growing demand for principle-based methods and structured work practices that can support systematic layout planning.

3 Methods

The following chapter outlines the methods applied in the study and explains how they have been used. A literature study has been carried out alongside interviews and analysis of site layout plans provided by Skanska. This methodological triangulation has formed the foundation to answer the research questions. Furthermore, considerations related to research quality and ethical responsibility are presented in order to provide transparency and allow an assessment of the credibility of the study.

3.1 Research Approach

The study was conducted using a qualitative research approach where a review of relevant literature was combined with interviews and a document analysis. By combining multiple sources of information, it was possible to examine the research questions from different perspectives while developing an understanding of CSLP in infrastructure projects. This methodological triangulation also strengthened the credibility of the study (Eisenhardt, 1989).

The research was initiated with a literature review to provide a theoretical foundation for the study and to analyze previous research related to CSLP, logistics and productivity in construction projects. Key concepts and recurring factors that influence the design of site layout plans were identified from the literature review. That helped form the analytical framework and gave an initial understanding of the factors that influence layout planning, which related to RQ1. It also contributed to an understanding of CSLP relationship to productivity, addressing RQ2.

With the literature review as a foundation, semi-structured interviews were conducted with professionals involved in CSLP. The purpose of the interview study was to gain insight from practical experiences on how layout planning is handled in real-world projects. It also helped to understand the challenges and considerations that could arise during the planning process. In the interview study, factors that influence the design of site layout plans in practice could be identified and contributed primarily to answering RQ1 and RQ2.

In parallel with the interview study, a document analysis of construction site layout plans was conducted from selected projects. The purpose of the document analysis was to examine how layout plans change throughout the production phase and to explore potential patterns in site layout designs. The analysis of site layout plans made it possible to relate experiences described in the interviews to actual project conditions. The document analysis mainly contributed to the foundation for RQ3 by providing examples of how site layouts are designed and evolved during projects.

Throughout the study, theory and empirical findings were continuously interpreted in relation to each other, which means that the study followed an abductive research approach (Dubois & Gadde, 2002). Insights from interviews and document analysis were gradually compared with existing research which helped deepen the analysis and refine the interpretation of the results. An iterative research process was used throughout the study in which empirical findings influenced the ongoing analysis and contributed to shaping the direction of the study (Eisenhardt, 1989).

Finally, the findings from the literature review, interviews and document analysis were integrated into a comprehensive analysis. This analysis formed the basis for the development of a structured checklist that aims to support the planning of construction site layout plans in practice. The purpose of this checklist was to translate the findings of the study into practical guidance, thus addressing RQ3. Figure 3.1 illustrates the overall research design and how the different methods contributed and were connected to the study.

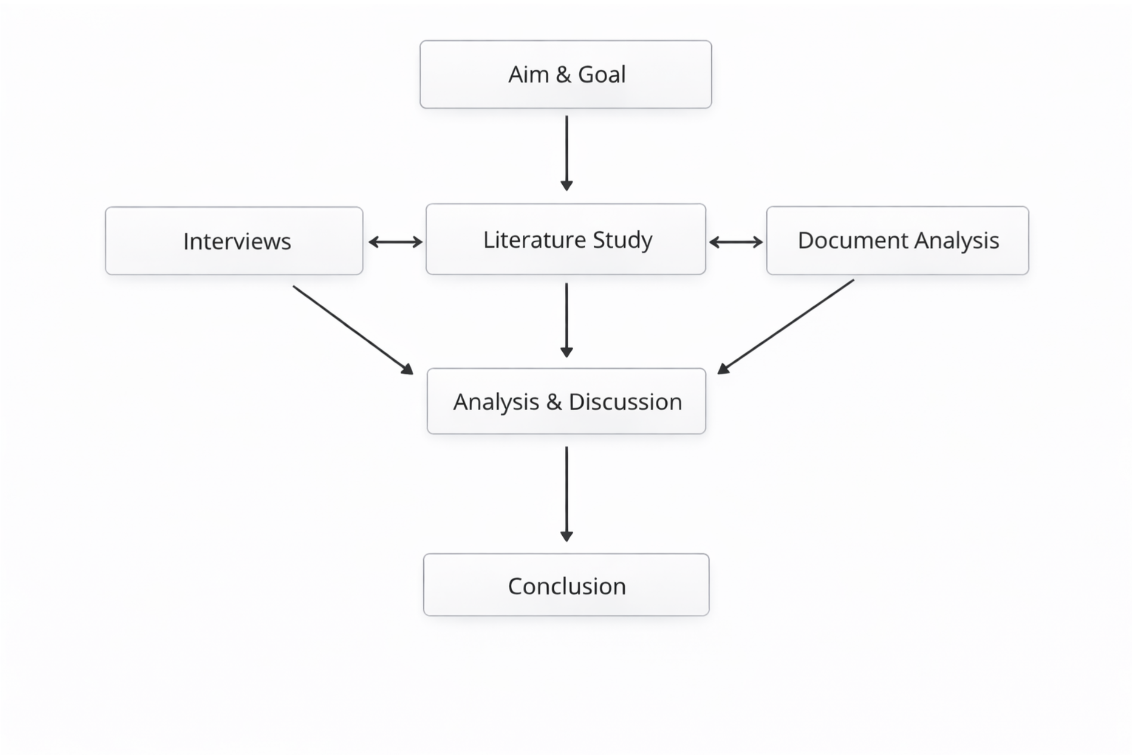

Figure 3.1: Overview of the study's research design

3.2 Literature Study Strategy

The literature study was conducted to get an overview of existing research within CSLP and to identify factors that influence how construction sites are organized. Particular attention was paid to studies addressing logistical challenges, movement flows and operational consequences in urban infrastructure projects. The review helped to clarify a research gap connected to the limited availability of structured and practically applicable approaches to site layout planning.

To ensure a systematic approach, literature searches were carried out through several databases, shown in Table 3.1. Table 3.1 also shows the keywords used to find relevant literature. As relevant studies were identified, their reference lists were reviewed to locate additional sources using backward reference searching, allowing the search process to develop progressively throughout the study.

Table 3.1: Overview of databases and keywords

Databases	**Keywords**
Google Scholar	“Construction”, “Site Layout Planning”,
Research Gate	“Logistics”, “Infrastructure”,
Science Direct	“Urbanization”, "Coordination",
Scopus	"Transport Routes"

The selection of literature focused on peer-reviewed journal articles and conference papers to ensure scientific quality. Publications were selected by reviewing their title and abstract. The literature was then analyzed to identify recurring challenges, key influencing factors and existing approaches to CSLP, which together formed the theoretical foundation of the study.

3.3 Empirical Data Collection and Analysis

The study is based on qualitative data collected through semi-structured interviews with professionals in the industry, complemented by document analysis of site layout plans.

3.3.1 Interviews

Interviews are one of the most commonly used methods for collecting qualitative data (DiCicco-Bloom & Crabtree, 2006). Through interviews, researchers can gain a deeper understanding of a subject through individual experiences and opinions (Rose & Grosvenor, 2001). In order to gain a deeper understanding of which factors influence CSLP development in practice, and how these factors affect the project, semi-structured interviews were conducted. *“Semi-structured interviews are the preferred data collection method when the researcher’s goal is to better understand the participant’s unique perspective rather than a generalized understanding of a phenomenon”* (Adeoye-Olatunde & Olenik, 2021, p. 1360). This method allowed for more natural conversations with open-ended questions, rather than following a strictly structured format.

The interview process involved five steps:

1. **Interview guide:** An interview guide was developed with a set of questions that align with the research questions (see Appendix A for the full list of questions).
2. **Selecting interviewees:** Interviewees were selected with support from the supervisor at Skanska, and recommendations from the interviewees themselves. All of them were involved in CSLP. The study focuses on infrastructure projects, however, perspectives related to building construction were also included. This was motivated by early insights indicating that CSLP is generally more developed within building projects. 11 interviewees had experience in infrastructure projects and 2 in building projects. An overview of the interviewees and their role is provided in Table 3.2.
3. **Conducting interviews:** The interviews were conducted in Swedish to allow respondents to express themselves in their native language and thus ensure the quality of the responses. Interviews with participants located in the Gothenburg area were conducted in person, while interviews with respondents based elsewhere or conducted under time constraints were carried out online. All interviews were recorded to ensure accurate transcription.
4. **Transcription and translation:** The interviews were transcribed in Swedish and the analysis was conducted on the basis of the transcripts. In the report, the findings were translated into English and efforts were made to preserve the meaning of the statements of the respondents.
5. **Analysis:** The interview transcripts were analyzed by highlighting parts that were related to the research questions or emphasized other important aspects. Then these parts were grouped into themes that showed patterns in the interviews. The themes were used to help answer the research questions.

Table 3.2: List of interview participants and their roles

Interviewee	Role	Project Type
A	Health & Safety Manager	Infrastructure
B	Site Manager	Infrastructure
C	Site Manager	Infrastructure
D	Survey Coordinator	Infrastructure
E	Project Manager	Infrastructure
F	Construction Logistics Consultant	Infrastructure
G	Site Manager	Infrastructure
H	Project Engineer	Infrastructure
I	Site Manager	Infrastructure
J	Survey Coordinator	Infrastructure
K	Project Manager	Infrastructure
L	Site Manager	Building
M	Site Manager	Building

3.3.2 Document Analysis

To increase the trustworthiness in qualitative research, interviews are commonly combined with document analysis. Document analysis can provide information that may not appear in interviews and can also confirm or deny interview findings (Bowen, 2009).

Site layout plans were collected and analyzed from different urban infrastructure projects at Skanska. Projects were selected with support from the supervisor at Skanska. An overview of the projects and their constraints is provided in Table 3.3. The analysis was structured around four predefined categories derived from the literature and interviews.

Each site layout plan was analyzed according to the following categories:

1. **External conditions and constraints:** Identifying factors influencing layout design, such as spatial limitations, surrounding environment and project phase.
2. **Placement of TFs:** Examine how TFs such as offices, storage areas and transport routes are organized.
3. **Movement flows:** Look at walking distances, transport routes and indications of unnecessary movement.
4. **Planning approach:** Evaluate whether the layout appear static or dynamic and how often it is updated.

Then the site layout plans from the different projects were compared to identify patterns in layout design.

Table 3.3: List of projects and their constraints

Project	Type	Duration	Area
1	Road & Bridge	5 Years	$130,000m^2$
2	Groundwork	1.5 Years	$21,000m^2$
3	Quay	4 Years	$6,500m^2$
4	Groundwork & Hospital	3 Years	$10,000m^2$

3.4 Ethical Considerations

To ensure that the study was conducted in an ethically responsible manner, established principles for qualitative research were followed. Ethical responsibility is particularly important in qualitative research, as there is a close interaction between researcher and participant (Arifin, 2018). This puts a responsibility on the researcher to protect the integrity of the participants throughout the research process. Key principles for this included ensuring voluntary participation through informed consent, maintaining anonymity and confidentiality, but also handling collected data in a safe manner. Ethical research also includes balancing the potential benefits of the study against risks participants may face (Arifin, 2018).

To adhere to these principles, all participants were informed about the purpose of the study and how data collection would be carried out. Before the interviews, the participants were given the opportunity to decide whether they wanted to participate or not. Furthermore, individuals were anonymized and no personal data was disclosed in the report in order to protect the integrity of the participants without compromising the analytical value of the study.

3.5 Trustworthiness

Credibility was strengthened through methodological triangulation where interview findings were complemented by a document analysis and a literature review. Combining multiple sources of data enabled a more nuanced understanding of CSLP while also allowing findings to be compared and cross-checked.

The interviews were conducted with respondents who had substantial knowledge of CSLP and represented different roles within the projects, contributing depth to the empirical material. All interviews were recorded and transcribed to reduce the risk of information getting lost or being misinterpreted, and to ensure that the respondents' perspectives were accurately represented.

Dependability was addressed by providing a transparent description of the research process, including the procedures for data collection and analysis. The analysis was grounded in the empirical material and related to previous research to reduce the influence of subjective interpretations.

Throughout the study, the authors also aimed to maintain a neutral stance in order to avoid shaping the results based on personal assumptions.

Data collection was also supported by organizational documents, strengthening the empirical foundation of the study. Although the research was carried out together with Skanska, a well-established company within the construction industry, the findings are considered relevant beyond the studied organization as many actors face similar challenges related to site layout planning.

3.6 AI Disclosure

This study has been supported by AI (Artificial Intelligence) tools. Scopus AI was used to help identify and gather relevant literature for the study. Chalmers AI Portal was used to transcribe the interviews. Chat GPT has been used to support the writing process by helping formulate text, as English is not the native language of the authors, and to brainstorm interview questions.

No confidential information about the company and the participants has been shared with any AI tools and all AI output has been critically reviewed.

4

Findings

This chapter presents the empirical findings of the study, based on interviews and document analysis. The results are structured around the study's research questions, and aim to provide an overview of how CSLP is carried out in practice within urban infrastructure projects. First, factors influencing the design of site layout plans are presented. Second, current practices related to CSLP are described. Finally, the relationship between site layout planning and on-site productivity is explored, with a particular focus on time losses, movement flows and coordination between activities.

4.1 Factors Influencing CSLP

The interview findings show that the design of site layout plans in urban infrastructure projects is influenced by several factors. These factors can be categorized into six main themes: surrounding environment, traffic flows, space constraints, project-specific factors, safety requirements and project phase.

4.1.1 Surrounding Environment

The findings show that the surrounding of the project is a key factor in the design of site layout plans in urban infrastructure projects. Projects can be located close to already existing infrastructure, housing, schools, hospitals, stores and other business operations, which affect both the available spaces and impose requirements on how the site is organized. Interviewee D stated that surrounding actors often have views that need to be taken into consideration, for example, regarding accessibility and disturbance. It was also revealed that other projects in the same or nearby areas can affect planning as this requires coordination of resources, spaces and logistics.

A concrete example of this was described by Interviewee I, involved in a hospital extension project where construction activities were carried out in close proximity to an ongoing hospital operation. This was reported to have a significant impact on how the work was planned and executed. In particular, representatives from the hospital had expressed concerns regarding activities such as piling, which are typically associated with high noise levels. Since the hospital continued to operate, construction work had to be adapted accordingly. This required adjustments to both the planning and execution of activities, including logistical changes to accommodate these constraints.

Similar challenges were described by interviewees in other projects, where CSLP was influenced by surrounding conditions, such as railways that could not be shut down during certain hours, or at all. In addition, nearby buildings imposed requirements on maintaining access routes, for example, to ensure that evacuation paths remained clear in the event of fire or other emergencies. Interviewee C highlighted that ensuring access to nearby roads required ongoing dialog and coordination with emergency services. The construction project therefore had to adapt its site layout and its planning to meet these external requirements in order to proceed with the work.

4.1.2 Traffic Flows

Managing traffic flows outside the construction site appears as a direct consequence of the urban context and is a crucial factor in planning. All interviewees mentioned that multiple types of traffic must be taken into consideration, including cars, cyclists, public transport and pedestrians. A general requirement is to minimize disturbances to the surroundings, which implies that traffic management solutions must be integrated into the layout planning. This is often achieved through the development of a TMP, which regulates traffic diversion and ensures safety during the project.

Traffic flow within the construction site also affects layout planning. Transport routes for materials, machinery and vehicles must be planned in a safe and efficient manner. This is partly due to the number of transports that a project has, as well as the size of the transports, which determine how much space is required for movement within the construction site.

4.1.3 Space Constraints

Surrounding environment and traffic in urban areas contribute to major space limitations. The findings show that space constraints are one of the most challenging aspects and that it puts high demands on the planning of available spaces. However, they also mention that building projects typically face even greater challenges with confined construction sites compared to infrastructure projects, making layout planning even more crucial in building projects. Interviewee C mentioned that space requirements are often underestimated during the planning phase, which can cause problems during construction. The interviewee said that “things always take much more space than you think” and highlighted the importance of including margins for TFs.

A common pattern among interviewees working in projects with, according to themselves, constrained space was the increased importance of internal vehicle transport. When multiple work operations take place within a confined area, the organization of transport flows becomes critical for maintaining both efficiency and safety. In such context, all respondents highlighted the importance of achieving so called "loop circulation". Loop circulation was described as when vehicles and machinery can enter the site, load or unload materials and then exit without the need for reversing or turning in restricted areas. This approach was described as a key strategy for improving logistical flow while simultaneously reducing safety risks. Interviewee I expressed that *"loop circulation is always something to strive for, as reversing vehicles in tight spaces constitute a significant safety risk"*.

The document analysis further supports this observation. In two of the four studied projects, loop circulation was not achieved. These sites were instead characterized by a single combined entry and exit gate and highly constrained working areas. However, the projects that had one gate for vehicles both entering and exiting the site was not described as a major issue in itself. The main concern was that vehicles, particularly trucks, had to reverse or maneuver within limited space before exiting the site.

4.1.4 Project-Specific Factors

In addition to external factors, the interview findings indicate that the characteristics of the project have a significant impact on the layout. The majority of the respondents mentioned that project type plays a crucial role. All respondents working within infrastructure projects agreed on some clear differences between building and infrastructure projects in relation to CSLP. Building projects were generally described as more structured and more proactive which was related to more confined workspaces, higher volumes of material flows and greater need for detailed coordination. Interviewee G, working in infrastructure, pointed out that building projects often involve a larger number of cranes and a higher frequency of deliveries compared to infrastructure, which requires careful planning of logistics. In addition the nature of deliveries differs between project types. Infrastructure projects are often dominated by transport of bulk materials such as excavated soil and aggregates which, according to Interviewee G, are perceived as less complex from a logistical perspective.

In contrast, building projects involve more interdependent delivery chains, where different materials and activities must follow a specific sequence. Interviewee G gave an example of this chain where reinforcement may be delivered one day, followed by concrete casting the next day, and then the removal and installation of scaffolding shortly thereafter. Combined with more limited space, this creates a stronger need for detailed and coordinated layout planning.

In infrastructure projects, planning was instead described as more flexible and adaptable. Changing ground conditions often require continuous adjustments during production. As Interviewee A expressed it, *"it is difficult to plan every step in advance, since conditions tend to change once work is underway"*.

Additionally, the specific type of infrastructure project is crucial. For example, quay projects require specific safety zones next to the water, and tunnel projects implies a lot of excavation material that requires well planned transport routes.

The size of the project, both in terms of scope and geographical extent, also affects site layout planning. For smaller projects, a simple sketch can be sufficient, while larger projects require detailed and dynamic planning. Furthermore, different work activities require different types of space and logistical solutions.

4.1.5 Regulations and Requirements

Regarding regulations and requirements affecting the CSLP, safety requirements were a recurring theme among the interviewees and a key factor that influences the design of site layout plans. This includes both the safety of on-site workers and the protection of third party.

The safety requirements identified during the interviews and the document analysis were:

- Emergency equipment: fire extinguisher, first aid kit, defibrillator, lifebuoy (for projects located close to water)
- Emergency exits and routes
- Emergency evacuation point
- Safety barriers and zones

In addition to safety requirements, it was also mentioned that a building permit for site accommodations are required from the municipality. However, Interviewee M emphasized that some municipalities do not require a building permit for site accommodations. Other respondents also pointed out that different municipalities may impose varying requirements regarding the design of the construction site.

4.1.6 Project Phase and Time Schedule Integration

Lastly, the interviews show that CSLP is closely connected to the different project phases and the overall project time schedule. Two respondents emphasized that CSLP should already begin during the design phase. In order to avoid misplacement and unnecessary relocation once work is underway, the site layout plan should be a priority before production begins. At the same time, it was consistently described that the site layout plan cannot be treated as static. Different phases involve varying space requirements, work operations and resource needs. This means that CSLP needs to be integrated with the project time schedule in order to enable efficient adaptation to changing conditions at the construction site.

Interviewee E specifically pointed out that current practices often lack a clear connection between layout planning and the project time schedule. According to this respondent, connecting the layout plan to key milestones in the time schedule would facilitate a more proactive work, *"so that you are not misled into relying on an outdated layout drawing"*. By linking the site layout plan to important stages in the schedule makes it easier to get an idea of what the work area has to consider, and reduce the need for late adjustments and improve overall efficiency.

The document analysis supports the observation raised by Interviewee E. Project teams often fail to establish a clear connection between the site layout plan and the time schedule. The review of site layout plans showed that most documents included a timeline at the top of the document. This timeline showed the period during which the specific layout plan was intended to be valid. However, the length of this period varied considerably across projects. In one case the same site layout plan remained valid for an entire year, whereas in most other cases the validity period was limited to approximately one or two months.

A common feature across all reviewed plans was that the timeline only indicated year, month and week. None of the site layout plans included milestones or similar reference points, as suggested in the interviews. In addition, gaps were identified between certain periods where no active site layout plan was defined. For example, one version could be valid throughout April, while the following version applied from June onward, leaving a one month gap without a clearly defined layout plan.

4.2 Current CSLP Practices

The findings of the interview study and document analysis describe how CSLP is currently carried out in practice. The findings are structured into four main themes: limited use of structured methods, experience-based and collaborative planning, use of digital tools, and dynamic updates of site layout plans.

4.2.1 Limited Use of Structured Methods and Checklists

The interviews show that CSLP is carried out to a large extent without a clearly defined or structured approach. Interviewee H and Interviewee J, both from the same company, were the only ones that had access to a formal internal checklist when developing site layout plans. However, only Interviewee H actively used it in practice and explained that the checklist served mainly as a reminder to ensure that key aspects were not overlooked. The foundation in CSLP still lies in personal experience and having dialog with colleagues.

Interviewee J, who had access to the same checklist but has chosen not to use it, expressed concerns about its usefulness. In particular, it was perceived as too generic and sufficiently adapted to the specific conditions of the individual project, which limited the checklist's ability to support or streamline the planning process.

Despite the limited use of formal tools or methods, a consistent finding in all interviews was a generally positive attitude towards further development of CSLP practices. Seven respondents clearly expressed an openness to more structured approaches, including the potential use of checklists or similar forms of support. Interviewee D was explicit about their thoughts about a more structured process in their answer by stating that *"There should be some kind of regulatory requirement document from the authority specifying what is needed at a construction site."*

4.2.2 Experience-Based and Collaborative Planning

CSLP was described as an informal process that varies depending on the individual and the specific project conditions. Although internal guidelines may exist within organizations, they are rarely applied in a consistent manner. Instead, all respondents that did not specifically use a checklist referred to relying on what could be described as a “mental checklist”, built up through experience which guided their planning decisions. At the same time, there was a recurring perception that a more formalized structure could serve as a useful complement, particularly as a form of backup.

A recurring theme in the interviews was that the planning process was described as largely based on “learning by doing”. By being involved in projects and through direct exposure to production activities, knowledge is gained and developed over time. This experience-based understanding forms the foundation for how layout decisions are carried out according to them.

In addition to individual experience, collaboration was identified as a central aspect of CSLP. Layout decisions are rarely made in isolation, but instead through ongoing dialog with other actors such as site managers, supervisors, blue collar workers and in some cases external stakeholders. This collaborative process helps ensure that practical considerations from different perspectives are taken into account even in the absence of a formalized method.

4.2.3 Planning Approach and Digital Tools

The development of a site layout plan typically begins with defining the boundaries of the working area and identifying key functions such as transport routes, areas for site offices and material storage. The placement of these elements is to a large extent based on practical judgment and prior experience rather than on a predefined methodology. All respondents used the digital tool Bluebeam when preparing layout plans, often in combination with AutoCAD drawings or orthophotos to create a clear visual representation of the site.

Beyond the specific tools used, the interview study highlighted that usability plays a more important role than the degree of advancement when selecting digital tools. Several respondents highlighted the importance of working with simple and easily accessible tools where changes can be made quickly without relying on external support, such as IT specialists. As Interviewee H stated, the ability to *“make changes easily”* was considered more valuable than working with more advanced systems.

This preference is also related to the role of the layout plan as a practical tool in production. Simple 2D representations are in general seen as more effective, as they are easier to interpret and communicate to personnel on site. At the same time, the use of digital tools appears to depend partly on individual competence and familiarity, meaning that more advanced features are not always fully utilized.

Although BIM is considered a tool with high potential to support layout planning, its use in infrastructure projects was described as limited. One explanation pointed out was that more advanced models do not always translate well into the practical context on site, where clarity and accessibility are prioritized. The planning process itself was described as iterative rather than linear. The layout is developed through a process of testing a design, evaluating it and then adjusting it as the project progresses. In this sense, the site layout plan is often described as a living document that is continually updated to reflect the current conditions on site.

4.2.4 Dynamic CSLP and Plan Updates

The findings show that the frequency of updating site layout plans varies between projects. However, there is a continuously ongoing change during every project and CSLP is therefore commonly described by interviewees, as a dynamic process that requires continuous adjustments throughout the project to reflect ongoing activities and changing site conditions. The initial planning is typically carried out prior to the start of production, but as the project develops, new requirements and constraints arise which means that the site layout plan must be revised. As a result, these necessary adjustments contributed to planning in practice often becoming more reactive than proactive, although opinions differed on whether this is desirable or simply unavoidable. Amongst the interviewees from infrastructure projects, the findings showed that CSLP is seen as more reactive. In contrast, the interviewees with experience in building projects described a more proactive approach to CSLP. This was explained by the higher level of detail and coordination required to manage complex material flows and multiple simultaneous activities.

All respondents agreed that, in theory, the best case scenario would be if CSLP always was proactive, allowing risks to be addressed in advance. However, opinions diverged when discussing how feasible this is in practice. Some argued that infrastructure projects are inherently unpredictable, particularly due to uncertain ground conditions and excavation work where unforeseen obstacles may appear during production. Under such conditions, detailed long-term planning is difficult to maintain, as plans frequently need to be revised once new information becomes available. Others said that CSLP would benefit from being more proactive than it is today, and that working proactively and anticipating future needs could reduce inefficiencies compared to reacting to problems as they emerge.

Another aspect raised was the complexity of coordinating CSLP across multiple contractors working within the same area, or close by. In one project, several contractors operated within the same area under a shared client. This required not only an individual site layout plan for each contractor, but also a coordinated one for the entire site. This overarching plan was updated once a week through coordination meetings where shared areas and routes were discussed. Those meetings required continuous negotiations and adaptation to ensure that all parties could operate effectively within the same space. Respondents who worked in more clearly defined project areas did not experience this challenge to the same extent.

4.3 Relationship Between CSLP and On-site Productivity

The findings indicate that the design of site layout plans has a direct impact on project productivity, especially in terms of time losses and associated costs. This impact is primarily reflected through movement patterns on-site, as well as coordination between disciplines and activities. However, the findings show that productivity is not the primary focus in CSLP. Instead, safety considerations are prioritized in the planning process.

4.3.1 Time Losses Related to Movement and Distances

A central finding is that site layout design significantly influences time losses through the movement of personnel, material, and equipment. Several interviewees highlighted long walking distances and inefficient transport routes as examples of NVAA. In particular, long distances to site accommodations were described as a recurring challenge. Interviewee D illustrated this by stating that *"If you have one hundred people working at the far end of the construction site and it takes them fifteen minutes to walk to the site cabin, that is fifteen minutes multiplied by one hundred people, and multiple that with three times a day for breaks, you can imagine how quickly the time adds up"*. Two respondents working in projects with larger site area described that, in addition to the main site accommodation, smaller site cabins have been strategically placed in different areas of the site. These solutions were described as beneficial in order to reduce long travel distances during breaks.

4.3.2 Importance of Initial Placement and Minimizing Relocation

The findings further emphasize the importance of placing TFs correctly from the beginning of the project. It was pointed out that poor initial placement often leads to repeated relocation of materials, equipment and site facilities, which cost both time and resources. Interviewee D described it as *"you do not want to relocate temporary facilities more than once. It is important to place them correctly the first time. Every relocation you make costs both time and money"*.

At the same time, another interviewee mentioned that it is difficult to avoid adjustments and relocation during the production phase, particularly in projects with limited space. Nevertheless, both agree that a well-planned initial layout is a way to reduce unnecessary work.

The site accommodation and cranes are mentioned as critical TFs that should ideally remain in the same location throughout the project. Cranes are described as expensive to move, and relocating the site accommodation can in some cases require a new building permit from the municipality, which can take several weeks to obtain, leading to considerable delays.

Interviewees D and F also highlighted crane relocation as a key driver in updating site layout plans. When cranes need to be relocated, the site conditions change to such an extent that the site layout plan must be revised to reflect the new situation. Both relocation of cranes and site accommodation were described as major changes that consistently require updates to the site layout plan.

This observation is further supported by the document analysis. In one of the studied projects, a total of 14 versions of the site layout plan were identified over a period slightly exceeding one year. In five of these revisions, one or more mobile cranes had either been stationed, removed or relocated. Due to the large crane radio, these changes clearly had a significant impact on the spatial configuration of the site, reinforcing the role of cranes as one of the most influential TFs in shaping the overall layout.

4.3.3 Coordination and Spatial Conflicts Between Disciplines and Activities

Another factor affecting productivity is the level of coordination in the CSLP. The findings indicate that poor collaboration between different actors involved in the project can lead to conflicts between working activities. In projects where different activities are carried out simultaneously within shared areas, spatial conflicts may arise.

Interviewee A provided a clear example of this. When excavation work started, they also started digging directly in the transport path. This prevented the concrete workers from continuing with their work and caused time losses. However, the interviewee emphasized that this was not due to poor layout design, but rather a lack of coordinated planning between the teams. Interviewee J stated that *"there is no single person responsible for CSLP, instead it is a team work, [...] and blue collar workers can provide very valuable input to the layout planning"*. In summary, coordination and involvement of different stakeholders in the layout planning was a recurring theme to avoid these types of issue.

4.3.4 Limited Focus on Productivity in CSLP

Despite the clear impact of layout design on time losses and costs, the findings indicate that productivity is not the highest priority in CSLP. All respondents emphasized that safety is a primary concern. For example, one interviewee stated that *"for me, number one is safety"*, while another highlighted that *"we work safely, or we do not work at all"*.

Some interviewees perceived a trade-off between safety and productivity, while others saw a strong connection between them. Safety distances and site boundaries require space that could potentially be used more productively, but at the same time, a safe construction site can help prevent accidents that disrupt production and affect productivity. Interviewee J expressed that *"after many years in the industry, I have realized that safety is the tool for the workflow. Everything is connected - it is a chain"*.

4.3.5 Use and Perception of Site Layout Plans

The findings also revealed different perceptions regarding the role and usefulness of site layout plans. It was highlighted that these plans must be actively used and constantly updated in order to provide value during the project.

Interviewee A was very clear in stating that *"a lot depends on how the site layout plan is actually used. It can look very well-prepared, but if it is not displayed anywhere and not actively used, it provides no value"*. The same interviewee had experienced situations where different work activities conflicted within the same area due to miscommunication. These conflicts resulted in the need to reschedule both ongoing and upcoming tasks, which led to increased cost and time consumption.

At the same time, there were divided opinions regarding the amount of effort that should be invested in layout planning. Some respondents highlighted a clear potential to improve productivity through extra planning, while others considered additional planning to be unnecessary and require too much time, which becomes inefficient in the long run.

Interviewee J described CSLP as a *"hot potato"* that no one wants to take responsibility for, mainly because of lack of knowledge. Many respondents believed that a checklist or a more structured planning process could facilitate CSLP and reduce the risk of it being seen as a *"hot potato"*, and instead be seen as an opportunity to enhance productivity.

5 Discussion

This chapter discusses the empirical findings in relation to the literature. The aim is to interpret the findings and explore how they contribute to a better understanding of CSLP in urban infrastructure projects. The discussion is structured around the research questions. First, the factors influencing CSLP are examined. Second, the relationship between site layout design and productivity is discussed. Finally, the developed checklist is reflected upon in relation to both theory and practice.

5.1 Key Factors Influencing CSLP

This section addresses RQ1 by discussing the factors influencing CSLP. The aim is to interpret these factors in relation to existing literature and to explore how they shape CSLP in urban infrastructure projects. The discussion is structured around three main themes: contextual and spatial constraints, flows and coordination, and the time perspective of planning.

5.1.1 Contextual and Spatial Constraints

The results of this study show that the design of site layout plans in urban infrastructure projects is influenced by several different factors. Although many of these factors are already well known in previous research, they appear in this study as more intertwined and dependent on the specific situation than what is described in the literature. Rather than being seen as separate variables that can be optimized one by one, the results show that they depend on each other, where changes in one part of the system quickly affect other parts. This indicates that CSLP in practice is dynamic, and depends on the context.

One factor that clearly stands out is the role of the surrounding environment. The interview study shows that projects in urban areas are heavily influenced by external conditions, such as nearby activities, existing infrastructure and the need to consider third party. In one of the projects analyzed, where the work was carried out directly next to a hospital, noisy activities had to be adjusted to ongoing operations. This shows that CSLP is not only about organizing resources within the site, but also about continuously adapting to and coordinating with what is happening in the surrounding environment. Tsegay et al. (2023) highlight how urban construction sites are affected by limited space and external factors, but the findings suggest that these factors play an even more active role in practice. The surroundings are therefore not only something to consider, but also something that largely shapes how both the layout and the work itself are being carried out.

Limited space also appeared as a key factor in the interview study, which supports previous research. However, the findings suggest that this constraint is often underestimated in the early stages. Several interviewees mentioned that space requirements tend to be larger than expected, which then requires changes during production. Zouein et al. (2002) point out that poor placement of TFs can have major effects on efficiency, and Tsegay et al. (2023) highlight how limited space creates site related challenges. The findings in this study support these ideas and emphasize that the issue is not only about physical limitation, but also relates to how space is planned and used in practice.

Another aspect highlighted in the findings is the importance of traffic flows, both inside and outside the construction site. The interview study shows that planning needs to consider different types of traffic, and that this is handled through specific TMPs. This means that layout planning in practice becomes closely connected to the surrounding transport system. In the literature, the focus tends to be on internal flows and distances within the site, as pointed out by Zouein et al. (2002). However, the findings suggest that external traffic flows are just as important in urban projects, meaning that CSLP needs to be understood in a broader context. This supports the idea that CSLP should be seen as part of a larger logistics system rather than as something isolated.

Fredriksson et al. (2025) have also identified a planning gap, where the construction phase is not fully integrated into overall urban and transport planning. They highlight that different actors, such as municipalities and contractors, may have different views on what a TMP should include and what its purpose is. This highlights the importance of coordination and communication between different actors. Even though a TMP and a site layout plan are not the exact same thing, there is a clear connection between them. A TMP mainly deals with external conditions, while the site layout plan focuses on what happens inside the site, and the findings suggest that these need to be better connected in practice.

5.1.2 Flows, Coordination and Organizational Complexity

In projects with very limited space, internal transport flows become especially important. Loop circulation was frequently mentioned in the interviews as something that is desirable in order to avoid reversing and tight maneuvering, and something the interviewees described as a key strategy both for a smooth flow and for a safe work environment. When this is not possible, such as when entry and exit are handled through the same gate, problems may arise regarding disturbance and safety. Kannimuthu (2025) argues that well-planned transport routes are important to reduce unnecessary movement, which is clearly reflected in the findings. At the same time, the study shows that these principles are not always easy to apply, especially in projects where space is highly constrained.

The findings also show that project-specific factors have a clear impact on layouts design. The interviewees agree that differences between project types are noticeable, where building projects are described as more space-constrained and coordination-intensive compared to infrastructure projects. Aaltonen and Kujala (2016) highlight that construction projects are generally complex in terms of organization, and Bygballe and Swärd (2019) argue that increased complexity leads to an increased need for coordination. The findings support this, but also show more clearly how this looks in practice, for example through dependencies between work tasks and more sequential material flows in some projects. This suggests that general CSLP models can become too simplified if they do not consider differences between project contexts.

Safety is described as a high priority in all interviews, which aligns with previous research. Marcano Pina and Sadeghpour (2023) point out that safety requirements are a key factor affecting layout planning, which is also confirmed by the empirical findings. At the same time, the findings show that the relationship between safety and productivity is not entirely straightforward. Some respondents see safety requirements as limiting how space can be used, while others see safety as necessary for an efficient workflow. Ismail and Yusof (2016) show that poor working conditions can lead to a high number of NVAAs, which can be seen as indirect support for the idea that a well-organized and safe site improves efficiency. However, the findings suggest that this relationship is not always obvious in practice. It often involves balancing different goals, and this is further discussed in relation to productivity in Section 5.2.

5.1.3 Time Perspective and Planning Approach

Finally, the findings show that project phases and their link to the project time schedule play an important role, but also show that this connection is weak or lacking in practice. The importance of adapting the site layout to different stages of a project through dynamic planning has been emphasized since the last three decades (Tommelein & Zouein, 1993; Andayesh & Sadeghpour, 2014). Nevertheless, the findings indicate that site layout plans are typically updated in response to emerging needs rather than being updated in advance. The document analysis also highlights that layout plans rarely are connected to stated milestones but instead to general time periods. This indicates that the DSLP described in the literature often turns out more reactive than proactive in practice. One possible reason could be that uncertainty in project execution makes long-term planning difficult. Several respondents mentioned that conditions are rarely stable enough for detailed long-term planning, especially due to unexpected findings related to ground conditions. This makes planning more challenging and according to several respondents, there seems to be some uncertainty regarding proactive planning in practice.

At the same time, there was a general agreement that projects would benefit from a more proactive CSLP, even if some level of flexibility still is needed. The findings also indicate that a clearer connection between the site layout and the project time schedule could reduce the need for late changes.

Overall, the study shows that the factors influencing CSLP in urban infrastructure projects should be seen as part of a connected system rather than as separate elements. The findings suggest that current research, which often focuses on algorithm-based approaches, only partially captures the challenges encountered in practice. Instead, CSLP appears to be a process where technical, organizational and contextual aspects interact, which indicate the need for more flexible and practically useful approaches.

5.2 Effects of Site Layouts on Productivity

This section addresses RQ2 by discussing the relationship between CSLP and on-site productivity. The aim is to interpret how different layout decisions influence productivity, particularly in relation to time losses, movement flows and coordination between activities.

5.2.1 CSLP and Productivity as an Interconnected Process

The findings show that the design of site layout plans is clearly connected to project productivity, especially regarding time losses and therefore costs. However, this connection is not caused by one single factor. Instead, it results from the interaction between different factors, such as how the layout shapes movement on site, where materials are placed, and how well different activities are coordinated in daily work. Rather than seeing productivity as the result of one specific layout solution, the findings suggest that it is the combination of how the layout is designed and how it is actually used that determines the project efficiency.

Tammy et al. (2019) and Nurhendi et al. (2022) explain that productivity in construction projects is often measured through labor efficiency, which makes this aspect particularly important since labor costs are a significant part of the total project cost. They express that labor costs can exceed 30% of the total cost, meaning that even small inefficiencies in how time is used can have a large financial impact. In this context, layout decisions become important. Especially since they affect how much time is spent on NVAAs like walking, waiting or redoing work, which in turn affects the overall cost of the project.

5.2.2 Time Losses, Flows and Coordination Issues

The findings also indicate that inefficiency is closely connected to NVAAs. Several interviewees describe that long walking distances and inefficient transport routes lead to repeated time losses in daily work. Ismail and Yusof (2016) argue that a significant part of time in construction is spent on activities that do not add value.

The findings in this study support this. It is showing that these types of activities are closely related to how the layout is designed, for example through where site accommodations, storage areas or transport routes are placed. This means that CSLP is not only about organizing space, but also about how much of the working time that can be used effectively.

At the same time, the findings show that the impact on productivity can be explained not only by physical design. Many of the problems identified, such as interruptions in workflows or the need for re-planning, occur when different activities are not properly coordinated. Hasan et al. (2018) point out that poor communication, rework and inefficient planning are key reasons for low productivity. The findings in this study suggest that these issues are closely linked to how site layout plans are used in practice. A site layout can work well on paper, but still not work well in practice if it is not used as a shared document to coordinate work, resources and space between different actors.

Respondents describe situations where work activities conflict with each other, which can lead to blocked transport routes or resources not being used as planned. This shows that productivity losses do not only happen because something is poorly placed, but also because the same space is used in different ways by different disciplines at the same time. For example, if one team starts working in an area that others rely on for transport or access, problems can quickly arise. One small disturbance can lead to waiting, interruptions, resources being moved around and sometimes even re-planning of future activities. Therefore, productivity should not be seen as something that comes from one single layout decision, but rather from how well the layout supports coordination throughout the project.

5.2.3 Cost Implications and Long-Term Effects

In addition, the findings also show that placement of TFs is important for avoiding time losses. Several respondents stress the importance of getting this right from the start, since poor placement often results in relocation. These changes do not only cause direct costs, but also indirect costs through disruptions in production. Sing et al. (2019) argue that a significant share of construction costs is connected to how the site is planned and organized, since layout decisions affect transport routes, material flows and access to work areas.

The findings from both the interviews and the document analysis support this. They show that poor CSLP often leads to time losses in the form of unnecessary movement, waiting and rework. These activities reduce efficiency, but they also increase the need for labor. When this happens repeatedly, for example due to long transport distances or frequent changes in layout, the time losses build up and increase the total project cost. This shows how closely time and cost are connected, where even small inefficiencies can have noticeable long-term effects.

Further on, the findings show that inefficient layout solutions commonly lead to increased number of transport and repeated material handling, which increases the use of labor. This is in line with Singh et al. (2019), who point out that longer transport distances are not only more time-consuming, but also increases the use of machines and energy, resulting in an even higher total project cost. Since CSLP starts early in the project, the findings also suggest that poor decisions at this stage can be difficult and expensive to adjust later. The interviews showed that late changes in the layout can lead to relocation of resources or the need for temporary solutions. This suggests that costs related to layout are not isolated problems but rather consequences of earlier decisions. Overall, this shows that CSLP should be seen as something strategic with a clear impact on the total project cost, and not only as a practical matter of organizing space.

5.3 A Checklist for Effective CSLP

The aim of this study was also to develop a checklist to support effective CSLP, which addresses RQ3. The checklist was developed based on both the literature study and the empirical findings. The findings showed that there is a lack of structured methods for CSLP, and that the planning process instead tends to rely on experience. This indicates a need for a checklist to support effective CSLP. However, the checklist is not intended to replace experience-based practices, but rather to work as a complement, where important aspects are highlighted.

The checklist is an attempt to transform the findings of the study into a practical supporting tool for CSLP in urban infrastructure projects. In contrast to the more advanced optimization methods identified in the literature study, the checklist aims to provide a more practically applicable supporting tool which is adapted to the conditions and constraints of the projects.

However, the checklist is designed at a general level, as CSLP is project-specific. The study has shown that variations between projects have a significant impact on how the construction site can be organized. This means that a detailed or standardized checklist would be difficult to apply across projects with varying conditions. The aim of the checklist is therefore not to provide a solution for CSLP, but rather to serve as a general supporting tool and framework for highlighting important aspects that need to be considered.

This section is structured according to the main components of the checklist and discusses how each component addresses the needs and challenges identified throughout the study.

5.3.1 Initial Site Assessment

The first part of the checklist, initial site assessment, aims to establish an understanding of the conditions that influence the design of the site layout. The findings highlight several key factors affecting CSLP, such as the surrounding environment, space constraints, project-specific conditions and requirements, all of which should be analyzed at an early stage. The findings also indicate that shortcomings in the initial assessment can have consequences later in the project, for example in the form of limited space, unclear transport flows and the need to relocate TFs.

Particularly in urban projects, the importance of initial analysis of site boundaries and available workspace becomes evident. The findings indicate that space requirements are often underestimated during the planning phase, leading to inefficient solutions during production instead. Previous research supports this by emphasizing that space constraints are not only a physical limitation but also a key condition influencing how work is planned and executed (Salah et al., 2021; Salah et al., 2024). By assessing the available space and identifying the main activities of the project and their space requirements, these conditions can be recognized at an early stage.

The surrounding environment was found to influence how the construction site can be designed, primarily through proximity to public traffic, nearby activities and third party. Despite this, the interview study showed that these aspects are often addressed reactively in practice, rather than as an integrated part of the initial planning process. By including an analysis of the surrounding environment as a step in the checklist, these aspects can be taken into consideration already in the early stages of planning.

In addition, identifying the type of project is a key part of the initial assessment. According to both the literature and the empirical findings, this factor is crucial. The project type reveals the main activities of the project, as well as the number of transports and actors involved, all of which are factors that influence how the construction site should be planned.

In this step, any laws and regulations affecting CSLP should also be identified and compiled. The interview findings primarily highlighted safety requirements that must be met. In addition to safety requirements, the literature also identified client requirements, environmental requirements and transport policies. However, the findings indicate that different municipalities may impose different requirements, making it important to identify and comply with the regulations applicable in the specific municipality.

At the same time, it should be noted that an initial assessment can not capture all possible future changes in a project. The purpose of this step is therefore not to create a static representation of the project, but rather to establish a foundation for further planning and enable more proactive decision-making.

5.3.2 Identification and Placement of TFs

A construction site contains a variety of different TFs, which may also vary between projects. TFs´ location have been shown to have a direct impact on project productivity, particularly in relation to travel distances and time losses. The findings indicate that inefficient transport routes and long distances between TFs contribute to NVAAs. Previous research also emphasize that well-planned placement of TFs can help reduce transport distances and repeated material handling, thereby reducing both time losses and costs.

This step in the checklist therefore aims to first identify all required TFs and estimate their space requirements, in order to strategically place them on the site. The facilities needed on a construction site vary between projects. However, those identified in the literature review and the empirical findings are mainly:

- Site accommodation
- Safety barriers
- Cranes
- Material storage
- Safety equipment
- Emergency exits and routes
- Emergency evacuation point

However, it is important to remember that, in addition to these, there are many other facilities that may be required. Therefore, this list should not be considered exhaustive. The identification of TFs should always be done in relation to the project specific needs.

In addition to the facilities mentioned above, site entrance and exits should also be determined at this stage. Entrances and exits have been highlighted as a starting point in CSLP, as they need to be adapted to external traffic conditions. Transport routes and pedestrian pathways on site should also be clearly marked in this stage. By incorporating movement flows for both materials and personnel into the planning process, better conditions are created for minimizing travel distances. At this stage, previous research suggests that optimization algorithms should be used to reduce travel distances. However, this is not currently implemented in Swedish infrastructure projects, as sufficient knowledge in this area appears to be lacking.

Given that safety has been identified as the highest priority on construction sites, safety zones should also be defined at this stage. This means that space must be allocated to ensure sufficient distances between workers and machinery. Consequently, the placement of TFs can not be optimized solely based on efficiency considerations. At the same time, a safe work environment leads to fewer accidents, which in turn reduces the risk of production disruptions.

5.3.3 Productivity-Oriented CSLP

A key aspect of the checklist should be to integrate productivity more explicitly in CSLP. The findings clearly show that the design of layout plans has a direct impact on productivity. At the same time, productivity was rarely found to be treated as the primary focus in CSLP. The purpose with this part of the checklist is therefore to move from treating productivity as something implicit to making it a central part in the planning process.

Minimizing transport distances is a key factor in increasing productivity. Singh et al. (2019) supports this by highlighting the relationship between long transport distances and increased time losses and costs. Long transport distances represent a clear example of NVAA, as they consume resources without contributing to creating any value to the project. Findings from the interview study indicate that long distances to site accommodations can be problematic in infrastructure projects, since they typically have larger areas. To address this, smaller site cabins for breaks can be distributed over the site. Alternatively, vehicles can be used to transport personnel over longer distances, such as cars or bicycles, with bicycles being a more environmentally sustainable option.

The checklist also highlights the importance of ensuring efficient movement flows on-site. This not only involves reducing distances, but also organizing flows in a way that minimizes crossing traffic, waiting times, and disruptions to ongoing activities. The empirical findings showed that loop circulation should be pursued where it is possible, in order to avoid reversing vehicles and ensure a smoother transport flow. Separating the entrance and exit can also contribute to more efficient flow. This part of the checklist is closely linked to logistics and should be planned in collaboration with the logistics team.

Another aspect included in the checklist is the separation of pedestrians and vehicles. Although this is primarily a safety issue, the findings indicate that safety and productivity do not necessarily conflict with one another. On the contrary, a clear separation can contribute to more efficient movement flows, allowing pedestrians to move freely without having to wait for passing vehicles, and the other way around.

Finally, the checklist emphasizes the importance of a well-considered initial placement of TFs to minimize the need for relocation during the project. The findings showed that relocating TFs is both time-consuming and costly. At the same time, it was found that in practice it is difficult to completely avoid relocation, especially in projects with limited space and a high degree of uncertainty. However, the initial placement should not only be optimal for the current situation, but also strategically placed to accommodate future needs.

5.3.4 CSLP as a Dynamic Management Tool

The purpose of this part of the checklist is to strengthen the role of the layout plan as a management tool. This means that the layout should not only be seen as a document prepared at the beginning of the project, but also as a support for daily operations that is continuously updated and communicated to relevant stakeholders.

The findings clearly show that CSLP in practice is a dynamic process influenced by changing conditions throughout the project. The layout plan should therefore be treated as a living document that is regularly updated based on project progression. Changes in project phase, work activities, and resource needs require continuous adjustments of the layout. When changes are omitted or carried out too infrequently, the layout plan risks becoming outdated and useless. It appears to be differing opinions regarding how frequently the layout plan should be updated. According to the literature, the need for DSLP is greater in projects with limited space and long construction durations. Hansen (2024) suggests that small-scale projects should have at least two layout plans, while large-scale projects should have at least three. However, the empirical findings indicate that projects often have significantly more versions than this. For example, one project had 14 updates over a little more than a year. Nevertheless, the number of updates should be adapted to project duration, available space, complexity and work activities.

Furthermore, the study shows that there is often a lack of clear connection between the layout plan and the project time schedule, which makes proactive planning of future needs more difficult. By linking the layout plan to the project time schedule and defined milestones, a more proactive approach can be achieved. This can also be connected to DSLP, where at least each milestone should imply an update of the layout.

Another important aspect highlighted in the study is the need of involving multiple actors in the planning process. It is very rarely that one single individual has full knowledge of all work activities in a project and all transports arriving at the site. Although the site manager is responsible for the site layout plan, they should involve blue collar workers, who spend more time on-site and have a better understanding of how things work in practice. In urban projects, it may also be relevant to include the municipality in the planning process. Previous research by Fredriksson et al. (2025) shows that there is often a gap between the long-term urban planning and the practical conditions during construction, where different actors have conflicting goals and priorities. By involving the municipality, better coordination can be achieved between the project´s needs and the requirements of the surrounding environment.

Finally, the findings emphasize the importance of clearly communicating the changes in the layout plan to all relevant actors. If updates do not reach those working on-site, the layout plan risks losing its function. For example, materials may be delivered to the wrong location because the driver followed the outdated version of the layout plan, which requires rehandling and can result in unnecessary time losses. This is why clear and continuous communication of updates is essential. This does not only involve distributing revised drawings, but also ensuring that everyone understand the implications of the changes.

6
Conclusion

The aim of the study was to analyze how the planning and design of site layout plans in urban infrastructure projects affect productivity in terms of time losses and costs. By combining previous research, interviews and a document analysis the study gave a picture of how CSLP works in practice.

The findings show that the factors influencing site layout planning are several and closely connected to each other. It becomes clear that CSLP cannot be broken down into independent elements. Instead, it is characterized by different conditions and how they interact, where changes in one part of the system quickly lead to consequences in another. Therefore, CSLP appears to be a process that is highly dependent on the specific context of the project rather than on general solutions.

One aspect that stands out is the role of the surrounding environment. For projects in urban environments, planning is highly influenced by external factors such as nearby activities and existing infrastructure. In some cases, this means that work has to be continuously adapted, making the layout not only an internal issue, but also something that must constantly evolve in relation to existing conditions. This suggests that CSLP is more dynamic in practice than what is presented in previous research.

The findings show that there is a clear connection between CSLP and productivity, but the connection is not always directly visible. It is not possible to point to one single layout solution as correct or incorrect. Instead, the impact seems to depend on how well the layout supports daily work on site. Several of the issues described in the interviews were related to time losses caused by waiting, unnecessary movement and rework. These types of NVAAs often arise in situations where flows do not work as intended or when different activities are not coordinated enough.

Another important observation is that even small inefficiencies can have noticeable consequences over time. What might seem like a minor problem in one single situation can, if it is repeated many times, affect both the project time schedule and the overall cost of the project. This reinforces the idea that CSLP is not just a practical issue, but something that is directly related to project costs.

At the same time, this study indicates that CSLP is carried out in a rather unstructured way. Many decisions rely on experience, and adjustments are often made when problems occur rather than planning in advance to prevent the problem.

Several interviewees also expressed that a more structured approach would be helpful in CSLP. The checklist below has been developed to address this. The idea is not to replace the experience-based approach, but to support it by highlighting important aspects and helping practitioners think more systematically about layout decisions.

Construction Site Layout Planning Checklist

1. Initial Site Assessment
    - Evaluate the construction site boundaries and available workspace
    - Analyze the surrounding environment
    - Define the type of project
    - Identify all major construction activities
    - Identify applicable requirements and regulations
2. Identification and Placement of TFs
    - Identify all required TFs
    - Estimate space requirements for each TF
    - Define entrance and exit points
    - Define transports routes for vehicles, machinery and personnel
    - Establish safety zones
3. Productivity-Oriented CSLP
    - Minimize transport distances
    - Ensure efficient movement flows
    - Separate pedestrians from vehicles
    - Ensure effective initial placement to minimize relocations
4. CSLP as a Dynamic Management Tool
    - Regularly update the site layout plan based on project progress
    - Link the layout plan to the project schedule and key milestones
    - Involve multiple actors in the planning
    - Communicate updates clearly to all relevant stakeholders

6.1 Limitations and Suggestions for Further Research

There are several limitations in this study that are important to highlight. First, the number of interviews conducted and the number of site layout plans analyzed is limited due to the given time frame for the study. Conducting more interviews with additional companies within the industry and analyzing more site layout plans would have been advantageous as it would have strengthened the results or nuanced them even more. Furthermore, this study mainly reflects the perspectives of site managers and similar roles. Conducting interviews with other users of the site layout plan could have provided additional insight.

The findings are also based on a limited number of companies. Studying projects and interviewing a wider range of companies within the industry could have increased its broader relevance.

Another limitation in this study is that the checklist developed has not been tested in a practical project. The checklist is based on the literature study and empirical findings. However, to assess its effectiveness, it should have been implemented in an urban infrastructure project.

These limitations also point to several suggestions for future research. One suggestion would be to introduce and evaluate the checklist in practice. In this study, the checklist was developed based on previous research, interviews and an analysis of site layout plans. However, its impact on the planning process and project execution has not been examined. Future studies could therefore implement the checklist in an infrastructure project to investigate its usability as well as its impact on productivity.

Another recommendation for future research is to put numbers on the relationship between CSLP and project productivity. This study has identified a clear connection between layout decisions, time losses and costs, but not the extent of this connection. Future studies could therefore measure and compare how different layout decisions affect walking distances, transport routes and number of relocation, which in turn affect project costs. Such research would provide a deeper understanding of the actual significance of CSLP.

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A

Appendix A

Background and Role:

Can you briefly describe your role and your experience with CSLP?

What experience do you have with infrastructure projects in urban areas?

Current CSLP Process:

Can you describe how the CSLP process is carried out? Are there any internal guidelines or standards

How do you ensure that important aspects are not overlooked? Is there a checklist?

How often is the construction site layout plan updated throughout the project?

What are usually the most common reasons for changes in the layout?

Do you perceive layout planning as more reactive or proactive?

Which tools do you use to create and update site layout plans? How well do these tools work in practice?

CSLP Factor:

What are the most important factors influencing the design of site layout plans in your projects?

How do urban constraints and surrounding conditions shape your site layout planning?

How does the project phase (e.g., early stage, production, completion) influence the site layout?

How do regulatory and safety requirements influence site layout planning?

CSLP Effect on Productivity:

Have you experienced situations where the site layout has caused time losses? What type of time loss was it, and how was it measured?

How do you perceive that layout decisions can be linked to costs?

Concluding:

If you could change one thing about how site layouts are planned today, what would it be?

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